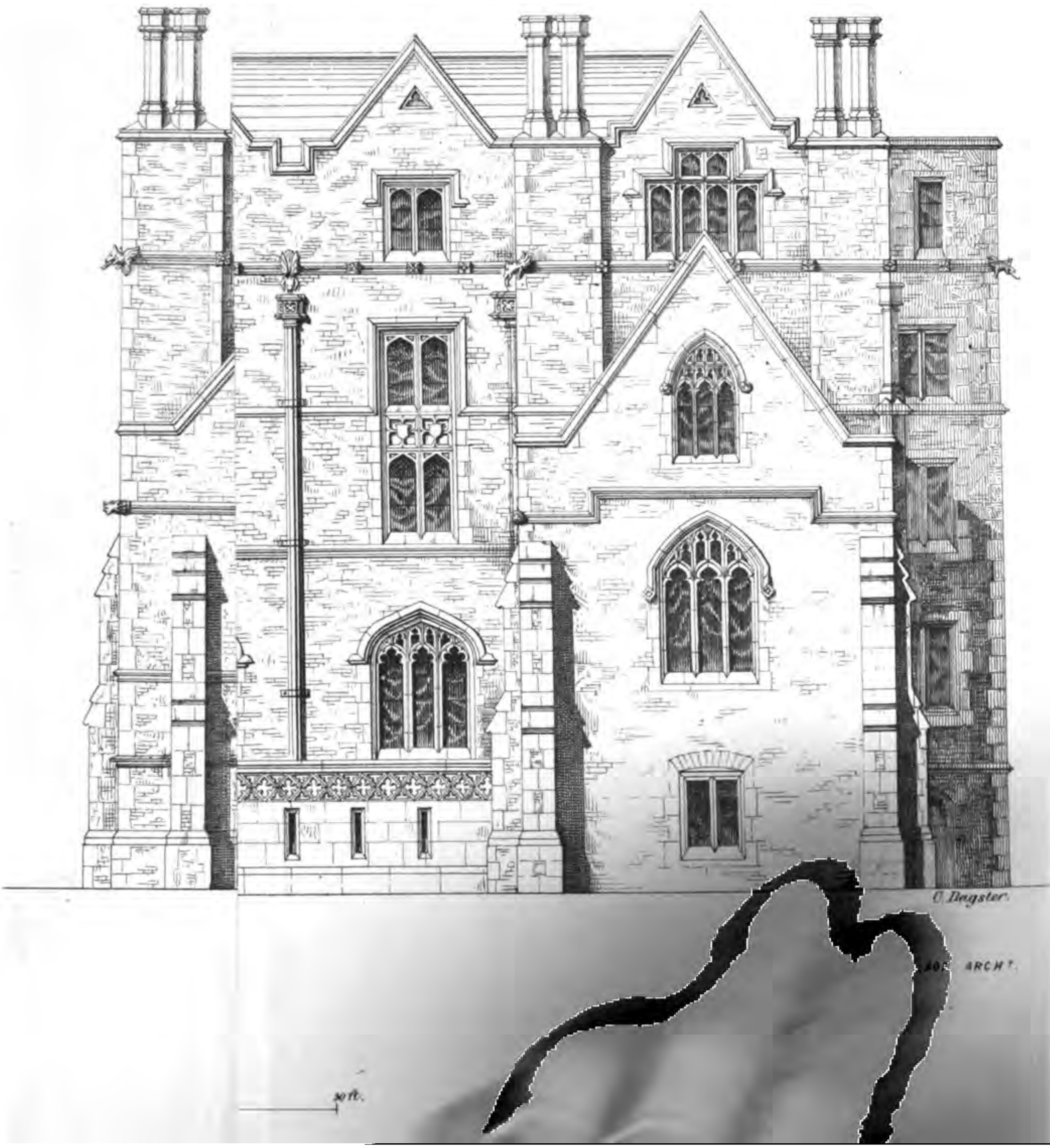

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THE

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INCORPORATED WITH

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VOLUME XV.—1852.

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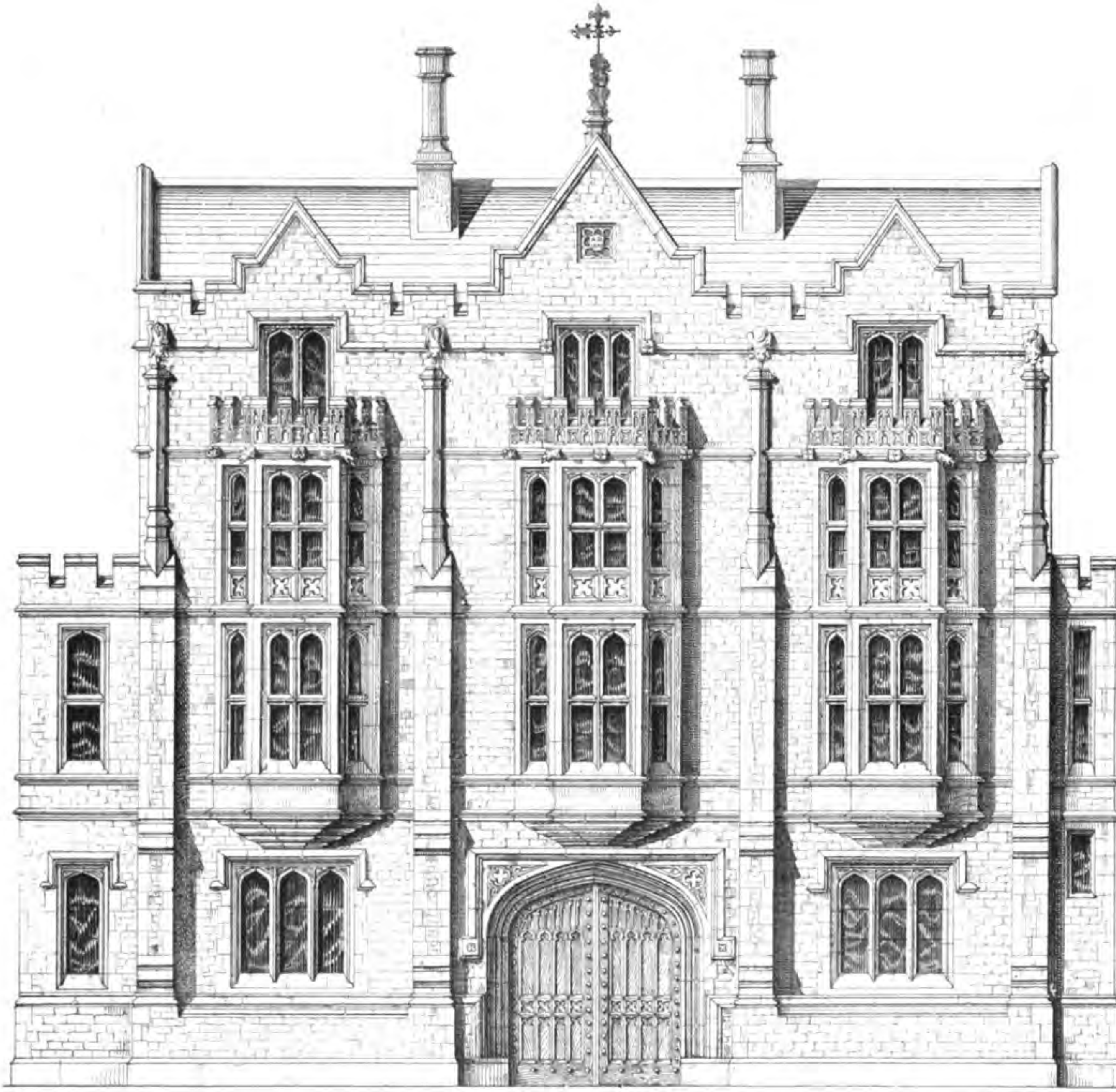
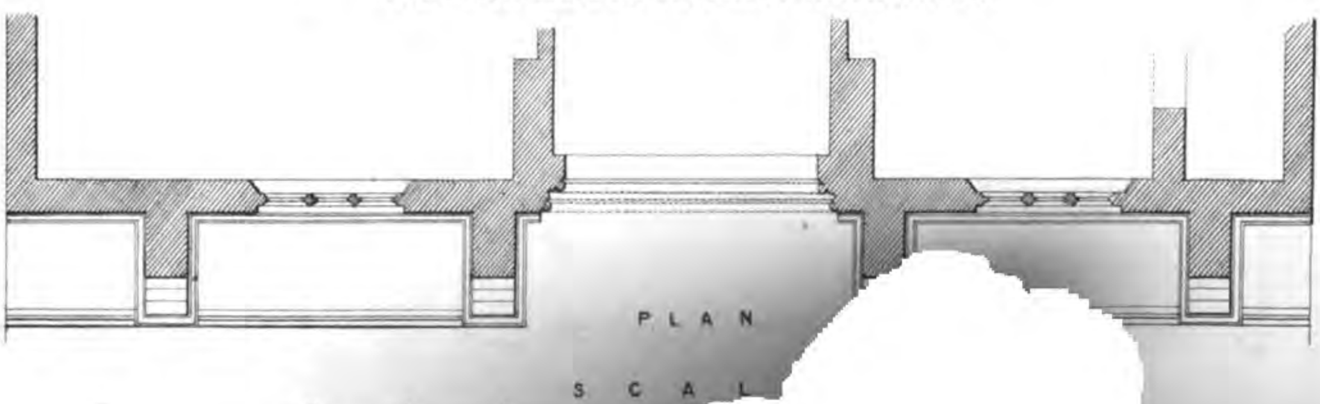


WESLEYAN NORMAL COLLEGE, WESTMINSTER.



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C. Bagster

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1852.

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LIST OF ILLUSTRATIONS.

THE

CIVIL ENGINEER AND ARCHITECT'S

JOURNAL.

WESLEYAN NORMAL COLLEGE, WESTMINSTER.—JAMES WILSON, Esq., Architect.

(*With Engravings, Plates* I. *and* II.)

THIS establishment, situated in the Horseferry-road, is an example of a normal college on a large scale, and therefore will be found useful as a study by those who may contemplate the erection of such a building, for which with the spread of education the demand is likely to become greater than it even now is. This College is intended for the reception of 100 students, male and female, under course of training as teachers, and has attached to it preparatory and infant schools for boys and girls, in which the children of the neighbourhood are educated, and which serve for the practice of the students in school management. These schools affording the chief occupation for the students in the course of their training, the plan does not exhibit so many special class-rooms as would be found in other colleges having the same number of attendants. On the other hand, it is to be observed that the space occupied by the attached schools so much extends the area of the buildings, that a normal college constitutes an establishment of a large class; thus the one in the Horseferry-road, with its playgrounds, covers a space of more than five acres. It is to be observed, nevertheless, that there is an economy in the cost of a normal college, because it provides not only for the instruction of the required number of schoolmasters, but likewise for the construction of schools for the neighbourhood. The architect of the large structure, which we have partially illustrated in our engravings, is Mr. James Wilson, of 38, Parliament-street, London, and Bath. The contractors for the building were Messrs. Curtis, of Stratford. The style is the Late Perpendicular; and the endeavour of the architect has been to obtain as much effect as the requirements of the economy imposed upon him by the committee would allow. The material is stock brick, with stone dressings, except for the Principal's house, which fronts the Horseferry-road, and which is of Sneaton stone, with dressings of Bath stone.

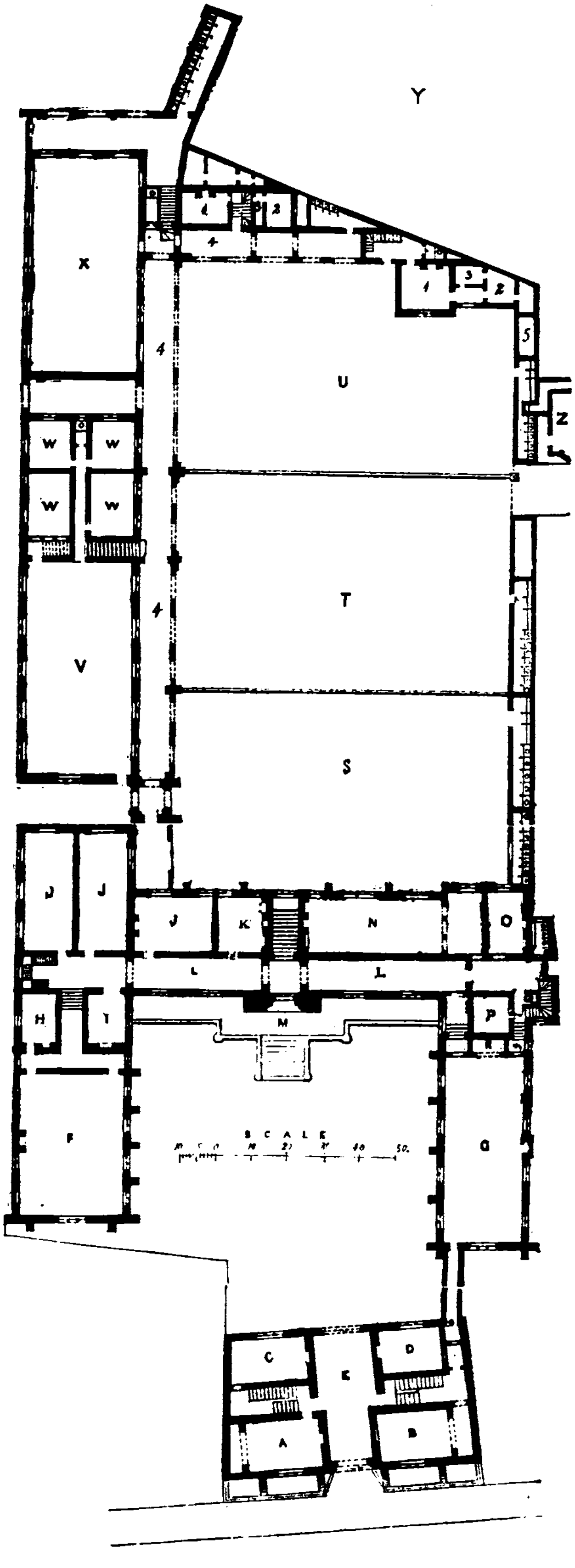
The portion of boundary on the Horseferry-road being restricted, the Principal's house is placed there, as shown in the annexed plan, and the elevation, Plate II., and is constructed of a more ornamental character and material. The ground-floor is pierced by the entrance-gate of the College, and the whole front is divided into three compartments of four stories each, in which the projecting oriel windows form an ornamental feature. Within the gateway there is, on one side the entrance to the Principal's apartments, which consist of ten rooms; and on the other, that to the secretary's room, board-room, library, and other offices belonging to the managers.

The College, properly so called, stands behind this house, and forms three sides of a square. The elevation is given in Plate I., but it is to be observed that the low gables there shown are the end elevations of the projecting wings. The College is approached from the entrance archway, and in its centre is a flight of steps leading to a front terrace, and to a door under an oriel window, and which leads to a small central hall, having a corridor on each side reaching to the wings. Beneath the terrace floor is a basement story, which includes the extensive domestic offices necessary for such a large establishment, and in one wing two exercising and other rooms for the male students. This basement story opens behind, on a lower level, and is there provided with a range of cloisters.

On the ground-floor are, in one wing, three class-rooms, an apparatus-room, and a lecture-hall for male students, with two masters' sitting-rooms; and in the other wing a female students' sitting-room (which is a long hall), a mistress's sitting-room, and a dining-hall, 52 feet long by 22 feet wide, with an organ recess. Near this dining-hall is a lift, for the service of the kitchen. The lecture-hall being a principal apartment, is carried up to the top of the wing, and has an open roof with hammer-beams. The dining-hall, however, is only one story in height, and its ceiling is panelled, with moulded ribs. The three upper stories are appropriated to dormitories, the third story to female students, and the two others for the young men. The dormitories are well provided with lavatories and baths, and comprise a separate apartment for each student, the dimensions being 9 feet by 7 feet, and 9 feet high. The central clock tower is made useful for containing the cistern for the supply of the apartments with water, and for security against fire. The building is throughout lighted with gas, and warmed with hot water.

Behind the College are the several practising schools, having separate entrances from the adjoining streets for the scholars. The practising schools include those for infants and older children of both sexes. There are four spacious rooms with the appropriate "galleries," and twelve class-rooms with a "gallery" in each. Within these schools is a quadrangle, serving as playgrounds, surrounded with cloisters and flanked with the two masters' houses. As the elevation of the street front of the schools is not given in our Plates, we may mention that it consists of a projecting centre gable, ornamented with an oriel window, and on either flank are cloisters communicating with belfry turrets at each corner.

PLAN, WESLEYAN NORMAL COLLEGE, WESTMINSTER.



References to Plan, Wesleyan Normal College.

A. Secretary's Room	L, L. Corridors	U. Junior School Playground
B. Dining Room	M. Terrace	V. Infant School
C. Waiting Room	N. Female Students' Sitting Room	W, W. Infant Class Rooms
D. Study	O. Master's Sitting Room.	X. Junior School
E. Archway	P. Waiting Room	Y. Senior Playground
F. Lecture Hall	Q. Lift	Z. Porter's Lodge
G. Dining Hall	R. Organ Recess	1. Kitchen
H. Apparatus Room	S. Infant School Playground	2. Scullery
I. Master's Sitting Room.	T. Industrial School Playground	3. Pantry
J, J. Class Rooms.		4. Cloisters
K. Head Master's Sitting Room		5. Tank

THE ARCHITECTURAL EXHIBITION.

THE opening of the Architectural Exhibition for 1852 is one of the events of the year, and is calculated to exercise a very beneficial influence on the art. There are, of course, many who will remark the absence of grand and original conceptions, and of colossal works; but such objections have not the slightest weight. The Royal Academy Exhibition is as little remarkable for such productions; but the Architectural Exhibition having originated with the younger members, still chiefly relies on them for support, though in the present year a great accession has taken place of names better known to the public. The younger member will mostly send studies, as his practice is small; but the mere opportunity of exhibiting studies is valuable, as is exemplified in the Portland Galleries, for many of the studies display an originality of conception, and a tastefulness of treatment often wanting in the representations of works executed. After making due allowance for the competition of the Royal Academy Exhibition, and the absence of the seniors of the profession, we consider the Architectural Exhibition as successful and important. It displays a great amount of talent, and affords strong proof of the progress, in this country, of architectural study. It affords, indeed, a much better indication of the future of architecture, and gives a more hopeful prospect than can be sought in the Architectural-Room of Trafalgar-square. It may be, this year's architectural display in the latter place may be stimulated by the exertions of the rival exhibitors, though this is little to be looked for; but, at any rate, the promise of successful duration lies with the Architectural Exhibition.

There is one feature prominent in the Architectural Exhibition which will challenge objection; and that is, its more popular form. The whole of the walls and some additional screens of the Portland Gallery are covered with drawings, generally well finished, and producing a most pleasing effect. The Exhibition is certainly well calculated to catch the public eye, and we are glad of it. We do not as yet regret the comparative minority of plans and practical details, because we consider it of great importance to inlist the popular sympathy for architecture as an artistic profession. We are glad to see the numerous well-touched elevations and perspective views; and we are glad to see the drawings of old and well-known buildings, because this is a legitimate place for such a display. Although perspective views may be abused to delude a competition committee, yet perspective views are essential to show that the designer has properly studied the artistic qualifications of his building; and with these the public have most to do. At a future period, and when the institution is better established, it will be desirable to institute a classification, distinguishing between original designs and copies of old buildings; and it will follow, too, as a matter of course, that designs which have been repeatedly exhibited should be excluded. The present collection contains several lithographs and engravings; but so far from objecting to their presence, we think great benefit may be derived from encouraging them. We would, however, form a separate branch for architectural engravings, and which would afford a very convenient opportunity for promoting the views of the architectural publishers and engravers, and thereby stimulate them to exertion. Judicious arrangements would promote the exercise of architectural painting and engraving, and thereby, while extending the basis of sympathy with the public, greatly advance the interests of architects. A good engraving of a great architectural work is calculated to do very much good, by making the labours of the architect better known, and by placing in many hands a valuable study. The painter of architectural groups and scenes, however, deserves no less the countenance of the architect, because a debt is due to every one who exerts himself in upholding the reputation of the profession, and in recording its most distinguished works.

Bearing all these considerations in mind, we are very much pleased that the present constitutes a large architectural exhibition, that the list of exhibitors is long and more numerous than that of last year, and that the catalogue is consequently more voluminous. It is worthy of mention, that a separate department has been opened for the display of materials, details, and inventions, applicable for architectural purposes, and that this already includes a large collection. Indeed, altogether, the arrangements reflect great credit on the committee, which is more strongly supported, and we are gratified to find that the suggestions we have thought it right to make in the interest of the profession have been carefully considered, and in many cases adopted. This will be received as an encouragement for all who feel an interest in the Exhibition; and we hope any one having a suggestion to make calculated to further its interests, will avail himself of the opportunity of putting it before the committee. The Exhibition, in its present state, is a good evidence of the beneficial results of co-operation, but still more of the successful exertion of individual energy; and we hope no one will neglect to contribute to the promotion of an institution which must prove beneficial to his profession.

In the absence of those architects who are engaged on the most important structures, consequent on their connection with the Royal Academy or the Royal Institute of British Architects, there are few designs which can be considered as belonging to the first rank: but this is only a temporary evil; and there is abundance of works entitled to great admiration, and affording the most available opportunity for the practitioner to study the resources and tendencies of his art in the present and in the future. Academicians will, in due time, have to take their places in the Architectural Exhibition, as well as in the Institute; but in the meanwhile, there is little cause to regret their absence. In the course of events, many of the gentlemen who now exhibit will become Academicians—if architectural Royal Academicians there are to be—or attain the first ranks of their profession; and for the present we have quite enough to do in studying the valuable productions they have sent to the Portland Gallery.

As a matter of course, churches figure largely in the collection; but we cannot say there is any prominent example, although there is a wide field of study in the various forms and combinations presented. Mr. G. Gilbert Scott, Mr. Lamb, Messrs. Habershon, Mr. G. Godwin, Mr. Wardell, and Mr. Nicholls are among the exhibitors in this department. We are glad to notice a large number of drawings of fonts, doors, and other ecclesiastical accessories, showing the extension of architectural labour to these details. Mr. Truefitt, Mr. V. T. Horden, Mr. Tayler, Mr. J. D. Wyatt, and Mr. Digweed, have several designs relating to such objects.

Although there are various classes of structures worthy of remark, we may call attention to the many designs illustrative of street and shop architecture. This is a very useful branch of study, and one in which the public will take great interest. For one church commission there are a score for shops, and yet few take advantage of the opportunities afforded by liberal employers. Of course, the improvement of the more conspicuous monuments is desirable; but the public taste will be sensibly affected by an improvement of those common structures which constantly meet the eye. If architects teach the public that a shop-front can and ought to be designed by an architect, the architect will be called in and employed. Indeed, in consequence of the improvement which has already taken place, architects are now frequently called upon for special designs by enterprising tradesmen; and the effect of example must be to increase the sphere of employment. Among the exhibitors of designs in this class are Mr. Fergusson, Mr. Truefitt, and Mr. R. Burt.

Not the least interesting works under this head, and not the least interesting in the whole Exhibition, are the warehouses erected in Manchester by Mr. E. L. Walters. Without apparently increasing the outlay, he has, out of such common structures, obtained palatial ranges which must be ornaments to the town, as they are memorials of his skill. We have often regretted that factories and warehouses, affording large and massive groups, are too often so idly, tamely, or barbarously treated as to be eye-sores to all who behold them. Mr. Edward I'Anson, jun., has a design for club-chambers, in which the ground-plan is occupied by shops.

There are, as usual, a number of drawings of villas and cottages. Among these are works by Mr. E. Walters, Mr. G. P. Kennedy, and Mr. Jayne. Mr. Walters is remarkable, as last year, by the tastefulness of his designs. Mr. G. P. Kennedy shows several designs in which judicious arrangements of terraces and gardens are made to promote the architectural effect. Some designs by Mr. Jayne exhibit tasteful and novel combinations of windows and doors.

Several designs are shown for public improvements, for large buildings, or as exercises of a luxuriant imagination. Mr. C. Fowler shows a gigantic stone arch for the Avon at Clifton (No. 86), in which "the abutments are to contain vaulted warehouses and cellars, communicating with the wharves; with arched galleries over and on the spandrels for public resort." Mr. T. Allom has a variety of designs, including embankments for the Thames, public baths, and other subjects, in some of which an Eastern fancy is traceable. Mr. Fergusson has in No. 211 his plan for a National Gallery. Mr. Ashpitel shows an extensive design for rebuilding Blackfriars Bridge, and throwing open the west front of St. Paul's. Mr. H. B. Garling has an ingenious design for remodelling the National Gallery, without disturbing the line of the present front, or altering the internal arrangement.

What will interest the public, as well as professional men, is the large collection of drawings of well known buildings. Mr. Fergusson has some Indian temples, and Mr. Ruskin several Venetian sketches. Other contributors are Mr. E. Sharpe, Mr. R. W. Billings, Mr. J. P. Seddon, Mr. J. K. Colling, and the Earl of Lovelace.

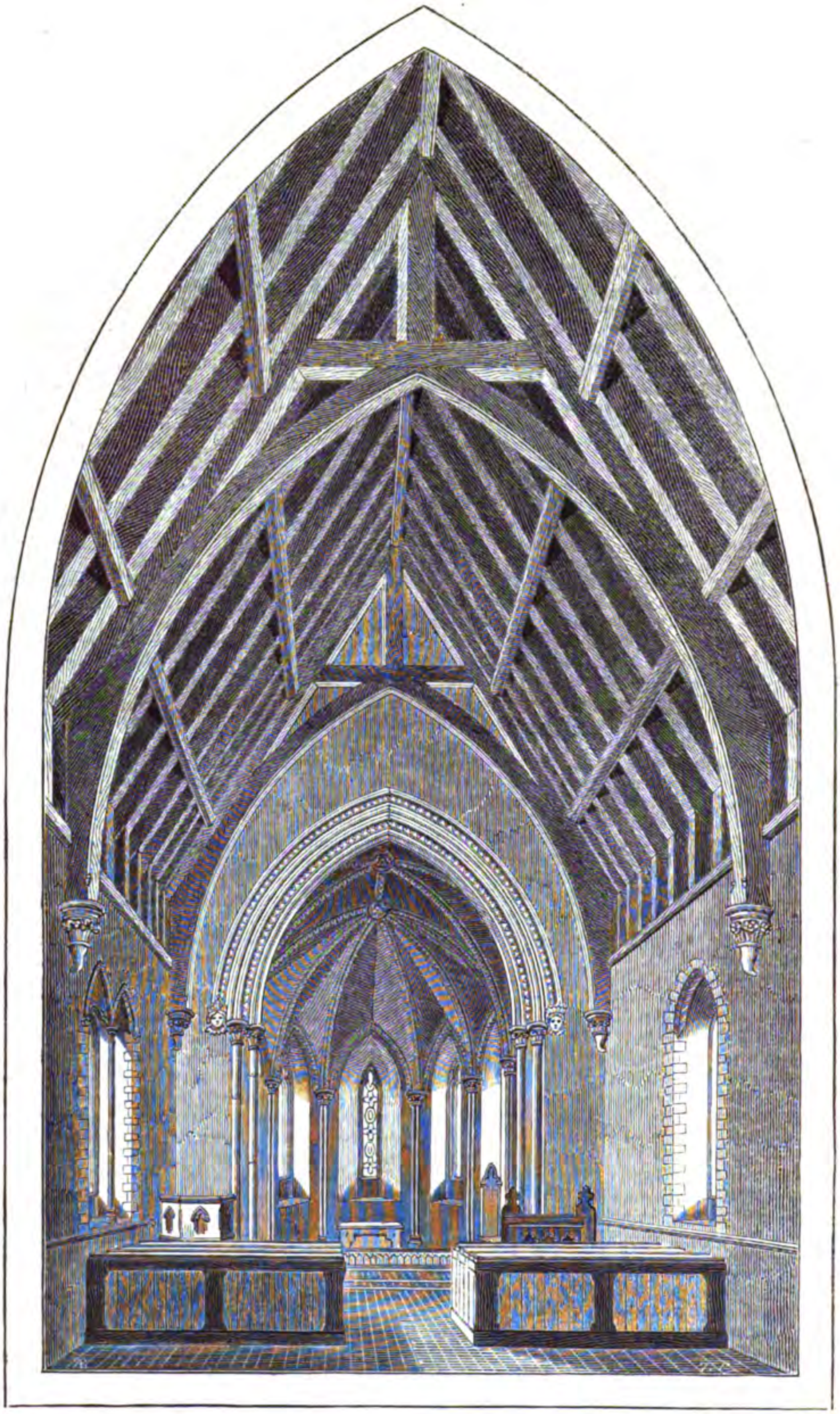
In a great many drawings polychromatic decoration is effectively introduced, and some very valuable examples are afforded in an important branch of the art. Mr. J. W. Papworth has an elaborate design for a county meeting room; a drawing by Mr. Edmeston (No. 93) has great merit; and Mr. Leonard W. Collmann shows a ceiling which has been executed at Liverpool. Mr. Boutcher has a tavern front. A screen, by Mr. S. J. Nicholls, unites polychromy and wrought-iron work, and so does a shop-front by Mr. S. F. Wadmore. Messrs. Gabriel and Hirst have introduced gilding effectively.

Iron castings have not been neglected; and besides a variety of drawings for canopies and other objects, we have to mention a pair of gates by Messrs. Cottam and Hallen. There is likewise a design for gates by Mr. W. Ellis; and for a lamp by Mr. W. Purdue.

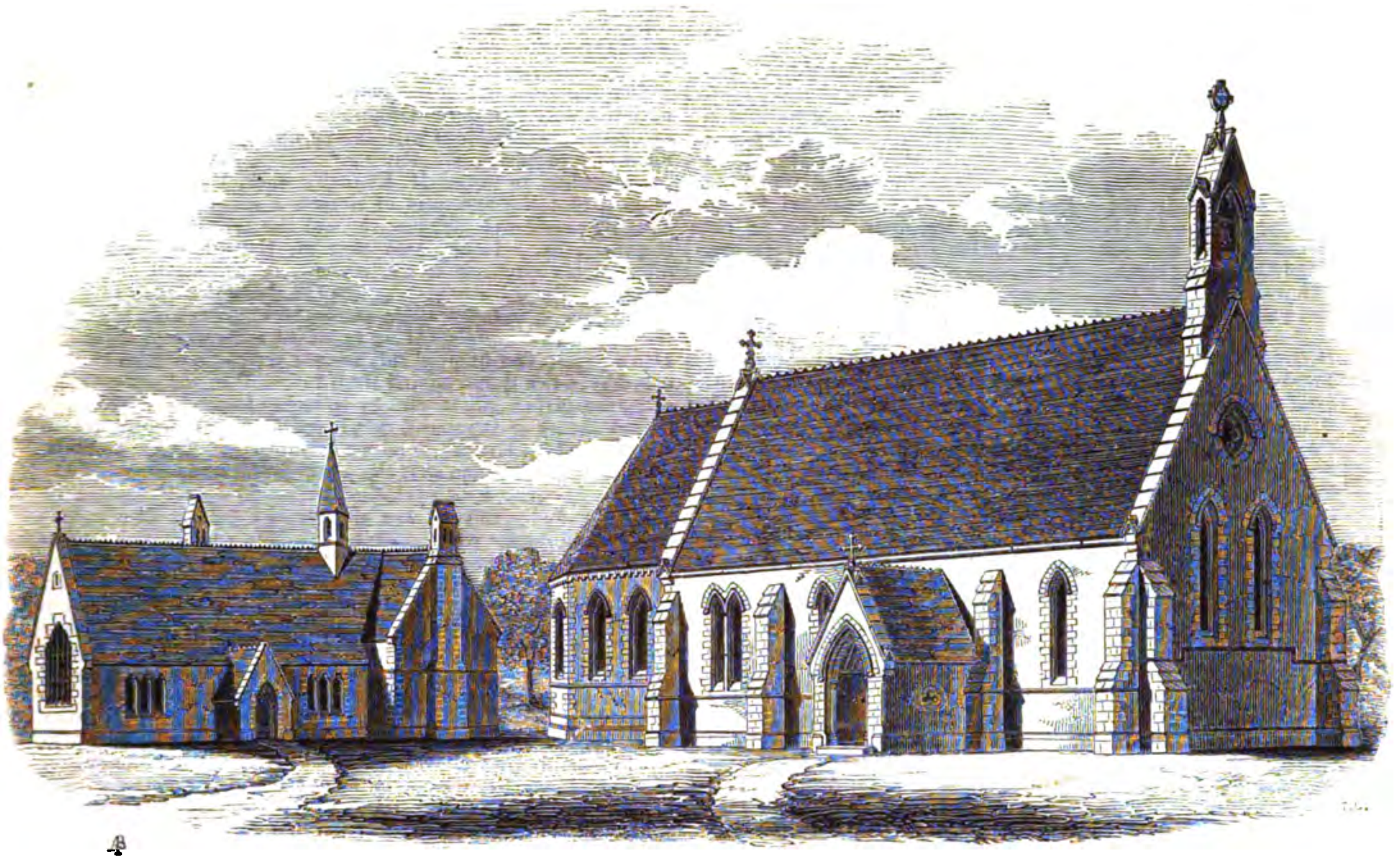
M. Hector Horeau exhibits a daguerreotype, the remarkable roof of the Panorama he is constructing at Paris, and some very bold plans. Mr. Turner, of Dublin, has a plan for a bridge over the Medina to connect East and West Cowes, and to allow shipping to pass.

Although it was not our intention, in the present notice, to describe particularly any one of the drawings exhibited by members of the Architectural Association, we cannot allow this opportunity to pass without earnestly directing the attention of our readers to a design sent in by Mr. Edmeston, the indefatigable and intelligent secretary to the Association, which affords unmistakable and cheering evidence that architects—at least the junior members of the profession—are gradually freeing themselves from the fetters of mere routine, and are desirous of availing themselves liberally and without too bigotted a regard for precedents, of whatever materials nature may offer or man may fashion for their use.

The design alluded to is No. 93, and is thus described in the catalogue: "Sketch for a Cottage, suggesting, in the *simplest* form, a system of iron framing, filled in with Tate's Patent Slabs of rough clay, covered with a very thin coating of porcelain clay, and then glazed. These Slabs may have any colour and pattern, or be in imitation of any marble. The cost of such a construction as this is estimated at about the same as 14" brickwork." The method employed by Mr. Tate was described by us in a former number (see *Journal*, Vol. XIV. p. 623), and the merits of the invention fully dwelt upon. The process is much after the manner formerly employed in erecting the old-fashioned timber and brick houses, many of which may still be seen in our country towns. We have reason to believe that this new style of construction will soon come into general use for cottagers' and labourers' dwellings; that is, so soon as its advantages—cheapness, lightness, durability, and weather-proof qualities—are generally known.



View of Chancel, Kidmore End Church, near Reading.



KIDMORE END CHURCH, NEAR READING.——ARTHUR BILLING, Esq., Architect.

KIDMORE END CHURCH, NEAR READING.

THIS church, of which we give an exterior and interior view, is designed in the Early English style. The plan is that of a double rectangle, consisting of a nave, chancel, north porch, and small vestry, the nave being 60 feet long by 22 feet wide, and the chancel 17 feet by 20 feet, the east end of which is of an apsidal form. The nave is lighted with simple lancet windows on the north and south sides; and at the west end, between each window a buttress of two stages is introduced, dividing each side of the church into four bays: in the second of these, on the north side, is the porch, which is of stone, with timber roof of open framework.

The west front has a gable turret, of a simple character, to contain one bell. The chancel is lighted by seven trefoil-headed lancet windows. Beneath one of the eastern windows, on the south side, is a recessed stone sedilia, for the officiating clergy. The chancel has a stone groined roof, supported by columns: the chancel arch embraces the whole width of the nave. The roof to the nave is to be of open framework.

The sittings are entirely free, and will accommodate 220 persons, and consist of plain open benches. The whole of the woodwork is to be stained and varnished. The walls are built of flint, with Bath stone dressings, and quoins to the windows and buttresses.

The funds have been supplied by voluntary contributions, aided by grants from the Incorporated Society, the Diocesan Church Building Society, and Henley Union Church Society. The site was given by the trustees of Mr. John Marshall. The contract for the work was 1220*l.*; Mr. Biggs, jun., of Reading, is the builder, and Mr. Wheeler the mason, who are carrying out the works under the superintendence of Mr. Arthur Billing, of Beaufort-buildings, Strand.

POLYCHROMATIC EMBELLISHMENTS IN GREEK ARCHITECTURE.

By THOMAS L. DONALDSON.

[*Paper read at the Royal Institute of British Architects, Jan. 12.*]

MR. DONALDSON prefaced his remarks on this subject—which is an explanation of the system, as illustrated in the recent work on the 'Polychromy of the Ancients,' by M. Hittorff—by announcing the presentation of many valuable works to the library of the Institute; among others the above-named work by M. Hittorff, and another which he could not but regard as a honour to this country, namely, a volume published by the Society of Dilettanti on the 'Principles of Athenian Architecture,' being the result of the investigations of Mr. Penrose, Fellow of the Institute. This publication was, indeed, the most important production on the subject since the time of "Athenian Stuart," and it investigated some of the most curious and extraordinary principles of design and construction, of which the public were totally ignorant some thirty years ago. The previous studies of Mr. Penrose, at Cambridge, had peculiarly fitted him for the task he had undertaken, and his learning, zeal, and perseverance, had enabled him to produce a work which was alike honourable to himself and the profession. He had demonstrated that there was not a straight line in the Parthenon, either vertical or horizontal, but that the whole consisted of a series of curves, by which the Greek artists had sought to regulate the optical illusions of the building, to correct what in nature would appear to be wrong, and to make the whole harmonious to the eye. Another valuable portion of the subject had reference to the polychromy of the Athenian temples, in illustration of which various beautiful examples were displayed, for which they were specially indebted to the care and accuracy of Mr. Willson, who had assisted Mr. Penrose in his laborious researches. Such a work as this must contribute to make architects better acquainted with the principles which guided the Greeks in the conception of those magic monuments which it was their pride and pleasure to imitate, and which he hoped they might some day equal.

Mr. Donaldson then proceeded to offer some explanation of the system of Polychromatic Embellishment in Greek Architecture, as illustrated in the above-mentioned work on the 'Polychromy of the Ancients,' by M. Hittorff, Honorary and Corresponding Member. He commenced his remarks by a tribute to the liberality of the Foreign Correspondents of the Institute, who, in the valuable works they presented to the library, set a noble example to the members. The subject of polychromy had occupied attention for above thirty years. Even Stuart had intimated that some portions of the edifices of Athens, carved and uncarved, were embellished by colour; but this fact was only considered generally, and not as a principle in the architecture of the Greeks. About the year 1830, M. Hittorff read a paper on the subject before the Institute of France, which was published in the 'Annals of the Archæological Institute of Rome.' That gentleman had been so much struck with the results of his observation of the remarkable ancient monuments of Sicily, as to arrive at the conclusion that it was necessary, for the full effect of those works, that the whole of the buildings should be painted. This principle, broadly and unreservedly advanced, was attacked by M. Raoul Rochette, then professor of archæology at Paris, a learned archæologist, but neither an architect nor an artist. In two articles on mural painting among the Greeks, M. Rochette endeavoured to prove that those works were executed simply on tablets, and not upon the walls of the temples. The subject then seemed to slumber, though M. Hittorff and others continued their investigations. He (Mr. Donaldson) had himself been quoted by many authors as the first to observe that the walls of the Theseum at Athens had been worked with a point, to receive a coating of plaster or stucco, enabling the whole surface to be painted. He had, in fact, brought to this country fragments from the Parthenon, the Propylæ, and the Theseum, which, on being analysed by Professor Faraday, gave ample evidence that painting did exist on those buildings, and showed what materials were employed for that purpose. The subject was forcibly brought before the attention of learned Europe by an important series of illustrations, published in Germany, by a gentleman then present, Herr Semper, some of whose drawings were displayed upon the walls of the room. Among these were restorations of a part of the Parthenon, a building at Pompeii, an Etruscan tomb, and a representation of the remains of colour visible on the Temple of Theseus. Mr. Donaldson also referred to a restoration of the façade of the Parthenon by Mr. Owen Jones, which he characterised as more ideal than that of Herr Semper, although displaying much study and ability. The work of Semper (in 1834) was followed in 1835 by another from the pen of Dr. Franz Kugler, 'On the Polychromy and Sculpture of the Greeks, and its Limits.' The latter branch of the question was an important one, for the restorations of both Hittorff and Semper were unlimited in their application of colour, and he believed the meeting would concur with them. Following, however, in the steps of M. Raoul Rochette, Dr. Kugler was of opinion that polychromy in ancient art was limited in its application. He, however, quoted with admiration the beautiful illustrations of Semper. Dr. Kugler's work was epitomised by Mr. Hamilton, in a paper published in the first volume of the 'Transactions of the Institute of British Architects,' which attracted much attention in this country. Another work by M. Rochette alluded to a publication by the Duke of Serradifalco, containing some remarks upon the subject; and then there came upon the field of this discussion one of the most learned and clearest reasoning minds which could be brought to bear on such a subject, in the person of the late M. Letronne.

The Institute of British Architects had appointed a committee to examine the traces of colour on the Elgin marbles, and the results of their researches, and the accompanying analyses of Mr. Faraday, were not only important in themselves, but agreed with those arising from similar investigations subsequently undertaken by scientific men at Athens. Other works on this interesting subject had been published, but, without dwelling upon them, Mr. Donaldson proceeded to develope the views of M. Hittorff, premising that a professional architect and practical artist, such as that gentleman, must necessarily possess qualifications for the investigation of such a subject superior to those of any mere antiquary or critic, however learned. In proof of the taste and skill of M. Hittorff, and his peculiar talent for the pursuit of this subject, Mr. Donaldson referred to the buildings erected by him in Paris, including the Cirque Olympique, various cafés and restaurants in the Champs Elysées, and the Basilica of St. Vincent de Paul, all of which displayed not only great originality of design and constructive skill, but a remarkable degree of taste and brilliancy of decoration, combined with the peculiarly admirable management of a profusion of colouring.*

Proceeding to notice M. Hittorff's work, Mr. Donaldson explained that the first part of it took a general view of polychromy, considered historically; and the second part discussed it practically. It appeared that M. Hittorff had especially directed his attention to the remains of the small tetrastyle temple of Empedocles at Selinus, in Sicily, which edifice he had restored, with polychromatic decorations throughout, his illustrations of that building being exhibited and referred to by Mr. Donaldson. The plan of this temple showed a portico of four columns in front, and behind them the walls of the pronaos and cella, measuring only 20 feet by 16 feet. It appeared, from the porous nature of the stone, that it required to be covered with stucco; and M. Hittorff, from his examination of the fragments, came to the conclusion that the whole building so stuccoed was elaborately covered with painting. The floor or pavement of the cella and pronaos was represented in the drawing as executed in mosaic work. There was, however, no such mosaic work found; but, on the contrary, there were traces of a floor of plaster. M. Hittorff found, by researches in other temples, an instance of a floor of painted stucco; and such floors were also found at Pompeii, Rome, and Olympia. The author accordingly restored the pavement of the Temple at Selinus in painted stucco, adopting forms and patterns similar to those of ancient mosaic floors. M. Hittorff, in conjunction with M. Zanthe, his fellow traveller, found some fragments of a fluted shaft on the site of the temple, with portions of a Doric entablature and an Ionic capital, and formed their restoration of the building by a combination of these discoveries. This combination of the parts of two orders was not uncommon in Sicily, Magna Græcia, and the East. At Agrigentum the tomb of Theron had a Doric entablature, while the capital of the columns was Ionic. In the remains at Pæstum, in the tomb of Absolom, near Jerusalem, and in the remarkable buildings at Petræa, similar instances were to be found; while the arch at Aosta, near Turin, presented even a Corinthian capital supporting a Doric entablature. Some of these examples were of later epochs; but there was more than one such example furnished by the truly classic period of ancient art. M. Hittorff also adverted in his work to many examples of the same practice, as being represented on the vases of the ancients. It was also shown on some frescoes at Pompeii. M. Raoul Rochette, ignorant of this admixture of two orders, objected on that ground to M. Hittorff's restoration; but it was evident, from the instances referred to, that the ancients did not confine themselves to the strict rules and limits of art, but allowed themselves, on the contrary, considerable license. Mr. Donaldson here referred to a restoration of the temple in question made by himself, from M. Hittorff's descriptions, &c., before he had seen the drawings of that gentleman; and although there were some discrepancies in respect to the colours in the two restorations, a strong general resemblance was, on the whole, observable. Mr. Donaldson then pointed out in detail (referring to the engravings) the application of colour to the various parts of the temple.

The torus of the base was ornamented in conformity with an authority found at Pompeii. The shafts of the columns had a general tone of yellow, which M. Hittorff conceived to have been the prevailing colour of the building, relieved by picking out several parts in different colours. The capital was modestly picked out, and the order generally, as restored by M. Hittorff, was less bold and positive in colour than in that restored by Mr. Donaldson. Reference was here made to the drawing of an Ionic capital, restored in colours, the original of which had been brought from Athens by Mr. Inwood. Even if it had been necessary to employ a Doric capital, that might have been coloured in the manner shown in the drawings, in which Mr. Semper decorated the abacus of the capital of the Doric column

* Mr Donaldson here incidentally adverted to the polychromy of the ancient Egyptians, which was well-known to have been general or unlimited in its application, and highly effective in its results. This species of polychromy might be advantageously studied in the work of M. Horeau, who was also present at the meeting.

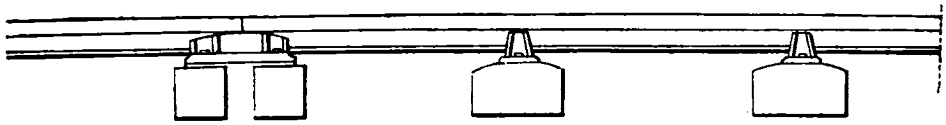
of the Parthenon, as well as the echinus, the latter with egg-and-tongue ornaments. Mr. Donaldson, without any conference with him, had applied the same mode of decoration, for it was not to be supposed that so important a member as the echinus, in the façade of the Parthenon, would he left plain between the fluted columns below and the rich frieze above. M. Semper stopped at the echinus, but Mr. Donaldson was inclined to think that some small ornament was also introduced upon the hypotrachelium, to give greater height and importance to the capital. In the Roman Doric, and in some examples of the Doric in Asia Minor of a late period, there was actually a sculptured ornament in the necking of the Doric capital; Mr. Donaldson thought, therefore, there was, very possibly, some ornamentation on this member of the order. What, indeed, was its use? In some instances, its lower boundary was formed by a mere line—in the Theseum not one-eighth of an inch deep—and therefore it was highly probable that, as a division between the capital and the shaft, it had some decoration to give it emphasis and expression.

In noticing the decoration of the entablature, Mr. Donaldson adverted to the statement of Vitruvius, that the ends of the beams (represented by the triglyphs) were painted with a blue wax. At Pompeii instances were found where the triglyphs were blue, and the metopes of a lighter colour; and there was an indication of blue paint on the triglyphs of an Etruscan tomb, engraved in M. Semper's work. In reference to the tympanum, Mr. Donaldson expressed a general opinion that sculpture was freely and even lavishly employed by the Greeks as a necessary adjunct to their temples, to impress upon the mind of the beholder the purpose and object of the building. The fronts of the Parthenon strikingly exemplified this view, and it was ably enforced in Mr. Penrose's work. Although there was not a fragment of sculpture left in the tympana of the Theseum, Mr. Penrose had discovered the holes by which the figures had been attached to the building. In restoring the tympanum of the pediment of the Sicilian temple, M. Hittorff, finding no traces of sculpture, had adopted a foliated ornament, based upon fragments of terracotta found in the same island. The metopes were also ornamented with a foliated pattern, on similar authority. It was well-known that the friezes of temples were richly decorated, often with figures and representations of processions; and although the frieze of the Erectheum, at present, was of a plain, dark-coloured marble, it was originally ornamented with figures in white marble. In the Theseum only a few of the metopes on the return were sculptured; and by some it had been supposed that the rest were painted. M. Von Klenze, in examining the fragments of the Propylæa, found that some of the blocks, which he supposed to belong to the metopes, were sunk to receive sculpture; whilst others had a perfectly plain face, and were incapable of receiving any, and he therefore thought they were intended to he decorated by painting: Mr. Donaldson, however, did not think there was sufficient authority for that opinion, because it would be an arrangement not only inconsistent in itself, but difficult to carry out satisfactorily, as it would involve the necessity of placing a triglyph, instead of a metope, in the centre, under the pediment on either front. With reference to the background of the tympanum, M. Hittorff had coloured it red in his restoration. Undoubtedly that surface generally bore colour of considerable depth, in order to throw out the sculpture, because the figures themselves, and the draperies, were painted, and consequently rendered a coloured ground necessary. Some fragments of the Parthenon had been thought to show traces of a red ground, and that colour had been adopted by M. Semper in his restoration of the Parthenon. The more general opinion, however, and that adopted by Mr. Owen Jones was, that the ground of the tympanum had been blue. Mr. Donaldson next referred to a running ornament introduced by M. Hittorff on the architrave. The application of colour, by M. Hittorff, to the mouldings of the pediment, was sanctioned by the authority of M. Semper, Mr. Owen Jones, and Dr. Kugler, though each of those gentlemen applied different colours. Mr. Penrose had found traces of the design of an ornament on the crowning ovolo of the Parthenon.

It was to be observed that the forms of decorative art were to be traced by progressive steps: what was at first a mere superficial delineation of ornament, afterwards became a substantial embodiment in sculpture. A question had been raised whether these ornaments were not the production of a later period, and of a less refined and more voluptuous taste; but, in fact, the design of the ornaments was of the same style, in purity of conception, as the monument itself. The fragments in the British Museum had the outlines of the ornaments deeply engraved upon the face of the mouldings, which it was not likely would have been so treated if the ornaments painted on them were a subsequent addition. The system, moreover, was not one of mere occasional introduction, but was generally adopted. The acroteria and antefixæ were introduced in M. Hittorff's restoration; and their importance in adding to the effect of the elevation must be admitted. There was ample authority for them, for they were actually discovered among the remains of the Temple at Egina, and the blocks for their reception still remain on the Parthenon. The question of the mode of covering the temple had been carefully studied by M. Hittorff. Byzas of Naxos was the first to introduce tiles of marble, common tiles having previously been employed. The refined taste of the Greeks led them to apply ornament to their roof-tiles. By putting together the fragments found in other places, M. Hittorff had restored the roof of the Sicilian temple at Selinus. The tiles were often painted on the inside as well as outside, because they sometimes formed the whole covering of the temple, and were visible from the interior. In other cases, as in the Parthenon, horizontal beams were used, dividing the roof into caissons.

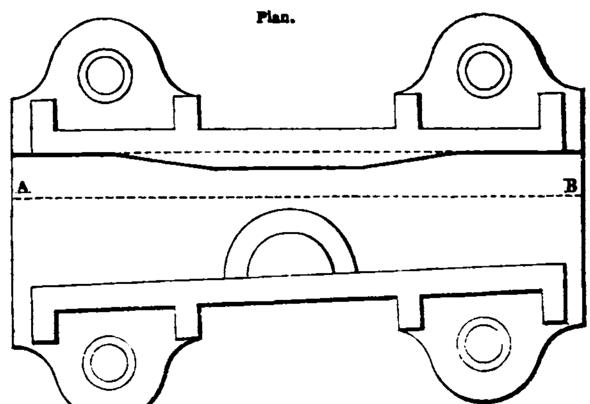
Before proceeding to the interior of the building, the wall of the pronaos was described: the whole of this was coloured. First, there was a dado of dark colour, and of considerable height: this dado was a remarkable and effective feature in the Greek temples,—sometimes it projected slightly; above that were panels of a lighter colour. All these decorations were authorised by paintings discovered at Pompeii, drawings of which were referred to. The door-cases of the temples were of stone, marble, or bronze. From his own examination of the Parthenon and the Propylæa, Mr. Donaldson was of opinion that bronze had been so employed in both those edifices; they were probably gilt, and embellished with a great variety of beautiful colours. The doors themselves were formed either of marble, wood, bronze, or mixed materials. Cicero, in his oration against Verres for mal-administration in Sicily, referred to the beautiful doors of the temple of Minerva, which were enriched with panels of ivory. The bronze doors of the Parthenon were illustrated in the work of Messrs. Taylor and Cresy. In M. Hittorff's restoration, the doors were supposed to be of bronze of various tones or tints. Of course the colours of the Florentine, the Venetian, and other bronzes might be introduced, to relieve and add to the effect. The upper panel was open to admit air and light, which was more necessary, for these temples were very dark, and chiefly lighted by lamps perpetually burning, as was still the case in the modern Greek church. Within the cella, at the further end, the restoration showed a statue of Empedocles, to whom the temple was dedicated, and who had been a great benefactor to the people of Selinus. There was an altar in front of the statue. The principal feature of the side wall was a large mural picture. Mr. Owen Jones introduced similar paintings on the outer wall of the Parthenon; and the like decoration was found at Pompeii, Delphi, &c. Above this painting was a frieze, or band, on which were fixed votive offerings of various kinds. It was well-known that competitors in the different games often made a vow to hang up the crown of victory in the temple, if they succeeded in gaining it. Besides these crowns, trophies, helmets, shields, cuirasses, swords, vases, musical instruments, beds, chairs, and numerous other offerings occupied this position: some of them were of gold, silver, and other metals. There were also statues of animals, as well as of men, busts, pictures, &c.; and these were placed in the temple, under the protection of the divinity, or as deposits in a sacred treasury, safe from the rude hands of the spoiler. Of course, the effect of these offerings and decorations would be increased by a background of colour. It was evident, upon the whole, that the Greeks considered they could not bestow too much decoration and splendour upon their temples, thereby marking at once their taste and their deep religious feeling. Having again referred to the drawings exhibited, as calling for a more minute examination on the part of his auditors, Mr. Donaldson expressed the hope that they would agree with M. Hittorff, that the temples of Greece and Rome were not merely occasionally or partially painted, but that the whole surface, both interior and exterior, displayed the full development of which that principle of design and embellishment was capable.

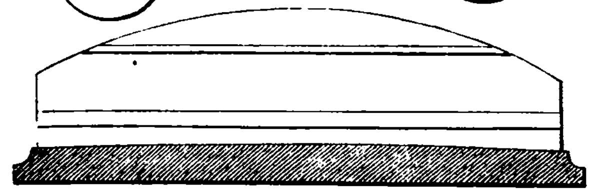
RAILWAY JOINT CHAIR.



Elevation of Rail.—Scale, 1 inch to 2 feet.

Plan.





Section at A B.—Scale, One Fifth.

Sir—Inclosed is a sketch of a railway joint chair, which has been in use for some time on the Leopolda Railway; and as I am not aware that anything of the kind has yet been adopted in England, I have taken the liberty of begging you will not deem it unworthy of a place in your valuable *Journal*. The chair is 15 inches in length, and weighs about 40 lb., or twice that of the common chair. It is supported by two cross sleepers, from 6 to 7 inches broad. The intermediate sleepers are about 1 foot by 6 inches. The rail is the common T form, with a wooden key. The advantage of this chair is, that a better and safer line can be maintained at a much less expense; the keys are less apt to shake out; and the rail is effectually prevented working out of the chair by the circular projection cast on to the bottom, and against which the corner of the rail is made to butt.

More than ten years ago, I pointed out the advantages of a chair on this principle on one of the most frequented lines in England; but though in possession of your *Journal* for the last seven years, I cannot find any remarks to lead me to suppose that my suggestion was ever acted upon.

I am, &c.

G. Richardson, C.E.

Della Strada Ferrata Leopolda.

Florence, December 26th, 1851.

ON TUBULAR GIRDER BRIDGES.

By William Fairbairn, M. Inst. C.E.

[*Paper read at the Institution of Civil Engineers.*]

(*With an Engraving, Plate* III.)

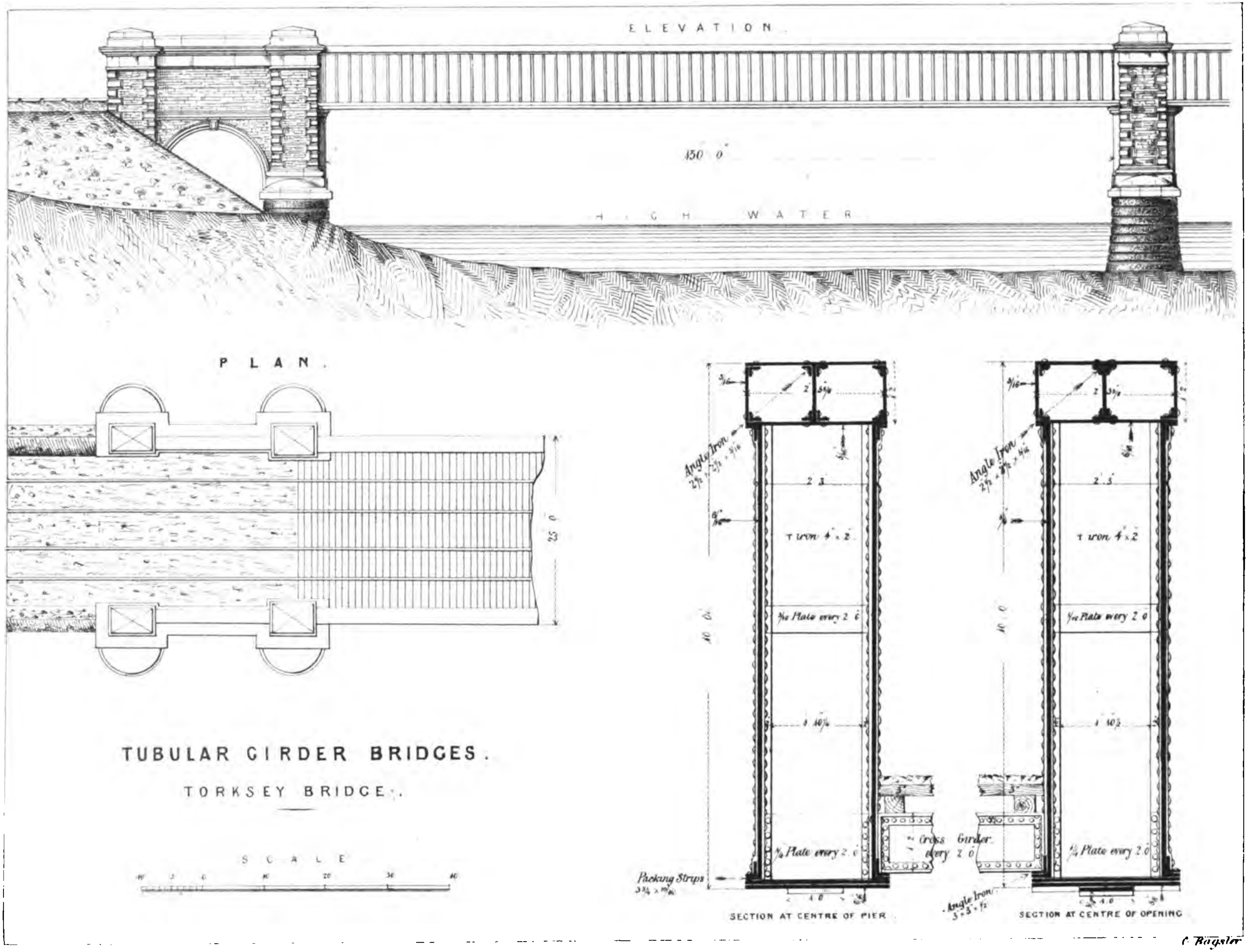
Doubts having been entertained as to the ultimate security of the Torksey Bridge, over the river Trent, the author has investigated the subject with the utmost care and attention. A difference of opinion appears to exist,—1st, as to the application of a given formula for computing the strength of wrought-iron tubular girders; 2ndly, as to the excess of strength that should be given to a tubular-girder bridge, over the greatest load that can be brought upon it; and, 3rdly, as to the effects of impact, and the best mode of testing the strength, and proving the security, of the bridge. These appear to be the chief points at issue: and, as a reply to both parties by whom he has been consulted, the author has endeavoured to enunciate such views as will, he trusts, settle the question, and prove satisfactory as to the strength and other properties of these important structures. Previous to entering upon the investigation, it may, however, be requisite to offer a few remarks relative to the construction, and other matters connected with the permanency and security of this description of bridge.

Every structure having for its object public convenience and the support of a public thoroughfare, should possess within itself the elements of undeniable security. Bridges and viaducts should especially contain those elements, as they are peculiarly liable to accident; and from whatever cause such accident may arise, the community must be equally interested in the strength and durability of the structure. In the introduction of a new system of construction, comprising the use of a new and comparatively untried material, it behoves the projector, on public grounds, to be careful and attentive to the most minute circumstance, directly or indirectly affecting the security of the bridge. In those of the tubular construction, considerations of this kind are of primary importance, as much depends not only upon the principle of construction, but upon the quality of the material employed and of the workmanship introduced, which in every case should be of the very best description.

In the construction of tubular-girder bridges, the author has endeavoured to apply these principles; and having a strong conviction of their great superiority in strength, durability, and cheapness, for traversing large spans, he has not hesitated to advocate their introduction. It, however, becomes necessary, from time to time, to submit them to a rigid examination, and before opening such bridges as public thoroughfares, it is essential to subject them to severe and satisfactory tests. These tests and examinations have been various and frequent, and it may safely be affirmed, that in no case, where tubular-girder bridges have been duly proportioned and well executed, has there been the least reason to doubt their security.

The first idea of a tubular-girder bridge originated in a long series of experimental researches, and during their first application to railway constructions the utmost precaution was observed in the due and perfect proportion of the several parts. These proportions were deduced from the experiments made at Millwall, upon the model of the Britannia Tubular Bridge; and, after repeated tests upon a large scale (full size), the resisting powers and other properties of this kind of bridge were fully established. From these experiments a formula was deduced, for calculating the ultimate strength of every description of bridge, from 30 feet up to 300 feet, or even to 1000 feet span; and as that formula is now before the public, it is believed that it may be relied upon as perfectly accurate. To relieve it, however, from anything like ambiguity, it will be well to state, briefly, certain points which should be taken into consideration in its application.

It has already been determined by experiment, that in order to balance the two resisting forces of tension and compression in a wrought-iron tubular girder, having a cellular top, that the sectional area of the bottom should be the sectional area of the top, as 11 to 12; which being the correct relative proportion of those parts, it then follows, that by any increase to the one, without a proportionate addition to the other, the bridge will be rendered weaker; inasmuch, as increased weight is given to the girder by the introduction of a useless quantity of material, which, in this instance, is totally unproductive. This being the case, it is of importance to preserve, as nearly as possible, the



TUBULAR GIRDER BRIDGES.

TORKSEY BRIDGE.

correct relative proportion of the parts, in order to insure the maximum of strength in the two resisting forces of tension and compression—an arrangement essentially important in these structures, and also in the application of the formula to determine the ultimate strength of the girder. If, for example, an excess of material was given to the bottom of a girder, the formula, $W = \frac{a\,d\,c}{l}$, would not apply, as the top and bottom areas would be disproportionate to each other, and that in excess would have to be reduced to the due proportion of 11 to 12; or, in other words, the additional strength must be omitted from the calculation, in computing the strength of the bridge. The same reasoning will apply, where the excess of area happens to be in the cellular top, although in this case the formula, $W = \frac{a\,d\,c}{l}$, still applies, as the excess cannot be considered in the calculation of the strength of the girder. Assuming, however, that these proportions are maintained, the above formula furnishes a correct principle, on which to estimate the strength of wrought-iron tubes of this description, whatever may be their depths, or their relative dimensions.*

In the case of the Torksey Tubular Bridge, of 130 feet clear span, the following are the dimensious of the girders in the middle, as given by Mr. Fowler:—

Sectional Area of the Top.

	Ft.	In.		In.		In.		In.
Longitudinal plates . .	2	$8\frac{5}{8}$	×	2	×	$\frac{3}{8}$	=	24·47
Vertical plates . . .	1	$1\frac{1}{4}$	×	3	×	$\frac{5}{16}$	=	12·42
Angle iron	0	$4\frac{3}{4}$	×	9	×	$\frac{5}{16}$	=	13·35

Area of cellular top as given by Mr. Fowler . .	50·24
Ditto, as given by Capt. Simmons	51·72
Mean	50·98

Sectional Area of the Bottom.

	Ft.	In.		In.		In.		In.
Longitudinal plates . .	2	9	×	2	×	$\frac{5}{8}$	=	41·25
Centre strip	1	0	×	$\frac{3}{4}$			=	9·00
Packing strip . . .	0	$3\frac{3}{4}$	×	2	×	$\frac{10}{16}$	=	4·68
Area of the bottom								54·93

Here there is an evident want of proportion, the bottom being greatly in excess of the top, which renders a reduction of the area of the bottom of the girder from 54·93 to 46·76 absolutely necessary. Hence, by the formula, $W = \frac{a\,d\,c}{l}$, or, $\frac{46{\cdot}76 \times 120 \times 80}{1560} = 287{\cdot}7$ tons, or 288 tons the breaking weight in the middle. From this is given $288 \times 4 = 1152$ tons, as the breaking weight, equally distributed over one of the spans of the Torksey bridge, neglecting the weight of girders, ballast, rails, chairs, &c., which are differently estimated, but must be deducted from the breaking weight of the bridge.

Mr. Fowler estimates an equal distribution of the load on the Torksey bridge, of a span of 130 feet, as follows:—

	Tons.	Tons.
Rails and chairs	8	
Timber platform	15	
Transverse beams	27	
Ballast, 4 inches thick	35	= 177
Half the weight of the four girders, which are each 46 tons in weight (it should have been the whole weight when equally distributed) . . .	92	
To this must be added the rolling load, as agreed upon between Mr. Fowler and Capt. Simmons.		= 195
Total load . .		372 Tons.

Now, as the ultimate strength of the bridge is 1152 tons, it follows, that 177 being a constant will reduce its bearing powers to $1152 - 177 = 975$ tons, as a resisting force to the heaviest rolling load that can be brought upon the bridge, being in the ratio of 975 to 195, or 5 to 1.* These appear to be the facts of the case; and although the principal girders do not attain the standard of strength which the author has ventured to recommend as the limit of force, they are nevertheless sufficiently strong to render the bridge perfectly secure. In the calculations for estimating the strength of bridges of this description, it is always assumed that the proportions of the top and bottom of the girder are not only correct, but that the sides are sufficiently rigid to retain the girder in shape. It is further assumed, that the whole of the plates are in the line of the forces, and that the workmanship and rivetting are good.

On the excess of strength that should be given to girder bridges there is a difference of opinion. The author, however, entertains a conviction that no girder bridge should be considered safe, unless it be tried under four times the greatest load that can be brought upon it; and in wrought-iron tubular-girder bridges, the breaking weight is computed at 12 tons to the lineal foot, inclusive of the weight of the bridge, or about six times the maximum load.

On this calculation, the Torksey bridge should have been constructed according to the annexed tables, which exhibit the strengths, proportions, and other properties of the girders, which are recommended in structures of this kind, and for spans from 30 feet up to 300 feet.

The second column gives the length of clear span from pier to pier; the third, the breaking weight of the bridge in the middle; the fourt, the area of the plates and angle-iron of the bottom of the girder; the fifth, the area of the cellular top; and the last column, the depth of the girder in the middle.

Table *showing the Proportions of Tubular Girder Bridges.*

	Span.	Centre breaking weight of Bridge	Sectional Area of bottom of one Girder.	Sectional Area of top of one Girder.	Depth at the Middle.
	Feet.	Tons.	Inches.	Inches.	Ft. In.
From 30 to 150 feet span, where the depth of the girder is 1/15th of the span.†	30	180	14·63	17·06	2 4
	35	210	17·06	19 91	2 8
	40	240	19·50	22·75	3 1
	45	270	21·94	25·59	3 6
	50	300	24·38	28·44	3 10
	55	330	26·81	31·28	4 3
	60	360	29 25	34·13	4 7
	65	390	31·69	36·97	5 0
	70	420	34·13	39·81	5 5
	75	450	36·56	42·67	5 9
	80	480	39·00	45·50	6 2
	85	510	41·44	48·34	6 7
	90	540	43·88	51·19	6 11
	95	570	46·31	54·03	7 4
	100	600	48 75	56·88	7 8
	110	660	53·63	62·56	8 6
	120	720	58·50	68·25	9 3
	130	780	63 38	73·94	10 0
	140	840	68·25	79·63	10 9
	150	900	73·13	85·31	11 6
From 160 to 300 feet span, where the depth of the girder is 1/18th of the span.	160	960	90·00	105 00	10 8
	170	1020	95·63	111·56	11 4
	180	1080	101·25	118·13	12 0
	190	1140	106·88	124·69	12 8
	200	1200	112·50	131·25	13 4
	210	1260	118·13	137·81	14 0
	220	1320	123·75	144·38	14 8
	230	1380	129·38	150·94	15 4
	240	1440	135·00	157·50	16 0
	250	1500	140·63	164·06	16 8
	260	1560	146·25	170·63	17 4
	270	1620	151·88	177·19	18 0
	280	1680	157·50	183·75	18 8
	290	1740	163·13	190·31	19 4
	300	1800	168·75	196·88	20 0

* Mr. Tate, an eminent mathematician, remarks upon the formula—

1st. With respect to $W = \frac{a\,d\,c}{l}$, where a is the area of the section of the bottom, and $c = 80$, the constant deduced on this supposition, will apply to all depths of the tube, within short limits of error, where such depths, or a, are large in proportion to the depth of the cells, and the thickness of the plates.

2nd. With respect to the formula $W = \frac{a\,d\,c}{l}$, when a is the area of the whole section, and $c = 26{\cdot}7$, then the tubes shall be similar in all respects, but a slight variation in depth, from that of similar form, will not produce much error, especially where the depth is considerable. At the same time it must be observed, that both formulæ apply with great exactness, where the tubes are similar.

* It is considered by some engineers, as very important to the strength of these bridges, that the girders should be continuous, or extending over two or more spans. This is no doubt correct to a certain extent, and although the fact is admitted, yet this consideration is nevertheless purposely neglected in these calculations; any auxiliary support of that kind acting merely as a counterpoise. It is considered safer to treat the subject on the principle of compassing each of the spans with simple and perfectly independent girders.

† The author has generally taken the depth of the girders at 1-15th of the span;

In these tables, the breaking weights of all the girders are calculated from the formula $W = \frac{a\,d\,c}{l}$; as for example:—

Taking from the table a bridge similar to that at Torksey, 130 feet span; W = the breaking weight; a = area of the bottom, 63·38 inches; d = 120 inches, the depth of the girder; c = 80, the constant deduced from experiments; and l = the length, 1560 inches, between the supports.

Hence $W = \frac{63{\cdot}38 \times 120 \times 80}{1560} = 390 \times 2 = 780$ tons, the breaking weight of the bridge in the middle, or 1560 tons equally distributed over the surface of the platform of the bridge.

From this it will be observed, that after deducting the permanent load of the Torksey bridge (177 tons), there remain 1383 tons as resisting force to the travelling load of 195 tons, which, according to calculation, is rather more than seven times the greatest weight that can be passed over the bridge;* 12 tons per lineal foot being assumed as the measure of the strength of a tubular-girder bridge, for a double line of rails, and which will cover all contingencies, either as regards the weight of the bridge, the permanent load, or the forces by which it may be assailed.

Another subject of importance is the force of impact and the effects of vibration, on bridges of this description; and although it is only recently that the author has the advantage of reference to the highly valuable Report of the Commissioners appointed to Inquire into the application of Iron to Railway Structures, he is nevertheless of opinion, that the principles upon which he has endeavoured to establish the construction of these particular bridges, ever since their first introduction, is perfectly secure, and may be relied upon as being calculated to meet all the requirements and the conditions of railway traffic.

He cannot agree with the Commissioners in some parts of that Report, as several of the experiments therein referred to do not appear to bear out the fact of increased deflection at high velocities. In several carefully conducted experiments on tubular-girder bridges, of spans varying from 60 feet to 100 feet, the deflection was found to be, as nearly as possible, the same at all velocities; and although the experiments at Portsmouth (at some of which the author was present) are highly valuable, and exceedingly interesting, he is nevertheless of opinion, that there must be a considerable difference in the effects of a weight, rolling over a cast-iron bar 9 feet long, and that over a bridge 60 feet long. It is true the Commissioners in their Report, have qualified the results obtained from these experiments, by others made upon existing cast-iron railway girder-bridges, where the deflection was reduced from an increase of the statical deflection, amounting to $\frac{8}{10}$-inch, as produced upon the 9-feet bars, at the velocity of 30 miles an hour, to $\frac{1}{7}$-inch upon a bridge of 48-feet span, at a velocity of 50 miles an hour; thus clearly showing, that the larger the bridge, and the greater the rigidity and inertia of the girders, the greater will be the reduction of deflection to the passing load. In the tubular-girder bridges, composed of riveted plates, it must be observed, that the Commissioners had no experience, nor were they acquainted with the strength, rigidity, and other properties of girders, composed of wrought-iron riveted plates. The deflection due to the passing load appears to be the same at all velocities, and unless there exist irregularities and inequalities on the rails, tending to cause a series of impacts, it may reasonably be concluded, that the deflections are not seriously, if at all, increased at high velocities.

On the effects of impact, the author perfectly concurs in opinion with the Commissioners, that the deflections produced by the striking body on wrought-iron, is nearly as the velocity of impact, and those on cast-iron greater in proportion to the velocity.* These experiments and investigations are extremely valuable.

The mode of testing bridges is a part of the inquiry which requires consideration, and in order to maintain unimpaired the elastic powers of the structures, the tests should not exceed the greatest load the bridge is intended to bear at high velocities; in fact, the Commissioners are correct in assuming, that the flexure of the girders should never exceed one-third of their ultimate deflection. In wrought-iron girders, the effects of reiterated flexure are considerably less in a well-constructed bridge, of similar proportions to those given in the table, than those of cast-iron. The deflection produced in these constructions, by the greatest load, will not be more than one-sixth of the ultimate flexure of the girder. On this subject, the effects of impact and resistance of tubular girders to a rolling load, were strikingly exhibited in the experimental tests made on the first construction of this kind, erected for carrying the Blackburn and Bolton Railway across the Liverpool and Leeds Canal at Blackburn.

That bridge is 60 feet clear span, and three locomotives, each weighing 20 tons, coupled together, so as to occupy the entire span, were made to pass over, at velocities varying from 5 miles to 20 miles an hour, producing a deflection, in the centre of the bridge, of only $\frac{3}{10}$-inch. Two long wedges, 1 inch in thickness, were then placed upon the rails in the centre of the span, and the fall of the engines from this, when at the speed of 8 miles to 10 miles an hour, caused a deflection of only ·420 inch, which was increased to ·54, or about ½-inch, when wedges 1½ inch in thickness were substituted. These were severe tests, and such as would not be generally recommended, as the enormous strength of these girders is now well understood, and they may safely be considered fit for service, after being subjected to the heaviest rolling load, or one sixth of the breaking weight, taken at high velocities.

Discussion.—Mr. Fowler said he was much indebted to Mr. Fairbairn for pronouncing the bridge to be of sufficient strength; but the investigation would have been more satisfactory if the structure had been viewed as composed of continuous girders, each stretching the full length of the platform, and resting upon the three points; this would be found to add one-fourth to the absolute strength of the part of the girder spanning each opening. The diagram (fig. 3,) had been prepared for the purpose of showing the effect of the continuity of the girder, the dotted line showing the curve of deflection, due to weighting the two openings equally with the weight of the structure itself alone; the full line showing the deflection due to an additional load of two trains of locomotives upon one span. The latter experiment proved that the distance from the point of contrary flexure to the centre pier was less than 25 feet, causing a practical reduction of the span from 130 feet to about 105 feet, and adding at least one-fourth to the strength of the bridge. Now any principle that added one-fourth to the strength of the bridge was, he considered, too important to be so lightly passed over; added to which, he thought the saving of cost in the construction of the work was an important additional consideration. He thought there was an error in the computation of the proportion between the bottom and the top of the girder, as it would appear that the area of the rivet-holes had not been deducted from the former, which should evidently have been done. Now the gross sectional area of the bottom being 54·93, and the rivet-holes diminishing the area full 5·25, an area of 49·68 would be left, making the proportion of 51 to 49·68, which corresponded very nearly with the proportion of 12 to 11 given in the paper. In building the first of these girder bridges (the subject being new to him), Mr. Fowler had been guided by Mr. Fairbairn's proportions, as he was the constructor of the girders; and it did appear extraordinary, that the dimensions of a bridge of 95 feet span, which had now been open for traffic for full two years, differed materially from the dimensions given in the paper. Now as that bridge had performed its duty efficiently for two years, it would be interesting to learn why Mr. Fairbairn had changed his views as to the requisite dimensions, and why that proportion of the depth to the span, which at so recent a period had been considered sufficient, should now be deemed insufficient. The drawing represented the strength of one girder calculated according to

but in cases where the span does not exceed 150 feet, it has been found more economical to adopt 1-13th of the span. For spans above 150 feet it is, however, more convenient, on account of the great weight of the girder, to adhere to the original proposition of 1-15th, in order to keep the centre of gravity of the girder as low as possible, and to prevent oscillation under a passing load. In situations where it is objectionable to increase the depth of the girder, it then becomes essential to increase the sectional areas of the bottom and of the cellular top, in the ratio of the depths.

* Since the table referred to above was completed, and which has been closely adhered to in the calculations of the strengths and proportions of wrought-iron tubular girders during the last eighteen months, 1 ton per lineal foot has been taken as the permanent weight of bridges, from 40 feet up to 100 feet span, and the rolling load as 2 tons per lineal foot; and in spans varying from 100 up to 300 feet, the permanent weight of the bridge is estimated at 1½ ton per lineal foot, and the rolling load also at 1½ ton per lineal foot. For practical purposes these proportions are found to be perfectly safe, although in spans above 300 feet, where the permanent weight of the structure becomes a large proportional of the load, it becomes necessary to introduce into the calculation new elements as regards strength, as may be seen in those for the Britannia and Conway Tubular Bridges.

* Vide Report of the Commissioners appointed to Inquire into the Application of Iron to Railway Structures. 1849.

Mr. Fairbairn's proportion and formula; therefore the total strength of the two would be equal to 1560 tons. The bridge had been tested by placing six locomotive engines, weighing together 222 tons, on one opening, occupying the whole extent of it, which, of course, was a greater test than if a similar weight had been placed at the same time on the other opening, as, in the latter case, one load would have balanced the other. The effect of placing six heavy engines in that situation was to cause a deflection of $1\frac{1}{4}$ inch, and on the removal of the load, the platform of the bridge immediately returned to its original level. Great care was taken to ascertain if the main beams had any tendency to approach each other with that weight resting on them, but there was no indication of such a change of form.

Mr. Bidder said, the Torksey bridge had excited the attention of the profession, from the fact of the Commissioners of Railways having objected to the opening of the bridge for traffic, on the plea of care for the safety of the public. Mr. Fowler had requested him, with other engineers, to examine the structure, in order to give an opinion as to whether the strength of the bridge was sufficient, and if not, to point out where it required strengthening. After careful inspection and consideration, the general opinion arrived at was, that the bridge was sufficiently strong for all practical purposes of public safety. So far as he could gather from the paper, that also appeared to he Mr. Fairbairn's opinion, although he had detracted from the value and weight of that opinion, by assigning other proportions to a bridge of those dimensions. As, however, the principles which had guided Mr. Fairbairn in his calculations were so entirely different from those Mr. Bidder had adopted for ascertaining the strength of girder bridges, he thought it was only right to state what he believed to be the correct principle. If right, he should have done some service in laying his views before the Institution; and, if wrong, he should have the advantage of being corrected. The first point to which Mr. Fairbairn had directed attention was the relative areas of the top and bottom of the girders: and he had stated, that the proportions between them should be in the ratio of 11 to 12, and that any excess of those proportions was so much dead weight uselessly employed; that is to say, if the 12 was increased to 13, it was so much weight added, without imparting any corresponding strength. Mr. Bidder thought that must be erroneous, because, in the tabular statement, instead of those proportions of 11 to 12 being rigidly adhered to, the ratio of 12 to 14 was occasionally adopted. He also believed Mr. Fairbairn was in error, in saying that the increase in dimensions over any assumed ratio was an addition to the weight of the bridge, without being any addition to its strength. The top of the bridge was exposed to compression, and the bottom to tension: between those two there existed the neutral axis; therefore, the compressing force on the one, and the tensile strength on the other, must be equal; the result must then be, that any addition to the bottom only removed the neutral axis so much further from the top, bringing it so much nearer to the bottom: it was true, that it might not gain all the advantage of that addition of metal to the bottom; but it was certain that some additional strength was obtained. Supposing the top and bottom to be in proportion of 11 to 12, the paper implied, that if 11 was added to the bottom, making it 22, no strength would be added to the bridge, but that it would be encumbered by an extra weight of metal. Mr. Bidder denied that position, and thought that the neutral axis being removed from the top, by any addition of metal to the bottom, even if that addition amounted to 34, the strength of the bridge would be increased by one-third; adding 50 per cent. in weight, and gaining 30 per cent. in strength. He did not mean to say that would be a judicious distribution of the metal, but he thought it wrong to suppose it would perform no duty, and much less, that it would be injurious. He thought it incorrect to fix any arbitrary limits to two quantities increasing in different ratios, and in that respect he was decidedly at issue with the deductions of the paper. He also dissented from the notion, that the depth of a girder should be restricted within any given limits; in practice, engineers were scarcely ever able to fix such limits, being generally guided by local considerations. The question of the proper depth of a girder was at present entirely unascertained; and it was clear the author of the paper could not have arrived at any precise notion on the subject, because the original table sent with the paper assigned the proportion of $\frac{1}{16}$th of the span for the depth of a girder of any span; but in the amended table, subsequently transmitted, that proportion was only retained up to spans of 150 feet, and the proportion of $\frac{1}{15}$th was adopted for all greater spans. Theoretically, the top and bottom could not be placed too far apart; in practice, the consideration was, the least amount of metal that would enable the top and bottom to be placed at a proper distance to prevent the sides from buckling. That was a question which could not be decided mathematically, but must be determined entirely by experiment. He was not aware what reasons had induced this alteration of the table within the last fortnight; but he thought it would not be wise to adopt blindly any empirical limit. He thought it a mistake to endeavour to ascertain the strength of a girder by finding the greatest weight it would sustain, and he was not aware of any received coefficient so large as 20 tons to the square inch; the largest he knew of was 16 tons. He agreed in the observations on the small effect of vibration, by railway trains passing over bridges; he believed it to be a mere ghost, raised by mathematicians to frighten engineers as to the strength of their structures; and he thought the engineers were bound, as standing between the mathematicians and the public, to apply to their deductions the principles of common sense. When once a certain length of girder was exceeded, the effect of concussion ought to be left entirely out of consideration. Mr. Fowler had placed on his bridge an extraordinary weight of 222 tons on one opening; and it was asked, what would be the effect of that weight in motion, treating it as 222 tons on one pair of wheels, propelled in a given direction; it must be remembered, that weight would be distributed over 72 wheels, each having a spring, and as that weight could only operate on a girder through the instrumentality of the rails, which were nearly 6 inches in depth by 1 inch in thickness, it would be seen that the effect, whether vertically or laterally, would be absolutely nothing on a structure of that weight and rigidity. The fracture of a rail, or a chair, laterally, by the action of a train, was a thing of rare occurrence, except when the carriages got off the line; as an engineer, he considered, practically, that might be omitted from consideration. It must then be supposed, that the strain would act vertically and snap the girder; but there was not a rail which was not subjected, by every train passing over it, to a much greater strain than any on the bridge in question. In his opinion, the effect of concussion on any bridge of such a span, with girders of such dimensions, was a matter unworthy of notice. In making a few observations, for the purpose of showing that the bridge, as constructed by Mr. Fowler, and so retained, in opposition to the report of the Inspecting Officer, was abundantly strong, he desired it might not be supposed that he wished to reflect on that gentleman, who had never shown the slightest desire to throw impediments in the way of any engineer, or that he should be supposed to wish to do more than to have the question fairly and honestly discussed before the Institution. Captain Simmons had stated in his report, that he should be satisfied if one opening of the bridge would sustain a load of 400 tons, with a strain of 5 tons to the inch, the dead weight of the bridge being 175 tons, leaving 225 tons for the rolling load. In order to submit it to a severe test, Mr. Fowler had placed 222 tons on one opening; but he would ask, under what circumstances of ordinary traffic was the bridge liable to be exposed to that test? It could only be on the supposition of three coupled engines travelling on each line, without any carriage being attached to them, and meeting on one particular opening. In practice, three coupled engines were not often attached to a heavy goods train, and it was not probable that three engines would often go out alone. The supposed test, however, required the same weight on both lines; it might be fairly presumed, that one of the sets of engines would have a train attached to it, and resting on the other opening; so that the effect would be diminished on the portion on which the engines rested. After subjecting the bridge to that weight of 222 tons, the deflection was ascertained to be $1\frac{1}{4}$-inch. Captain Simmons said, if it would bear that weight, and not have more strain than 5 tons on the inch, he would be satisfied; whatever extent of weight that was derived from, the effect on the tension of the iron would be the same, and taking the strain on the bottom to be 5 tons to the inch, the deflection ought to be 2 inches; it was actually only $1\frac{1}{4}$ inch, therefore the experiment proved the strain was not 5 tons to the inch. Mr. Bidder had not been quite satisfied on that point until Mr. Wild's experiments, on a similarly proportioned beam, showed the point of bearing was practically reduced from 130 feet to 105 feet, by the continuity of the tubes over the centre pier, by which the length of the girder exposed to strain, was not only reduced, but the weight being equally diffused, was also diminished, and therefore the deflection would be reduced as the square; this induced the conclusion in his mind, that the Torksey bridge was abundantly strong for all purposes of public safety.

Mr. Eaton Hodgkinson said, it was with great reluctance that he made any observation in the absence of Mr. Fairbairn, differing as he did from him in many of his conclusions. Mr. Fairbairn had in his paper adduced a formula, with a coefficient attached, for the strength of wrought-iron tubes; but the adequacy of that formula might be questioned; indeed if the tubes were made as proposed in the paper, it was doubtful whether it might not be unsafe and dangerous, to rely upon the formula. When Mr. Hodgkinson made experiments many years ago, to ascertain the strength and best form of cast-iron beams, they may be regarded as almost unknown in our metropolis. So he used the same simple formula, with a coefficient deduced from numerous practical experiments on the fracture of cast-iron beams. This formula depended merely on the tensile strength of the bottom rib, and on the depth and length of the beam. These data he considered sufficient for that material; for in cast-iron beams, of the best form, there would be more than twice as much metal in the bottom flange as in all the rest of the beam in the middle.* This was not the case with the new tubular girders. The defective elasticity of cast-iron rendered it difficult to draw such precise conclusions from it, as from a material of more perfect elastic force, such as wrought-iron. The formula he had found suitable for cast-iron beams would not, he conceived, be applicable to tubes of wrought-iron, where the bottom (whose tensile force was alone included) bore but a small proportion to the whole sectional area; and the sides of the tubes had as much sectional area in them as all the rest. The side plates themselves, without the angle-irons to stiffen them, might be equal at least in sectional area to the plates in the top and bottom; and to employ a formula that would reject half the material in the tube, because the estimation of its forces could not be easily arrived at by a simple arithmetical computation only, was not in accordance with the knowledge of the present day. It might however be said, that the formula was applicable to similar tubes of a particular form; but the tubes in Mr. Fairbairn's table were not similar, and its applicability to tubes of the various kinds in the table was doubtful; and especially to tubes of other forms, as that of the Torksey bridge, the strength of which Mr. Fairbairn had computed by it. The complete solution for the strength of tubes in general, was more troublesome than difficult. If, for instance, the top and bottom of the tube differed from each other in sectional area, or in form, it would be necessary, first, to obtain the situation of the neutral line, and this would be in the centre of gravity of the section. Secondly, it would be necessary to find the moments of the forces exerted by each of the plates in the top, bottom, and sides of the tube; or, in other words, the forces of the particles of each, multiplied by their distance from the neutral line. The sum of these moments must be equated to that from the weight laid on, and the leverage from the length of the tube between the supports. Then, for the strength of the tube of the second form, the formula

$$W = \frac{2f(bd^3 - b'd'^3)}{3ld}$$

would apply, where d, d', were the external and internal depths respectively; b, b', the external and internal breadths; l, the distance between the supports; f, the strain per square inch of section sustained at the top and bottom of the tube; and W the weight which, being laid on the middle of the tube, would produce that strain.† If f be taken at 8 tons per square inch, it would be within the elastic force of the material: some tubes of simple plates had borne as much as double that pressure, or more. Mr. Fairbairn asserted that the comparative thickness of the top and the bottom of a tube should be as 12 to 11, this having been the case in the large tube made in London; but Mr. Hodgkinson contended that there could be no constant proportion between the thickness of the top and the bottom. A tube of one thickness of metal might be well proportioned, but double the thickness would render it very much out of proportion. The resistance of thin plates to a crushing force, applied in the direction of their length, was found to vary nearly as the cube of the thickness. Doubling the thickness of a very thin tube at the top would give six or seven times the resisting power there; whilst doubling it at the bottom only gave twice the strength. This property of compression extended only to plates of tubes not strained to more than about nine tons per square inch: it was not easy to give proper proportions for these kinds of tubes, without further practical information. Mr. Hodgkinson had made many experiments, which were given in the Report of the Commissioners, in order to supply that information; but the inquiry was still in its infancy. Empirical laws might by degrees be laid down; but real elementary calculations should, at present, alone be attempted; and these principles, when in practice the plates were thick enough not to buckle by the compression, had long been understood.*

From experiments on the resisting powers of rectangular cells of wrought-iron, 4 inches, and 8 inches square, and 10 feet long, compressed in the direction of their length, the thickness and crushing weights per square inch were—

Cells 4 inches square. Inches.	Tons.	*Cells 8 inches square.* Inches.	Tons.
·03	5 nearly	·06	* 5·9 nearly
·06	8·6 „	·139	9· „
·083	11 „	·219	11·5 „
·134	10 „	·24	Not crushed with 12 tons.

These experiments, so far as they extended, showed the weakness of cells with thin plates; and rendered it probable, that the thickness of the plates should be in proportion to the lateral dimensions of the cell. The practical use of cells in the top of the tube girders was to prevent the plates from becoming crippled, or wrinkled in that spot; but this would be better done by thick plates than by rectangular cells, which, in Mr. Hodgkinson's experiments, were generally crushed with a pressure of 12 tons per square inch of section, or even less. A rectangular tube of great thickness, nearly 7 tons weight, 47 feet long, 45 feet span, 3 feet deep, and 2 feet wide, made of plates ¾-inch thick at the top, bottom, and sides, when bent transversely by a load in the middle, was not perceptibly crushed at the top, with a pressure of 12 tons or 15 tons per square inch of section; and it required upwards of 17 tons to produce any indication of wrinkling in the top. The same tube, when its top and bottom plates, in the middle, were replaced with others of the same thickness, and its side plates were made of half the thickness, or ⅜-inch thick, was not corrugated or wrinkled in the top, though it was considerably shortened by the compression there, and had taken a deflection of 7·33 inches, with a load of nearly 103 tons in the centre, and a pressure in the top plates of 18 tons per square inch of section. Tubes of half

* In the strongest cast-iron beam, as obtained from these experiments, the area of the sections of the top and bottom ribs, in the middle, was as 1 to 6 nearly; and the bottom rib had 2·4 times as much in its section as all the rest.

† For the manner of computing the strength of the Conway Tube, *see* Appendix, by Mr. Hodgkinson, in the Report of the Commissioners on the Strength of Iron, pp. 174, 175. In tubes formed of simple plates, with cells at the top, as in those made by Mr. Fairbairn, the section of the top and bottom being nearly equal, the strength might be computed, by assuming another form, of nearly equal strength, and easily calculable, in the following manner:—

Fig 1.

Section of Tube as formed.

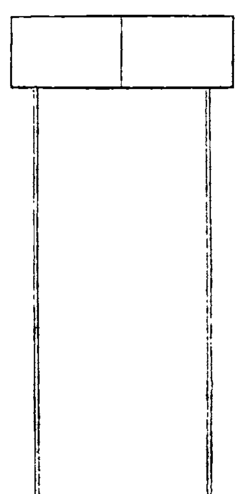
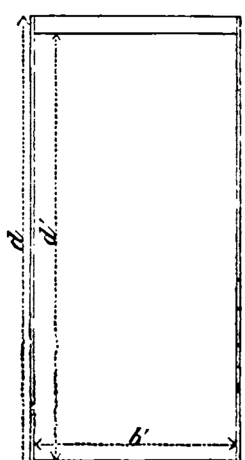


Fig. 2.—Section of Tube nearly equivalent in strength, the thickness of the bottom and sides being equal to those in the former; and the top of equal area of section to that of the cells in the former, and placed at the height of the centre of gravity of the cells.



* Vide Appendix to Report of the Commissioners on Iron Beams, page 116.

that thickness at the top would probably have wrinkled with a few tons per square inch of section there. These facts showed the great importance of increasing the thickness of the plates of tubes; and his experiments rendered it evident that the square cellular tops might be advantageously dispensed with, by increasing the thickness of the plates on the top by riveting them together, and thus placing the resisting forces at the top and bottom of the tube as far asunder as possible. If, also, in addition, longitudinal ribs of cast-iron were riveted to the plates along the top, to resist compression, when the wrought-iron failed, a great increase of strength would thus be obtained, as had been shown by his experiments.

Mr. C. H. WILD begged first to read the following extract from the Second Report by Captain Simmons, the Government Inspector:—

"In reply to the question, 'Whether if I still remain of opinion that this viaduct cannot be opened with safety to the public, what further strengthening will be necessary?' I have to state, that for reasons before adduced, I do not consider that the viaduct can be opened for the continuous passage of trains with safety to the public, and that it will not be in a condition to be opened until it shall have been so strengthened, that a load of about 400 tons (including the weight of the beams themselves and all the standing parts of the bridge), distributed equally over the platform of one span, shall not produce a greater pressure upon the top plate of the girders than five tons per square inch.'"

In consequence of this opinion, Mr. Wild had, at the request of Mr. Fowler, entered into calculations to ascertain what the compressive strain on the top of the bridge would be under the prescribed conditions, when it was found that it would be less than 5 tons per square inch, the limit defined in the report. As this result differed from that arrived at by the Government Inspector, recourse was had to experiments to confirm the truth of the calculations. Among the many points noticed in Mr. Fairbairn's paper, was one which he must consider not only unphilosophical, but positively dangerous. The paper said, "It is considered by some engineers, as very important to the strength of these bridges, that the girders should be continuous, or extending over two or more spans. This is no doubt correct to a certain extent, and although the fact is admitted, yet this consideration is purposely neglected in these calculations; any auxiliary support of that kind acting merely as a counterpoise. It is considered safer to treat the subject on the principle of compassing each of the spans with simple and perfectly independent girders." The importance of the effect of continuity was acknowledged by all authorities, so that it could not be admitted that this was an element the consideration of which might, with any propriety, be neglected. The Torksey bridge consisted of two openings, each of 130 feet; the two being spanned by a continuous girder resting on the central support. If such a beam was placed on the three supports A, B, C (fig 3), and were loaded uniformly, it would assume the shape of the dotted line A m B n C. It was evident that between A and m, the upper portion of the beam would be compressed, whilst in the part m n, over the support, the reverse effect would be produced; the beam might therefore be divided into three parts. At the point of contrary flexure m, all horizontal forces ceased, and there existed merely the vertical strain due to the suspension at that point of half the weight of the beam A m. If the

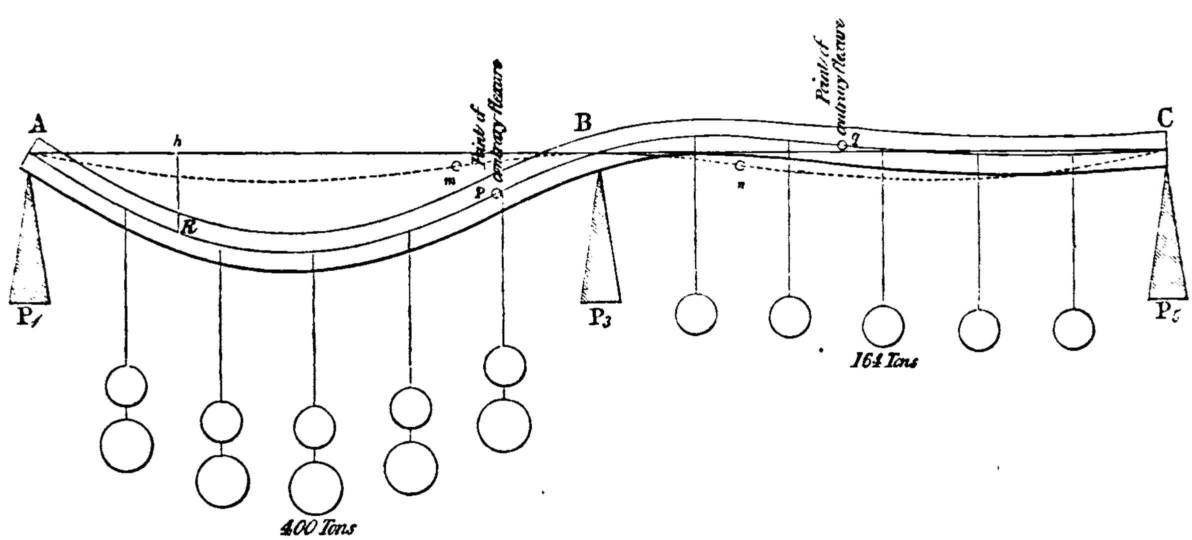


Fig. 3. Diagram of Deflection.—The dotted line represents the position of the girder as deflected by its own weight only—viz., 164 tons distributed over each span.

continuous beam were hinged at the points of contrary flexure, and so divided into three independent beams, the previously existing conditions would remain unaltered. This being the case, it would be an evident error, if in calculating the strength of such a beam, A B only were taken as its length. In order to check, practically, the calculated position of the point of contrary flexure, the experiment was tried on a large wooden model, by loading it first with such weights as represented the constant load due to the structure. The model beam then took the form shown by the dotted line, and the point of contrary flexure was found to be $30\frac{1}{4}$ inches from the point B. The model was then severed and hinged at that point, when the curve and the deflection were found, as might have been expected, the same as before. In order to ascertain the point of contrary flexure in a beam loaded as prescribed by the Government Inspector, over one span only, an additional weight was added, having to the weight previously applied on that span the same proportion as 400 tons, the prescribed load, had to 150 tons, the weight of the structure; the point of contrary flexure then approached to within $21\frac{3}{8}$ inches of the central support. The beam was again severed and hinged at that point, and the curve was formed as regularly as before, the deflection on the heavily-loaded side being $5\frac{1}{8}$ inches. The beam was then cut in half, making it into two detached beams, the ends meeting on the central pier, when it was found on the heavily-loaded side that the deflection was increased to $9\frac{3}{8}$ inches. As much weight was then removed as reduced the deflection to the same amount as had, in the continuous beam, been produced by the weight representing 400 tons, and the proportion borne by the weight requisite to produce a given deflection in the detached beam, was to that requisite to produce the same deflection in the continuous beam as $65\frac{1}{2}$ to 120. Having found the position of the point of contrary flexure in a beam, loaded in the proportions prescribed by the Government Inspector, it was easy to calculate the strain upon the top cells of the Torksey bridge. The virtual length of the girders would be $130 - 21\frac{3}{4}$ $= 108\frac{1}{4}$ feet: the load upon these girders would be $\frac{108\frac{1}{4}}{130} \times 400$ $= 333$ tons; or upon each girder 166 tons, or upon the centre 83 tons. If, for the sake of simplicity, the value of the side plates was omitted, the strain upon the top cell would be—

$$83 \times \frac{108\frac{1}{4}}{4 \times 9\cdot 5} \times \frac{1}{50} = 4\cdot 67 \text{ tons per inch,}$$

being less than the limiting strain of 5 tons per inch, defined by the Government Inspector. The experiments, therefore, fully corroborated the truth of the calculations previously made, and showed the compressive strain per square inch, on the top cell of the girder, to be less than that for exceeding which the Government Inspector had condemned the bridge, and thus an important line had remained for some considerable period closed at a great pecuniary sacrifice: the railway company had been, and were still deprived of the use of their property, and the public convenience suffered, not in consequence of any omission on the part of the engineer to provide adequate strength for the public security, but from the pernicious effects of government interference, and from the necessary consequence of the want of practical skill, always demonstrated when officers, whose duties were strictly military, were intrusted with the control of civil works.

PROFESSIONAL EDUCATION.

The question of diploma or no diploma will be debated so long as there are colleges and schools for engineering, and so long as doctrinairism exists. It is a part of the tactics which the latter sect employ to lead the world astray, to point out some defects in existing systems, and to put forward some doctrinaire system, without the least reference to the absolute law that the new system must have defects as well as others. It is not enough that an existing system works very well, and that there is no evidence of other systems working better, but we must give up the testimony of our senses and all the results of experience for imaginary advantages. With regard to the diploma or scholastic system, instead of at once admitting that such system must be the acme of superiority, we earnestly request our readers to survey the history of engineering in this country, before they suffer themselves to be barked away from what, after all, may be the state of affairs most conducive to the public benefit.

In the first place we will refer to experience, whether the present system, or no system, allows first-rate men to be produced? The answer to this is—Smeaton, Milne, Brindley, Watt, Trevithick, Jessop, Dodd, Rennie, Bell, Bramah, Murdoch, Woolf, Telford, Stephenson, the Scotch Stevenson, Huddart, Brown, Galloway. In the present day we have certainly men enough to maintain the character of the profession in every department.

In most other countries of Europe, engineering, so far from being a free profession, is monopolised by government officials; but, without casting any reflections upon them, we may simply say that the engineers of no country have a superiority over ours, and that during this century foreign engineers have been behind, and, following in the way in which we have led, have looked up to this country as the real school of instruction. It is to be observed that many countries have a greater abundance of institutions for promoting theoretical knowledge than are to be found here, and that, in most, theoretical knowledge and the diploma system have full sway; but still the broad fact remains, that England is the great school of engineering knowledge. Even the engineering literature of the continent, copious as it is, is only a reproduction of English types. It is to be presumed, therefore, from a comparison of facts, that the diploma system is not better than our system of free practice.

It is further to be observed, that England affords abundant scope for employment, and that first-rate men are better paid than on the continent; but, notwithstanding this, so far from the superiorly-educated engineers of the continent coming here and driving ours out, it is the other way. That strangers have full liberty here is proved by the instances of Labelye, Fulton, Brunel, Perkins, and so many others; but though men of genius come here from abroad because there is a free field, and although several strangers are now in practice, yet they form an inconsiderable fraction. On the other hand, it will be observed that English engineers have always been employed abroad, and have there executed some of their most remarkable works. We may enumerate Perry, Trevithick, the Rennies, the Stephensons, Gibbs, Tierney Clarke, Brunel, Buddicombe, Allcard, Lowe, Clegg, the Taylors, Whishaw, Galloway, Fairbairn, Lindley, Milne, Cresy, Cockerell, Manby, Simpson, Vignoles, and Locke. At this present time, from Spain to Russia, from Norway to Italy, there is hardly a country of Europe which has not placed some of its great works under the direction of our engineers; while here there is not one great work for which an engineer has been called in from abroad. Those which have been executed here, such as the Thames Tunnel, have been the productions of men established and naturalised here.

So far as to the *personnel;* but experience is likewise available as to the works produced. In this country, the ability of the engineers has been sufficient to carry out every class of work which has been compassed on the continent, to give the older classes of works a new or greater development, and to lead the way in new branches of employment. Aqueducts for water supply we have not, it is true, made; but we have comparable works in those carrying our canals. When the Hollanders and French had shown us the way in artificial navigations, we quickly covered our island with a network of water communications, which gave us like advantage with Holland, which surpassed Flanders, and which France has for fifty years tried to imitate. In land drainage we are pupils of the Hollanders, but we have, in the Bedford Level, given examples of large undertakings of this kind, as we have on a smaller scale around our coasts. We had older instances of sea beacons, but we have on the Eddystone, the Bell Rock, the Skerryvore, and the Skerries, produced unequalled monuments, while we have introduced constructions of iron, and the screw pile and hydraulic pile for sands. Of bridges there were many old masterpieces, but the class of works executed here justly excite admiration; while in this, one of the oldest branches of engineering, and one of the most limited type, the way has been led to numerous modifications and improvements, greatly extending the range of application. Suspension bridges, those of cast-iron, tubular bridges, and those on Potts's hydraulic piles, were first introduced here; while numerous examples of less striking modifications in skew arches, lattice and girder bridges, have been copiously supplied. In tunnels and subterranean works we have ample proof of our success.

Although government docks and harbours on an extensive scale have been executed by the French engineers, yet the commercial dock system has here been so expanded as to have reached a new era. Many of the outport docks would rank as first-class works were it not that Liverpool and London so greatly surpass all other dock systems. The extension of our commercial harbours, with the jetties, chain piers, and breakwaters, is likewise a noticeable fact.

The system of town sewage, and that of agricultural drainage, have been, as it were, renewed in this country, and are now received as models elsewhere.

We hear much of the scientific mining of the continent, but we know this simple fact, that many branches of mining have here received an unexampled development and acquired a decided superiority; while our miners, notwithstanding the competition of the High Dutch, are extensively employed abroad.

Of many of the most important branches of engineering we may almost claim the invention. If we name the steam-engine, the railway and locomotive, gas, the steamboat, and the electric telegraph, we enumerate strong claims to distinction, and on which it is unnecessary to expatiate. One word, "the steam-engine," says enough.

Very great works have been executed on the continent since we have led the way, some by Englishmen; but even with the advantages of our preliminary essays and failures, it has not yet been found that the theoretical proficiency of the continental engineers has acquired for them any great superiority. Even in France, large branches of engineering have been competed for by the civilians, and have been acquired by them from the corps of the Ponts et Chaussées. Of Holland it may be remarked, that when the profession was free the Hollanders had a great mastery in engineering, and supplied us during the sixteenth and seventeenth centuries. At the present moment, with a thoroughly organised waterstaat, they are followers of ours.

Of the United States we have said nothing as yet, because there, as with us, the diploma engineers are wanting; the States are independent of foreign supply of engineers, although there is full scope for talent. The Ponts et Chaussées have no more swept the field across the Atlantic than they have here. Compare, too, with the continental states the independent way in which our brethren have carried out a vast system of canals, railways, steam navigation, and electric telegraphs. Look at their bridges, waterworks, and dry docks, and decide by facts and from the teaching of experience, whether the United States lag behind France, Prussia, or any country which can boast of highly instructed government functionaries. When we have such strong evidence from the English on both sides the Atlantic, it becomes hardly doubtful as to the present superiority of the open practice of engineering as compared with the diploma practice.

Those who put forward a system of imaginary perfection, nevertheless, seldom pay attention to the merits of that which they oppose: their great game is, to point to defects which must be acknowledged, while the defects in their plans may be contested by them, because no experience has yet been had. This, however, can hardly be said to be the case on the present occasion, because there is the opportunity of comparing English untested engineers with the examined engineers of France; and, moreover, with English examined engineers. We are quite ready to admit that there are many men of great ignorance among the large body of English engineers, but the real question is, as to the result in practice. Here we are ready to admit that bridges have fallen down, piers been washed away, and retaining walls slipped; but what we do say is, that examples of failure are not more considerable in proportion to their works among our engineers than among those of the continent, or among the royal engineers.

In whatever way a comparison is made, it is so strongly in favour of English engineers that even the most prejudiced cannot deny the fact, while they adhere most strongly to their own views of the great benefit of scholastic instruction, college examinations, and a university diploma. It certainly is much better that an engineer should have a sound acquaintance with mathematics, physics, and mechanics, than that he should be ignorant of them; but though this is a truism, it does not follow that we are to adopt the whole formula of college examination and diploma. As the question now stands, the *onus probandi* is on the other side: but what they can prove on their own behalf seems very problematical. Results are the true test, and it might suggest itself to the advocates of diplomas, that the results, not being in their totality the production of accident, must depend on some principle.

We must allow that it seems paradoxical that the diploma engineers, with all their instruction, should fall behindhand, and the other engineers, with all their ignorance, keep ahead; still, such are the facts and we must deal with them. We may be told there is greater scope for energy in England, and many admissions may be made and explanations offered as compared with the continent; but then the case is met here, for we have a whole staff of academical engineers, but although many of these are employed by the government to take away the bread of the civil engineers, we are not aware of one Woolwich engineer who is deriving an income from the free employment of the public. In France, too, civil engineers compete with the academic engineers, so far as the monopoly given by the government to its creatures allows, and therefore local grounds cannot afford the true reasons for the difference.

We believe the great reason to be, that the diploma system is morally vicious. It puts up a wrong test—that of scholastic instruction, which experience proves is of minor importance in the course of a professional career—and it places the responsibility of a college diploma against the responsibility to public opinion: thus a schoolboy is produced, with schoolboy attainments and schoolboy self-satisfaction; and the false start is seldom made up for. In the first place, the diploma is a nonessential. A surgeon is called in on an emergency, when there is no opportunity to test his qualifications; but an engineer is called in deliberately, as is an attorney or barrister, and there is ample time to select him and to ascertain his acquirements, experience, and moral accountability. For the protection of the public a diploma cannot be wanted of an engineer, for in his case the less protection the public have the better: the public must share in the responsibility of employing an engineer, and the more discrimination they show the better it will be for the profession. The public, too, are less likely to submit for a continuance to presumption, extravagance, dilatoriness, breach of faith, and want of pecuniary honesty, all of which may flourish despite a college certificate. It happens very fortunately that the public seldom resort to a professional man without in some way inquiring about him, and receiving a satisfactory account of his previous exertions. This is a responsibility which should be in the highest degree upheld, but which the diploma system would invade without giving any effective guarantee against ignorance.

Whatever necessity may be pleaded for a diploma in the case of medical men, it is unfortunately notorious that the diploma is no guarantee for efficiency. A number of scoundrels dissipate their time and the money of their fathers in idle and dissolute pursuits, and when the time for examination comes, prepare for it by means of a "grinder." If the farce of an engineering examination were countenanced, professors would certainly flourish, and would obtain more employment; but a new branch of occupation would forthwith start up, which would be that of the grinder—some of the professors, no doubt, figuring in that capacity, as is usually done. The medical idler having obtained his diploma, is happy to pronounce his education at an end, makes a mockery of science, and may be found at an advanced age boasting that he has not opened his books since he left college, nor has he added to them. The condition of a large mass of the general practitioners is truly deplorable: once qualified, they enjoy a certain monopoly of public appointments, which assists them in establishing themselves in local practice, even if they have not a small sum to set up a blue-bottle shop. The settlement of one of these vipers in a small town or village serves most effectually to keep out a better man, and the population are exposed to the malpractices of a brute who ought not to be intrusted to the care of cattle. The diploma is no safeguard against ignorance, and is an efficient protector of idleness, for nothing better can be invented for those dispositions who are willing to purchase a career of comparative immunity by a few months' exertion. What the physician or surgeon does from choice the engineer does from necessity. He labours assiduously and constantly throughout his life to acquire greater proficiency, knowing that he has to pass the constant examination of the public, and that he has no diploma to plead as a set-off for ignorance or malpractice.

The engineer, it is to be remarked, must secure himself in practise by his own exertion. Any one can compete with him; the smith, the mason, the carpenter, can make their way to his side and push him from his stool. There is no marked line within which he can entrench himself, nor is there any legalised scale of fees to secure his emolument. The government trains up competitors against him; the ingenuity of his Yankee brethren is free to seek employment as he is; and any foreigner who can speak English may set up with as good a charter as he has. If, therefore, he does not qualify himself, and acquire all the theoretical and scholastic information which is necessary for him, he must take the consequences. In some cases he must share with those having special qualifications the honour and emolument of plans; in others, having launched beyond his depth, he will be subjected to complaints, litigation, inquests, commissions of inquiry, the control of the press, and indeed a severe exercise of justice which may result in the abridgment of his professional earnings or the close of his career.

With regard to the range of professional acquirements, it must vary according to the pursuits and necessities of each individual; but we are justified in believing that it is as high for all practical purposes as among any diploma practitioners—not less by the result in the works produced, than in those brilliant examples of scientific research which, notwithstanding the illiberality of the government, has been carried to such an extent as to cast lustre on our profession and country. From the time of Smeaton downwards, the career of experimental investigation has been sedulously cultivated, often from the private means of the inquirers, and which has resulted in the greatest benefit to practical science. How valuable have been these labours in promoting the improvement of the steam-engine, in ascertaining the strength of materials, and in determining the form of the screw propeller, is known to all, but we may fairly refer to that grand series of experiments which promoted the achievement of the tubular bridge. So long as such exertions flourish, it cannot be said that science is unhonoured among us, or that there is any fear of its abandonment; and such living proofs are more satisfactory testimony than the knowledge that all the engineers in the country have got their class certificates, and once in their lives passed through an examination.

One special benefit we have, and which is worth all that the diploma system can offer to us, is the free career open to every one of the working classes who chooses to avail himself of it, and which the diploma would effectually stop. In perusing the annals of the profession, or in scanning its present ranks, we remark with just pride, such a man was a millwright, such a one a carpenter, another a mason, this a cabinetmaker, that a mathematical instrument maker, one an engine tender, here a locomotive driver, there a plumber. The rise of George Stephenson from the coal heap, to be one of the heads of the engineering profession in the world, is worth all the diplomas ever invented. A college examination would shut out our greatest men, and would be a most clumsy test to determine when Brindley, Rennie, or Stephenson was entitled to practise as an engineer.

While the absence of the diploma or artificial test allows the profession to be recruited with men of practical acquirements from every mechanical trade, it gives the same freedom of entry to men of genius in other walks of life. Thus we draw recruits from the medical profession, the royal and merchant navy, the army, or wherever they are to be found. The ranks are open to men of collegiate education and those who have carried off university prizes; and if college men do not get the greater share of the emoluments of the profession it is their own fault and not want of opportunity. At the present time there is the likelihood of the profession being stocked with men who mean to apply themselves seriously to its pursuit, instead of being a harbour for the idle sons of industrious fathers, who can give them sufficient to pay college expenses and make a start, leaving them to quarter themselves on the public.

A further result of the diploma system, in narrowing the profession and constituting an injurious monopoly, would be in closing it against members of the middle classes of limited means. The diploma would be preceded by a college course and college fees, and which would act as a prohibitive tax, to the very great prejudice of the profession. Whatever the sufferings of junior members, and such must be felt in all professions, the value of the professional status of each must depend on the aggregate exertion, and which will be much less in a close profession. It must be remembered, too, that those who propose to assimilate engineering to other close professions, forget that the monopoly of public situations is not available, inasmuch as the government here has its own corps of nominees.

If the diploma system were adopted, civil engineers would be reduced to the same state of inertness as the government engineers, and, instead of enjoying their present superiority, would fall to a lower standard. They would abandon their present claims to public employment, bring themselves to the scholastic level of their rivals, and would be no more employed in virtue of their diploma than they are now in virtue of their practical attainments and experience. This would be the effect of a change which can produce no good, but would bring evil. For the protection of competent members of the profession, a diploma is not wanted for the keeping out of incompetent members; so far from being efficient, it would rather act as a shelter and a shield to that class, as it does in other professions.

Although many of our arguments have been shaped chiefly as the issue affects civil engineering, yet mechanical engineering is equally interested in resisting the diploma delusion. The diploma system will be introduced for mechanical engineering if it be introduced for civil engineering. The French and the Prussians form mechanical engineers in the schoolroom; and why should not the same scheme be tried here? It is very true, it seems to practical men highly absurd to propound such a system, but the theoretical advantages are quite as great as when assumed for the other branch of the profession. If, too, we admit that stationary and marine engines have exploded once in ten thousand times, we shall be called upon, on the ground of public security, to submit all those engaged in the manufacture of machinery to a strict examination in physics, mechanics, chemistry, geology, and the other necessary branches of science; for we shall be told that no man, who cannot pass a satisfactory examination as to the principles on which the construction rests, ought to be allowed to jeopardise the lives of the public. It is worth while remembering, that a system of scientific instruction and examination was actually propounded for engine-drivers.

To sum-up the question as it really stands, experience is against the diploma system and in favour of the free system; and, except for the benefit of professors, examiners, and grinders, there is no object in adopting the diploma system, and thereby shifting the responsibility from the public and the engineers and reposing it on a board of examiners. An engineer may safely be tried by his works, and the public safely be left to judge of them, with full reference to the previous training or occupation of the candidate for employment.

THE GEOMETRIC PRINCIPLE OF BEAUTY IN THE MOULDINGS OF ANCIENT GRECIAN ARCHITECTURE.

By D. R. Hay, F.R.S.E.

[*Read at a Meeting of the Architectural Institute of Scotland.*]

(*With Engravings, Plate* IV.)

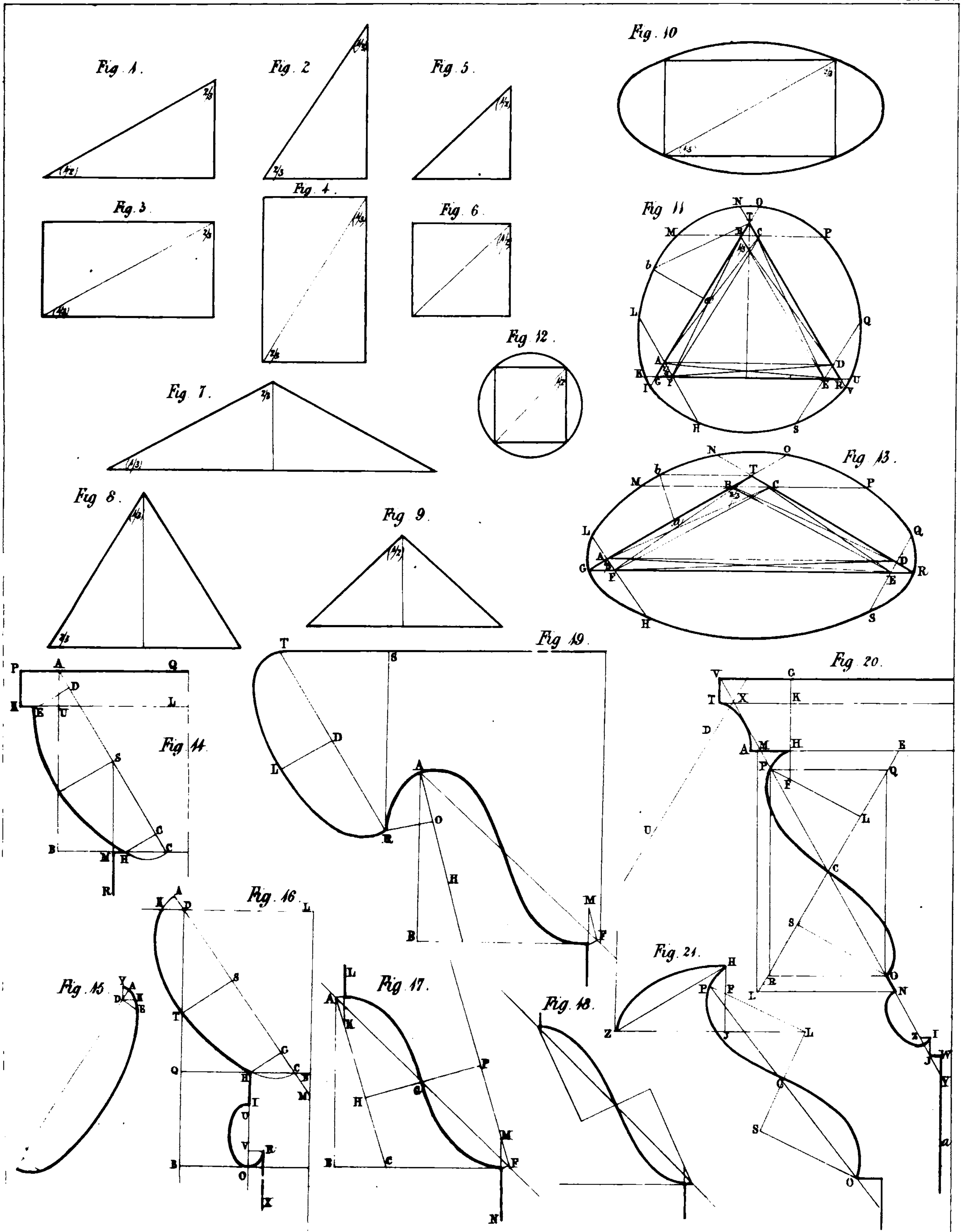
When one of my profession presents himself before a meeting of an Architectural Institute to read a paper upon a subject in any way more intimately connected with so comprehensive an art than that of his own practice, some apology on his part is demanded.

I therefore trust that as the application of æsthetic science in architecture takes a very wide range, commencing with the simply beautiful in art, and approaching the grandly sublime in nature, and that as I have on this occasion confined my illustrations to some architectural details which lie at the very threshold of that science, and regarding which there still exists much difference of opinion among architects themselves, the slightness of the aggression will be some excuse.

In the article "Architecture" in the Encyclopædia Britannica, its author observes,—"Greek architecture is distinguished for nothing more than the grace and beauty of its mouldings; and it may be remarked of them generally, that they are eccentric and not regular curves,"—and adds, that "the hand alone, directed by good taste, can adapt them to their purpose and give them the spirit and feeling which renders them effective and pleasing." But the author of a similar article in the Encyclopædia Metropolitana is of a different opinion. He says that "the outline of a section of a Greek moulding is, in almost every case, a portion of some conic section, which," he adds, "may be either elliptical, parabolical, or hyperbolical." Thus it appears that these two great authorities are diametrically opposed to each other on the subject of these curves; while a later investigator (Mr. Penrose) has endeavoured to prove that all the curves of the mouldings of the Parthenon at Athens are either parabolical or hyperbolical. The subject is therefore still open to discussion. But instead of attempting by any process of measurement the difficult task of endeavouring to prove which of these kinds of curved lines have actually been employed in the construction of mouldings in the ancient architecture of Greece, I shall endeavour to point out which of them is the most practically efficient to be employed in the reproduction of similar mouldings in the greatest beauty and variety.

It will, however, be necessary, in the first place, to show what are the primary elements of all architectural forms. For this purpose I shall take the right angle as produced by the meeting of a vertical with a horizontal line for a fundamental angle, and deduce from its division these elements in the following simple manner:—To produce a figure from the meeting of the vertical with the horizontal line, an inclined or oblique line is required, and the figure produced by these lines is a right-angled triangle, either isosceles or scalene, its parts being a right angle and two smaller angles, which together are equal to another right angle. One of the smaller angles is that made by the oblique line with the vertical line; and the other, that made by the same line with the horizontal line. If we therefore name the triangle after the smallest of these angles, the other two are understood, and a very simple terminology may thus be established. I therefore name every right-angled triangle after its smallest angle. For instance, a right-angled scalene triangle, fig. 1, whose hypothenuse makes an angle of 30° with its horizontal side, I call the horizontal scalene triangle of ($\frac{1}{3}$), because 30° make one-third of the right angle. But, on the other hand, when the hypothenuse of the same triangle (fig. 2) makes an angle of 30° with its vertical side, I call it, for the same reason, the vertical scalene triangle of ($\frac{1}{3}$), and thus every right-angled triangle may be named.

The same terminology may be extended to rectangles. For instance, when these triangles are united in pairs by their hypothenuses, the rectangles they form (figs. 3 and 4) may respectively be termed the horizontal and vertical rectangles of ($\frac{1}{3}$). When the vertical angle is 45° or half the right angle, the isosceles triangle (fig. 5) may be termed simply the right-angled triangle of ($\frac{1}{2}$). And when two of these triangles are united by their hypothenuses, the equilateral rectangle or perfect square (fig. 6) is thus formed, which may in like manner be termed the rectangle of ($\frac{1}{2}$). Thus every rectangle as well as



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GRECIAN MOULDINGS.

By D. R. Hay, F.R.S.E.

every triangle may have a name, which at once distinguishes it from every other figure of its own kind, and which, at the same time, conveys a perfect idea of its relative proportions.

The same terminology is equally applicable to isosceles triangles, for when the same right-angled triangles are united in pairs by their sides (as in figs. 7, 8, and 9), the two first of these triangles may be termed the horizontal and vertical isosceles triangles of $(\frac{1}{3})$, and the third simply the isosceles triangle of $(\frac{1}{2})$, by which names the relative proportions of their parts may also be perfectly understood. These two figures are the primary elements of all architectural forms.

Each rectangle and each isosceles triangle has a curvilinear figure which belongs to it, and to which may be applied the same simple but comprehensive terminology. These curvilinear figures are the circle, the ellipse, and the composite or inclined ellipse, and they may be called the secondary elements in the æsthetics of architecture. The first of these belongs to the perfect square, for its axes, like the sides of that figure, are all equal. The second belongs to every other rectangle agreeably to the proportions of its elementary angle. Thus fig. 12 may be termed the curvilinear figure of $(\frac{1}{2})$; fig. 10, the horizontal curvilinear figure of $(\frac{1}{3})$; fig. 11, the isosceles curvilinear figure of $(\frac{1}{3})$; and fig. 13, the horizontal isosceles curvilinear figure of $(\frac{1}{3})$.

These two latter figures, although each described by one continuous line, are when analysed found to be composed of a series of ellipses harmonically combined—the first amounting to twelve, and the second ten. Two of these ellipses are always horizontal, and the remainder inclined.* As this figure has two elementary angles, one of which determines its axis, and the other its inclination, the various combinations of these angles lead to great variety.

These are the three kinds of curves which belong to the rectangle and isosceles triangle, and which I conceive to be, along with these two rectilinear figures, capable of producing all the beauty of abstract form of which architecture is susceptible, and that neither parabolic nor hyperbolic curves are requisite in the æsthetics of that art.

In my present illustrations of the harmonious combination of these elements, I shall confine myself to the following mouldings which decorate the Doric temples of ancient Greece—namely, the *Ovolo*—the *Cyma Recta*—the *Cyma Reversa*, or *Ogie*—the *Cavetta*—the *Bead*—and the *Hawk's Beak*.

The Ovolo with Fillet and Bead.

This moulding is one of the most simple applications of the curve of an inclined ellipse. It is sometimes accompanied by a fillet, sometimes by a bead, and sometimes by a cavetta; and the proportions of these accompaniments seem derivable from the inclined ellipse, of which the body of the moulding is composed. For example, fig. 14 is the section of an ovolo moulding, similar to that which surmounts the pediment of the Parthenon at Athens, and it may be constructed as follows:—Let the line A B represent the vertical depth of the intended ovolo moulding, including its fillet. Through A draw A C at an angle of $(\frac{1}{3})$ with A B. Taking A C as the major axis, describe the inclined ellipse of $(\frac{1}{3})$, whose foci are D and G, and centre S. Through D and G draw perpendiculars to the axis, meeting the ellipse in E and H. And through A, E, and H, draw horizontal lines P Q, K L, B C. Through S draw a vertical line S M R. Make A P K U a square, and the section is complete, M R representing a part of the corona. Thus the rectilinear accompaniments being deduced from the inclined ellipse, which gives the curve of the moulding, all the parts relate harmonically to each other. This example may be termed simply the vertical ovolo of $(\frac{1}{3})$, because the angle of its curvature and the angle of its inclination are both 30°, or $\frac{1}{3}$ the right angle.

* This figure I have elsewhere called the "composite ellipse;" and, as stated in the text, it is composed of arcs of either ten or twelve ordinary ellipses. It may be described around any isosceles triangle by the following process:—Take the side of the triangle T G, fig. 11, as the major axis of an ellipse (which may either be that of $(\frac{1}{3})$, as in each of the examples given, or any of the smaller harmonic angles, and through T draw T *b*, making the angle of the required ellipse with T G. Bisect T G in *a*, and taking *a b* as a semi-minor axis, the foci will be found at A and B. Fix corresponding foci, C D F K, on the other side and base of the triangle. Fix a pin into each of those six foci, and one at the point *b*, and tie a thread tightly around them, using a little wax to prevent the knot from slipping; when quite secure, remove the pin at *b*, and insert a pencil or any tracing point, and by moving it round the pins, and keeping the thread tight, the vertical composite ellipse of $(\frac{1}{3})$ will be described. In this figure N O and H S are arcs of horizontal ellipses, and H I, I K, K L, L M, and M N on the one side, and O P, P Q, Q U, U V, and R S on the other side, arcs of inclined ellipses, all harmonically blended. Between the isosceles triangles of $(\frac{1}{3})$ and (1-6) there are, inclusive, *22* of a harmonic kind, and an equal number of ellipses. Therefore, as these may be combined interchangeably, the variety of those figures between the angles of $(\frac{1}{3})$ and (1-6) amount to 484.

The next example, fig. 16, is an ovolo of $(\frac{1}{3})$ and $(\frac{3}{8})$—that is, its angle of curvature is $\frac{1}{3}$ the right angle, or 30°, and its angle of inclination 33° 45′, or $\frac{3}{8}$ the right angle. This is accompanied by the bead, and is constructed as follows:—Let the line D B represent the full vertical depth of the intended ovolo moulding, including its bead and fillet, and D Q the vertical depth of the ovolo curve. Through D draw A D M at an angle of $(\frac{3}{8})$ with D B, and through D draw a horizontal line K L, and through Q another horizontal line Q N, cutting A M in C. With the inferior end of its major axis at C and its superior focus in D describe the ellipse of $(\frac{1}{3})$, whose foci are D and G, and centre S. Through G and S draw perpendiculars to the major axis meeting the ellipse in T and H. Through H draw the vertical line H I O, making H I equal to H G, and I O equal to T S; and taking T O as the major axis, describe the ellipse of $(\frac{2}{5})$, whose foci are U V. Through V draw V R horizontal, and through R draw R X vertical. The line K T H I O R is the section of the moulding, and R X the face of the antæ which it surmounts.

Fig. 15 shows the various modes in which the curve of the inclined ellipse may be terminated in the construction of this moulding. In this way there may be constructed between the inclined ellipse of $(\frac{1}{3})$ and that of $(\frac{1}{8})$ and $(\frac{1}{2})$ 286 varieties as to curvature and direction, setting aside the various ways in which the curves of the three examples are ended. And this can be done without in any way diverging from the harmonic relation between the angles of curvature and of inclination, a variety amply sufficient for the architect to select from according to his taste and judgment.*

The Cyma Recta.

This is one of the most beautiful compositions of the curve of the inclined ellipse, and the moulding may be constructed as follows:—

Let A B, fig. 17, represent the vertical depth of the intended moulding. Through B draw B F horizontal and equal to A B. Join A F, and bisect it in G. Draw A C, making the angle B A C $(\frac{1}{8})$. Draw H G P at right angles with A C. With A H and H G as semi-axes, describe the elliptic curve A G; and with P F and G P as semi-axes, describe the elliptic curve F G. Through the foci K and M draw K L and M N, and where these lines cut the circumference of the ellipses ends the curve of the cyma recta.

It will be observed that the curve of this moulding is that of the vertically† inclined ellipse of $(\frac{1}{3})$ and $(\frac{1}{8})$, while the direction of the moulding is that of $(\frac{1}{2})$. The varieties of the cyma recta that may be thus produced are as great as those of the ovolos. Fig. 18 is another example, the curve being that of the inclined ellipse of $(\frac{3}{10})$ and $(\frac{1}{8})$, and the direction of the moulding $(\frac{1}{2})$.

The Hawk's Bill.

This moulding, fig. 19, is composed of the cyma recta and ovolo combined, thus:—Having described the curve of the cyma recta, bisect A H in O, and through O draw O R at right angles with A H. Through R draw R S vertical, and R T at an angle of $(\frac{1}{3})$ with R S. Make R D equal to A H, and taking it as a semi-major axis, describe the elliptic curve of $(\frac{1}{3})$ T L R. In the Parthenon this moulding surmounts the enriched ovolo (fig. 16) in the capital of the antæ of the pronaos.

The Cyma Reversa, with the Plinth, Cavetta, and Bead.

The cyma reversa, or ogie, as it is sometimes called, is another beautiful composition of the curve of the composite or inclined ellipse, and the moulding which it forms is of frequent occurrence in Grecian architecture. Like the ovolo, it is generally accompanied with the plinth, the cavetta, or the bead, and sometimes with all three, as in the following example, which is constructed as follows:—Let P R, fig. 20, represent the vertical depth of the intended cyma reversa between the axes of its two elliptic curves. Through P and R draw P Q and R O horizontally. Through P draw P O at an angle of $(\frac{1}{8})$ with P R. Through R draw R Q at an angle of $(\frac{1}{3})$ with R P, and cutting P O in C. Bisect Q C in L, and C R in S, and join P L and S O. With P L and L C as semi-axes, describe the horizontal inclined elliptic curve of $(\frac{1}{8})$ C P H, whose superior focus

* The degrees of inclination employed in constructing an ovolo moulding between $(\frac{1}{3})$ and $(\frac{1}{8})$ being 13, and the ellipses 22, the variety of this moulding is 286, independently of that which arises from the various modes of terminating the curve of the inclined ellipse shown in fig. 15.

† When the angle of inclination is less than 45° with the vertical line, the ellipse is vertically inclined; when more, it is horizontally inclined.

will be F, and with S O and S C as semi-axes, describe the horizontally inclined elliptic curve of ($\frac{1}{8}$) C O. Through the focus F draw F G perpendicular to P Q, cutting the elliptic curve in H, and through H draw A M H E horizontally. Produce C P to M, and through M draw M B vertically. Produce C R to B, and through B draw B N horizontally, and the line H P C O N is the section of a cyma reversa or ogie moulding of ($\frac{1}{3}$) with its inclined plinth. To add the vertical plinths, cavetta, and bead, produce F H to K, making H K equal to ($\frac{1}{3}$) M B, and produce H K to G, making K G ($\frac{1}{2}$) H K. Through K and G draw horizontal lines K T and G V. Produce C P M to V, cutting K T in X; through V draw V T vertical, and through X draw X D U at an angle of ($\frac{2}{3}$) with X M P. With its major axis upon X U, and through T, describe an elliptic curve of ($\frac{1}{8}$), whose superior focus is D, and centre U, and the cavetta and vertical plinth which surmount the cyma reversa are proportionally formed. For the bead, produce O N to Y, and with a major axis upon N Y equal to ($\frac{1}{3}$) of the whole vertical depth, describe an elliptic curve of ($\frac{2}{3}$) and ($\frac{1}{8}$), with its circumference passing through N. Through its inferior focus Z draw Z I, horizontal, cutting the elliptic curve in I, and through I draw I J, vertical, cutting O Y in J. Through J draw J W horizontal and equal to $\frac{1}{2}$ I J, and draw W *a* vertical.

The cyma reversa is sometimes surmounted by a horizontal cavetta, as in fig. 21.

CONSIDERATIONS UPON SOME OF THE PRODUCTIONS CONNECTED WITH ARCHITECTURE IN THE EXHIBITION OF 1851.

By John W. Papworth.

[*Extracts from Papers read at the Royal Institute of British Architects, November* 17, *and December* 15, 1851.]

When the possibility was suggested of assigning the investigation to the members of the Institute best qualified to report upon the different productions connected with architecture in the Exhibition, it appeared, although the utility of the proposition was at once granted, that there was but little probability of their undertaking the task, and the attempt to accomplish it was therefore thrown upon the proposer's hands. It was not, perhaps, likely that mere visitors to the Exhibition would receive valuable new ideas as to propriety and beauty from the simple inspection of its contents: I confess to being one of those who believe that the perception of the latter is to be taught, and that those who have been familiar with the bad require able teachers to point out the difference between the good, the mediocre, and the worthless. To a considerable extent the public press has honestly and conscientiously discharged this office, and I have not hesitated to reproduce some of the best suggestions from that source.

To Mr. Owen Jones we must ascribe the general effect of the arrangements. On the British side there appeared a wonderful exemplification of the national character, and of the notions which every one entertains of his freedom and independence of action. Like street architects, every body did the most for himself, desiring to display his contributions in the very best position possible, with as little regard to his neighbours as the regulations would permit; and it could only be by a constant supervision that anything like an *ensemble* was obtained. Bed-posts, conservatories, glass cases, and sign-boards appear to have formed the stock notions of construction, worked into a presentable form by a variety of modifications. These fittings, however, being remarkable for lightness and light-giving, for a considerable amount of elegance, and remarkable adaptation to their purpose, presented a great contrast to those on the foreign side, where government authorities did almost everything for the exhibitors, and massed their works in decorated and darkened apartments.

Commencing our investigation with the mineral products, we find that Tuscany submitted a granite, said to be from the quarries of S. Pietro del Campo, in Elba, which supplied the columns used in the cathedral and baptistry of Florence; and the Grand Duke Cosmo I. caused a large block to be cut into a basin, measuring nearly 66 feet in circumference, and placed in the gardens of Pitti Palace. The celebrated single block in the Duomo at Ravenna, which is said to be of the same granite, was the largest example of the use of that material in construction until the erection of the statue of Peter the Great, in St. Petersburg. The monolithic columns of St. Isaac's Church, in that city, so far surpass the most imposing English specimens that were shown at the western entrance of the building, that it is hardly worth while to mention them, except as promises of what may yet be done to rival ancient Egyptian luxury, which, imitated by Roman vanity, far surpassed in the use of this rock, and of porphyry and alabaster, anything which modern architects dare to propose even to themselves. Prussia exhibited one pedestal, of columnar form, made from a variety of granite-like formation, or rather gneiss, which might be called a garnet rock, being singularly studded with crystals of that mineral, some of them very fine and almost transparent. Such a rock was also brought from Scotland, from the summit of Ben Resipole. Of the Cornwall porphyries, I noticed the size 6 feet by 3 feet of that sent from Retire, in Withiel. There were not many specimens of foreign work of this kind; but the few that have to be mentioned include some specimens remarkable for the difficulty attendant upon their execution. The fine red porphyry tazza, standing upon the garnet rock column which has been mentioned, was accompanied by a slab: both of them were of exquisite finish, worked on a very fine and hard material; while the examples of granites, porphyries, and jaspers, from Sweden and Russia, exhibited the results of an amount of labour rarely expended in these days of utilitarianism, except where the rate of reward is inadequate, or where, for some especial service of luxury, the element of costliness forms the ground of an undue claim to admiration. The vases especially, constructed of materials which, as far as difficulty of working is concerned, may be regarded as gems, were marvellous instances of finished skill; while they must be considered worthy of admiration for the same reasons which induce us to regard with wonder the labours of the ancient Egyptians in erecting their pyramids, and raising obelisks of monolithic blocks.

Those who are engaged in processes requiring the adaptation of a lathe will read with interest the account given in the descriptive catalogue of the machinery employed in the imperial factories of Ekaterinburg and Kolyvan, for producing such works, averaging three feet high. The true jaspers are probably in many cases altered schists; but some porphyries, and various other quartz-like rocks, are so commonly associated with them, under the same name, that it is difficult to define very exactly the meaning of the term, under which a large quantity of trifling articles passed under our eyes: we have been taught to regard it as expressing something precious, but in the mountains near the river Korgon, in the Altai, there is a mass of jasper, 300 feet thick, which rests on a bed of red porphyry.

It is to be hoped that the display of various specimens of serpentine from Ireland and Cornwall will call attention to a new mine of wealth to be opened. Already the Americans have imported these productions as one means of decoration, while they may be regarded as almost unknown in our metropolis. So much has been said and written on the stones fitted for building purposes, which we possess, and to such a length would any consideration of them extend—for the United Kingdom can show a specimen of almost every useful stone known—that I shall be content to pass by the old red sandstone and Devonian series, with the varieties of the carboniferous limestone, only observing, that here again exist disregarded sources of manufacture in the hydraulic limes, beautiful marbles fit for interior decoration, and almost forgotten quarries, such as the black flagstone, or Posidonia schist, in the Isle of Man, which is said to have supplied the stones for the steps of St. Paul's Cathedral. The green, or Mona marble, which was partially in demand five-and-twenty years ago, is another instance of the oblivion into which our own resources are allowed to fall. In the millstone grit division I observed nothing new. With the employment of white marble in objects of high art, our researches have on this occasion no connection; indeed it was in its use for chimney-pieces only that the statuary presented himself to any extent in the Exhibition. Of these the Austrian specimens were decidedly the least successful; three or four very showy chimney-pieces, some with mirror frames, were exhibited, which it was impossible to pass unnoticed, but on which it was equally impossible to bestow anything like unqualified admiration. The chimney-pieces from France, in which less attempt at display had been made, offered a hint for the revival of the now old fashioned style of box chimney-piece; these French specimens advanced nine or ten inches at least into the room, so that even in a large example, the deepest shelf need not project much before the frieze. Prussia exhibited a Carrara marble specimen, not particularly striking; but Belgium, besides a small one, sent that by Leclercq, which appeared in my judgment the most sumptuous of its sort. No one, I am confident, can recollect the English examples by Brine, Thomas, and others, without feeling that the superiority of design was infinitely on the British side; one with a round-headed opening and curved bedmould, had considerable graceful simplicity, and yet richness of effect; and the elegance of those executed for Stuart and Co. of Sheffield, by Messrs. Nelson of Carlisle, should not be overlooked. Decidedly successful for taste, and even more excellent for detail, was the very beautiful tazza of Oriental alabaster, sculptured by Della Moda, which was placed in the nave near the Roman department. It measured more than 4 feet across the handles, and was about 3 ft. 6 in. diameter. The material, the stalagmitic carbonate of lime, was obtained in an unusually large block of the rarest and most beautiful quality, from quarries anciently worked in Egypt, which have recently been re-opened. The Greek government has also been occupied with attempts at restoring the value of their ancient quarries; and we saw with pleasure, that besides the celebrated white marbles, the lichnites (flesh-coloured variety), the rosso-antico, the cipolino of Karysto, and the porfido verde antico were represented. Besides these, we had assurances of other superb marbles having been found: one, reddish sky-blue with green spots, from Krokea; another from Sparta, amethyst coloured with well-marked yellow veins; another, violet breccia; a water green marble; and the porfido di vitelli, a pea green ground, with small round bright crystal spots of light green, not yet exported. Tuscany also promised to supply giallo di Siena, Broccatello, Bardiglio, Lumachella, Porta Santa, Oriental alabaster, and Verde di Prato, in large blocks, as well as the common cipollino and white marbles. It was stated that the black and red marbles from the quarries of Pescaglia, did not sufficiently represent the blocks that had lately been extracted, which were considered far superior as to colour, fineness of grain, diminution of specks, and total absence of small capillary veins. The Portuguese marbles did not much please my eye; the pegmatite (a granite in which component minerals form very distinct masses closely compacted) passing into protogine (granite, whose mica contains magnesia), arrested attention, from the statement that this, which seemed not very easy to work, came from the province of Alemtejo, in the district of Portalegre, within the city, and that most of the houses are built of it; the effect in a picturesque view must be remarkable. Neither in the government collections of Spanish and Portuguese marbles, nor in those of private individuals, did I observe any specimens of surpassing beauty. It was noticed, that although eight contributions came from the famous Isla dos Pinos, in the vicinity of Cuba, and that marbles had long been found there in great abundance, they had not yet been used in that rich Spanish colony, which absolutely imported a supply from Italy and the United States. In fact, the ordinary marbles of these countries, and of Germany, Belgium, and France, are generally like our own, not only coloured, but distinctly veined, and their value depends upon the absence of cracks and flaws, brightness of the ground, a good arrangement of the veins and patches of colour, and the possibility of obtaining large blocks of equal texture and quality at a moderate cost. In the actual use of common marbles, the Exhibition proved that our continental neighbours last named had long preceded us, by the evidence of a multitude of slabs and specimens, worked for the most part very thin, and showing that cheapness of application was considered more important than finished workmanship. Liege and Namur, in Belgium, contributed specimens of black marble, which seemed to be cut from larger blocks than that supplied from Nassau, and also to be a better material, as its fossiliferous limestones, taking a polish, were rather metamorphic than truly crystalline. Derville and Co. represented a government collection, in which one hundred and eight fine specimens of no small size exhibited the resources of France to great advantage, and must have helped materially to keep up the taste for the pretty marbles of Languedoc, Vosges, and the Pyrenees. Tarride, Sons, and Co. of Toulouse, recommended one piece of black and white Pyrenean marble, as being the sort selected for use in the tomb of Napoleon. Black, grey, and red marble, found near Rübeland, in Brunswick, were represented by pieces of excellent character; and it was noticed that blocks are obtained 9 feet by 5 feet in dimensions.

The small space set apart for Rome contrasted strongly with the expectations which such a name was likely to inspire; yet, on examination, that little collection contained the representation of mercantile value to a larger extent than might be supposed; the Cavaliere Barberi alone, without the manufactory of the Vatican, would have supplied an exhibition; and if we add the illustrated works of Canina, the room would have had interest enough, even without the labours of the Cavaliere Moglia in mosaic. Barberi is, I suppose, the most celebrated practitioner in this style of ornamentation, and by the adoption of machinery, he has shortened, by nearly one half, the time which would be occupied in the execution of large works in the Vatican. Russia exhibited studies of Florentine mosaic, of very high character; but, as may be naturally supposed, Tuscany, from its possession of very large quantities of pietre dure, chalcedony, the Arno pebbles, agates, and cornelians, and the help of experience, stood first in the display of that species of work. Bosi, of Florence, seemed to me to exhibit the best taste on the Italian side. On the English, Redfern was, I thought, equally successful in a table of 4 feet diameter, with judiciously introduced spots of malachite. Bovey and Champernowne also showed the class of coloured marbles which our eye demands. One specimen in Class 30, appeared to contain the germ of an original system of symbolic, or rather iconic design, in the endeavour to render the stone work, as well as the glass, in Gothic windows, figurative of familiar ideas. The mention of the Maltese carvings will close this branch of our investigation; all of which exhibited examples of a school whose existence is as surprising as its excellence.

The slate self-acting cisterns, shown by Struthers, were ingenious illustrations of the filtration of water by ascension; the filtering medium being packed between two pierced false bottoms, the water from the cistern at the top passed by a pipe into the fourth or bottom division, through the packing in the third, and rose in the second by the pressure of the water in the cistern or top division. Slates were also exhibited from the neighbourhood of Stamford, and from several parts of Ireland, including Valentia, the slate stone from which is said to be non-absorbent, and to require nearly six tons as the crushing weight of an inch cube. It is raised in slabs about a foot in thickness, and, having no true cleavage, requires to be sawn. Canada also possesses this useful material; as well as Trinidad, a fact which excites some surprise, when we recollect that large quantities of shingles are sent to the West Indies. It is, I presume, a recent discovery. The United States, Nassau, France, and Sardinia, were the only foreign countries which showed slates; from the latter there was a slab about 5 ft. 6 in. square. France sent a slate billiard table, and some fine slabs, 5 ft. 6 in. by 3 ft. 11 in. by ⅜-inch thick. The Slate Company of Angers, which manufactures one hundred and thirty millions of slates, like those of Cornwall, and the Slate Company of Rimogne, exhibited each a series of the sizes usually made. The slate of the latter company is remarkable for its tenacity and strength; by exposure to the open air it acquires increased hardness and consistency, its surface becomes polished, and upon being struck it gives out a clear metallic sound. The joints of slab roofing are generally made with tongues in grooves set in cement, covered by ribs; but it is difficult to make a joint that will stand, on account of the material swelling and shrinking like glass; at all events it is disturbed by the slightest settlement. Attempts to remedy this disadvantage were exhibited in Taaffe's patent, and in the so-called improvement on the same, by Russell, in both of which the principle of **I** cramps and screws or nails, with zinc gutters under each line of junction of the slate, is adopted. No arrangement, however, appears to me so good as that of lead drawn in grooves, and covered by ribs set in putty on the slates, screwed down to the rafters; as no gutters are required, and holes in the slate are avoided as much as is possible. The patent slate ridges and hips seem well contrived. It will be seen that I place no reliance on constructions of iron and slate, except under shelter, or in very peculiar circumstances.

Passing for the present the imitations of marbles, we may notice those of stones. Ransome's patent stone differs from cements and other artificial stone in the employment of silica, both as the base and the combining material. It may be regarded as a collection of particles intimately combined with silicate of soda, by which they are held together as by a kind of glass. Another manufacture consisted of an admixture of caustic carbonate of lime (with or without magnesia), and silica in a gelatinous state, which produced a hydrous silicate of lime as a result. The largest collection in illustration of this branch was shown by White and Sons, and was divided into two classes

—the natural and the artificial. The first consisted of Sheppey stone, and nodules dredged up off Harwich, from which respectively are obtained the varieties of the article known as Roman cement, introduced by Dr. Parker about fifty years ago. These stones, as well as those from Christchurch and Romsey, which yield the Medina cement, are found among the older tertiary deposits. The Whitby stone is found in the lias formation, and gives the cement known as Atkinson's. At Wolverhampton and in Derbyshire, cement stones occur in connection with iron stone, which imparts to them a ferruginous tint. Other districts yield natural cement stones; but the above-mentioned are those which are best known in commerce, being extensively used both for mortars and stucco. The name of Greaves is intimately connected with that of blue lias lime; and this material was abundantly represented in the Exhibition. The artificial cements, composed of a mixture of carbonate of lime and argillaceous earths calcined together, were chiefly represented by the so-called Portland cements, furnished by White and Sons, and by Robins, Aspdin, and Co. The first named firm exhibited the celebrated brick beam, and specimens of concrete, consisting of one part of cement to ten of gravel; the second showed several instances of tests of strength of the cement, pure and mixed with sand; but as some of the statements made since the exposition vary considerably from those which I noted, I have put them aside. The inutility of the experiments, made with much parade on Portland and Roman cements, is apparent when we consider that a single trial, under complicated conditions, can never be taken as affording a quotient for use as a constant in calculation, and that we have had no series of experiments made by rival manufacturers on the same day and in the same place and manner; and that, moreover, the results so obtained can only show the properties of the best materials supplied by the manufacturer, while no architect can tell with certainty on every occassion what cement the workman uses. Hamelin's mastic seemed to be wholly unrepresented or forgotten. I do not exactly know where to place what was called "cement-stone," a limestone believed to be the basis of Peel Castle mortar; a cement made from the "curl-stone," found at Coal Port; Dyer's patent metallic cement; Furze's fusible mineral cement; Orsi and Armani's patent metallic lava; nor Spence's patent zinc cement. The latter should be inexpensive, as it is manufactured entirely from refuse matters. Among the British possessions, New Zealand sent a Roman cement stone; and France two hydraulic limes. It was said that by the process of Henri de Villineuve, engineer, a superior hydraulic lime might be obtained from all carbonates of lime, without the addition of other substances, and that the cement exhibited possessed different degrees of rapidity in setting. Belgium also sent an hydrofuge stucco, or plaster; Holland an hydraulic cement; and Wurtemburg "an hydraulic chalk cement, hardening under water in a few minutes." Portugal presented hydraulic clays from the Azores, and hydraulic scoriæ, by which, with the addition of lime, "an hydraulic bitumen, called Argamassa cement," is produced. From Prussia, we received a "Roman cement," being an argillaceous carbonate of lime with magnesia; the double silicate may probably be of very great solidity. Ant. Peppini of Florence displayed some neat octagon paving squares, "in cement called Calcarea." The renowned Roman hydraulic cement is said to have been made of a mixture of volcanic sand and lime. I did not notice pozzolana from the Papal States, Tuscany, or Naples, although I believe there were specimens. Greece sent a box of this volcanic earth (a silicate of magnesia?) from Santorin, which was ash-coloured, and said to have the same qualities as the Italian: mixed with lime it solidifies and sinks in water. A considerable quantity is exported annually to Turkey and Trieste. Spain also claimed to exhibit this material, but gave it the *alias* of soapstoue of Somontiu. The United States also sent steatite, or hydrated silicate of magnesia, combined with a little alumina and oxide of iron: its peculiar greasy feel has been the origin of the name of soapstone. It is much more abundant, and more extensively used in America than in England; and, being almost as readily worked as the soft woods, and with similar tools, it is applied to many purposes for which its superior durability renders it preferable—as baths, and the jambs of fire-places; and it is used in Switzerland for stoves of superior quality. Large beds of the pure material are found in the English possessions in Canada. The terms mortar, stucco, and cement, are at present so indiscriminately employed as to cause considerable confusion, and a strong feeling of the necessity of some authoritative scientific lexicon. I shall pass a few specimens, for the third great division of imitative stones. Gypsum, or hydrous sulphate of lime, called alabaster when in a semi-crystalline form, and selenite when in crystals, being heated from 250° to 275° Fahrenheit, becomes an anhydrous sulphate; and, reduced to a fine powder, furnishes the plaster of Paris of commeroe. The peculiar stone obtained from the tertiary deposits of the Paris basin contains above 7½ per cent. carbonate of lime, and 3 per cent. of clay, which so greatly improves the cement as to have given the peculiar name to the preparation in other countries. The genuine article from Paris was submitted, as well as supplies from Ireland and Canada. The English sources are chiefly in Derbyshire, Nottinghamshire, and Cumberland; and when combined with alum, the products are the hard artificial cements known as Keene's and Parian patent cement. The effect of the last, vitrified, is exceedingly good. Gypsum is also understood to be the basis of Martin's cement. Of these rivals we shall all recollect the handsome specimens which were exhibited. It will hardly be supposed, that of all foreign nations Tunis supplied nearly the most interesting examples of this material. The wall decoration, closely resembling that of the Alhambra, hardly seemed to be a cast, and was remarkable for the way in which the top surfaces were modelled so as to be relieved easily from the mould, and to show to advantage either on a level with or above the eye. Spain sent an original piece of the Alhambra wall decoration; and Don Rafael Contreras, of Aranjuez, exhibited a portion of his copy of all the Alhambra-work of this kind in the same material, one-quarter of the real size.

We may divide the subject of coloured glass into four modes of manufacture—viz. stained or flashed, solid or pot, enamelled, and etched glass. Without touching, it was very difficult to decide how some specimens were executed: those by Chance and Co. obtained my highest approbation for the quality, too often lost, of lucidity; and I think they consisted chiefly of flashed-glass, cut, where requisite, to produce the lights. The specimens by Hall and Sons were also very satisfactory. I noticed no foreign glass of this sort. Hedgland, Hardman and Co., and Gaunt, exhibited works in the antique style; and I observed a window from a very clever design by T. T. Bury. The Belgian and French were single specimens of the second division of manufacture: the latter, consisting of works for Ely Cathedral, by Gerente, seemed poor and ineffective. The work by Toms appeared very good in taste and execution; and I must group together here the names of Ballantyne, Claudet, Hetley, and Wailes, with one exhibitor from Austria. All these seemed to present a third-class of work, partly stained, and partly painted glass. The enamel school, I think, included Messrs. Baillie, Bland, Gibbs, Gibson, and Tobey, the St. Helen's Company (whose taste I question); two clever examples from Austria, one from Saxony, a good specimen from Holland, and five from France, of which I can say nothing favourable, but that No. 229 was perfectly a picture, and that Lasson's work contained a beautiful female figure, and was in all respects more in accordance with our notions of glass-work. The American glass, as white glass, appeared to me to be, without exception, the finest that I had ever seen for material, but very badly manufactured. The numerous varieties of glass decorated with opaque patterns, embossed or marbled, differed in no respect from that which we see daily advertised. Chance and Hartley stood pre-eminent for their window-glass. The French glass, the Belgian, and the Prussian, followed in the order of merit in which they are mentioned: the Bavarian was indifferent. Glass tubing seemed to have attracted much attention both in Holland and England: metallic joints seemed generally to be contemplated; but I apprehend that the recent introduction of vulcanised india-rubber to form the joints of iron-pipes, is equally applicable to those of lead, terracotta, stoneware, and glass. Except Swinburne's glass domes, I did not observe any glass for ordinary use—as tiles in roofs, on the English side. France sent some, 15 inches by 9 inches, under the name of Francis Fox, with terracotta tiles, 14 inches by 9 inches. Prussia sent glass tiles and pantiles; and Brunswick exhibited glass tiles, very good glass slates, and excellent lace glass. Before quitting the subject, it may be remarked, that the artists of the mediæval ages, being much more moderate in their demands upon their material, were more primitive, and, perhaps, more successful than their modern rivals in the effect produced, while their successors have certainly advanced in an artistic point of view, but at the expense of transparency, breadth, and simplicity. As a general rule, the modern works are too much paintings, in the strict sense of the word—too opaque in their shadows, in fact, too much shaded; whereas painting on glass, to be really effective, should be almost entirely outline and colour, and as free from non-transparent shading as possible, for this becomes a sort of neutral tint when opposed to the light; hence the muddy character of much modern glass. I think it must be borne in mind that a stained glass window is a means of admitting modified and tempered light into a building—hence it must be transparent; that the picture is to be seen from a distance, generally considerable—hence that boldness, breadth, and harmony are more favourable to its effect than minute detail; and lastly, that the artist is not producing a work for isolated exhibition, but is labouring in combination with the architect of the edifice which he is to adorn, and with which his work is expected to harmonise, not to jar and contrast by painful and violent effects of light and shade; in short, that the window ought never to lose for an instant its character as a window, that is, a means of admitting of light, which is its absolute and æsthetic relation to the chamber which it illuminates. Enamel painting on glass is decidedly pushed much further than in former times; but we must doubt if it has advanced in its legitimate object, that of an adjunct to architectural effect.

Terracotta, as a decorative adjunct to buildings, is one of the objects which the Exhibition was well adapted to bring under notice. After the progress made of late years, particularly by the firm of the Ladyshore works, it might seem remarkable that the combination of elegance with durability which it offers, should not have secured employment of the material commensurate with its capabilities, did we not call to mind the competition with which it has been met by the makers of artificial stone, and which has prevented its adoption for re-duplications of a pattern.

Other difficulties arise from the very nature of the processes to which it is necessary to subject each branch of the manufacture, for we may regard the term terra cotta, in its most extended sense, as including even the finest porcelain. The component parts of the usual terracotta are potter's clay, fine sand, and pulverised potsherds, mixed with water and thoroughly incorporated, and either modelled or cast in the state of a thin paste, in porous plaster moulds, which absorb the moisture. After air drying, the objects are baked in proper kilns at a very high temperature, during which process the shrinkage is sometimes very great. It is foreign to our purpose to enter into a detail of the different gradations in manufacture which exist between terracotta, as baked fire-clay, and porcelain, but all of them are subject to the inherent defects of contraction and distortion. The natural abundant distribution of the clays which are found underlying coal seams in the colliery districts, conduces much to the extensive application of the material, which, for the purposes of ornament, is gradually recovering the importance which it acquired in Italy, France, and Germany, from the fourteenth to the sixteenth centuries. Besides the productions of the Ladyshore works and other firms, a kind of perfect pottery, salt glazed and very nearly approaching to a true porcelain, was shown in the shape of drain and water pipes, vases, garden pots, architectural ornaments, and cases for plants, constructed upon Ward's principle. A bath, of the usual adult size, made in one piece, of fire-clay, plated with porcelain and glazed, was also exhibited. These baths are at present much used in public as well as private establishments, and I may observe, that although they will bear a heavy blow without injury, yet they are liable to crack on the first inlet of hot water, if they are bedded solidly or fitted tightly; they should therefore stand on piers or bearers, and be free from any thing which may prevent the expansion and contraction of the material. An Ionic capital for Cliefden House, a Gothic pinnacle for a chapel at Tottenham, and some samples of "Parian" vitrified, seemed to promise well. In my own experience I have found that articles badly manufactured in terracotta are likely to scale away on the surface, a defect which arises chiefly, if not always, from an improper mode of filling the moulds. A beautiful chimney-piece, designed in the style of the Renaissance, was an instance of the happy results which can be obtained in the so-called Parian or Statuary porcelain. A terracotta tablet, of the large size of 3 ft. by 2 ft. 3 in. with the lines unusually sharp and true, from the Bank Park Pyropolite works, Prestonpans, arrested my attention; the colour, generally a difficult question, seemed very satisfactory, as was also the case in a specimen from Newcastle, in "Barnett's clay," which had a delicate reddish hue. Various decorations for bricks and cornices, in relief, would have met with my unqualified approbation, but that I am not prepared to admire branches of purple grapes pendant from green leaves, made in terracotta, either for external or internal decoration.

The foreign specimens of plastic skill were not so numerous. Holland sent stoves, brackets, capitals, and balustrades, in all which it was rivalled by a contribution of very beautifully worked ornamental articles, including a Corinthian capital from Nassau. Wurtemburg was more ambitious, if not so fortunate in the ornaments of a church recently built in a kind of Decorated Gothic, a rose window from which, 3 ft. 6 in. in diameter, was shown. Russia exhibited a table-top, 4 ft. 8 in. in diameter, a size which has perhaps never been equalled, from the Imperial porcelain manufactory; and Austria sent several specimens of syderolite, or terralite, or stone clay, in small articles. Prussia seemed to me to display the best taste in the application of a union of silvering and gilding to clay ornamentation. A Gothic vase, or rather an attempt at a Gothic vase, was remarkably successful for skilful workmanship, as was also a fountain by the same firm. In one instance, the sense of touch was requisite to decide whether some chimney-pieces were of bronzed iron, as they seemed, or the clay imitation, which they really were. The German ornaments for architectural uses in clay, the articles of earthenware and faience, the stoves, elevated by the designs imparted to them, all these might perhaps compete with analogous products of English manufacture for cheapness; but I am very far from conceding to them a general superiority, or eevn equality in taste. The Royal Porcelain Factory of Berlin exhibited a grand faenza dish, in the style of Giulio Romano, nearly 18 inches in diameter, whose value was perfectly arbitrary, with some colours, blue and green, such as are not used here. France alone, in the works of Debay, Mansard, and Virebent, produced architectural ornaments in terracotta of a class at all able to enter into competition with the English productions; indeed, the colossal brackets, after Puget, from the Hotel de Ville at Toulon, were works of the very highest order of decorative art. There was something interesting in the resemblance between the forms of the pottery from Tunis and the most highly prized specimens of antique Greek taste.

Roof-tiles were exhibited from France, which, although exceedingly heavy, were apparently well qualified for keeping out driving winds and rain; while they were more judicious in construction than those from Switzerland: the effect of these last, which were of a brown colour, glazed, was exceedingly good, and deserved the attention of the English builder. The same praise was due to the plain tile, spotted like granite with black on a yellow ground, from Coal Island, exhibited by the Royal Dublin Society, and to that from an estate near Tipperary. An excellent cream-coloured tile was exhibited from Darlington. With respect to the floor-tiles, I was especially attracted by the self-coloured specimens in blue, red, and drab; indeed, the display was one of the richest in suggestions to the architect on the use of clay articles. Great merit was also displayed in a tile 12 inches square by $1\frac{3}{4}$ inch thick, and in a curved brick forming a portion of a chimney-shaft. Very few specimens of floor-tiles had been sent from the continent: among the best were some painted and burnt tiles from Spain—"azulejos"—and from Switzerland, among which latter was a very excellent blue tile, with a white pattern in raised work, in the style of the fifteenth and sixteenth centuries. But, beyond doubt, the most superb display of all the collections of such ornament was to be seen in the revived majolica-ware (the peculiarity of which consists in covering coarse material with a fine opaque glaze), such as is seen in tiles from the Alhambra: the pattern is stamped upon the surface by a plaster mould, it is then fired, and, the indentations being filled with the opaque glazes, the tile is complete, after having been fired a second time to fix them. The majolica-ware is perhaps best adapted for walling; the encaustic tiles for floors when they have to resist abrasion. The embossed-wall tiles were also deserving of great admiration, and, no doubt, a means will be found of appropriately using the patent process of printing in colours. The pilaster of flowers and foliage on a blue ground, in the Raffaellesque style, on a series of bricks placed one above the other, was perhaps the greatest curiosity in the building court. The pavement tiles above-mentioned are very different from Singer's tesseræ—which are formed of ordinary porcelain, cut by machinery out of thin layers of clay, as well as from those made by Prosser's process, in which the materials, in a state of powder, are subjected to great pressure, and reduced to a compact substance of excessive hardness. Excepting from Luxemburg, Rome, and Prussia, I did not notice any other mosaic pavements: the two first seemed to be made on the antique, and the last on Prosser's principle. Various specimens of hollow, rhomboidal, ornamental, and waterproof bricks, were furnished by different makers who put forth the respective merits of their productions: attention may be directed to those moulded upon the face as quoins, and to others from Newbury, which were intended for cornices and architraves. A circular drain-pipe, 6 inches in diameter, and only half-an-inch in thickness, was stated to have resisted a pressure of 114 lb. to the square inch, equivalent to that of a column of water 262 feet high. In the Austrian division the drawings, models, specimens, and explanation furnished by M. Alois Miesbach, of his seven brick manufactories, were highly deserving of notice. Of these, those at Ingersdorf, on the Wienerberg, supposed to be the largest in the world, and that at Rákos, near Pesth, are the principal. The annual production of the whole amounts to 107,150,000 bricks and tiles, and finds employment for 4880 hands. The specimens of sand used for stuccoes and mortars, cements, &c., were very completely furnished from Bristol, St. Agnes, near Truro, and from Limerick. The red sand, found only at Mansfield, is of great value in the production of fine castings in metal, as it is said to possess fineness of grain, porosity, great purity and smoothness, which latter property contributes a highly smooth and even face to the castings.

The mention of these qualities, as essential to castings, brings to our consideration the subject of working in metal, in respect to which I would venture to lay down the position, that the value of the material, if the nobler kinds are used, should not exceed that of the artistic labour; while it should be much beyond that of the mechanical working impressed upon it. In other words, if the article be merely a subject for daily use, and, consequently, nearly plain, its size is a matter of little consideration in an æsthetic point of view; but the more nearly the two values approach each other, the more likely is the labour of the artist to be disregarded and lost in the feelings excited by the material upon which he has worked. To myself this has become so very evident, that I am inclined to submit it as the reason why there has always been a general understanding as to the size of objects executed by the sculptor. No doubt there are some instances in which, without sufficient reflection upon the mutability of human affairs, or regard to the principles which should guide the perception of the beautiful, works of dimensions too large for the materials, have been executed in modern times in this country, as well as on the continent; but the taste of ancient days avoided with jealous care such extravagances, except in the most extreme cases. I believe I am not far wrong in saying, that for gold, a height of 4½ inches is the limit; that in silver, double that dimension is the extreme; and that although we may again double this for some other materials, 3 ft. 6 in. is the turning point of discretion for bronze; and lastly, while for life-size we have marble at command, for colossal statues we ought to avail ourselves of the varieties of stone and granite.

The French department contained examples of the most delicate and highly-finished ornamentation in the precious metals. This is a class of work but rarely attended to by our manufacturers, the parts in English work being smaller, and the ornament larger in proportion: now I am persuaded that rules similar to those which I have indicated for sculpture, might be well dictated to the designer of such ornaments as Holbein drew and Cellini executed. France certainly stood first, and I think almost alone in this department, the works exhibited being unequalled even by some of the productions of our own manufacturers. Austria sent a silver mirror-frame in the Renaissance style, which was excellent; and all the gold-work, manufactured by Ignace Sazikoff, of Moscow, seemed in good taste, though the styles, it might be observed, were tainted with a foreign element, as the Gothic was Moresque, and even the Louis XV. ornament had imbibed an Asiatic feeling. The prodigious opulence and splendour of England and France are admitted to have surpassed the productions of Germany, its markets being, in fact, too poor and too contracted to admit of its maintaining any serious competition in this branch of industry with either of those wealthy countries. But in point of taste and elaborate and scientific execution, the Zollverein was not behind them in small, but valuable contributions from Berlin, Hanau, and Dresden; and the centre piece, by Wagner of Berlin, with figures about 6 inches high, in oxidised silver, appeared to me to be in its way a most perfect production of real ornamental silver-work. A very large class of articles in bronze seemed to have great affinity with the productions of the silversmith, and to have equal claims to commendation for the taste with which they are executed. A statement of a saving of 30 to 50 per cent. on the ordinary method of gilding which was put forward by Mazarin, as the recommendation of a patented invention of a substitute for gilding, deserves attention, especially where temporary accommodations are to be provided for large public assemblies; and the process discovered by Captain Ibbetson, for bronzing iron by electro-plating, and thus dispensing with varnish, or any similar substance, must prove of great value to the architect.

The most important specimens of ormulu were certainly the candelabra from Russia; of these, the smaller, 10 feet high, and for thirteen lights, were said to be valued at 500*l.* each; and the larger, 15 feet high, and for eighty-one candles and four carcel lamps, was priced at 633*l.* 6*s.* 6*d.* The ornamental parts were good in themselves, but not applied with so much taste as might have been expected; they were rivalled in this respect by a chandelier, 15 feet high and 6 ft. 6 in. in diameter, for fifteen lights, which was perhaps the most tasteful specimen contributed from the United States. Nothing of this class, however, seemed to me so highly deserving of admiration as the gilt bronze lustre for sixty lights, from Hanover, which was of very beautiful design and execution in the Renaissance style. As works of mechanical art it would be unfair to rank the copies, half the size of the originals, of the gates of the Baptistery at Florence, exhibited by Barbedienne; but the two noble brazeros, or brûle-parfums, from France, deserved the honour of particular notice for their execution, as much as the French lacquered lock furniture, and the stamped brass work from Germany were below criticism.

Of the Russian productions, the various objects formed of the mineral called malachite—a green carbonate of copper—attracted universal attention; and among them the chief and most costly was a pair of folding doors, with their frontispiece in the style of Louis XVI., measuring 14 ft. 5 in. high and 7 feet wide. The mineral was veneered upon copper, laid on oak, and great ingenuity was shown in the manner in which the pieces, when cut, were adapted to each other, so as to form a homogeneous pattern, and jointed in a very coarse cement, made of the stone itself. A chimney-piece and three vases, with their pedestals, also exhibited, were hardly less valuable than the doors, and the whole value of these goods was stated at nearly 18,000*l.* All these works in malachite were open to criticism; and I confess that I felt much disappointed when I saw the productions that had been so much discussed. If the material was really one of the most valuable, it had been degraded in the opinion of persons competent to form a just estimation of such objects; for there can be no doubt among those who studied the feeling of the connoisseurs who entered the department, that there was little more attention paid to these articles than if they had been merely imitations in plaster or painting; indeed, to bestow admiration on articles for ordinary use because they are made of extraordinary materials, is one of the significant marks of barbarism in the arts, which can only be exhibited by those who have no correct idea of the relative merits of mere intrinsic value, difficulty of workmanship, and finish of execution, as distinguished from the evidences of genius and the stamp of art. As an example illustrative of my meaning, I would call attention to the Bagnarola, cut out of a magnificent block of Oriental lapis-lazuli, which was exhibited in the Roman division, for it must be allowed that this simple object derived more value from its entirety, than if it had been cut up into slices and veneered to form a writing-desk; in fact, we recognised at once that the material was shown as something rare and costly.

To all who are interested in the quality and price of iron, the statement made by M. Adrian Chenot, that the iron and steel shown by him were produced from what he called metallic sponges, must be provocative of curiosity. The Franklinite iron, from the United States, said to consist of 67 parts peroxide of iron, 17 oxide of zinc, and 16 sesqui-oxide of maganese, was stated to excel the best Swedish bar-iron in ultimate strength. Mr. Morris Stirling's experiments on the mixture of cast and scrap-iron, would lead to the supposition that the high quality must be derived from the presence of the zinc. France excepted, Russia was the only foreign country which seemed to have recognised iron as a principle in construction. Belgium showed "tôle" or plate-iron, stamped with excellent effect; the Austrian department contained specimens of Sengler's iron post paper, in the shape of remarkably thin sheet-iron; both these might furnish very useful hints for the builder. Of all the iron castings, the most delicate that I had ever seen were two busts, life size, from the Royal Ordnance at Trubia in Spain, and a candelabrum, from the Prussian Royal Foundry at Berlin; but these must be considered as the finest examples that government factories could produce. For real business purposes, nothing seemed of higher merit than the railing by Messrs. Baily, which was the only specimen of such clean and highly-finished work that came under my notice. Other specimens conveyed the idea, that the original forms had been softened down too much in the clay model, or that the wood patterns had been painted over so often as to have lost their sharpness.

In ornamental iron casting—a branch of trade to which France has of late years devoted special attention—it was generally supposed that our traditional superiority would be lost; fortunately, we could afford well to acknowledge the high excellence of the works exhibited by our continental neighbours in France, Austria, and Prussia, without detriment to the recognised merits of our own. It would be useless to enter into a discussion of the economic merits of the various ranges, stoves, grates, and closets which were exhibited, as they each required practical experiments, continued for some time, to test their respective advantages. Holland exhibited two stove grates, of which the design and execution were admirable. Austria sent beautifully cast stoves; and Belgium supplied a very well executed projecting stove grate, which was suggestive of a different style for such articles. In the collection sent from the United States, there was, unfortunately, not one stove whose exterior was inviting; if not excessively plain, they were overloaded with tasteless ornamentation; several varieties in principle of the Arnott and other stoves were shown, but the English patterns were not to be recognised. In the French collection, there were small grates of all kinds, and a common English elliptic register with hobs much improved; but beyond doubt the most excellent specimens of design and execution on the part of the Continent was occupied by M. Laury; in fact, one of his productions was received into the Sheffield department. For propriety of decoration, good style, and high finish, these stoves were pre-eminent. On the English side, the articles exhibited by the various manufacturers were generally as good in execution as they were, for the most part, commendable for design; and the style of the Renaissance, adopted in several instances, was apparently re-produced in better taste than elsewhere in the same material. The minor works in metal deserving mention consisted of enamels on iron, used for the mosaics of the tomb of Napoleon at the Invalides; iron bedsteads, pure block tin pipes of all sizes to an inch in diameter from the United States, produced in continuous lengths by hydraulic pressure; carefully arranged lightning rods, and the various applications of gas to domestic purposes.

In the department of zinc ornamentation the English side had very little, and that of not much importance. Prussia sent beautiful castings for architectural decoration, plates for roofing, as tiles or slates, and thin zinc, including two pieces as thick only as paper, and a specimen of roofing to resist changes of temperature. Holland contributed very tasteful and well cast articles; and Belgium a pair of elegant vases 3 ft. 6 in. high. The Vieille Montagne Company presented examples of dormer windows, with hip-knobs and gable-ornaments, which would alone have attracted every architectural visitor.

In the department of models of architectural works, England's supremacy in the Exhibition must have been so unquestioned for the number and the high finish of the specimens, that instead of speaking of the merits of these models, which were generally of works already well known, I have contented myself with noting those particulars of foreign works which appeared likely to be most interesting. In the division allotted to the United States, there was an attempt to solve the difficulty of opening the gates on a road without causing the passenger to dismount; a model of the Pennsylvania single line railway, uniting Philadelphia with Pittsburg, exhibiting the Susquehanna viaduct, 3800 feet long, making a "rider" bridge in three sections of seven divisions, each with a clear span of 150 feet; a floating church, 90 feet long, 40 feet wide, and 106 feet high to the top of the spire, and an iron bridge trebled at the ends. Holland contributed two models invented by a self-taught engineer, who was unable to express his ideas on paper; one represented a swing bridge, in which the lines of rail formed the tops of cranes, which revolved to allow masted vessels to pass. The original was constructed near Schiedam, where the railway crosses the river at an angle of 87°. The bridge shown by the other model was built near Leyden, where the railway crosses the river at an angle of 82°. In it two parallel platforms, sliding diagonally in opposite directions, and moved simultaneously by one man, afforded an opening when required. Austria sent no models of importance, but the description in the illustrated catalogue of the establishment, belonging to the Imperial Printing Office at Vienna, will be sufficient to surprise those who will refer to it. Prussia exhibited the model of a restoration of the Greek theatre, made by Gläzer at Breslau; the Cathedral at Madgeburg, a model in lime-tree wood; and a representation of the fountain at Nuremberg. Switzerland contributed three models in wood, in the well known style of its domestic buildings, a model of Strasburg Cathedral, in card board, and a copy of the Nuremberg fountain above mentioned. France exhibited two very important models in metal, one of the roof, 120 feet span, over the Douane at Paris, executed in 1844, by A. Gretevin, architect; the other, the moveable metal cupola of the observatory at Paris, constructed in 1843, to receive the great parallactic telescope; the diameter being 12 mètres, or 39 ft. 4½ in., the height of the cupola about 30 feet, and the weight 92,300lb. (42,000 kilog.) The whole cupola was a most complete specimen of the construction adopted. Except in one instance I saw no model from the Continent of the modern style of framing timber roofs, as practised in England. Tordeux, of Cambray, showed a machine, weighing 25lb., to obviate the necessity of scaffolding in the construction of factory chimneys; and there was a most ingenious contrivance in a neat model showing a system of windows, blinds, and shutters, combined in a simple manner, and without machinery, springs, or gear.

In the specimens from New South Wales Mr. Shield contributed the idea of using our squared timber in the construction of bridges, where labour, ironwork, and time, are all costly; and this, with his other models, was well deserving of study. The twin staircase, exhibited by Banks, was one of those inventions which seem to be ingeniously useless, if we recollect the necessity in large establishments for space in the staircases, to allow persons, heavily loaded, to be continually passing each other. A similar principle was contained in the self-supporting pulpit, by Melville, which would be at least useful in crowded counting-houses, if not thought adapted for ecclesiastical purposes. A spiral staircase was also exhibited in a small model, by Schrüder, of Darmstadt, whose series of models for the elucidation of practical geometry was one of those additions to our means of studying geometric design which I would hope to see made to the collection of this Institute.

A few years ago the upholsterer was the only professional decorator employed by the middle classes, but now they are beginning to comprehend that, before expending large sums in decorating their houses, it may possibly be of advantage to obtain the opinion of those who understand, or may be supposed to have studied the relation which the respective parts of a room should bear to each other and to the whole when complete in its decoration; and that simply filling a house with furniture, painting, and papering in any manner, and purchasing curtains and carpets without any reference to congruity with the other articles, may not be precisely the best mode of expending money to advantage, or obtaining a satisfactory result. At any rate, the admirable specimens displayed in the Exhibition, in almost every available style of decoration, are sufficient proofs that the world is beginning to appreciate professional services, and to estimate the due importance of decorative adjuncts, as types of refinement and civilisation. And here I cannot but allude to those architects who are known to have afforded their services for these purposes on the late occasion, while I have reason to believe that the like honourable mention might be made of many others at present unknown, if the names of the designers had been attached to the different articles. The time must come when this act of justice will be done, and manufacturers generally will discover, what some of them already know, that the name of a designer of reputation is no slight recommendation to their wares. As an illustration, I would just point to the Austrian Furniture Rooms, and the English Mediæval Court. This last certainly presented the most conspicuous display of harmonious art and skill,—of art in the designer, and of skill in the executant. The master mind which suggested the forms and the colours had evidently supervised their development; each ornament and each detail gave proof that the head which thought them directed also the hands which wrought them. The French Saloon, which might be placed in competition with the Mediæval Court, presented great tact in the harmonious arrangement of articles, discordant in their styles, but combined with such knowledge of the effect of colour as to disguise, in a great degree, the discrepancy. In the only other instance of a combined collection, that in which the Zollverein's best goods were placed, this happy tact was not so conspicuous, and the eye soon became fatigued.

It was observed by a foreign visitor, that the Exhibition contained two states of feeling for domestic decoration, that at the western end being considerably mixed with elements foreign to it, while that at the east end was nearly free from any alloy of Anglicism; and he afterwards urged that there was no truly national taste in Russia or Germany, as the Parisian fashion for every sort of decoration was eagerly watched and followed. There can be no doubt of the correctness of this opinion. Upon the eastern side there were exhibited in the products of the European nations great elegance of proportion, vivacity of light and shade, and a wonderful fluency of design, mixed with a malicious, not to say perverse, carelessness as to whether a piece of furniture should belong to any given style at all, or equally to three or four. This was opposed on the English side by stern dignity, extreme breadth of light, and a remarkable air of utility, united, on the other hand, to a sometimes pedantic adherence to the peculiar features of the fashion employed. To sum-up this train of thought, it will suffice to add, that beauty in the one case and grandeur in its antagonist were attained; and it must be left to the spectator's particular temperament to decide, to which for himself he would give the preference. We pass to the mural decorations, most of which were of a fairly first-rate character as regarded the English side: the continental and American States followed the French fashions, and I do not feel called upon to admire the pictures, extending over the side of a room, which that fashion involves. The English paperhangings were chaste and well-drawn, based chiefly upon the observance of nature, without being merely natural in treatment. In the department which depends upon botanical productions for materials, we may class the excellent collections of the various woods employed for building and for furniture. These were so extensive, and of such equal merit, that I am compelled to refer you to the articles, "wood" and "timber,' in the 'Index to the Illustrated Catalogue,' to obtain an exact notion of the riches which we gain from this division of the natural kingdom. The parqueterie and marqueterie from Belgium, from Russia, and from Austria, were all remarkable specimens, and might be classed, according to their relative rank, as they are here set down. The succedanea for real wood—such as gutta-percha, cannabic, papier-maché, and carton-pierre—exhibited by various manufacturers, both in England and abroad, seemed to answer their purposes; but I must confess that the proposal from the United States, to veneer india-rubber upon deal for furniture, did not appear to contain the germs of a successful invention.

It may be asked, what good has our profession derived from the Exhibition? One result, at any rate, can be named with satisfaction: the critics of the daily press have discovered, for the first time, that the prestige of foreign superiority in arts was a mistake, and they have at last recognised the fact, that the examples of English skill—alike in carving in wood and stone, in metal-work of all sorts, in woven fabrics and embroidery, in stained-glass and mosaics—were of such a character as at once to refute the often-repeated fallacy, that the English, as a people, were deficient in taste; while the truth was they had simply very much neglected it. These gentlemen, however, with a few honourable exceptions, have fallen into the same mistake as the council of chairmen—they have looked to the mercantile, and not to the artistic value of the objects exhibited.

In concluding this revision of some portions of my note-book, I have purposely omitted many things, fearing that they might be considered trivial; and had I known that the Messrs. Chevalier and Blanqui would have expressed almost the same opinions on many of the objects, though with far greater decision, I should have preferred offering a translation of their Report to the National Institute of France, to troubling you with listening to my own.

NEW GAS WORKS AT HAMBURGH.

WILLIAM LINDLEY, Esq., C.E.

(*With an Engraving, Plate* V.)

AMONG the accessories for the accommodation of a modern city, a gaswork is among the most essential; but in practice it seldom happens that a complete establishment can at once be formed. A work is generally begun on a small scale, and extended without regard to unity of design, and consequently some unnecessary outlay is incurred, while the best accommodation is not obtained. We have, therefore, gladly availed ourselves of an opportunity to lay before our readers the plan of the works which Mr. Lindley has carried out for lighting the populous city of Hamburgh. It is now pretty generally known how far that engineer contributed to the reconstruction of the city, and provided for the water supply; and we shall show, from his own reports, the means adopted by him for carrying out the gas-service when it was placed under his direction. We do this the more readily, because we consider the plans have considerable merit, in carrying out a large undertaking in a restricted space, and on a comprehensive plan, without disturbing the service of the town, and which necessarily was a more protracted operation than it would have been could the enterprise at once have been carried out without impediment.

It seems that in the year 1844, the Gas Company purchased some old engine-works, for the purpose of conversion into gas-works, so that they might at once carry out the contract for lighting the town and suburbs. They built a gas-house with 168 retorts, and converted one of the old buildings into a purifying-house. They likewise set up three gasometers and several coal-sheds. In the streets mains were laid down and lamp-posts set up, and in due time the lighting of the town began. After a few months, however, a succession of unfortunate circumstances contributed to bring the enterprise into difficulties, and it became necessary to provide for a systematic reorganisation of the whole establishment. In October 1846, Mr. Lindley was called in, and he proceeded to lay before the directors that plan which is given in our Plate. The necessary measures were taken to obtain the requisite extension of space, and leave was given by the municipal authorities for occupying some of the neighbouring land.

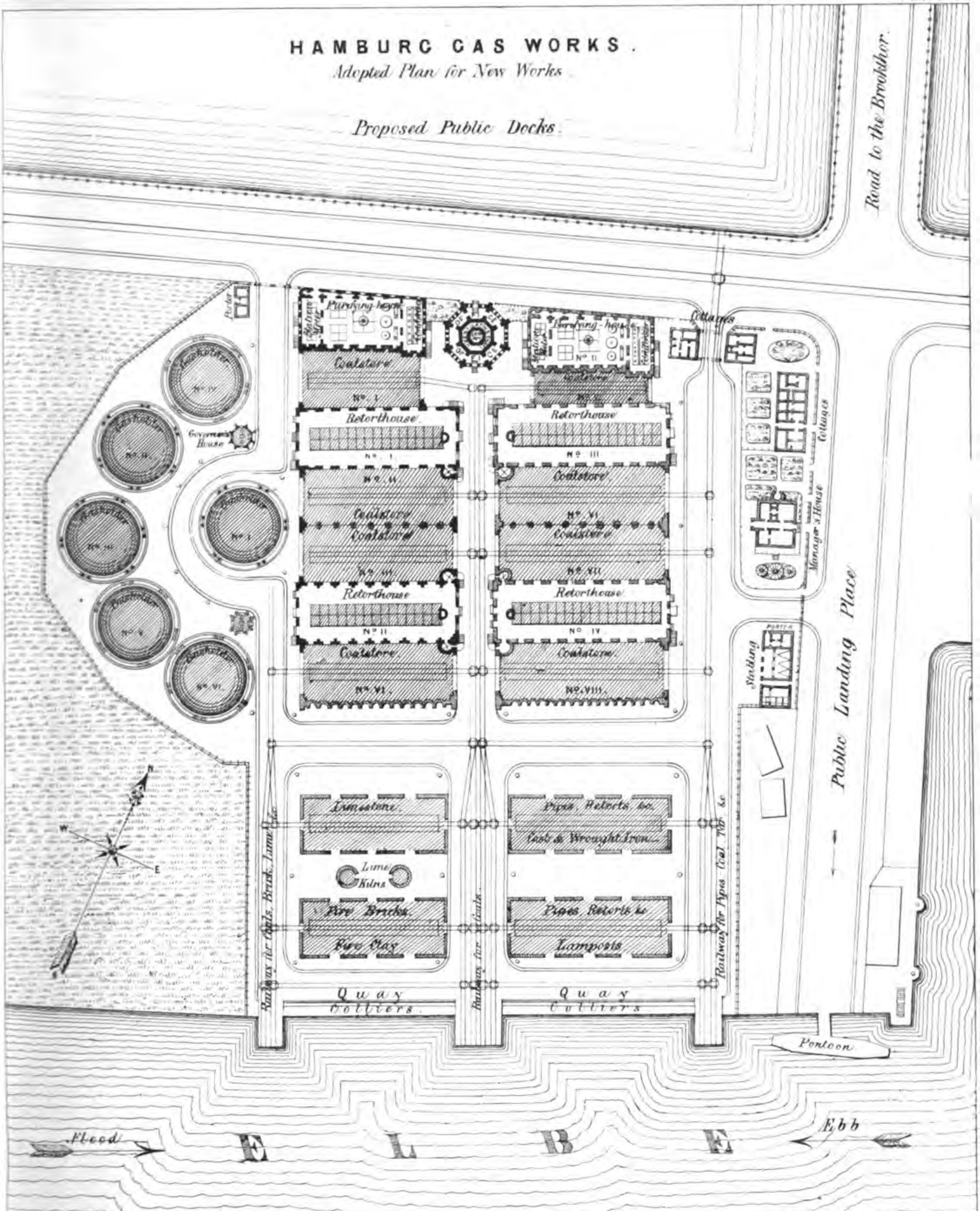
The first measure necessary was, on account of the situation of the establishment on the river Elbe, to take security against inundation, and the ground was raised 22 feet above the datum line, so that the new buildings could be safely proceeded with. The top of the shaken chimney of the old engine factory was taken down, and the stump having been secured with iron clamps, was used for the old gas-house until the new chimney could be completed.

It appeared, from accurate borings, that the soil was of a most dangerous character. The superstratum was partly shingle, liable to be flooded, and resting on bog. It was therefore necessary to go to a depth of 18 feet under the datum line, or a total depth of 40 feet to reach the sand and obtain the required security, and therefore piling was resorted to.

The most essential proceeding was to begin the great chimney and the purifying-house No. 1, while the old purifying apparatus was in use. The chimney shaft is 13½ feet below, and 12 feet above, inner diameter, and is 250 feet above the level of the new soil. It was considered necessary to carry up the shaft so high, not only to give better draft to the retort houses, but to carry the smoke to such a height as to avoid nuisance to the neighbourhood. Outside the chimney shaft is a towerlike covering of 35 feet outer diameter, which is used for the purpose of preventing the injurious effect of the chimney cooling down, and for drawing off the injurious gases which might otherwise accumulate in the building. As the chimney and its casing were obliged to be placed on extended foundations, advantage was taken to put up a one-story building on them for the various offices.

The purifying-house stands likewise on a pile foundation, which bears the foundation of masonry on which rest the vaulted cellars and roofing. In this building are the purifying apparatus, two gas meters, the connecting mains, and the refrigerating room and apparatus. The building has a slate roof on iron girders.

The next building in order was the retort house No. 1, built for 150 retorts. This also rests on a pile foundation, and is,



The Works executed are in Black, the Proposed extension in faint lines.

100 50 0 100 200 Feet

W. LINDLEY, ENGINEER

like the purifying-house, on arched cellars, on which the flooring of the retort furnaces rests. The superstructure of the building is, like the others, of brick, roofed with slates and iron supports. The smoke shaft of the several furnaces is carried underground, in a channel of brickwork, to the great chimney. So likewise other brick shafts carry off the noxious gases to the outer casing of the chimney.

Simultaneously was erected, between the purifying-house No. 1, and the retort-house No. 1, a coal-shed, having its roofing laid on the side walls of those buildings, and being covered in with slate and glass, and having at each end a gable wall of brick.

Meanwhile it had happened that the original retort-house, which had been set up in 1844, became so weak that it could hardly be used with safety. The heavy iron roof was therefore obliged to be taken off, and the manufacture of the gas carried on in the open air until the new retort-house No. 1, was completed. To provide for the stoppage of the old retort-house, the retort-house No. 2, was begun in the previous year. This, like the companion building, rests on piles, and is of like structure, except the roof, which is of rolled zinc plates.

Between the two new retort-houses are two coal-sheds, No. 2 and 3, the roofs of which are supported in the middle by a row of cast-iron columns, and at the sides resting on the walls of the buildings. These are roofed and finished like the coal-shed No. 1. The coal-shed No. 4 alone is wanting, to finish the complete plan.

Besides the three gasometers, each of 85 feet diameter, and 26 feet high, preparations were made for building a fourth, and room is left for two more, for which the plan provides.

The drainage of the buildings is provided for by a main sewer to the Elbe, into which the side drains under the foundations discharge. These drains not only carry off the refuse of the establishment, but likewise drain the foundations, which is the more important as the vaults are 10 feet under the highest flood point of the Elbe.

The gaswork is provided with water from the town works, and has, in the upper room of the refrigrating department, two iron tanks, each containing 100 hogsheads, kept full on constant service, and from which service pipes, provided with taps, in case of fire, lead into every part of the establishment.

The various buildings are of the most solid construction, of incombustible materials, and with every provision for durability. It will be seen from the plan that provision has been made for the extension of the buildings if required, while space and labour are economised in the design of the coal-sheds. By placing these sheds immediately by the side of the retort-houses the greatest possible convenience is afforded, and freedom of access is secured. The coal is readily conveyed to the retorts, while the cellaring provides for storing the coke, and likewise for the lime, which is kept under the purifying-houses.

The ventilation of the building is complete, so that the men can comfortably carry on their work in the retort-houses. The gases from the slaking of the lime in the vaults of the purifying-houses are likewise carried into the outer shaft of the chimney, and even the foul air of the waterclosets is conveyed to the same receptacle.

The capacity of the chimney for smoke and gases is such, that it is adequate not only for the present works, but any prospective extension.

From the works on the Grasbrook, two trunk-mains of 18 inches diameter each are carried into the city, through the Brook-gate. One is for the lower, the other for the higher service of the city and suburbs; each is supplied with the requisite branches, communicating with every street and court. The length of mains is about 400,000 foot run, or 70 miles.

In 1850, the remaining outer walls of the old retort-house were well secured, and provided with a light roof of iron and rolled-zinc plates. The interior was converted into a sal-ammoniac work, a smithy, and place for auxiliary retorts. All three establishments communicate, by underground shafts, with the chimney. Thus the noxious gases from the covered pans in the sal-ammoniac work are carried off into the inclosing shaft, and an important manufacture carried on without annoyance to the neighbourhood.

In the winter of 1850, besides the old tar-tanks, a new one, of 40 feet diameter, was constructed to receive the tar and ammoniacal liquor from the retorts, the first being pumped-up for sale, and the other into the covered pans of the sal-ammoniac work.

On the plan will be seen a landing wharf on the river Elbe, providing for the delivery of sea-borne coal from the ship to the works.

By these arrangements, in the course of four years, a complete and new establishment has been constructed, according to a comprehensive plan, and with every regard to durability and to economy of cost and maintenance.

SANITARY IMPROVEMENTS IN TOWNS.

Lecture *read before the Society for Promoting Public Improvements in the Borough of Leeds; on the 18th December,* 1851. By Samuel Clegg, jun., M. Inst. C.E.

It was with much pleasure that I accepted the flattering invitation of your committee to read the second lecture before you, for I anticipate that by the efforts of your Society much good will be done, not to this town only, but to those which may be induced, from seeing the benefits resulting from such a Society, to follow its example. This lecture is upon subjects which require no prefatory remarks; and as I fear I shall detain you at some length, I will, if you please, plunge into the matter at once.

The improvement of the public communications in the town, by widening narrow streets, the formation when required of new streets, well arranged and spacious;—A better and cleaner construction of the roadways of the public streets;—The more efficient consumption of smoke arising from manufactories and furnaces;—The promotion of such works as public walks and gardens, model lodging-houses and cottage dwellings, and public baths and wash-houses,—are some of the objects to which the operations of your most useful Society are to be directed: they are the most important objects, and I shall therefore beg to call your attention to the great public benefits certain to arise from such improvements.

Upon the ornamental decoration and architectural embellishment of the streets and buildings of the town—another object of this Society—I shall not dwell, for such improvements will be self-evident. As man becomes civilised, the love of the beautiful arises: his eye requires to be pleased as well as his mere physical necessities provided for; and from this faculty of our nature the fine arts result,—but the fine arts must *follow*, they must not lead. We must provide the means of *health*, for without health the dwellers in great houses, although "adorned with Pentellic marble and fine gold," could not enjoy their beauty: and the true meaning of the word *improvement*, is this provision. Straight, wide streets, good pavement, the absence of smoke, open spaces for exercise, and baths for ablution, all tend towards this end; but these of themselves are not enough, and I wish to tell you what things are required besides. I shall apparently wander from my point, no doubt. I shall mention works required in a town beyond those I have stated, but I will not lose sight of them; and I will explain to you, as well as I am able, why such would be *improvements*.

Health—that great blessing which gives elasticity and vigour both to mind and body, which creates in us the energy to labour, and enables us to enjoy repose when labour is done—is not an essence parcelled out to man at his birth in unequal quantity and quality, to be borne by him through life as a gift of fate, but it is a quality which he is, by an all wise Creator, permitted to have great control over. *Fresh air and water are given to him*; by these agents, and the power of intellect directed to the study of their uses, he obtains *ventilation* and *cleanliness*, in which two words the whole secret of *public* health is contained. I say *public* health, meaning the health of the great mass of any community, for of those afflictions laid upon individuals for some wise though unseen purpose which man cannot curb, I do not speak, nor of the diseases of individuals caused by their disobedience of Nature's laws, but of that *common* health which may be enjoyed by the inhabitants of any town generally, if care of the general welfare be taken. Of these two elements in the sanitary condition of a town—ventilation and cleanliness—cleanliness perhaps ranks first, for pure air and dirtiness cannot co-exist. What must be the result of drawing air for the purposes of ventilation from foul sources? Why, drawing malaria from the outside to the inside of the house. Look at many parts of Lisbon, particularly that which lies between the castle hill and the low ground; it stands well for drainage, but there is no provision for any; the sewage and exuviæ alike of palaces and hovels are received upon the surface of the streets, and, until very lately, allowed to lie there. Scavengers now, after the sounds of "aqua vie" have ceased, make their lazy appearance, and partially remove the pestilential matter; but still fevers are very prevalent. The works necessary for maintaining cleanly streets, which lie beneath the surface, are wanting.

Constantinople is worse than this. The sun striking upon its domes and minarets, covers it as it were with burnished gold; a beautiful verdure surrounds it, and pure waters wash it on every side. Can this beautiful city, rich with the choicest gifts of heaven, be pre-eminently the abode of pestilence and death?—where a man carries about with him the seeds of disease, to all whom he holds dear; if he extend the hand of welcome to a friend, if he embrace his child, or rub against a stranger, the friend and the child, and the stranger, follow him to the grave?—where, year after year, the angel of death stalks through the streets, and thousands, and tens of thousands, look him calmly in the face and, murmuring "Allah! Allah! God is merciful!" with a fatal trust in the prophet, lie down and die? We enter the city, and these questions are quickly answered. A lazy, lounging, and filthy population; beggars basking in the sun, and dogs licking their sores; streets never cleaned but by the winds and rains; immense burying-grounds all over the city; tombstones at the corners of the streets; graves gaping, ready to throw out their half-buried dead—the whole approaching to one vast charnel-house—dispel all illusions, and remove all doubts; and we are ready to ask ourselves if it be possible that, in such a place, health can ever dwell. We wonder that it should ever, for the briefest moment, be free from that dreadful scourge which comes with every summer's sun, and strews its streets with dead. Of what avail is it to rear splendid palaces here? The improvements wanted lie beneath the surface.

I will yet paint another picture, and travel to Demerara for my subject: here disease takes a different form. The houses are drained, the streets are clean; but by what kind of sewerage is this effected? By open ditches, cut so as to have a fall towards the river at low water, and to be filled at the rise of tide. It is difficult to describe the horrors of these open sewers: the muddy river leaves a slime, absolutely moving with reptile life, and bubbling with the escape of noxious gases. The excessive heat, the undrained fields of Guinea grass, and its own low level, cause it to abound in paludal miasmata, especially fatal to those who sleep in the lower rooms of the houses. Drainage, by producing a dry soil, improves the healthiness of such localities in a wonderful manner.

It may now perhaps be asked, can such spots as these exist? —and the answer at once is "Yes; nor need we travel from our own towns to find them." There are even in Leeds localities which only want the addition of a hotter sun to render them as unwholesome as any I have quoted. "By far the most unhealthy localities of Leeds," says the report of Mr. Smith, of Deanston, "are close squares of houses or *yards*, as they are called, which have been erected for the accommodation of working people. Some of these, though situated on comparatively high ground, are airless, from the inclosed structure; and, being wholly unprovided with any form of under-drainage or convenience, or arrangements for cleansing, are one mass of damp and filth." "In some instances," he continues, "I found cellars, or under-rooms, with from two to six inches of water standing over the floors, and putrid from its stagnation in one case, from receiving the soakage of the slop-water standing in pools in the street adjoining. The ashes, garbage, and filth of all kinds, are thrown from the doors and windows of the houses upon the surface of the streets and courts. From causes besides these, the feelings of the people are blunted to all seeming decency; and from the constantly contaminated state of the atmosphere, a vast amount of ill-health prevails, leading to listlessness, and inducing a desire for spirits and opiates, the combined influence of the whole condition causing much loss of time, increasing poverty, and terminating the existence of many in premature death." We may trace the cause of disease to insulated spots even in the same street. For instance, one of the unhealthiest parts in Durham, says Dr. Reid, is a portion of the street of Gilligate, from about No. 14 to No. 50; and want of cleanliness is evidently the reason. And Liverpool, Nottingham, Manchester, Portsmouth, and indeed most large towns, will furnish us likewise with examples.

The inquiries into the state of districts before and after improvement have distinctly shown that increased facilities for the removal of refuse in and about the habitations of the poor, have been rapidly followed by a marked improvement in the health, and by a reduction in the rate of mortality of the district. An instance of this kind was observed in Manchester, by ascertaining the amount of deaths in twenty streets, before and after their improvement, by which it was ascertained that the deaths immediately subsequent to the drainage and paving of the streets were diminished more than 20 per annum out of every 110. In Liverpool, by the removal of cellar dwellings, the average duration of life has been increased; in Bradford and Bristol, the same; and in the neighbourhood of London, a doctor lost his living from the arching over of an open sewer. In Leicester, the average age of death in the drained districts is 24, while in the undrained districts it is 18. In the lowest districts of London, during the cholera in 1849, the deaths were 1 in 118. In the highest districts the deaths were 1 in 347; and by the present system of sewerage, the lowest and highest districts mean actually those badly and better drained.

These facts might be multiplied were it necessary, nor need we confine our observations to towns. It has been distinctly proved that the sickness we hear of (and which some of us have perhaps felt) in tropical countries does not arise from climate, but from undrained spots, covered perhaps with a thick mud produced from the decomposition of plants; the hot sun evaporates the unwholesome moisture, the wind spreads it abroad, and the night dews charged with it, fall and contaminate the breathing air of the neighbourhood. I could instance several cases within my own experience where the character of a neigbourhood for health, has been completely and immediately changed by drainage. It might be supposed, and very naturally supposed, that from the exceedingly imperfect sewerage of all our towns, without perhaps one exception, the subject of drainage has only very recently engaged the attention of legislature or of engineers: this, however, is not the case. The Egyptians, four thousand years ago, provided drains to lead refuse away from the vicinity of their habitations. The magnificent works of the Romans, both in Rome herself and throughout her dependencies, show the vast sums of money and the amount of thought they must have expended to maintain health and cleanliness. In Great Britain, we find a chapter of Magna Charta to protect public drainage works against encroachments. Henry III. used to visit in person embankments and watercourses, to see the laws carried out. Indeed, all our rulers up to Henry VIII. gave serious and frequent thought to such measures, and the earliest fundamental provisions were based upon the footing that drainage works, as well as measures for the maintenance of the free flow of running waters, were of general public and national, rather than of exclusively local consideration; and there can be no doubt, that it is the duty of the government by effective superintendence, to insure proper attention to works of drainage.

Whether the works shall be under the immediate management of the direct or the indirect representatives of the people, is a matter of little consequence and is fairly open to question; but no one can doubt that whosoever is empowered to construct works essential to the public safety, should be compellable to construct them, and that competent and responsible officers should be appointed to see that this evident duty is efficiently performed.

The first operation then, towards improvement in any town, must be directed to its efficient drainage and sewerage. Every particle of refuse should be taken away towards a well-chosen outfall, with a regular and certain flow through smooth, water-tight, and air-tight channels, of proper dimensions and form. I say proper *dimensions*, for we must carefully avoid the preposterous sewers often provided: for instance, a sewer has recently been made at Newcastle-on-Tyne, 7 ft. 6 in. high by 4 feet wide, where a 12-inch pipe would have served the purpose much better; and other sewers, 3 feet and 4 feet high, have been made for single streets, where a 6-inch pipe would far better attain the proper objects of the construction. In all these cases, the cost of the large sewer is of course far greater than that of the pipe, and the enormous expenses attending the former have effectually prevented the proper carrying out of drainage improvements. And I say proper *form*, because the superiority of the egg-shape, by giving increased hydraulic depth to the run of water, and thus greatly increasing its power of removing impurities, has been so completely established over that of the flat-bottomed sewer, that the continued use of the latter is inexcusable.

If the natural outfall be a river, and the sewage is not to be reserved for fertilising the lands around, let its exit be far down below the town, and below the last weir or other obstruction (should such exist) to the regular current of the stream. If it be a tidal river, let the outfall be so far down that the flood tide shall not have time to return the offensive matter up to the town, but be met by the ebb, and kept away from it: this is presuming the town to be large, and the river so small as to have its waters sensibly polluted by the sewage. If there be another town below the one I have just imagined, and on the same river, and if it be essential that the sullage should not pass that lower town, either because it takes its water supply from the river, or for other reasons, the difficulties for insuring an outfall for the upper town would be increased—not physically, but in a pecuniary point of view; it would not be an engineering, but a commercial difficulty.

My statement of this being a difficulty would, however, be denied by many, for there are strong grounds for believing that the sewage of a town, if applied to land in the form of liquid manure, would not merely repay the expenses of its application, but leave a very large surplus towards reducing the rates of the town; there are cases of productiveness increased four or five fold by sewage irrigation. This subject is, however, too large a one to be treated of in a lecture which merely introduces drainage as a kind of prologue, and would not have been touched upon at all, but that in treating of improvements, I felt that the unquestionably first and greatest could not be passed over in silence.

The surface drainage of the streets is only second in importance to the drainage of the houses, for unless the water which falls upon the streets be immediately led off, the inhabitants are subjected to great annoyance from mud and dirt, and the ratepayers to great expense from rapid destruction of the roadways; and if streets are dirty the air is necessarily impure, and therefore that which enters the houses must be impure. A slight but regular rounding must be given to the paved or broken stone surface, off which the rain will immediately run into the channels, which will immediately convey it at once by the gulley shoots into the sewers; and the channel should be that only which is formed between the curve of the road and the kerbstone. No hollows, in which water can lodge, can be permitted without injury; and the greatest care must be taken to keep the gulley shoots clear, and to have them properly trapped—a most important, but almost universally neglected precaution, as is proved by the bad odours arising from gulleys in every town of which I have any knowledge. The danger and annoyance hence arising must be prevented, by insuring the rapid removal of refuse from the drains, by trapping all the openings by which foul air from the sewers can escape to injure and annoy the inhabitants, and by providing openings where its escape will not cause either danger or annoyance. However rapid and perfect may be the removal of solid refuse from the sewers, the air of channels conveying foul water must itself be foul (though less so than might be supposed), and cannot be allowed to escape into our houses or streets with impunity; hence the necessity of confining it by traps. But traps are never perfect, and may not be universal; and if they were, would render entrance into the sewers for examination or repair impossible; hence again, the expediency of providing appointed channels for the discharge of that air of which it is so important to get rid. It has been proposed to employ the stack-pipes from the roofs as foul-air channels, by connecting them with the sewers; this affords some local relief, because the escape of foul air at the top of the house is less annoying than in the street; but this is rather diffusing than removing the evil. If, however, the foul air be passed through *fire*, all the organic gases and vapours it contains are resolved into simpler and innocuous elements, principally nitrogen, water, and carbonic acid; and the evil is destroyed effectually. In such a town as Leeds, there ought to be no difficulty in effecting this. Here there are numerous furnaces, and there would be little expense and need be no inconvenience in connecting each large sewer with the ash-pit of one of these furnaces, by which the foul air would be drawn through the furnace, completely decomposed, and diffused in the form of inorganic and imperceptible gases, with the products of combustion. By the adoption of this plan, odours of the most distressing nature—such as those arising from bone boiling, or whale blubber—have been effectually destroyed. If this plan were adopted with the sewers, a current of fresh air through them might also be maintained, and they might always be entered with safety, as indeed they now may be generally.

It will be perceived that this plan of ventilation, of which the passing of the foul air through fire is an essential part, is free from the objection attending projects for ventilation simply, either by currents of air or steam-jets. These do little more than shift the nuisance from ourselves to our neighbours; and if our neighbours do the like, we shall gain little by the change. Neglecting to decompose the foul air is the reason of the failure of attempts to ventilate sewers by chimney-shafts at Paris, Antwerp, and elsewhere.

Most people are, I imagine, willing to admit that there is great comfort in street cleanliness; and all will admit, with equal readiness, the sanitary and economical advantages attendant upon a completely organised system for maintaining such a state of things, when a few facts relating to it are mentioned.

The greater proportion of the dirt removed from the surface of paved streets consists of horse manure; and the quantity of it is somewhat startling, for it is estimated that it amounts, in London, to no less than 200,000 tons a-year. Between the Quadrant in Regent-street and Oxford-street, a distance of a third of a-mile, three loads of dirt, almost all horse manure (for the surface was wooden pavement), are on an average removed daily. Much of this under ordinary circumstances dries and is pulverised, and, with the common mud, is carried into houses as dust, and soils clothes and furniture, so that linen is dirtied at least twice as fast as in the country districts, and the population is therefore subjected to a double expense to obtain the same amount of cleanliness. The odour arising from the surface evaporation of the streets when they are wet is chiefly from horsedung; and susceptible persons often feel this evaporation, after a shower, to be highly oppressive. Slight showers only wet the mud, and on ill-paved streets occasion a considerable amount of this insalubrious surface evaporation.

The most perfect mode of cleansing the surface of a street, is by applying a strong jet of water from a stand-cock, or a fire-engine: it cleanses everything away, and sweeps it into the nearest sewer, leaving the pavement as clean as it would have been after a thunder shower; and with sufficient pressure, this cleansing is effected in one-third the time and at one-third the usual expense of the scavengers labour of sweeping the surface with brooms.

With respect to scavengering, Dr. Sutherland says:—"In those narrow filthy closes, and similar close localities, which exist more or less in all large towns, it would, in my opinion, be of very little good, in a sanitary point of view, to endeavour to keep them clean by *sweeping*. The very process may at times do mischief, for at the best it involves the smearing of the surface with unwholesome and offensive matters, so as to expose a larger evaporating surface to the atmosphere. I have often found (he says) the air in these places insupportably offensive after the work of the scavenger was completed. Not unfrequently the paving is in a very defective state; and the broken surface adds materially to the local unhealthiness by the accumulated filth which it harbours. In such cases scavengering is of no use; but it is precisely in these that surface-washing is most effectual: it cleanses away everything." But Dr. Sutherland is not an engineer, or he would have added, pavement as well as filth, for the jet of water undermining the loose stones would soon have left it without any organised covering. A good pavement is even more essential to the perfect operation of *washing* than to the *sweeping* of the streets. Without a proper surface, streets cannot be kept clean by any process; and the good of putting a hard surface upon a roadway is strongly shown by what is said by Mr. Evans, one of the pavement commissioners of St. Olave's Union. A dirty court had been paved: It had only been done a fortnight, and this gentleman states, "After it was done, I saw, I think, eighty children playing there, from about two years old up to nine; before, they could not play on account of the water which was stagnated in the channels. It struck me as a father and a grandfather; I said, 'Dear me, if we never did more good than this we ought to be very glad.' I wish to impress strongly upon the minds of any gentlemen who have the power of carrying out improvements, only to consider the eighty children, and their mothers at the wash-tub."

Now, a few words as to the most effectual, and, in the end, most economical mode of paving; and your Society, by promoting good pavements, will find that this is not the least important of its objects.

It is a very palpable, though a common error, to consider *that* road the cheapest which costs the least in direct expenditure *merely*. If, however, this so-called cheapest road causes waste of horse-power, undue wear and tear of horses and vehicles, loss of time by being unfit for rapid transit, and also occasions loss to the inhabitants by filling their dwellings with dust and covering their clothes with dirt, it is evident that such a road, however apparently cheap, is ultimately really very dear. There is an apparent diversity of interest between those who use, and those who pay for our public streets, as the principal loss from bad roads falls directly upon those who keep or employ horses and carriages, while the expense of road repairs falls upon the inhabitants generally. A little consideration, however, will show that this diversity of interest is much more apparent than real, if it is the interest of *all* that there should be easy, safe, and cheap means of transit through the public streets; and any increase in the cost of transit is a source of indirect expense, even to those who have no horses of their own, as it must add to the cost of everything carried through the streets, and of all hired vehicles, and of all the numberless conveniences which accompany residence in a large town. It must also be remembered that it is very wasteful to allow a road to go out of repair, since it is less costly to keep a road up than to restore it. In no instance is the truth of the old adage — "a stitch in time saves nine" — more apparent. It is quite evident that *that* roadway is best for the owner or user of a horse or vehicle which can be travelled over most easily, safely, quickly, and cheaply; and that ease, safety, speed, and economy in use, are to be obtained by having the road firm, even, smooth (without being slippery), and perfectly free from mud or dust, or any form of unattached materials. It is also evident that the same qualities will render the roadway most free from noise, dirt, and dust—the three great causes of annoyance and injury to the inhabitants of all ordinary streets.

The only question which remains to be considered is, whether the advantages of good streets to the inhabitants generally, are worth their cost? If the question had to be decided in accordance with the interests of the users and owners of houses merely, no doubt whatever would be entertained.

Of whatever nature the surface of a road is to be, it is essential that its foundation should be of firm material, well consolidated, and perfectly drained; if not, the crust becomes loosened and destroyed, the road is rough and uneven, and wears into holes and ruts. Having obtained a good foundation, the next point is to cover it with a hard, compact crust, impervious to water, and laid to a proper cross-section. Now, of what nature must be this crust to be efficient? Mr. Pigott Smith, the intelligent surveyor to the commissioners of the Birmingham Street Act says, that when properly constructed and managed, and well water-cleansed, in conjunction with the sweeping machines of Mr. Whitworth, and kept watered, macadamised roads are the best adapted for the streets of a large town of any description of road yet tried. I however very much doubt the correctness of this assertion. I must, however, in candour, allow that a fair chance is rarely if ever given to broken stone roads in towns. It seems to be quite forgotten that heavy traffic necessitates proportionately frequent repairs. *Perfection* in the first formation of the road, and constant, never-ceasing care in maintaining the surface, are both essential to its permanent value. Under no circumstances must any imperfection of surface be allowed. If a hollow be not immediately repaired, it very quickly extends over the surface. All loose stones must be carefully picked off, as every loose stone passed over by heavily laden carriages, if not ground to powder, breaks the crust of the road. If water be permitted to lodge on the surface, it will cause great mischief. The neglect of these essential precautions render a road formed of broken stones very expensive; and I only remember one instance of such a system of management that would make labourers sufficiently attentive to do all these things, and do them well, if the surface were exposed to the constant and great wear and tear due from the traffic over the streets of a busy town. The instance to which I allude is found at Birmingham; it is done, and done well, in that town. For the outskirts, however, macadamised roads are admirable, provided they are well managed. The usual practice of allowing them to be constantly muddy in wet, and dusty in dry weather, and get thoroughly out of repair, and then to heap upon them broken stones for the wheeled traffic to grind down, is abominable. The roads in the parish in which I reside are thus vilely managed. I pay my rates with grumbling, for they are heavy, and might be much less with better roads; and I abuse the road surveyor with right good will. Thin coatings of broken stones or broken gravel should be laid on to every part of the road directly it requires it. The surface should be kept watered in dry weather, and *swept* in wet weather; the scraper is a great enemy to a broken stone road. A road which is perfectly dry loses its tenacity, and the surface grinds into dust; but watering without sweeping merely changes one nuisance into another—dust into mud. I am not sanguine enough to expect that a country road can be kept up with the care of one in the immediate vicinity of a town, for the cost would fall too heavily on the inhabitants; but they *may* be kept in repair with more judgment. I submit that this case comes under the head of *improvement*, such as is contemplated by your Society.

The chief matter under consideration, however, is *street* pavement; and I will beg to lay before you a method of forming your street surfaces, which I consider all but perfect. The system has been called "Euston paving," from its having been first adopted at the London terminus of the North-Western Railway, but should be called "Birmingham pavement," for it was introduced from that town by the able town surveyor, Mr. Pigott Smith. The manner in which this paving is laid may be simply described.

The ground is first removed to a depth of 16 inches below the intended level of the pavement, the foundation being shaped to the convexity of the intended surface of the road, which may be very small indeed. A layer of strong gravel, 4 inches thick, is then spread over the surface and compressed, by being rammed equally throughout; after which, another layer of 4 inches of gravel, mixed with a small quantity of chalk or hoggin, is laid on, the ramming being continued as before; this is followed by the last layer, also 4 inches thick, of the same material, but of a finer quality; the whole mass is then compressed by the rammer into the smallest possible space. Thus the surface of the foundation is sufficiently perfect in all its parts, both in shape and solidity, and is ready to receive the pavement. The stones used should be Mount Sorrel granite, from 3 to 4 inches deep, 3 inches wide, and averaging 4 inches in length, neatly dressed and squared. These stones are laid on a bed of fine sand 1 inch in depth, spread over the surface, and are carefully and closely jointed in the laying, so as not to allow any single stone to rock in its bed. The rammer is then applied over the whole, each stone receiving its blow in rotation; and this is repeated again and again, until no further impression can possibly be made upon it. The operation of ramming having been completed, a small quantity of screened gravel is sprinkled over the surface, and the street is opened. The action of the first water upon it fills-in the interstices at the corner joints of the stones, leaving the foundation impervious to wet, and thereby securing perfect cohesion.

The street paving of many large towns, the metropolis in particular, has been for years carried on under three systems—bad, very bad, and middling. The general method is to employ granite, in blocks of from 8 inches to 14 inches long, 6 inches to 9 inches wide, and 9 inches deep. These are merely laid in rows upon the subsoil, and rarely upon concrete; and, after the usual practice of grouting and ramming, the street is thrown open for the traffic, which is expected to perform the last duty of the pavior, and to settle each stone upon its bed, for the large wooden rammer is altogether insufficient for this purpose, as may be observed from the irregular settlement of the blocks, caused by the rapid concussions from the carriage-wheels immediately after the traffic has been restored. The results produced are great noise as the carriages pass over, imperfect foothold for the horses, and risk to the axletrees and springs from the jolting; and it also totally precludes any chance of the road being kept in a systematic state of cleanliness.

The Birmingham paving is distinguished by the extreme quiet it affords under busy traffic, by the numerous joints affording a very perfect foothold for the horse, and by the traction being less than on the best macadamised road. The cleansing of this pavement is also another important consideration. The arch of the road abutting upon the kerbstone on each side, enables "Whitworth's sweeping machines" to brush off effectually every particle of dirt from kerb to kerb, thus insuring the cleanliness of the road at all seasons of the year; whereas in all those roadways where the side channels are formed in deep hollows, which is usually the case, this valuable machine is found comparatively useless beyond the centre portion of the road. The cost of this Birmingham paving is much less than the ordinary kind, the former being 9*s.*, the latter 15*s.* per square yard. The average cost of maintenance, and including the first cost, would not amount to more than 1*s.* 6*d.* per yard per annum for ten years. After a trial of this paving at the Euston Station for twelve years, no perceptible abrasion had taken place on the angles of the stones, nor did the surface present any appearance of wear.

Unevenness in ordinary paving frequently arises from the constant alterations made by the gas and water companies, who take up the street, and, not having any interest in the *surface*, lay it down again very roughly, or as roughly as they are allowed to do; and it appears to be the general feeling now, that no perfect state of surface, either as to smoothness or cleanliness, can be maintained until all the public bodies, such as gas and water companies, paving and sewer commissioners, be united and directed by one interest. The energies of a Society such as this, directed to the provision of good paving and a clean street surface, will, there can be no question, gain much; and when once a general perfection is reached, more will be done to keep up the good state of things. The voice of a large section of the community is respected everywhere.

Having clean streets, the inhabitants of Leeds will be freed from two evils—dust in dry, and mud in wet weather; but there is a third enemy to cleanliness of house and of person, which is more difficult to be subdued: I mean *smoke*. Now, smoke is a nuisance however it may be produced, whether in the furnace of a manufacturer or the fireplace of a private house; and in both every particle of smoke made is so much fuel unburnt—*i. e.* lost. Ever since fires from bituminous fuel were introduced, a portion of it (sometimes thirty per cent.), in the shape of smoke and carbonic oxide has been allowed to escape up the chimney. For a long time now, the cry has been, "Consume your smoke:" the public admit the advantage that would accrue to them by doing so, but seem to despair of the possibility—or why has the nuisance continued? Furnaces have been contrived which spread the fresh coal upon the blazing mass of fire so evenly and thinly, that all the bituminous matter is converted into inflammable gas, the products of the combustion of which alone escape into the atmosphere; but all these furnaces are complicated, and thus liable to get out of order; they are expensive, and therefore not of universal application. It is true, one patentee, Mr. Chanter, offers to alter furnaces of any description, by his being paid the amount of saving in fuel for the first four years; still, he has not met with very much encouragement.

What, then, is to be done to the furnace to render it capable of consuming its own smoke? Shall I surprise you when I say, *nothing?* for, with few exceptions, the furnaces are capable of doing so; the exceptions are, when the grate-bar surface is short between the door and the bridge, and when the doors are so ill-fitted or so disproportionately large that much cold air passes *over* instead of *through* it. Now, we will suppose the length of the fire to be 3 ft. 6 in., and this to be in a glowing heat, with little flame, and no smoke passing off from it,—this is the time for the furnace to be fed. The usual practice is to throw the coal on until it covers the fire; the portions of coal in contact with the fire become ignited and their gases are inflamed, but that coal which is not in contact with the fire is not sufficiently heated to burn completely, yet so much so, that the most volatile of its elements are driven off, and the fire being smothered no flame can ignite them, but they pass off in dense black smoke. You will constantly have observed that clouds of this volatile fuel will suddenly issue from the head of a chimney-shaft, and that it will continue to issue for some time, gradually growing less in volume, until it disappears; this sudden appearance of smoke is caused by feeding the fire, and its disappearance is when the fresh fuel becomes incandescent.

The smoke, then, is produced by smothering the fire: do *not* smother it, and the nuisance will not arise. The fire should be fed thus. With a broad, hoe-shaped tool, rake back the front portion of the fire, and in the space thus left vacant deposit the fresh coal, in small quantities and rather frequently, closing the fire door directly. The smoke that would pass off from this new fuel would have to pass over the hot surface of the old fire, and it would be converted into flame before it reached the bridge, and no smoke would issue from the chimney. When the fire is first lighted there is no hot surface to perform this operation, and by this method there would be some smoke arise until the furnace is well in heat, but the quantity would be insignificant and its duration short. The more highly bituminous the coal used, the more care would be required in firing; with Welsh coal there is no difficulty. I have crossed the Atlantic in a steamer consuming from 26 to 30 tons of Welsh coal daily, without seeing any smoke. I made the firemen feed their fires in the way I have described; I at first met with opposition and difficulty, but the firemen soon found that their work was lessened instead of increased; and the engineers also assisted me, finding their steam kept up more uniformly. The saving effected was at least 100 tons for the voyage of twenty days.

As I have already said, with few exceptions every furnace may be so used as not to smoke; and I may add, that *few* may not be *made* to smoke: the care is in instructing the fireman what to do, and in inducing him to do it. We usually succeed in making men do as we desire, by rendering their duty and their interest identical. Acting thus, a master manufacturer in Manchester, after trying without benefit several infallible patents, succeeded in preventing smoke from his furnace by simply rewarding the fireman, in the shape of a small addition to his wages for the additional attention exacted; and there is but little doubt, that if masters would allow their servants to participate in the profits arising from the saving of fuel, that both parties would be benefitted by the arrangement, and the nuisance of smoke prevented.

With the saving of fuel the public generally have no direct concern, but the nuisance of smoke is a very serious mischief both to individuals and society: to individuals, by increasing dirt, by obscuring light, and checking ventilation by rendering persons unwilling to open their windows; sociably, by driving out of manufacturing towns all who can afford to live elsewhere, and so depriving the society of the town of many of its most intelligent and refined members.

Against such a mischief the public ought to be protected, and the law ought to compel a diminution of the nuisance to the smallest practicable amount. What hardship would there be in rendering every one liable to a moderate fine who carried on his business in such a manner as to inflict more nuisance on his neighbours than was unavoidable? What more just mode of adjudging this than to assume that if A's furnace made more smoke than B's, both being used for a like purpose, A made more smoke than was necessary: if B *does* make less smoke than A, surely A might and ought do so, and if necessary ought to be *made* to do so. Let then the authorities proceed resolutely to find in succession the owner of the chimney that emitted the greatest quantity of smoke; there would always be a *worst* until all were cured. Whip up the last horse till all get to their proper speed, and very quickly there would be little cause to complain of Leeds as a particularly smoky town: and the masters, if they would confess, would acknowledge that such a law would be of great benefit to them.

Though most furnaces may be made, by proper and careful firing, not to smoke, yet I would not be understood as saying that with *all* this may be accomplished with equal ease and economy; the great fault of steam-boiler furnaces, especially those in the coal districts, is that the grate-bar surface is too small—particularly too short—to admit of that quiet combustion which is necessary for burning the fuel completely and obtaining for use the greatest possible amount of heat. It has been suggested that the most efficacious way of remedying that defect would be by putting a duty upon coal, so as to render economy of fuel a matter of as much importance in Yorkshire as it is in Cornwall, where they cannot afford to allow thousands of tons of carbon and carbonic oxide to escape unburnt. This saving is no exaggeration. I saved 100 tons of coal in twenty days, with engines of 500-horse power, by causing complete combustion of fuel: how much, think you, might be saved by doing the same with all the furnaces of Yorkshire?

As the efficacy of a tax on coals is not likely to be tried, and certainly will not be recommended by me, I would suggest that the same good might be accomplished without the evils, by simply trying how the greatest possible effect may be got with the least quantity of fuel, and insisting then that it shall be got. The amount of heat obtained is easily calculated from the quantity of water evaporated: to ascertain this quantity, nothing but a simple water-meter is needed, and, in the absence of a better, two barrels, or other vessels of known capacity may be got, from which the feed might be drawn alternately, one to be filling whilst the other is emptying. Let such a plan be adopted, and smoke would quickly cease, as it would be proved to be a very expensive thing.

There are so many successful methods, when properly used, of avoiding smoke, that it may be invidious to mention any in particular. There are, however, two that may be named, not because they prevent smoke more perfectly than others, but because a good method of feeding the fire has been adopted, which has some attendant advantages: these are Jukes's and Hall's. Mr. Jukes uses jointed bars, which form a sort of endless chain, made to pass slowly over rollers fixed before and behind the fire: this carries the fuel gradually along, the consumed ashes falling over the back roller into the ash-pit. Mr. Hall employs bars which, by an advancing and receding motion, slowly push the fuel from a hopper in front towards the ash-pit behind. Before the fuel reaches the back of the furnace its volatile parts have been distilled, and these passing over the incandescent carbon are burned as bright flame.

It is clear that by either of these plans it would be easy so to measure the speed, as to pass the coal into the ash-pit before it is consumed, but after all matter that would produce smoke in a common fire has been driven off. Such coke would be very suitable for household use, and ought to be sold at a low price, as the manufacturer would have received the full value of the gaseous parts, which are wasted when coke is made in an oven.

Domestic fires may however be made to consume their own smoke, and I should be glad to hear of some member of this Society trying it. The grate would require to be altered. The fuel must be confined in a cage, with bars at the top as well as at the bottom and front; and this cage must be hung upon a centre, so that it may be turned bottom up. A grate of this description was recommended by Dr. Franklin, and used by him successfully. The process would be this: when the fire required replenishing, turn the cage, open the bottom (which must be provided with hinges for that purpose), place the new coals upon those already burning, close the bottom, and turn the grate or cage down again; the smoke from the new coal would have to pass through the ignited fuel above it, and would be consumed.

The act for the prevention in the metropolis of smoke from furnaces used for the purposes of manufacture, comes into operation on the 1st of January; the possibility of obeying this most wise measure will then be proved. I mentioned that smoke was an enemy to cleanliness: to this truism I must add, that it is likewise a direct enemy to health, by irritating the lungs of those who inhale it constantly. The chief constituents of coal smoke, or soot, are carbon, sulphate of ammonia, and resin. The insoluble carbon affects the lungs mechanically, and the sulphate of ammonia chemically; but it acts still more injuriously, by deterring cleanly housekeepers from opening their windows as frequently as is necessary for free change of air.

We will presume now that we have obtained clean streets and clear air; and having done away with the enemies of cleanliness, let us now consider the advantages to be gained by the rich and poor alike, by affording to the workman (to the representatives of the sinews of trade and manufacture) comfortable homes. Our great and good Prince has set us an example which all must be proud to follow; and your Society, recognising the promotion of such works as model lodging-houses, public baths and wash-houses, and parks for recreation and exercise, shows a benevolent and wise spirit, which, if it meet with its reward, will be responded to by all who recognise a poor honest man as part of God's creation. We all know the —I am afraid I must say—usual condition of the dwellings of the working classes. The well-to-do mechanic strives, by the internal cleanliness of his house, for comfort; but he is often defeated by the bad arrangements for drainage, by damp arising from the walls—especially when the subsoil is not naturally dry —by the insufficient supply of water, and by the want of ventilation; and this last want is especially felt in the sleeping-rooms where often there is no fireplace, and the window and door always closed. Every adult spoils about ten cubic feet of air each minute; therefore the sleeping-room should be the first to be ventilated, as in the daytime the inmates may be much in the open air. The well-to-do mechanic, then, has difficulties to contend with; but what must he said concerning the habitations of the lower orders—the *completely* ignorant and *poorest* classes—where several families occupy one room whose cubic contents may not exceed 1000 feet, and which is covered from floor to ceiling with antique dirt, into which light is scantily admitted, and water never finds its way? The effects of such dwellings upon the health and moral condition of such people are too well known; and I am glad to escape from the necessity of detailing them.

It has been said by some who have been commissioned to report upon the condition of the poor, that it is the tenant, and not the tenement, that makes the unwholesome dwelling. If such places exist not, they will make them. Place them in an airy habitation, they will turn it into a noisome hovel. If they have drains, they will allow them to become obstructed; if free ventilation, they will close it up; if the clearest sunshine, they will shut it out by negligence and filth. I cannot believe this—at all events, it is the exception, and not the rule; and if such be the case at all, does it not arise from perfect ignorance of a better state of things? for when, until very lately, have societies been found, having for their object the amelioration of such a class? Such societies are now thickly forming, and we shall soon see if such statements be true. But granting that it be true in part, it certainly is not true generally, still less universally. What, for instance, can be a more striking contradiction of this assertion than the efforts which every one must have observed made, under the most discouraging circumstances, by the poor inhabitants of the dirtiest streets and courts, to preserve the cleanliness and tidiness of their houses? Who has not seen the poor man's wife scrubbing away on her knees to make her door-step clean in the morning, though she must know, from repeated experience, that but for a short time can this respectability of appearance be maintained?—and who can doubt, when there is this "pursuit of cleanliness under difficulties," that such persons would not appreciate and profit by the facilities they ought to have? But we need not speculate on the point: the experiment has been tried, and has succeeded. When people find it possible to keep their houses in a state of comfort they had not before experienced, they make the effort. A higher standard of feeling gets introduced among them, their late condition becomes disgusting and unbearable, and very quickly such a change is apparent that it is hard to believe that it is the same population, that were before so debased and miserable.

Concerning public thoroughfares, and the sanitary ends they should be made to answer. As streets are originally formed as passages of communication, it is too common to regard them *as such only*. This is a great mistake: their office as the principal channels for fresh air is quite as important, as it is evident that if the air in them be not pure and fresh, *that* in the houses cannot be so. The greatest care should therefore be taken in laying-out new streets, that the new buildings should as little as possible impede the passage of the air to the centre of the town, as well as that the new thoroughfares should be as convenient as possible to the largest majority of those who will have to use them. In general, both these objects will be attainable by the same means; but not always, for sometimes a tall building may be so placed as very seriously to impede the free passage of the air, though it may be unimportant as an impediment to traffic. On both these accounts, it is incumbent upon the governing authority of a town to obtain powers for regulating the general arrangement of future increments of that town; otherwise the growth of suburbs will be unnecessarily injurious to the centre.

In considering the value of proposed new openings in the centre of a town, their value as ventilators, as well as facilities for traffic, must be taken into account; and every opportunity should be taken advantage of for removing impediments to both. And let us never forget that, important as trade is, *health* is still more so, and deserves the first consideration.

In almost all towns, there are numerous streets through which it is rarely, if ever, necessary that a cart should pass, as they lead only to the houses in the streets themselves. If such streets, instead of being paved, were *flagged*, and used only for foot-passengers, they would be much cleaner and drier, and much more suitable, and safer play-places for the numerous children with which such places always abound. The provision of safe play-places close to their parents' dwelling, would, little as it is thought of, be among the greatest blessings that could be conferred upon *young* children especially. The excessive mortality among such in a town is most lamentable, and one of its great causes (next after foul air, *the* great cause) is the want of active bodily exercise; and so long as no play place but the dirty and dangerous street is provided, most town children must be debarred from that constant exercise for which nature so evidently intends them. From what I have said concerning ventilation, it will be palpable that no courts with closed entrances should be allowed to exist. From evidence, it appears that they should be at least 12 feet wide, or wider if the houses are lofty; and the ends, if required to be fenced off, should be so by an open railing, which would obstruct the passage of the air but little.

Your Society contemplates the promotion of improved cottage dwellings; such efforts, I rejoice to say, are increasing fast. Model lodging-houses in towns, and rural dwellings in the agricultural districts are becoming numerous: both are needed. In towns, new streets are built, new thoroughfares opened, which intersect rookeries and nests of fever, which must be removed that the new locality may be thriving; and where are the inhabitants of such to find new dwellings? Must they go still further to crowd the as yet undisturbed courts and alleys? They must if suitable abodes be not provided for them; and they are being provided. All that science and practical experience can do to render such new habitations cheap, cleanly, and durable, is being done. Such erections were first taken up as an experiment; hence they were called *model* dwellings. Much perseverance on the part of improvers was necessary in the first instance: they were objected to at first by the very people for whom they were designed. The hollow brick, the cleanly and simple pieces of apparatus essential to their entire success were found expensive; not so now however, and such buildings will go on increasing. And why? Because they are found to be a species of charity which yields to the giver a reward in *this* world; in other words, they are found *to pay*.

One great secret of the growing favour of *improvement* projects, for the amelioration of the condition of the working classes, probably lies in the fact that these projects are discovered to be self-supporting, and not merely eleemosynary, some even yielding a large return by way of interest on capital expended. Charity is a blessed thing; but if the men who endeavour to provide the poor with better houses, and with more extended facilities for comfort, health, and recreation, make their efforts successful in a pecuniary sense, they do a far greater amount of good than any mere act of charity could accomplish. They relieve themselves from the invidious position of administering ostentatious benevolence, and at the same time place the poor upon that footing of equality which is most consistent with mutual self-respect, and permanent good feeling. When public baths and wash-houses are found to pay their cost, and to answer as mercantile speculations; when garden allotments are found to be attainable without loss to those who originate and conduct them, and with pecuniary profit to those who cultivate them; and when it is discovered by capitalists that decent dwellings for the people, built with a proper regard both to amenity and utility, and with all the appliances of modern science and discovery, can be constructed so as to pay a very fair per centage on the sums invested in them, a practical victory has been gained, of a higher amount of benefit than could accrue from any acts of pure philanthropy, however extensive. This is our present position; and the abolition of the window-tax, which formerly prevented the outlay of money upon blocks of buildings for the working classes, may be expected, in due time, to lead to a large increase in the number of such edifices in all our great towns. But while rejoicing at this prospect, we would ask whether nothing is to be done for the rural districts? The agricultural labourers of England lie under peculiar disadvantages in this respect. Too often, by the operation of the law of settlement, the owners of the soil, to rid themselves of the support of paupers, demolish cottages and huts, and force the labourers to reside beyond the boundaries of their domains or their parish; in some instances, as far as from 4 to 6 miles from the scene of their daily toil. No new homes are provided for these people, who often cluster too thickly for health or decency in buildings already overcrowded, or betake themselves to the nearest town, to be a burden upon the shopkeepers, and to congregate in miasmatic and pestilent places, where the cholera is their visitant, and typhus their constant companion.

I fear I have detained my hearers too long, and I have not found it in my power to treat the subjects of my lecture in so interesting a manner as I should have desired. My studies are matters of fact, hard and dry; and I have not learned those flowers of speech which go so far to bind the attention of an audience, and take so much from the irksomeness of the task of listening. That you have lent me your ears so patiently, I beg to thank you, and conclude with wishing the Society for the Promotion of Improvement in this town all the success it deserves.

METROPOLITAN WATER SUPPLY.

Report *to the General Board of Health, by* Edward Cresy, Esq. C.E., *on the Works of the Water Companies for Supplying the Metropolis with Water.*

My Lords and Gentlemen—In conformity with your instructions, I have visited the establishments of the several waterwork companies of the metropolis, and examined their mode of supply, the extent of their reservoirs and filter beds, the power of their engines, pumps, &c. The river Thames affords water supply to five of the companies, and the highest point from which it will be taken is at Thames Ditton. The quantity of water flowing in the river at Long Ditton on the 16th October 1847, was very accurately observed by Mr. James Simpson, who has afforded me the following information. The length of the river over which the velocity was taken was 330 feet; the average sectional area of the river 1120 superficial feet; the hydraulic mean depth 5 ft. 4 in.; the mean velocity calculated from fall, and the hydraulic mean depth, 10·98 inches per second; surface velocity from the average of 30 experiments with floats, 14·24 inches per second; mean velocity 10·97 inches, or ·91 feet per second: $1120 \times {\cdot}91 = 1019$ cubic feet per second. The volume of water, therefore, passing down the Thames at Ditton in a dry summer season would amount in the 24 hours to $1019 \times 86{,}400$ seconds $= 88{,}041{,}600$ cubic feet, upwards of 530,000,000 gallons daily. And supposing the water at the time these trials were made to be as the watermen stated, lower than had been known for 40 years, the average annual quantity passing cannot be estimated at less than 193,450,000,000 of gallons annually. From the statement given in by the several water companies, the following is pumped from the Thames annually:—

	Gallons.
Grand Junction Waterworks	1,289,184,930
Southwark and Vauxhall	2,195,006,370
Lambeth	1,123,200,000
West Middlesex	1,216,929,312
Chelsea	1,438,458,000
Total in the year	7,262,778,612

Assuming the five companies annually pump from the Thames the above quantity, and 193,450,000,000 of gallons to be that which annually flows past Thames Ditton, it appears that nearly a twenty-fifth part is required by the companies for distribution throughout their five several districts of the metropolis.

If we add the above quantity of	7,262,778,612
That afforded by the New River	2,109,339,311
East London from the Lea	3,222,753,876
Hampstead (probably)	100,000,000
	12,694,871,799

And supposing the whole taken from the Thames at that point, then more than a fifteenth of the whole volume would be required.

The Grand Junction Waterworks have their chief pumping establishment a little above Kew-bridge, on the north side of the river Thames.

Engine Power.—The engines are six in number at the Brentford works:

The Grand Junction engine		300-horse power.
Maudslay's engine		130 „
Boulton and Watt	East Cornish engine	130 „
	West ditto	130 „
North Filter engine		40 „
South ditto		40 „
Another engine at Paddington		70 „

There are seven Cornish boilers, 33 ft. 3 in. long, 6 ft. 6 in. diameter inside, with an internal tube 4 feet in diameter, which are applicable to the working of the whole or in part; 3170 tons of coal were consumed here last year. The 300-horse engine makes 7½ to 11 strokes per minute; but it was working, when I saw it, 8 strokes per minute, each stroke lifting 380 gallons of water. The 130-horse engine varies from 11 to 14 strokes per minute, and gives 150 gallons to a stroke, or 1650 in a minute. The 40-horse engines give 6 strokes a minute, and produce 520 gallons a minute. The two engines of 130-horse power made by Boulton and Watt, are capable of lifting 190 gallons each per stroke, after allowance for waste. The 40-horse, which is upon the Cornish principle, and called the Filter engine, will lift 520 gallons per stroke, and make 11 or 12 in a minute. The chimney is circular on the plan, 3 ft. 8 in. internal diameter at the top, and 7 feet at the bottom; it is 131 feet in height from the surface of the pavement of the engine-house, and 143 ft. 8 in. above Trinity high-water mark. There are three air-vessels, one of which is attached to Maudslay's engine; it is 5 feet in diameter, 14 feet above the relieving pipe of the pump, and usually contains from 10 to 12 feet of compressed air when the engine is at work. The air-vessel attached to Boulton and Watt's engine is 5 feet in diameter, 13 ft. 6 in. above the delivery pipe of the pump, and usually contains from 8 to 10 feet of compressed air when the engines are working. The other air-vessel is attached to the Grand Junction engine; it is 5 ft. 2 in. in diameter, 14 ft. 8 in. above the delivery pipe of the pump, and usually contains from 8 to 10 feet of compressed air when the engine is working. The whole of these air-vessels are supplied with air by means of small pumps attached to and worked by the different engines. The stand-pipe is at the top 218 feet above Trinity high-water mark; it has a cistern or reservoir at the summit 11 feet deep and 4 ft. 6 in. diameter. The larger middle or ascending pipe is 5 feet diameter at the bottom and 3 feet at the top; it is made of cast-iron. After the water has reached the cistern at the summit, it descends by four other cast-iron pipes, each 12 inches in diameter, the area of the ascending column being four times as much as the whole of those by which the water descends. The whole of the water is pumped up to the cistern at the summit of the pipe, descends, and then passes off by an iron main 30 inches in diameter to Poland-street, Oxford-street, a distance of six miles.

Supply.—The water is taken from the Thames, on the Surrey side of the river, 360 yards above Kew-bridge; after passing through an iron pipe laid down in the bed of the river, it is received into a well lined with brick, 8 feet diameter and about 22 feet in depth; from thence it is pumped into a depositing reservoir of rather an irregular form, the area of which, as near as could be obtained, is 130,491 superficial feet at the surface, and the depth about 10 ft. 6 in., the banks being 21 feet above the level of Trinity high-water mark. The filter-bed adjoining is 473 feet by 148 feet, and contains an area of 70,078 superficial feet. The total depth, from the top of the bank to the top of the sand, is 8 ft. 9 in. The water passed into this varies in depth as it is required, the depth being at times only 3 feet, at others 7 feet, above the surface of the sand. Both the reservoir and filter-bed have been partly sunk below the natural level of the soil, and the embankments formed of the earth removed. The insides of the slopes are puddled with clay, and a lining of concrete, as well as a brick pavement, have been introduced, and cover the whole of the portions which receive the water. The filter-bed is composed of gravel and sand laid alternately to the entire depth of 4 feet, varying in coarseness as it ascends, the top being a layer 1 ft. 6 in. in depth of fine sand. The filter-bed is frequently cleaned out by removing a few inches of the fine sand, which is put into two wooden frames, each holding about two cubic yards. These boxes or frames have an iron-plate, 6 inches above the wooden bottom, which is perforated with small holes five to a square inch, or about the eighth of an inch in diameter. Water is forced into the space between the wooden and iron bottom, when all the matter held in the sand is washed to the surface and removed by hand. In twenty minutes or half an hour, the whole is so thoroughly cleansed that it is fit to be again placed in the filter-bed. A culvert of brick, 3 feet in width and 2 ft. 6 in. in depth, passes off the water from the filter to the pumping-well. The reservoir at Paddington, which is about 89 feet above the level of Trinity high-water mark, is lined with brick, and the bottom coated with gravel; it will hold 3,400,000 gallons. At Campden-hill is another similar reservoir, the contents of which are 6,000,000 gallons; the two latter are used for stores only. The pipes for distribution, all of iron, are divided into trunk-mains, branch-mains, and side-services. The first vary in their internal diameter from 30 inches to 24 inches; the second from 12 inches to 6 inches, and the latter, or side-services, from 6 inches to 3 inches. The engines employed to pump the water for distribution are the four first enumerated, and the three that were at work may thus have their power summed up:—

	Strokes per minute, lifting 218 feet.		Gallons per minute.
The 300-horse engine	8	380 gallons per stroke, or	3040
130 „	10 or 11	150 „	1650
130 „	10 or 11	150 „	1650
			6340

Then 6340 gallons × 1440 minutes = 9.129,600, or 9,000,000 of gallons in 24 hours, would be the quantity that could be lifted; but it does not appear necessary, to produce the monthly supply, which may be taken at the very utmost as 135,000,000, that the engines should work more than half their time; and it is generally stated, that this company has double the engine power it employs. 1,289,184,930 gallons of water are annually raised about 230 feet in height; or, at 10 lb. to the gallon, we may say 12,891,849,300 lb. is raised to that level; and considering the statement of 1 lb. of coal as sufficient to raise *one million pounds of water one foot high*, we require here a sufficient quantity to lift 2,965,125,369,000 lb. to that height, we ought to assume that 2,965,125 lb. of coal would be the annual consumption, which is equivalent to about 1323 tons only. But the actual quantity of coals consumed to do that work has been 3170 tons for the year. The difference probably may be accounted for from the pumpings from the reservoir to the filter, which is a frequent operation; 2283*l.* 4*s.* 11*d.* has been the average cost of the coals, or 2350 gallons are raised 230 feet high for one pennyworth of coal. I have had no means of accurately measuring the number of yards of mains, but, from the information given, believe that there are 16,060 yards of iron main, varying from 30 inches to 24 inches, internal diameter; 26,095½ yards of branch-main, varying from 12 to 6 inches, internal diameter; and 98,882½ yards of side-service, varying from 6 inches to 3 inches, internal diameter. The highest service afforded by the company is 150 feet above high-water mark, and the lowest about 12 feet. The average current expenses annually appear to be for the last seven years 12,537*l.* 7*s.* 6*d.*, and the quantity of water raised and supplied last year, 1,289,184,930 gallons, which gives 1000 gallons for 2½*d.* nearly. As far as my observations have extended, I have no reason to doubt the accuracy of the evidence which has been given upon the quality of the water, or the statements with regard to revenue or supply.

The Southwark and Vauxhall Company take their water by a galvanised iron-pipe 4 feet in diameter, which is laid to the full current of the river, near the Red House, Battersea; a sluice lets the water to the pumps.

Engine Power.—There are at the works on the Surrey side of the river four steam-engines:

No. 1 has a cylinder 64 inches in diameter, a stroke of 10 ft. 6 in.; pumps, 32 inches in diameter, a stroke of 10 feet: Cornish.

No. 2 has a cylinder 64 inches; stroke 11 ft. 8 in.; pumps, 33½ inches diameter, with a 10-ft. 6 in. stroke: Cornish.

No. 3 has a cylinder 31 inches diameter, with a 6-ft. 3 in. stroke; pump, 21¼ inches diameter, with a 3 ft. 7¼ in. stroke.

No. 4 has combined cylinders of 24 and 40 inches diameter, with an 8-feet stroke; pump, 60 inches diameter, 8 feet stroke.

The power of the four engines is that of 355 horses. After the water of the Thames is admitted into the first reservoir, it then passes into a depositing reservoir; it is then passed into the two filtering reservoirs, from whence a 4-feet iron culvert leads it to the pumps of the engine-house, from whence it is forced into the mains for distribution by two of the engines—viz., one of 50-horse power, and one of 130-horse power, working over the western stand-pipe through a 20-inch main; the other engine of 145-horse power, works over the eastern stand-pipe, through a 27-inch main; the fourth engine lifts the water from the river into the reservoir; it is of 30-horse power. There are eight Cornish boilers, which on an average burn daily, 17,920 lb. of coal, or annually, 6,540,800 lb.; four of the boilers are 28 feet long, and 5 ft. 6 in. in diameter; and four, 32 feet long, and 6 ft. 6 in. diameter. There are six stand-pipes of cast-iron, which are 185 feet above Trinity high-water mark. There is one rising-pipe, 30 inches in diameter; one falling-pipe, 30 inches in diameter; one rising-pipe, 18 inches in diameter; one rising-pipe, 4 feet in diameter; two falling-pipes, 2 feet in diameter each: these communicate with the 27-inch and 20-inch iron-mains laid for distribution. The quantity of water pumped over these stand-pipes in 1849, was 2,195,006,370 gallons; or 21,950,063,700 lb. weight lifted 185 feet by 6,540,800 lb. of coal. Supposing one pound of coal can raise one million pounds one foot in height, we require 185 lb. to lift the same quantity 185 feet high; or to lift the 21,950,000,000 lb., 4,050,750 lb. of coal only, instead of 6,540,800 lb. The two depositing reservoirs, when filled, have a depth of 17 feet, and their surface is then 13 ft. 6 in. above high-water mark; they will contain 21,000,000 gallons of water, and require to be filled nine or ten times during each month. The two filter-beds have an area of 120,000 superficial feet, and contain 21,000,000 gallons when filled. Taking the average current annual expenses at 11,000*l.* per annum, and the quantity of water at 2,195,006,370 gallons pumped in the year, it is not 1½*d.* for a thousand gallons. The engine power and mains of this company are capable of giving a much larger supply of water than is at present demanded, and their works at Battersea are admirably arranged.

The Lambeth Waterworks at present draw their supply from the Thames, near Hungerford-bridge, where the present works are established; the water is pumped to brick reservoirs at Brixton and Streatham-hill. The reservoirs at Brixton are built of brick, on a clay foundation; their area is about three acres, and they are calculated to contain, when full, 12,150,000 gallons. There is also another reservoir of an acre and a quarter, capable of holding 3,750,000 gallons, on the other side of the Brixton-road. The water is filtered through sand and gravel, which is frequently taken out, and cleaned upon floors of paved brick, laid down near the filters. There are five steam-engines altogether employed:

		Diameter of Cylinders.	Stroke in Feet.	Strokes per Minute.	Height of Service above Trin. H. W.
One of	120 H. P.	64⅝	8	14	140
„	90 ..	46½	$8\frac{1}{12}$	12	140
„	12 ..	20½	3	22	100
Brixton	20 ..	16¼	3	33	200
Streatham	10 ..	11	2⅝	38	350

The reservoirs on Brixton-hill are 110 feet above the level of Trinity high-water mark; that at Streatham, 185 feet above the same datum. After the water has been pumped into the first, the 20-horse engine pumps it into the reservoir on the opposite side of the road, where the 10-horse engine lifts it to the Streatham reservoir: 1,123,200,000 gallons of water were pumped up during the last year. The average annual expenses are 16,877*l.* 16*s.* 5*d.*, and after deducting interest on borrowed money, 2883*l.* 15*s.* 8*d.*, the cost for every thousand gallons appears to be about 3*d.* I find no reason whatever to doubt any portions of the evidence given in.

The West Middlesex Waterworks derive their water from the Thames, which is received in two reservoirs, in area about sixteen acres. Here the water remains until it becomes clear, by depositing what is held in it mechanically. From the lowest reservoir, there is a 36-inch iron pipe laid under the bed of the Thames to the wells of the pumping engines at the company's works at Hammersmith.

Engine Power.—The following are the dimensions and powers of the engines, when working full speed, 22 hours out of 24 hours, to allow two hours to each engine for repairs:

	Diameter of Cylinders.	Stroke.	Diameter of Pumps.	Nominal Horse Power.	Gallons per 22 hours.
No. 1	54 in.	8 ft.	20 in.	70	1,912,680
No. 2	54	8	20	70	1,912,680
No. 3	64	8	23	105	2,530,440
			Total . .	245	6,355,800

or 2,319,867,000 gallons per annum. From Hammersmith, the water is pumped into a reservoir at Kensington, which is 111 feet above the level of high-water mark; this is lined with brick; its contents are 3,456,000 gallons. Another reservoir lined with brick at Barrow-hill, the contents of which are 4,752,000 gallons. The highest service is 207 ft. 6 in. above the level of Trinity high-water mark. Taking the average current expenses at 14,095*l.* 5*s.* per annum, each thousand gallons supplied costs between 1¼*d.* and 1½*d.* There is ample land for the construction of other reservoirs or for filtering-beds, and the company has power to deliver a much larger supply if required.

The Chelsea Waterworks derive their water from the Thames, by an iron main laid across the bed of the river, near the Red-house, Battersea. The water is received into filtering reservoirs, being pumped into them at a particular time of the tide, when the river is most clear. These several filters are irregular in their form; their area together may be estimated at 90,000 superficial feet; they are built with great care, and on a substruction of brick is laid several courses of coarse gravel, shells, and sand, of 8 feet in thickness, through which the water is passed previous to being pumped up for delivery. Every precaution is taken to cleanse the surface of the water in these filters; at each angle is a small aperture, through which a current may be induced, whichever the way of the wind; the scum accumulated can be drawn off, and passed through sewers constructed to receive it.

Engine Power.—From the filters the water passes to the pumps for distribution, and at present there are five engines for the purpose, viz.:

Engine.	Diameter of Cylinders.	Length of Stroke.	Strokes per Minute.	Maximum Height of Service.
The 120 H.P.	65 in.	8½ ft.	13¼	157 ft.
65	50	8	14	157
36	31	6	13	106
75	54	8	18	32
24	27	4	27	32

The two last pump up the river water into the filters, the three first pump for distribution. 1438,458,000 gallons were supplied by this company during the last year, and the average annual current expenses is about 19,245*l.* 13*s.* 7*d.*; then each thousand gallons of water sent out costs about 3½*d.* These works are maintained in admirable order, and there is abundant power and means to furnish a much larger quantity of water, should it be required.

The New River Waterworks receive their supply from several ources—viz.:

	Cubic feet per minute.
Chadwell Spring, which affords	500
River Lea	1340
Amwell End well	196
Amwell Hill well	285
Cheshunt well	50
Tottenham Court-road well	70
	2441

2441 cubic feet of water is the quantity capable of being afforded during the summer season.

Engine Power.—At the Amwell-end well there is an engine which works two 17-inch pumps, with a 6 ft. 3 in. stroke, 10 strokes a minute, which lift 30 feet at a stroke. At the Amwell-hill well are two 20-inch pumps, with a 6 ft. 3 in. stroke, making 10 strokes a minute, and 50 feet lift. At the Cheshunt well is oné 12-inch pump, with a 6 feet stroke, making 10½ strokes per minute, 105 feet lift in two heights. At the Tottenham-court-road well is one 14-inch pump, with a 6 feet stroke, making 11 strokes per minute, 203 to 204 feet lift in two heights. There are, in addition to the above, engines for the distribution of the water at Stoke Newington, and at the New River Head. The total amount of engine power altogether may be estimated at 720 horses, one-half of which only is in use in the summer months, and probably about one-third in the winter months; 2000 tons of coal are annually consumed.

Reservoirs.—The reservoirs used by this company, and their respective areas, are as follows:

Cheshunt—	A.	R.	P.	Stoke Newington—	A.	R.	P.
No. 1 . . .	11	0	0	No. 1 . . .	22	2	0
No. 2 . . .	7	2	0	No. 2 . . .	20	0	0
	18	2	0		42	2	0

At the New River Head is another reservoir, with an area of 5 acres; and at Tottenham-court-road another, built with brick sides, about 200 feet in diameter. The quantity of water delivered is 5634,000,000 gallons annually. The average annual expenditure is about 45,818*l.*, or about 2*d.* for every thousand gallons delivered. The river expenses appear to be a very considerable item, and the maintenance of the banks, bridges, &c. incur annually much expense, which the other water companies, drawing their supply from the Thames, are not subjected to. There is power in engines; and a quantity of water far beyond the present distribution could be afforded by this company. Their works are admirable in arrangement, and executed with the greatest skill; but notwithstanding, the cost of the water to the public seems higher than that which is afforded by the other companies.

The East London Waterworks, at Old Ford, draw their supply of water from the River Lea. There are six reservoirs and a canal, containing altogether 35,000,000 gallons; they are generally lined with Kentish rag or fine gravel, and the whole maintained in the most admirable order. The water is cleansed by depuration, or being suffered to remain long enough to deposit all impurities held in suspension. The water which is taken into the reservoir near Lea-bridge is distributed by the water-wheels at that station: the quantity may be about 12 per cent. of the whole. The waterworks stream affords about 1 per cent. of the water supplied, and a water-wheel is employed for its distribution: 87 per cent. of the water supplied is distributed by the engines at the works at Old Ford; and the following are the dimensions and power, when working at full speed for 24 hours round:—

	Diameter of Cylinder in Inches.	Stroke in Feet.	Diameter of Pumps in Inches.	Stroke in Feet.	Horse Power.	Gallons per Twenty-four Hours.
Wicksteed Engine	90	11	44	11	170	7,954,330
Cornish Engine . .	80	10	41	9	120	6,345,216
The Ajax	60	8	27	8	80	3,723,149
The Hercules	60	8	27	8	80	3,723,149
The Twins.	36	8	17½	8	73	3,454,616
Lea-bridge Water-wheels with Pumps 3			{20¼ 11	7 3	} 40	1,444,416
Stratford Water-wheel			{11 9	8 8	} 5	582,482
					568	26,734,126

The quantity of water which could be raised for the supply of the district, if all the engine-power was in constant use, would amount to 9,757,955,990 gallons; whilst the actual quantity for the last year was only 3,222,753,876, or about one-third only. The average annual expenditure seems to amount to 17,379*l.* 11*s.* 6*d.*, which does not much exceed one penny for the cost of 1000 gallons. These works are most admirably arranged, and possess power far greater than is at present employed. Every precaution is taken to distribute the water clear that can be adopted, where filter-beds are not constructed: the reservoirs are extensive, and the water is suffered to remain a sufficient time to be freed from all impurities which are held in it mechanically.

The Hampstead Waterworks receive their supply of water from the surface drainage of Hampstead, and from two artesian wells: there are several reservoirs at Highgate and Hampstead, whose areas united comprise about 35 acres; but no estimate can be formed of their contents without making accurate measurements: the water is not filtered, but delivered after it has been subject to depuration. At the Highgate works is a high-pressure non-condensing engine of 12-horse power; at the Kentish-town well is a 60-horse Cornish engine, which has a 44-inch cylinder, with a 10-feet stroke: 234 tons of coal were used under the boilers during the last year.

From what I have observed of the expenditure of these several water companies in the construction of engines and engine-houses, for pumping and for the distribution of the water, vast economy would have been the consequence if one general system had been laid down originally, which would have permitted of one management; one central system of works would not have required so much as half the engine-power now employed, and, consequently, the necessary buildings and engines would not have cost more than one-half the original outlay, besides the advantage gained of having the entire works within one boundary wall. In the laying down of the mains also, there would have been the greatest advantage if their diameters could have been proportioned to their absolute duty, and made to perform their distribution more after the natural arterial system: the trunk-mains, which vary in size from 30 inches to 24 inches; the branch-mains, from 12 inches to 6 inches; and the side-services, from 6 inches to 3 inches internal diameter might, by having their proportions of length given them, have been laid down with a very considerable saving of the original outlay.

The amount of engine-power employed by the several companies is as follows:—

	Horses.		Gallons.
Grand Junction	840	to raise	1,289,184,930
Southwark and Vauxhall	355	"	2,195,006,370
Lambeth	252	"	1,123,200,000
West Middlesex	245	"	1,216,929,312
Chelsea	320	"	1,438,458,000
New River	720	"	2,109,339,311
East London	568	"	3,222,753,876
Hampstead	72	about	100,000,000
Total	3372		12,694,871,799

But the total quantity of water delivered had been estimated at 16,748,440,362 gallons, some of which is not pumped. Then, from what has been already stated with regard to engines of the East London Waterworks, it would appear that if engines of 568-horse power could raise 9,757,955,990 gallons, and engines of 142-horse power could raise 2,439,488,998 gallons, engines of 710 could raise 12,197,444,988 gallons; then the engine-power possessed by the different companies is more than four-and-a-half times that which is required to perform the works demanded of them. At all the engine-houses the boilers are covered with cinders, ashes, or some other non-conducting material, the pipes jacketted with felt of several thicknesses, and it is reported, that since these precautions have been adopted, a saving of 12½ to 25 per cent. of fuel has been the consequence.

The length and weight of iron-main employed for the distribution of water cannot be correctly estimated from the data afforded by the different companies; but we may suppose the following number of yards to be not far from the truth:—

200,000 yards of trunk-main, varying from 30 to 24 inches internal diameter say, average 26 inches.
400,000 yards branch ditto, varying from 12 to 6 inches internal diameter say, average 8 inches.
1,200,000 yards side-service, varying from 6 inches to 3 inches internal diameter say, average 4 inches.

1,800,000 yards, or upwards of 1000 miles.

The reservoirs and filter-beds requisite to purify all the water distributed would occupy an area only of not more than 70 acres of land. We require daily 40,000,000 gallons of water, and therefore it should have depositing reservoirs to contain double that amount, and filter-beds to hold the same quantity. Seventy acres of reservoir and filter-bed, with a depth of 10 feet water, would contain 160,000,000 gallons, or thereabouts.

	Gallons.
The Grand Junction have capacity in their reservoirs and filters for	17,900,000
Southwark and Vauxhall	42,000,000
Lambeth	15,900,000
West Middlesex	35,000,000
Chelsea	
New River	
East London	35,000,000
Hampstead	

The capital expended by the several companies:—

	£	s.	d.
Grand Junction	522,295	4	9
Southwark and Vauxhall	435,247	0	0
Lambeth	307,352	8	1
West Middlesex	684,560	6	1
Chelsea	455,712	0	0
New River	1,421,717	0	0
East London	745,781	0	0
Hampstead	81,231	0	0
*			
	£4,653,895	18	11

The interest of which at 5 per cent. would be, per annum, 232,694*l.* 15*s.*; and if we take the quantity of water which is annually distributed at

	£	s.	d.
* Kent Water Company's Capital	202,104	13	6
	4,653,895	18	11
	£4,856,000	12	5

Interest at five per cent. 242,800*l.*

17,000,000,000 gallons, we shall find that every 1000 gallons must be charged 3¼*d.* to cover the interest of the capital expended.

I have carefully read over the evidence given in by the agents and officers of the several companies, and believe the whole to be correct as stated; the books of entry are well kept, and it would be practicable to obtain from them the hourly working of the engines, and quantity of water distributed for the same period if it is required. Before concluding, I must apologise for not rendering the report upon so important and interesting a subject complete; being limited in time, it has not been possible to collect all the information required to do so, and which the several companies will afford most willingly, should it be the wish of your Honourable Board that the inquiry should be continued.

EDWARD CRESY, C.E.

REGISTER OF ENGLISH PATENTS

RICHARD JEX CRICKMER and FREDERICK WILLIAM CRICKMER, of Page's-walk, Bermondsey, engineers, for *improvements in packing stuffing-boxes and pistons.*—Patent dated July 3, 1851.

Claim.—Combining metal with flexible and elastic materials for packing stuffing-boxes and pistons.

For packing stuffing boxes, sheets of wire cloth (the inventors prefer three) are laid on two or more sheets of canvas, then on a sheet of vulcanised india-rubber; then on two or more sheets of canvas; and finally, on another sheet of wire cloth or metal. These are formed into a ring, and joined together at the side or edge. The india-rubber being expanded, when put in its place, contracts, which preserves a tight joint, and prevents the escape of steam or water through the stuffing-box. When the rings are placed on each other, care must be taken that the joints are not placed above each other.

For packing pistons, sheet metal, perforated with holes, is used, which the inventors prefer to wire cloth. The same system of laying the coats is adopted in this case. The india-rubber is compressed, and expanding, causes the packing to be in close contact with the interior of the cylinder. The joint enables the ring to be placed around the piston without removing the cross-head.

The canvas or other woven fabric or fibre is prepared by saturating it in a solution of sixteen parts of grease or fat, to which is added three parts of black-lead, two of sulphur, and one of alum; but the inventors do not make any claim for this.

THOMAS, EARL OF DUNDONALD, Admiral of her Majesty's Navy, late of Chesterfield-street, Middlesex, for *improvements in the construction and manufacture of sewers, drains, waterways, pipes, reservoirs, and receptacles for liquids or solids, and for the making of columns, pillars, capitals, pedestals, vases, and other useful and ornamental objects, from a substance never heretofore employed for such purposes.*—Patent dated July 22, 1851.

The invention consists in the employment of the Bitumen Petrolium, or natural pitch of Trinidad and the British North American Colonies, a substance not heretofore used for the above-mentioned purposes. When it is required that the article or construction should be firm and strong, it is recommended that the indurated bitumen should be used; when it is required that they should be flexible, the bitumen of the Pitch Lake of Trinidad should be used; and when great elasticity is required, the bitumen may be mixed with natural bitumen or naphtha.

For the construction of sewers or reservoirs, loose gravel should be thrown on to the surface, previously formed of the required shape; on this, bitumen and gravel in a fused state is poured. A core is placed along the intended sewer, so that the bitumen may not be too thick, and may have an even surface; in the same way foundations, under or above water, can be formed. The bitumen is poured into the water, which causes it to set; but it still retains sufficient heat to allow of the further quantity thrown in to unite with it. It is proposed to form pipes by casting them in a mould; the several lengths of piping may be united by heating the ends and pressing the two portions together. Plates or sheets of bitumen are formed by pouring it out and passing heated rollers over it, care being taken that the bitumen does not stick to them: these sheets are available for forming floors; in this case one inch is the best thickness; and for lining cisterns, the walls of damp rooms, and other purposes, in this case half-an-inch is the best thickness. The sheets can be formed into pipes by bending them, when hot, round a core, and uniting the edges by heat. The bitumen forms an excellent covering for the wires of electric telegraphs. The wire can be drawn through the bitumen when warm; or when more than one wire is used, a hempen rope is placed in the centre, around which the bitumen is poured; it is then passed through a die having projections, which cause indents to be formed on the exterior of the bitumen. In these receptacles the wires are placed, and around these and the already formed body of bitumen a further coating is formed, thus perfectly insulating them. Various articles can be formed by casting. Lastly, the indurated bitumen can be used with great advantage in forming water-courses, by which the means mountain streams which exist in many portions of the colonies can be rendered available, instead of running to waste.

Thomas Sanders Bale, of Cauldon-place, Stafford, manufacturer, for *certain improvements in the method of treating, ornamenting, and preserving buildings and edifices, which said improvements are also applicable to other similar purposes.*—Patent dated July 17, 1851. [Reported in the *Mechanics' Magazine.*]

Claims.—1. The facing of buildings and edifices externally with plain hollow, corrugated or indented casings, tiles, or slabs, termed by the patentee, "weatherproof ceramic casings," such casings being either self-vitrifying bodies, or veneered, coloured, ornamented, vitrified, and glazed as described.

2. The ornamenting and preserving the interior of buildings and edifices by means of such casings adapted and applied thereto.

3. The casing of the exterior and interior of buildings and edifices with various kinds of bricks, blocks, &c. termed by the patentee "glazed veneered bricks," such bricks being either self-vitrifying bodies or veneered, coloured, ornamented, and glazed as described.

4. The manufacture of blocks, cornices, and other architectural subjects, either in self-vitrifying bodies, or veneered with coloured surfaces burnt in, or on the body, and vitrified, ornamented, and glazed, in order to be made weatherproof; and the application of the same to form chromo-encaustic architectural works, in contradistinction to the ordinary porous terracotta, paint, &c.

5. The coating of bricks, tiles, blocks, slabs, or casings for buildings, either before or after firing, with a superior surface applied thereto as "slip," "dust," or "layer," termed in every variety, "veneer," and coloured, vitrified, and glazed; and also the veneering with other substances, as stone, glass, and vitrified surfaces, such articles in a fired state, and the application thereof to the ornamenting and preserving of buildings.

6. The manufacturing of tiles, quarries, slabs, or blocks, hollow, for floors or pavements, and the ornamenting of floors and pavements thereby.

7. Certain methods of treating and ornamenting solid tiles, quarries, slabs, bricks, or blocks for floors or pavements, tesseræ, &c. and of imitating tesselated or mosaic work.

8. The manufacturing and veneering simultaneously bricks, tiles, and all such articles formed of plastic materials, as are, or may be employed for building purposes by means of suitable apparatus.

9. A method of perfecting or finishing hollow bricks, tiles, or blocks.

10. The application of glass and other diaphonous tiles or slabs, treated and ornamented in manner described for the construction of flooring or pavements.

11. Certain modes of treating building stones or blocks, by vitrifying or veneering and vitrifying the surfaces thereof, or by chipping out portions of the surface of the stone, and filling in the chipped out portions with slip, and then glazing and vitrifying the same.

John Holmes, of Birmingham, machinist, for *improvements in machinery for cutting and stamping metals.*—Patent dated June 24, 1851.

The invention consists, first, in an arrangement of machinery for punching buttons, eylets, rings, nails, steel pens, and other articles, from sheets of metal. The metal sheets are wound round a roller; these pass over a breast roller, and under a plate. At this point it is seized by a pair of metal jaws, which hold the sheet and draw it forward. These jaws receive the motion to perform this from a cam, worked by an eccentric in the main shaft of the machine. This main shaft also causes the punchers to move up and down. They pass through the plate above mentioned, and the metal blanks fall down into a receptacle provided for them. The object of the plate is to prevent the sheets rising or being disturbed after each motion of the punchers. The principal claim is for the method of drawing the sheets through.

The second part of the invention relates to an improved fly press, for manufacturing buttons, eylets, embossed discs, &c. The framework, screw, and lever are of the same construction as usual. To the screw is attached a hollow puncher, which the inventor claims. To this is attached a die, which fits on to a fixed die underneath. The centre part of the moveable die is fixed, but the outer portion is moveable; the centre portion forms the holes and centre of the button, the exterior the rim of the button. In the centre of the hollow puncher is affixed a spring, which forces out the finished button from the die, and renders it self-clearing. There are several claims for certain machinery to effect this; also a claim for the die. When buttons, &c. harder than brass, are manufactured, they are submitted to two processes; the first forms the button roughly, the second finishes it.

Charles Payne, of Wandsworth-road, for *improvements in drying animal and vegetable substances, and in heating and cooling liquids.*—Patent dated July 3, 1851.

Claims.—1. Improvements in drying animal and vegetable substances; 2. Improvements in heating and cooling liquids.

The substance to be dried is placed in a chamber which has an exhauster attached; the chamber is air-tight, with the exception of certain openings to admit the heated air; the more numerous these openings the better, in order that the air may be divided, and the temperature in all parts be equal. Chloride of lime or quicklime is placed at the bottom, to dry the air, as it is important that an equal temperature should be maintained. For the purpose of drying many substances, a smaller chamber is attached by tubes to the one above described. This has attached to it tubes provided with throttle-valves, to which a thermometric apparatus is attached. As the temperature increases or diminishes, so this apparatus acts on the valves, and allows, in the one case, dry air from the atmosphere to pass into the mixing chamber, and heated air from a furnace in the other case, whereby an even temperature is constantly maintained.

The improvements in heating and cooling liquids consist in employing apparatus for exhausting, in combination with suitable means for producing currents of heated or cold air, according as the liquids are to be heated or cooled. By this means the liquids are heated or cooled much quicker. The inventor does not claim the use of the exhausting or thermometric apparatus separately.

REVIEWS.

The Orders and their Æsthetic Principles. By W. H. Leeds, Esq. Second Edition, with considerable Additions. London: J. Weale. 1852.

Mr. Leeds' name cannot fail to recommend whatever it is attached to, for although every one may not agree with him in his doctrines—on the contrary, some may have reason to deprecate them—all must acknowledge, to themselves at least, that his opinions are eminently deserving of attention; and that howsoever some of them may be disliked, it would be no easy matter to gainsay them fairly, or by solid argument. With regard to the present treatise on the "Orders" it was so favourably spoken of on its appearance, and its character is now so well established, that a notice of it would be almost superfluous, were not this new edition greatly enlarged. Besides the notes—one or two of them, by the bye, rather pungent ones—and other fresh matter, we now find an Appendix, containing some detached pieces of criticism, which, although certainly *hors d'œuvres*, are so interesting, and pregnant with instructive remarks, that most of those who have the first edition will, we fancy, gladly possess themselves of the new one also, more especially as there is no increase in price, notwithstanding the great increase in quantity. With respect to quality, the Appendix contains a good deal of shrewd and stirring stuff. The first paper in it, entitled "Ruskin's Doctrine concerning the Orders," will no doubt greatly scandalise those who have cried up that gentleman as an oracle; and some of whom have even gone so far as to talk of the *insolence* of any one's presuming to question the soundness of the principles so dogmatically insisted upon by him. What, then, will be thought of Mr. Leeds, who, whatever others may be, shows himself to be neither awed by Mr. Ruskin's imputed ability as a critic, nor at all charmed by his eloquence as a writer? Most probably they will say just nothing, but leave Mr. Ruskin to fight his own battle, should he think fit to do so, with an adversary who is quite a match for him. On the other hand, some, and not a few either, will not be at all sorry that he has met with his match, and that he has here received well-merited castigation for his reckless and virulent abuse of the Ionic Order and of the Renaissance style—in fact, of modern architecture altogether.

The next paper, which discusses "The Possibility of a New Order," shows very clearly the mistakes and misconceptions which have hitherto unavoidably led to failure in all attempts to produce an entirely fresh order. From what is there said, it is evident that Mr. Leeds is anything but a bigotted and blindly superstitious admirer of Classical architecture. He advocates for the "Orders"—and not for them alone—that degree of freedom and unfettered artistic treatment which would first call for and exhibit individual talent. Whereas, according to the present system of stereotype forms and details, there is comparatively little difference between one man's Greek or Gothic, or whatever else the style may happen to be, and another's—between the masters and the pupils. We get correctness, but it is the correctness of plodding routine. He says truly—

"At any rate, if we have actually studied the Classical Orders to any purpose, and familiarised ourselves with the gusto of the antique generally, we ought to be able now to infuse something of the spirit and temperament of that style into our own conceptions. The possibility of doing so is indeed hardly to be questioned, when we find that sculptors, and even architects, can produce original ideas in correct Classical taste for vases, candelabra, and similar productions of artistic design, for which no positive and pedantic rules have been laid down—rules which, though they serve to bolster up mediocrity, and help mechanical dulness to pass itself off for art, operate as a clog upon genuine talent."

After quoting the above, we need hardly say that Mr. Leeds is far from orthodox; still, for our own part, we sincerely wish that his heresy may prove contagious: nor is it at all improbable that it will spread, it being communicated to the public in the form—far more popular than dignified—of an exceedingly cheap elementary treatise, several thousands of which, we understand, have been already sold.

The Glossarial Index is a feature as admirable as it is original and peculiar, and of itself alone would afford evidence, were it elsewhere wanting, not only of more than ordinary intelligence of, but also a most earnest relish for, the subject. After all, however, well satisfied as we are for the present, satisfied we shall not be for the future unless Mr. Leeds takes up his pen again, and gives a companion treatise on that general modern style of European architecture which is derived from and founded upon the Classical Orders.

Hydraulic and other Tables, with remarks on the Tides, Tide Tables, &c., and the principal Phenomena of British Tidal Rivers. Second Edition. By NATHANIEL BEARDMORE, M. Inst. C.E. London: Waterlow and Sons. 1852.

IT may be remembered that Mr. Beardmore produced some hydraulic tables which we recommended as very valuable; and we stated at the time that we thought he could produce considerable additional information, which is proved by the work now before us. We are glad to see that this has been done, and a mass of useful materials brought together, which will be found most acceptable to every branch of the profession as well as to the hydraulic engineer. The additional matter includes the whole subject of sluices, weirs, velocities, drains, circular and egg-shaped culverts, pipes under pressure, the friction of bends, water-power, steam-power, flood discharges, flow from large districts, wells, value of water by meter, rainfall of England, suspension bridges, cast-iron beams, mountain barometer, marine surveying, tidal phenomena, dimensions of docks, hydraulic ram, and hydraulic problems, with copious tables of tides. What will be none the less acceptable are the several plates, including tide charts of the Irish Channel, English Channel, co-tidal lines of the world, the rivers Mersey, Severn, Tyne, and Nene.

The work is very closely printed, and is put in a very compendious form.

Key to Tate's Exercises on Mechanics and Natural Philosophy. By THOMAS TATE, F.R.A.S. London: Longman, Brown, Green, and Longmans. 1852.

WE were happy to notice Mr. Tate's Exercises, and we now announce the publication of the Key to those 'Exercises on Mechanics and Natural Philosophy.' In this will be found many practical problems, carefully worked out, and which will be found useful, not only to the student, but the professional man.

As an example of Mr. Tate's useful work, we give a few of his exercises:—

"*Ex.* 12.—What must be the traction of a horse to draw a load of 2 tons up a hill having a rise of $\frac{1}{2}$ in 100, the coefficient of friction being $\frac{1}{20}$?

Suppose the load to be moved over 100 feet.

Resistance friction in lbs. $= \frac{1}{20}$ of $2 \times 2240 = 224$ lb.

Work due to friction $= 224 \times 100 = 22400$.

" " gravity $= 2 \times 2240 \times \frac{1}{2} = 2240$.

$\therefore$ Total work to be done by the horse $= 22400 + 2240 = 24640$.

But we have also,

Work of horse = traction $\times$ 100.

$$\therefore \text{Traction} \times 100 = 24640; \quad \therefore \text{Traction} = \frac{24640}{100} = 246{\cdot}4 \text{ lb.}$$

Ex. 13.—A horse can just draw a load of 1 ton up a hill (having a small inclination), while he can draw a load of $1\frac{1}{2}$ tons down the hill: it is required to find the rise of the hill for every 100 feet, when the coefficient of friction is $\frac{1}{20}$.

Suppose the hill to be 100 feet long, and let $x =$ the no. ft. rise of the hill in 100 ft.

Resistance friction up the hill $= \frac{1}{20}$ of 2240 lb. $= 112$ lb.

" friction down the hill $= \frac{1}{20}$ of $1\frac{1}{2} \times 2240$ lb. $= 168$ lb.

Work due to gravity up the hill $= 2240 \times x$.

" " friction " $= 112 \times 100$.

$\therefore$ Total work to be done by the horse up the hill $= 2240 \times x + 112 \times 100$.

Work due to gravity down the hill $= 1\frac{1}{2} \times 2240 \times x = 3360 \times x$.

Work due to friction down the hill $= 168 \times 100$.

$\therefore$ Total work to be done by the horse down the hill $= 168 \times 100 - 3360 \times x$.

Now, since the horse is supposed to exert the same traction in going up the hill as he does in going down the hill, therefore he must do the same work in both cases; hence we have—

$$2240 \times x + 112 \times 100 = 168 \times 100 - 3360 \times x,$$
$$\therefore 5600x = 5600; \quad \therefore x = 1 \text{ foot,}$$

which is the rise of the hill for every 100 feet.

Ex. 14.—The work in moving a load (say of 1 ton) up a hill, of small inclination, is $1\frac{1}{2}$ times the work in moving the same load down the hill; required the rise of the hill, supposing the coefficient of friction to be $\frac{1}{10}$.

Suppose the hill to be 100 feet long, and $x =$ the rise in this distance; then we have

Work up the hill $= \frac{1}{10}$ of $2240 \times 100 + 2240 \times x = 22400 + 2240 \times x$.

Work down the hill $= \frac{1}{10}$ of $2240 \times 100 - 2240 \times x = 22400 - 2240 \times x$.

Hence we have, by the question,

$$22400 + 2240 \times x = 1\tfrac{1}{2}\,(22400 - 2240 \times x);$$
$$\therefore 5600 \times x = 11200, \quad \therefore x = \frac{11200}{5600} = 2 \text{ feet.}"$$

THE WORKING ENGINEERS' STRIKE.

FEW circumstances have given us greater pain than the strike by which the working engineers have paralysed a great branch of industry. With every feeling of commiseration for the sufferings of the men, and after a due consideration of the statements put forward by them, we cannot find a justification of the course they have pursued, while we see painfully the injurious results which must be inflicted on them, on their employers, and on the country. If any other ground for the strike were admissible, most certainly the issue of it must be unfortunate in a trade so much dependent on foreign orders for its prosperity, and which has to compete with foreigners for its existence. The amount of the export trade in machinery is so large, that it ranks among the chief staples of manufacture; but it is carried on against the competition of Americo-English and Belgians. In some articles our rivals have advantages in the price of labour, in others by their neighbourhood to the markets to be supplied; and they are prepared to profit by every incident which promises to extend their trade and to cripple ours. The result of the strike must therefore be disastrous. The business of individual factories will be checked, that of particular towns diverted, that of the country generally diminished, while the workman will in the end receive lower wages, besides encouraging the construction of machines to supersede his labour and to give employment to other branches of trade. The effect of strikes has been uniformly injurious, but more particularly to the working classes: and this promises to be no exception.

It must not be lost sight of, that with all the pretension to be for the benefit of the working engineers, this strike is not only directed against the other labourers employed, but against the best of the working engineers themselves. The most skilled, the most thrifty, and the most industrious workmen are to be restricted in their earnings, in order that the idle and dissolute may receive wages which they have not earned. In this, as in other instances, success has emboldened the intriguers. They have been able hitherto to annoy and coerce the employers, and thus they proceed more confidently to the present desperate venture.

With regard to the position of the employers, we think they are quite right in maintaining their ground. They are, as they say, the customers of the men, and they are contending for the rights of themselves and their workmen, to bargain with each other free from the dictation and coercion of any individual or organised body. The idea has been abandoned that legislatures can propose, or governments secure, tariffs or assizes of wages and prices; and surely the time has come when the insane pretensions of unions and union scales should be set aside by working men and the public. No union ever got for a good man better wages, but each union has deprived many a master of work and many a man of employment.

The following statement of the case of the employers gives their reason for declining arbitration, and for resisting the claims of the unionists:—

"On Saturday the establishments of all our members were closed. The conditions of an honourable pledge to each other have been faithfully fulfilled; and masters and men, free of their mutual engagements, will be once more called upon to settle the conditions of any new contract into which they may find it for their reciprocal interest to enter.

"The step which we have adopted, with regret, made all the more acute by a sense of the hardship it will inflict upon the innocent and the deserving, entails upon us all a certain heavy loss. We are reluctantly reconciled to it by the conviction, maturely weighed, and painfully arrived at, that our well-disposed workmen had better patiently bear a present burden than linger under a permanent oppression; and that we ourselves can only arrest the encroachments of irresponsible dictation, and the gradual but certain progress of that spirit of exaction to which we have already, from motives of conciliation, too easily yielded (to the injury of our trade, and the certain ruin of the operatives, at whose instance unwise concessions have been too readily made), by taking our stand at once, and coming to a reckoning now and here.

"All we want is to be let alone. With less than that we shall not be satisfied. Until we accomplish that, we shall not re-open our establishments. With every respect for noble and distinguished referees, whose arbitration has been tendered to us, and with no reason to doubt that their award would be honest, intelligent, and satisfactory, we must take leave to say, that *we* alone are the competent judges of our own business; that we are respectively the masters of our own establishments; and that it is our firm determination to remain so. To this principle we recognise no exceptions. We should as little dream of permitting each other, as a common neutral stranger, to lay down the rules by which we are respectively to manage our individual affairs. Ours is the responsibility of the details; ours the risk of loss; ours the capital, its perils, and its engagements. We claim, and are resolved to assert the right of every British subject, to do what we like with our own, and to vindicate the title of our workmen to the same constitutional privilege. Artisans and their employers are respectively individuals—each legally capable of consent—each severally entitled to contract. Our agreements for their service are made with them in their separate, not in their aggregate capacity. They have labour and skill to sell; we have capital to employ it, and to pay it. Who, then, or what, should stand between these two single parties to a lawful bargain, and dictate to the buyer what he should give, or control the seller in the conditions of his service? In the most literal sense, we are the customers of the working classes; and the interference of self-constituted arbiters with the internal economy of our establishments is not less preposterous than would be a command from our baker as to the number or the price of loaves we should consume; or a mandate from our butcher as to when we should dine, and what should be the meat. We altogether ignore the proposition that we should submit to arbitration the question whether our own property is ours, and whether we are entitled to be the masters of our own actions.

"Our business renders us more obnoxious to strikes than any other, and renders precautions against them more imperative. The heavy expense of our machinery and tools, and the peculiar character of the work we produce, render over-time, piece-work, and irregularity of employment, an unavoidable and certain incident of our calling. We cannot, like the spinner, the weaver, or the cloth-worker, manufacture on speculation, and produce without order, certain that ultimately the article will be required, and must always be in demand. The same yarn will weave to any pattern, the same cloth will fit any coat;—but we can only produce to order, and we must produce our commodity when it is ordered. Our customers require all their purchases for a special purpose, and at a particular time. Perhaps they are useless to them, unless supplied when stipulated—certainly they will cease to employ us, if we fail to finish to our time. Belgium and Germany are not far off. Piedmont and Switzerland are quite within competitive distance. The United States begin to manufacture for themselves, and even to meet us in neutral markets. France, but recently our largest customer, is now our most formidable rival, and in spite of her disadvantages in reference to the raw material, almost entirely supplies her own demand. If we are to enjoy an equality of advantages with our competitors in the common market of the world, we must consent to bind ourselves to complete our contracts on a day, early, and certain. Short-sighted unionists, aware that we work against time, some of us under actual penalties, all of us under peril of the loss of trade if we fail in punctuality, induce the men, when the master is in his greatest difficulty, to take advantage of his necessities to wring from him humiliating and unjust concessions, which leave him without profit, or threaten him with loss. Afraid to subject himself to the repetition of practices which present to him only alternative betwixt heavy fines for failure of contracts, or loss of business-character, and exorbitant remuneration for inferior skill, the master declines otherwise profitable orders, draws his operations narrower, and diminishes the demand for labour; and this dread, spreading generally through the trade, and too amply justified by offensive interference, forced upon every master, induces a universal disposition to decline the most valuable custom, and thereby seriously to depress the business, and circumscribe the employment of the country."

PILE FOUNDATIONS.

Rule for Calculating the Weight that can be safely trusted upon a Pile which is driven for the Foundation of a Heavy Structure. By John Sanders, Brev. Maj. U.S. Eng.

A simple empirical rule, derived from an extensive series of experiments in pile-driving, made in establishing the foundation for Fort Delaware, will doubtless prove acceptable to such constructors and builders as may have to resort to the use of piles, without having an opportunity of making similar researches. I believe that full confidence may be placed in the correctness of this rule, but I am not at present prepared to offer a statement of the facts and theory upon which it is founded.

Suppose a pile to be driven, until it meets such an uniform resistance as is indicated by slight and nearly equal penetrations, for several successive blows of the ram; and this is done with a heavy ram (its weight at least exceeding that of the pile), made to fall from such a height that the force of its blow will not be spent in merely overcoming the inertion of the pile, but at the same time not from so great a height as to generate a force which would expend itself in crushing the fibres of the head of the pile. In such a case it will be found that the pile will safely bear, without danger of further subsidence, *as many times the weight of the ram as the distance which the pile is sunk the last blow is contained in the distance which the ram falls in making that blow, divided by eight.* For example, let us take a practical case in which the ram weighs 1 ton and falls 6 feet, and in which the pile is sunk half-an-inch by the last blow; then, as half-an-inch is contained 144 times in 72 inches, the height the ram falls, if we divide 144 by 8, the quotient obtained, 18, gives the number of tons which may be built with perfect safety, in the form of a wall, upon such a pile.—*Franklin Journal.*

PROCEEDINGS OF SCIENTIFIC SOCIETIES.

INSTITUTION OF CIVIL ENGINEERS.

Dec. 23, 1851.—Sir WILLIAM CUBITT, President, in the Chair.

The Annual General Meeting for the election of the President, Vice-Presidents, and other Members of Council, for the ensuing year, for receiving the Annual Report of the retiring Council, and distributing the medals and premiums, was held on this evening.

The Report referred particularly to the late Great Exhibition, many of the competing designs for the building, as well as the suggestions for the guarantee fund, and several important points connected with the classification, &c., having emanated from members of the Institution; and amidst the Royal Commissioners, the Building Committee, their Executive staff, and the Jurors, many were to be found; even the designer of the present building, and those whose energies were so successfully devoted to the task of its construction, also belonged to the Institution; whilst the weight of responsibility, the arduous duty of supervision, the honour of acting as the master mind to weigh the requisites, to determine the design, and to govern the construction, were reserved for Sir William Cubitt, the President. The visitors from foreign lands received much assistance and information in their inquiries in this country, and it was confidently hoped, that the relations with other countries might become more intimate, and that collective and individual benefit would be promoted.

The principal papers which had been read were noticed, and their objects and merits explained in a few expressive sentences; though it was regretted that they were not so numerous as usual, and in consequence the list of subjects for the ensuing session had been much altered and modified, and the attention of gentlemen known to possess information on any subject, had been directed to it, with a pressing request that they would favour the Institution with the results of their experience.

The following medals and premiums were awarded:—Telford Medals to Messrs. Clegg, Wyatt, Swinburne, Bruce, Hughes, Struvé, and Newton; and Council Premiums of Books to Messrs. Glynn, Blackwell, Leslie, and Carr.

In speaking of the subject of publication, the completion of the Library Catalogue was mentioned, and it was stated, that not only was the utility of the work admitted by the members, but the plan of its formation, and the accuracy of its execution, had been generally approved by the best authorities; this, it was hoped, would lead to the presentation of standard works of reference for the library, which it was desirable to bear in mind was supported entirely by voluntary contributions.

Notwithstanding several deceases and resignations, the effective increase in the number of members, which now amounted to seven hundred and sixteen of all classes, was equal to that of any previous year, and far greater than the average.

Memoirs were read of the following: the Most Noble the Marquis of Northampton, Honorary Member; Messrs. W. Brunton, G. S. Dalrymple, J. Farey, W. Mackenzie, and H. Renton, Members; and Colonel Jervis, B.E., Messrs. S. B. Moody, J. H. Tasker, G. B. Thorneycroft, W. West, and J. Wilson, Associates.

The memoirs were succinct records of eventful lives. They noticed feelingly the virtues and talents of Lord Northampton;—the mechanical skill of Mr. Brunton—almost the last of the old school of engineers;—the patient industry and laborious research of Mr. Farey, to whom, with the Lowries, the engravers, was due the merit of improving the style of illustration of the scientific works of the present time;—the gigantic engineering undertakings of Mr. Mackenzie, who, with his coadjutors Mr. Brassey and Mr. John Stephenson, had, since 1833, executed railway and other works, to the amount of upwards of seventeen millions sterling, and from a very humble station, had risen by his own talent and industry to a high station among his compeers;—the brilliant military career of Colonel Jervis and his greater merits, in devoting his time and energy to the introduction of the blessings of education among the natives of India;—the practically useful careers of Mr. Thorneycroft and Mr. Wilson, two men who, from the positions of a workman in a forge, and the son of a farmer, rose by industry, talent, and upright conduct to great wealth and the first rank as eminent iron masters in Staffordshire and in Scotland, and to serve as models of the most useful class of this country.

The Report concluded with the expression of a hope on the part of the Council, that the profession would be firmly united for the prosecution of the legitimate objects of the Society, and by their acts, in and out of the Institution, would strive to confirm the universal confidence in the skill, honour, and integrity of English engineers.

The thanks of the Institution were voted unanimously to the President, Vice-Presidents, and other members of Council; also to the Auditors and the Secretary, for their great exertions on behalf of the Institution, and to the Scrutineers of the Ballot, for the kindness with which they undertook that office.

The following gentlemen were elected to fill the several offices in the Council for the ensuing year:—James M. Rendel, *President*; J. K. Brunel, J. Locke, M.P., J. Simpson, and R. Stephenson, M.P., *Vice-Presidents*; G. P. Bidder, J. Cubitt, J. E. Errington, J. Fowler, C. H. Gregory, J. Hawkshaw, J. R. M'Clean, C. May, J. Miller, and J. S. Russell, *Members*; and J. G. Appold, and E. L. Betts, *Associates of Council.*

Sir W. CUBITT, President, returned his sincere thanks to the members, for the kindness which they had evinced towards him during his tenure of office, and expressed the hope that the same good feeling would be exhibited to his successor, whose eminence in the profession, and undoubted abilities, well qualified him to hold the office with advantage to the Institution and credit to himself.

Jan. 13.—JAMES MEADOWS RENDEL, Esq., President, in the Chair.

The proceedings of the evening were commenced by an Address from the President on taking the Chair, for the first time, after his election; but we omit giving the brief abstract of his Address, in the hope of giving it in full in our next number.

Jan. 20.—The Paper read was "*On the Alluvial Formations, and the Local Changes, of the South-Eastern Coast of England. Second Section,—from Beachy Head to Portland.* By J. B. REDMAN, M. Inst. C.E.

Westward of Beachy Head the effects produced by local variations in the beach were traced,—the "fulls" tailing across the outfall of Cuckmere Haven, and driving the outlet eastward, creating a barrier of beach at Seaford—at an early period the outfall of Newhaven Harbour—where an ancient outlet existed on the site of the present entrance, subsequently projected eastward, by the passage of shingle from the westward, until rendered permanent by piers. The recent degradation of the shore along Seaford Bay, from the shingle being arrested to the westward, and the unavailing attempt to stop this movement by blasting the cliff at Seaford Head were noticed. The waste of the coast at Rottingdean, the modern changes at Brighton, the great variations in the outlet of Shoreham Harbour, until rendered permanent by artificial works, were examined; as well as the analogous effects on the coast generally at Pagham, across the entrance of which a spit had been formed, similar to those at the ancient harbours of Romney and Pevensey. The anchorage of the Park, off Selsey Bill, once presumed to have been a portion of the site of a bishop's see, prior to its removal to Chichester, owing to the progressive waste of the shore. At the back of the Isle of Wight, the peculiarities of the land-locked harbours, and the protection afforded by the shore defences to Portsmouth harbour, so little altered in its general outline since the time of Henry VIII., were described, as also the remarkable promontory called Hurst Point, many of the characteristics of which were similar to those of the Chesil Bank, Calshot Point, and other formations, such as a low flat shore to leeward (eastward), and a highly inclined beach seaward, with a tendency to curve round to the northward and eastward, and eventually to inclose a tidal mere, or estuary. The elevation and size of the pebbles increased towards the extremity of these points, and in places on the sea slope an intermixture of coarse sand and shingle, which had become solid and homogeneous by age, cropped out through the modern beach. The remaining portion of the coast of Hampshire and that of Dorsetshire, as far as Weymouth, were then minutely described, and the paper concluded with a particular account of the Chesil Bank, which in magnitude far exceeded all other formations of the kind, and which it was considered might be attributed to the waste of the great West Bay.

Numerous diagrams, compiled from ancient and modern maps, together with sections and sketches of the various alluvial spits along the coast, were exhibited; and it was shown, that all these local accumulations had many features in common, and were subject to the same alternating effects of loss and gain, and were the resultant of causes in constant operation, the whole exercising a most important influence on harbour and marine engineering generally.

In the discussion which ensued, in which Sir C. Lyell, Sir E. Belcher, Mr. Rennie, Capt. O'Brien, Mr. Scott Russell, and the author, took part, the peculiarities of the different parts of the coast were still further described, and the formation of the moles of shingle were attributed, by some of the speakers, to the action of the tidal currents, but more generally, by others, to the mechanical power of the waves alone, which appeared to account for the apparently anomalous fact, that the largest pebbles were always found on the summit and to leeward. Chesil, Hurst, and Dungeness beaches were referred to, as remarkable instances of results produced by such causes; and the effect of the severe storm of November, 1824, on the base of Hurst Beach, was alluded to.

A short account of Mr. Deane's submarine researches on the Shambles Shoal, off the Bill of Portland, was read, describing that shoal to consist entirely of a bed of small broken shells, arranged in parallel shelves, or steps, instead of, as had been supposed, being formed of boulders and pebbles. This peculiar arrangement of light shells, at depths varying from 4 to 9 fathoms, must be the result of the action of the currents forming a spot comparatively without motion, and induced curious speculations as to the causes of the accumulation, and the effects that might be produced on similar aggregations by artificial works.

Jan. 27.—The Discussion upon the above paper was renewed, and many of the views stated by the author were still further argued. It was stated, that the formation of such points as Dungeness and Langley were always found to windward of the outfall of a river, which, in the former case, passed through a clay district, bringing down much deposit, forming an accretion, or delta, in the low shallow water at the outfall. This was thought to be a more natural explanation of such phenomena, than to assign them to the mere force or action of the waves, or the tidal currents, causes which must have been in operation, unchanged, for ages; and it was asserted, that it was physically impossible for any tidal currents which existed in the channel to have had much to do with their formation. A shallow shelving coast was also thought to be favourable to the formation of these points, and Selsea Bill was instanced as a case in which this accretion was actually in a state of progression, whereas Dungeness and Langley might be supposed to be nearly completed. Other speakers argued, that these formations took place on clay deposits, whether they simply formed the coast line, or were protruded beyond it, and that the Shambles shoal was formed on a nucleus rock, with a superficial covering of shells.

The depth at which shingle would travel under water was considered to be a very important point in this question, as on it really depended the right principles for executing many engineering works. From actual experience, it had been observed, that it did not travel at a greater depth than from two fathoms to three fathoms; so that when a natural headland, or an artificial work, as a pier or groyne, was projected into that depth of water, the passage of shingle round it was arrested.

Some difference of opinion appeared to exist as to the position of the largest pebbles on a cross section of these banks. On the one hand it was asserted, that they were invariably found to have attained the greatest altitude; that this was the case in the Hurst, Langley, and other beaches to the eastward, and that it might be attributed to the force of the approaching wave being greater than that of the receding one, so that large pebbles brought up by the former would be left, whilst the smaller ones would be clawed away by the reflux. On the other hand, the Chesil Bank was cited as an instance to the contrary, where the smallest pebbles were stated by some authorities to be on the top. Both parties, however, agreed that the largest pebbles were always to be found at the leeward point of the formation.

With regard to the action of the meeting of the tides in the Channel, as shown by the charts of Captain Beechey, it should be observed, that the point of junction and parting oscillated over a sea-board of nearly sixty miles, and therefore its action would be over a corresponding latitude, and thus it could exercise but little influence in isolated cases.

The Paper read was a "*Description of a Cast-Iron Viaduct erected at Manchester, forming part of the Joint Station of the London and North-Western, and Manchester, Sheffield, and Lincolnshire Railways.*" By A. S. Jee, M. Inst. C.E.

The object of this structure was to obtain increased accommodation for the goods station of the two companies, which was formed on brick arches, at a level of about 30 feet above the adjacent streets, the arches themselves being used as goods warehouses, and the communication between the two levels being effected by means of hoists. This extension was 700 feet long and 36 feet wide, and as it was necessary that it should cover, without interfering with, the lines of way on the low level, a row of Doric columns of cast-iron, surmounted by an entablature forming the inclosure of the station, was arranged, each about 20 feet apart from centre to centre, on the outer boundary of the space to be occupied, and on these one end of a transverse cast-iron girder was placed, the other end being supported by the brick arching. To the transverse girders, longitudinal cast-iron girders, one to each rail, were attached, and to these half-balks of Memel timber were bolted, the whole being planked with 3-inch deals, on which three lines of way, and an ample supply of turn-tables for working the traffic, were laid.

To effect a communication between this station and a warehouse belonging to the Sheffield Company, Store-street had to be crossed, which was done by means of wrought-iron girders, 68 feet clear span, of peculiar construction. The top part of these girders consisted of a cylindrical tube, 2 feet in diameter, made of boiler-plate half-inch thick; the middle web was 3 ft. 6 in. in depth, and formed of plates $\frac{7}{16}$-inch thick; the bottom flange was 20 inches in width, and at the centre was composed of three plates, each $\frac{3}{4}$-inch thick, diminished to one plate at the ends. These girders were each tested with a weight of 60 tons at the centre, when the deflection was not found to exceed one inch.

The whole of the cast-iron work was of Stirling's toughened iron, by which a saving in weight, of about one-fourth of the quantity that would have been necessary with ordinary iron, was effected, without any diminution in the absolute strength. Messrs. Robinson and Russell were the contractors, and they had most satisfactorily performed the work, the total cost of which, including twenty-one turn-tables, was under 14,000*l.* or about 20*l.* per lineal foot.

The Paper announced to be read at the meeting of Tuesday, February 3rd, was "The Construction and Duration of the Permanent Way of Railways, and the modifications most suitable for Egypt, India, &c." By W. B. Adams.

ROYAL SCOTTISH SOCIETY OF ARTS.

Jan. 12.—Dr. Lees, President, in the Chair.

The following communications were made:—

"*On some new methods calculated to facilitate the application of Ancient Arts to the decoration of Sepulchral Monuments.*" By D. Wilson, LL.D. — Dr. Wilson commenced by calling attention to the want of taste, and the misapplication of heathen symbols, so frequent in our cemeteries, where, in Scotland especially, the Christian is seen to reject the Cross—the symbol of the Christian faith—for inverted torches, serpents and globes, urns, sarcophagi, and the like obsolete or meaningless symbols. He then stated in detail various processes calculated to render the restoration of monumental brasses easy, by diminishing the cost of their production. In illustration of this portion of the paper, a selection of rubbings from ancient sepulchral brasses was exhibited. The next process adverted to was a modification of the encaustic style, highly advantageous from its extreme durability, and its resistance to moisture. This was also illustrated both by ancient and modern specimens. The third process may be described as a modification of the ancient incised slab, combining with it some of the advantageous applications of colour peculiar to the former. In describing its advantages, Dr. Wilson specially adverted to the unsuitableness of white marble for exposure to our variable climate; and expressed his conviction that some more durable substitute must be soon generally recognised as indispensable for the mural monuments of our public cemeteries.

"*Description of a Galvanic Apparatus for Medical purposes.*" By W. Hart, Jedburgh.—This galvanic apparatus is designed for medical purposes, and contains an improved regulating index, moving on a circular scale, having seventeen gradations of power, but which might be increased to any extent, and which is considered exceedingly convenient and economical. The battery contains six platinised lead plates, and seven of zinc, all in one cell, which is made of lead and platinised, exposing a large surface of metal, and producing a large quantity of electricity without intensity. To put the machine into action, the plates must be let down to the bottom of the trough, which is to be previously half-filled with a solution consisting of one part of sulphuric acid and nine parts of water. The two binding screws in front of the box fix the wires joined to the handles for receiving the shock. To stop the galvanic action, the plates are to be lifted to the upper part of the half-filled trough. The machine can be produced at a cheap rate, and kept up at very little expense; and is so simple that any person can use it.

NOTES OF THE WEEK.

M. Mathias.—It is with deep regret we announce the death of M. Mathias; and none the less so, that it was caused by himself. The civil engineers of France owe a great debt of gratitude to M. Mathias, not only for the works which he published, but for his personal exertions to promote the interests of their profession, to obtain its emancipation from government control, and to extend the bases of scientific instruction. In England —where he had so recently been to prepare a French catalogue raisonnée of the Exhibition—his merits were well known to many, and his loss will be regretted more particularly by those who having visited Paris had experienced his readiness to promote the studies of professional men.

Bangor Board of Health.—Mr. Austen, C.E., has sent in his report on the Bangor Survey to the General Board of Health. He states,—That he has examined very fully the plans of the Borough of Bangor, prepared for the purposes of the Public Health Act by Mr. Johnson, surveyor, by direction of the Local Board of Health of that district, and considers that the work has been very creditably and satisfactorily carried out. The lines of construction of the survey have been judiciously laid out, and very carefully measured and plotted. On examining the work on the ground he found that the detail had been very accurately laid down, but it appeared to be wanting generally in little features and points of information which would be found essential to its completeness for the purpose in view, and that the plan would be improved also, owing to the peculiarity of the site, by a closer system of levels than had been inserted, or than would be usually necessary. These suggestions having met with attention, he has recommended that the approval of the General Board of this survey may be granted. The General Board have, in accordance with this report, given their approval. The drainage of the town has been taken under consideration, and the Board have appointed Mr. Johnson, their surveyor, to carry it out, and to superintend the whole of the details.

Proposed Railway at the Cape.—The project of a railway from Cape Town to Wellington has been under consideration, and the engineers, Messrs. Fox and Henderson, have offered to construct such a railway, in a thoroughly efficient manner, for the sum of 500,000*l.* The total length of the proposed line, inluding branches, is 72½ miles. The lines are to be opened and at work within eighteen months after the contractors are placed in possession of the land: and the whole work is to be completed in two years.

Servia.—Mr. White, C.E., is on his way to Belgrade, to treat in the name of an English Company with the Servian Government for the construction of a railroad from Alexinac (probably Alexinitza, near Nissa, on the Bulgarian frontier) to Semendria. It is expected that the Servian Government will continue the railroad from Semendria to Belgrade at its own expense.

LIST OF NEW PATENTS

GRANTED IN ENGLAND FROM DECEMBER 11, TO JANUARY 22, 1852.

Six Months allowed for Enrolment unless otherwise expressed.

Thomas Twells, of Nottingham, manufacturer, for certain improvements in the manufacture of looped fabrics.—December 15.

Frederick William Norton, of Paisley, Renfrewshire, North Britain, manufacturer, for certain improvements in the manufacture or production of plain and figured fabrics.—December 16.

John Gedge, of Wellington-street, Strand, Middlesex, for improvements in the treatment of certain substances for the production of manures. (A communication.)—December 16.

James Souter and James Worton, of Birmingham, for improvements in the manufacture of papier maché, and in articles made therefrom, and and in the manufacture of buttons, studs, and other articles where metal and glass are combined.—December 17.

William Hirst, of Manchester, manufacturer, for certain improvements in machinery or apparatus for manufacturing woollen cloth, and cloth made from wool and other materials.—December 19.

Moses Poole, of London, gentleman, for improvements in apparatus for excluding dust and other matters from railway carriages, and for ventilating them. (A communication.)—December 19.

Henry Clayton, of Atlas Works, Upper Park-place, Dorset-square, for improvements in the manufacture of tubes, pipes, tiles, and other articles made from plastic materials.—December 19.

Samuel Wilkes, of Wolverhampton, brass founder, for improvements in the manufacture of kettles, saucepans, and other cooking vessels.—December 19.

Joseph Burch, of Craig Works, Macclesfield, for improvements in printing and ornamenting cut pile, and other fabrics and yarns.—December 19.

Christopher Rands, of Shad Thames, miller, for improvements in grinding wheat and other grain.—December 19.

James Frederick Lackerstein, of Kensington-square, civil engineer, for improvements in machinery for cutting or splitting wood and other substances, and in the manufacture of boxes.—December 19.

Frederick Bousfield, of Devonshire-place, Islington, gentleman, for a new manufacture of manure.—December 19.

Charles Howland, of New York, engineer, for improvements in apparatus for ascertaining and indicating the supply of water in steam-boilers.—December 19.

William Elliott, of Birmingham, manufacturer, for improvements in the manufacture of covered buttons.—December 19.

Rodolphe Helbronner, of Regent-street, for improvements in apparatus used when obtaining instantaneous light.—December 19.

John Thornton and James Thornton, both of Melbourne, Derby, mechanics, for improvements in the manufacture of meshed and looped fabrics and other weavings, and in raising pile and looped fabrics and other weavings.—December 19.

William Emery Milligan, mechanical engineer, of New York, for certain improvements in the construction of boilers for generating steam.—December 19.

Charles Lamport, of Workington, Cumberland, ship-builder, for improvements in reefing sails.—December 19.

Richard Archibald Brooman, of the firm of J. C. Robertson and Co., of Fleet street, patent agents, for improvements in sounding instruments. (A communication.)—December 19.

John Davie Morries Stirling, of Black-grange, North Britain, Esq., for certain alloys and combinations of metals.—December 22.

Sydney Smith, of Nottingham, for improvements in indicating the height of water in steam-boilers.—December 22.

Augustus Applegarth, of Dartford, Kent, for improvements in machinery used for printing.—December 24.

Antonio De Sola, of Madrid, Spain, for certain improvements in the treatment of copper minerals. (A communication.)—December 24.

Christopher Nickels. of York-road, Lambeth, and Thomas Ball and John Woodhouse Bagley, of Nottingham, for improvements in the manufacture of knitted, looped, and other elastic fabrics.—December 24.

Alfred Vincent Newton, of Chancery-lane, Middlesex, mechanical draughtsman, for improvements in separating substances of different specific gravities.—December 24.

Joseph Stenson, of Northampton, engineer and iron manufacturer, for improvements in the manufacture of iron, and in the steam apparatus used therein; part or parts of which are also applicable to evaporative and motive purposes generally.—December 27.

Robert Beck Froggatt, of Sale Moor, Chester, manufacturing analytical chemist, for improvements in the preparation of certain compounds to be used for the purpose of rendering woven and textile fabrics, paper, leather, wood, or other materials or substances waterproof and fireproof, and also in machinery or apparatus employed therein.—December 31.

Francis Hastings Greenstreet, of Albany-street, Mornington-crescent, for improvements in coating and ornamenting zinc.—December 31.

George Gwynne, of Hyde Park-square, Middlesex, Esq., and George Fergusson Wilson, managing director of Price's Patent Candle Manufactory, Belmont, Vauxhall, for improvements in treating fatty and oily matters, and in the manufacture of lamps, candles, night-lamps, and soap.—December 31.

George Collier, of Halifax, York, mechanic, for improvements in the manufacture of carpets and other fabrics.—December 31.

Francis Clark Monatis, of Earlstown, Berwick, builder, for an improved hydraulic syphon.—December 31.

David Napier, of Millwall, engineer, for improvements in steam-engines.—December 31.

Thomas Barnett, of Kingston-upon-Hull, grocer, for improvements in machinery for grinding wheat and other grain.—January 8.

Joseph Addenbrooke, of Bartlett's-passage, London, envelope manufacturer, for improvements in the manufacture of envelopes, and in machinery used therein.—January 8.

Charles Dickson Archibald, of Portland-place, Middlesex, Esq., for improvements in the manufacture of bricks and other articles made of plastic materials, and in cutting, shaping, and dressing the same; as also stone, wood, and metals, and in machinery and apparatus employed therein. (A communication.)—January 8.

William Cook, of Kingston-upon-Hull, working coppersmith, for certain improvements in the construction of steam-engines, consisting of a rotary circular valve for the regular admission of steam from the boiler alternately into the chambers of the two cylinders of double-acting engines.—January 12.

Alcide Marcellin Duthoit, of Paris, France, statuary, for an improved chemical combination of certain agents for obtaining a new plastic product.—January 12.

Robert John Smith, of Islington, Middlesex, gentleman, for certain improvements in machinery or apparatus for steering ships and other vessels.—January 13.

Jean Antoine Farina, of Paris, France, for a process of manufacturing paper.—January 13.

James Aikman, of Paisley, Renfrew, North Britain, calenderer, for improvements in the treatment or finishing of textile fabrics and materials.—January 20.

James Macnee, of Glasgow, North Britain, merchant, for improvements in the manufacture or production of ornamental fabrics.—January 20.

Thomas Kennedy, of Kilmarnock, North Britain, gun manufacturer, for improvements in measuring and registering the flow of water and other fluids.—January 20.

Peter Armand Lecomte de Fontainemoreau, of South-street, Finsbury, for certain improvements in treating fibrous substances. (A communication.)—January 20.

Henry Graham William Wagstaff, of Bethnal-green, Middlesex, candle-maker, for improvements in the manufacture of candles.—January 20.

Peter Wright, of Dudley, Worcester, vice and anvil manufacturer, for improvements in the manufacture of anvils.—January 20.

John Whitehead the younger, of Elton, near Bury, Lancaster, dyer and finisher, and Robert Diggle, of the same place, foreman, for improvements in bleaching and dyeing, and washing, scouring, and other processes connected therewith.—January 20.

George Lowe, of Finsbury-circus, London, civil engineer, and Frederick John Evans, of Horseferry-road, Westminster, civil engineer, for improvements in the manufacture of gas for the purposes of illumination, and of improvements in the purification of gas, and of improved modes in treating the products arising from the manufacture of gas.—January 20.

Frank Clarke Hills, of Deptford, Kent, manufacturing chemist, for improvements in manufacturing and purifying certain gases, and in preparing certain substances for purifying the same.—January 22.

Peter Armand Lecomte de Fontainemoreau, of South-street, Finsbury, London, for certain improvements in railways and locomotive engines, which said improvements are also applicable to every kind of transmission of motion. (A communication.)—January 22.

Edward Tyer, of Queen's-road, Dalston, gentleman, for certain improvements in the means of communication by electricity, and apparatus connected therewith.—January 22.

James Pillans Wilson, and George Fergusson Wilson, of Wandsworth, gentlemen, for improvements in the preparation of wool for the manufacture of wool and other fabrics, and in the process of obtaining materials to be used for that purpose.—January 22.

Walter Marr Brydone, of Boston, for improvements in apparatus for signal and other lights for railways.—January 22.

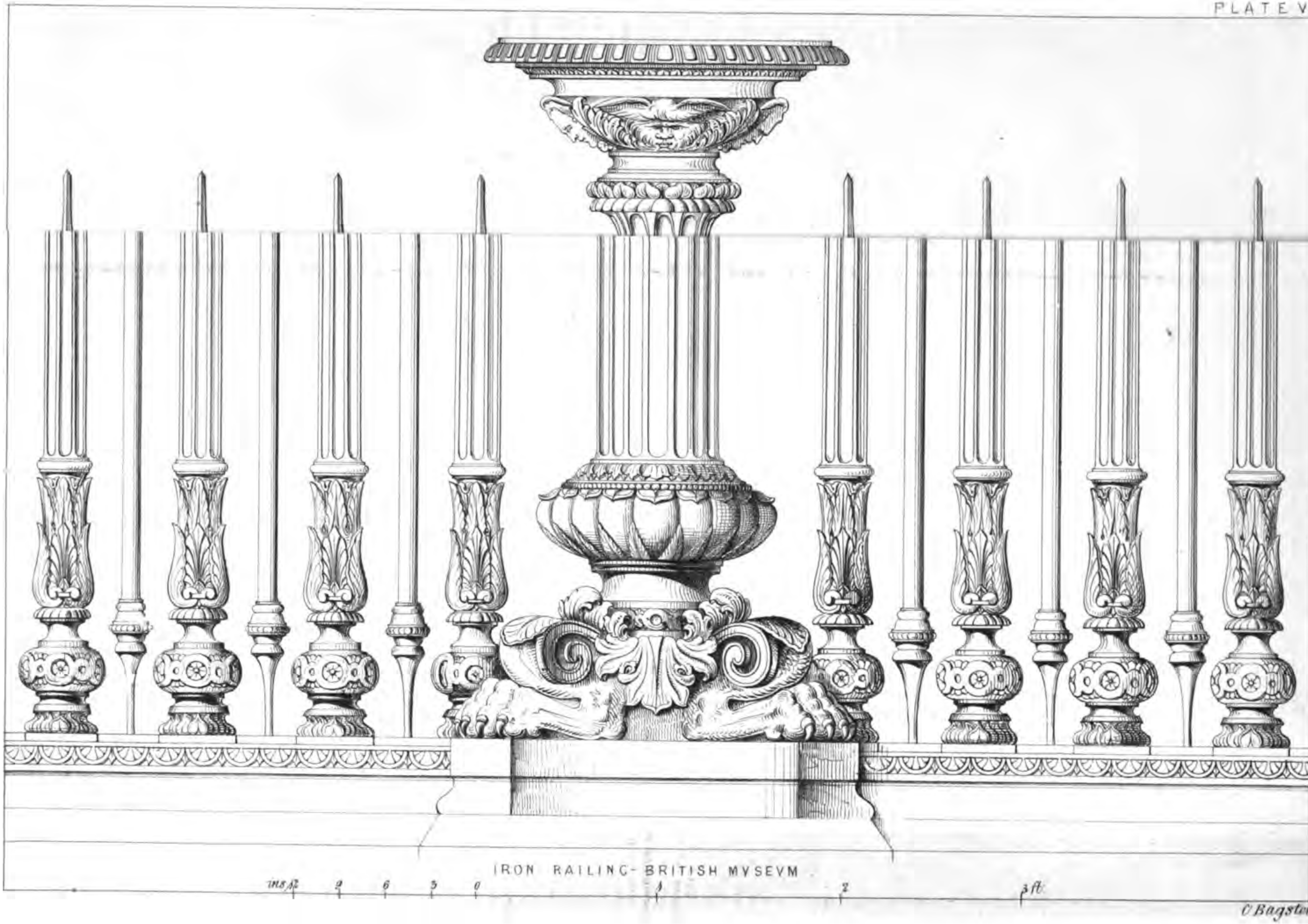
TO CORRESPONDENTS.

DISCHARGE OF WATER OVER WEIRS AND OVERFALLS.

If our correspondents, who are unable to understand correctly the calculations of the Tables, or the discharge of water over weirs, will make use of the following Table, they will be able to see that Mr. Bakewell's calculations conform exactly with the formula.

Inches.	Fractional part of a Foot.	Decimal part of a Foot.	Square root of the Decimal.
1	1/12	0·0833	0·289
2	2/12	0·1666	0·408
3	3/12	0·2500	0·500
4	4/12	0·3333	0·577
5	5/12	0·4166	0·645
6	6/12	0·5000	0·707
7	7/12	0·5833	0·764
8	8/12	0·6666	0·816
9	9/12	0·7500	8·866
10	10/12	0·8333	0·913
11	11/12	0·9166	0·957

PLATE VI.



IRON RAILING - BRITISH MVSEVM

ORNAMENTAL AND POLYCHROMATIC IRONWORK.

THE RAILING OF THE BRITISH MUSEUM.

Sydney Smirke, Esq., Architect.

(*With an Engraving, Plate* VI.)

Two assemblages, important in their influence on English architecture, have lately been held. One is the conversazione in the gallery of the Architectural Exhibition, when Earl de Grey came forward to inaugurate its permanent establishment, and liberally gave it a sanction which the leading architects will follow, although they ought to have given it first. The other event to which we allude is the paper read by Mr. Donaldson, at the Royal Institute of British Architects, on M. Hittorff's theory of polychromy, and the discussions which afterwards took place. These presented a gratifying aspect, and an unsatisfactory one. It was gratifying, and a striking proof of the healthy progress of architecture among us, to find a long and animated discussion held on a professional subject, and in which brethren from the leading countries of Europe took part. The public meetings of the Institute, and the publication of the proceedings, have done and will do more than anything else for the healthy *morale* of architecture among us. In the debate a man must give some testimony of the faith within him; and no more convenient opportunity presents itself of airing and deodorising those antiquated and mouldy prejudices which heretofore were carefully stored-up and garnered beyond the public ken. It was very gratifying to witness the amount of original research, practical knowledge, and great ability brought to bear in the discussion on the polychromy of the ancients; but we found, with less pleasing feelings, an extent of prejudice and an absence of wholesome reasoning on the part of so many speakers, that we felt the Institute had not yet accomplished its task. Instead of the sound logical discussion of a body of men of intellect, there was a great likeness to the partizan debating of a select vestry, a Conciliation Hall conclave, or even of the Houses of Parliament. With too many of the architects it was a faction fight, not whether truth should prevail, but whether long-accustomed prejudice should be protected. As we shall have occasion to refer to some of these exemplifications of the tyranny of rococoism, we shall not now detail the list of individual actors.

Mr. Donaldson, it is true, presented a particular theory of M. Hittorff on Greek polychromy, but the discussion not unjustifiably took a wider range. Bringing the questions at issue to distinct propositions, the leading ones would be these:—First, Did the Greeks use colour in architecture?—second, Ought we to use colour in buildings of the Greek style?—third, Is colour generally admissible in architecture?—and fourth, Ought we to adopt it here?

The first proposition is a simple one as to the general fact; but though every one was forced to allow that the Greeks did use colour in some parts of their buildings, yet the general endeavour was, to come to a conclusion that the *status quo* of whitewashism was the normal principle. Whatever the other questions may be, this first one is a simple question of fact; and we do say, that the course the discussion took does show an extent of prejudice, and a partizan style of argumentation on scientific questions, which in some degree detracts from the dignity of the profession. The weight of evidence is now so strong, that when the simple question is put, no one can deny that the Greeks did use colour in architecture, but in the desire to evade the consequences, few were strong-minded enough to adopt even a justifiable form of opposition. There were, however, two courses laid open, which left an escape for the purists,—first, that the Greeks were in the wrong in employing colour, as they did not know anything about it; and next, that the birds and flowers in this country did not exhibit any colour, and that therefore the climate was opposed to its indulgence by the inhabitants of the island.

Although the use of colour must be candidly acknowledged, doubts may exist as to the mode of its application, but we think they may be conciliated. Several opinions prevailed. One was, that the whole external surface was stuccoed and coloured; another, that the stone was covered with solid colour; and another, that the surface was only washed with ochre or other colouring. We can see no reason for tying ourselves down to the adoption of any one of these propositions as a general law. Just as we admit that there was a difference of the primary material—in one district marble, white or red, in another, freestone — so we think that, as each system propounded has authority in evidence, all may have prevailed separately or concurrently. A reasonable latitude of doubt exists as to the mode in which particular temples, the Parthenon or the Theseum, were painted; and, likewise, as to the treatment of individual members—the echinus, the epitrachelium, or hypotrachelium. These points are fairly open to doubt, and each will be determined hereafter by further research and the collation of evidence.

The real thing fought for by the opposition was not the truth—that they wished to evade, and they raised technical objections as freely as barristers—but the orthodoxy of the whitewash theory in classic art. In order to arrive at a just estimate of this theory, we will first sketch its history, then that of polychromy among the Greeks, and bring the two into comparison. The essence of the whitewash theory is, that pure white marble is a valuable and beautiful material, and the only one to be used for first-class sculpture and architecture; and it is the belief that the Greeks held this theory. The modern doctrine, for such it is, arose at a late period, was fostered during the decline of the arts, and matured in their expiring state. In the prime of modern art this theory did not prevail, as the practice of Michael Angelo, Rafaelle, Titian, Rubens, and Alonso del Cano shows, some of whose finest monuments are elaborately decorated architectural interiors. England has had the chief part in nursing the theory. The destruction of the monasteries had among other effects that of the destruction of the national schools of art; and with the extension of classical teaching a greater reverence arose for classical art. The schools of art were roofless, the patrons of art no more, and in time even artists became extinct, so that, for work at all decent, foreigners had to be called in—and yet even these foreigners executed decorated interiors whenever allowed. The church, however, was sacred from them, and the whitewash-brush of the churchwarden swept from our finest buildings all traces of the colourist. Thus the public mind was in a blank state to take strongly to the new theory, which was fortified from without. Of the buildings of the Greeks nothing for a long time was known, and when they were explored they were found in ruins, in a condition far from their pristine glory. Careful research would however have shown, as it has to subsequent explorers, traces enough of colour. Herculaneum and Pompeii were passed over as coming within the category of the period of decadence. The specimens of sculpture which came to us from Rome had been buried and washed, and were adopted as sufficient evidences of the naked marble theory. Thus, when the Adams began the restoration among us of what they were pleased to call classic architecture, no one permitted himself to doubt that whiteness was the sublimity of art; and if it had not been for the painters, who were then coming into life, colour would have utterly vanished before the churchwardens. Thus the accidental growth of a prejudice in this country has given it stability, and until a late period no one was allowed to contemplate external or internal polychromy as a legitimate mode of decoration. Stucco clothed the outside of a building, white-lead and whitewash gave purity and simplicity to the interior, to which in some cases marble statuary, chimney-pieces, and reliefs, gave enhanced dignity. If maple and varnished deal could have been introduced, in time a whole interior might have been completed in white. Athenian Stuart and the Elgin marbles did nothing against the reign of marble, but rather confirmed it. It is said there is no book so bad as not to have something good in it; and so it seems in other things, for Puseyism and Puginism have done much to redeem us from the reign of the pseudo-classic. On the continent, be it observed, this latter system has had little influence except among the High Dutch, and even among them it is exploded. In France, even when the Greek style ruled triumphant, the taste of the French people refused to resign colour.

We cannot go so far as one of the debaters at the Institute, and describe the Greeks as descended from the Egyptians and the Assyrians, because that is as great an ethnological error as if they were said to be descended from negroes; but the Egyptians and the Assyrians were undoubtedly the fathers and teachers of the Greeks in art, and the forms which we look up to with so much admiration were no more indigenous among the Greeks than among ourselves. Yet at the Institute it was objected even to mediæval decoration, that it was foreign, imitative, and not in accordance with the genius of the English people. We may here too observe, that our climate is put forward as another obstacle to our indulgence in colour, as if we liked beautiful birds, beasts, plants, and pictures less than the inhabitants of the tropics,—or as if, on the other hand, we were to seek the masters of colour not among the Titians, Rubens', and Murillos, but among the woolly denizens of Timbuctoo, Bambarra, or Ashantee. The Greeks adopted polychromatic decoration from their foreign teachers, made it their own—as they did religious and political institutions, as they did even the alphabet—and, as the evidence of their writers and the remains of their works show, successfully practised it in common with every branch of art. Here, too, we must pause again. Treatment of form, we are told, is the distinguishing function of the architect and sculptor, with which the study or application of colour is inconsistent; yet, will these speakers tell us that Rafaelle, Corregio, or Vandyke had nothing to do with form, or are in any way inferior to him who puts up a travestie of the Parthenon or carves out the nymph Onostechneia?

The case stands thus: that the Greeks themselves tell us they used colour—their modern sectaries tell us to believe they did not; and we are called upon to destroy the harmony of the arts, and to disintegrate colour from its natural associations. The way of nature is clear, notwithstanding the prejudice about climate—in this island too, without exception, in this nursery of artists, where rich landscapes invite the imitative hand of genius—the way of nature is clear that the treatment of colour is among the great and glorious attributes of beauty. Here all is beautiful but the works of man; and why, even if perfection of form could be obtained by the one-sided practice of art, are the works of man to be exceptional? Fortunately, the healthier sympathies of the public, and the labours of enlightened artists, have solved the question. The successful exertions of our great painters, and even of our minor painters, have not been without influence on the architects, and already such examples have been produced by the latter as to claim the public approbation, and to determine the progress of art.

We might allude to several works of decoration which are worthy of any period of art; but we may successfully point to that great national monument, the British Museum, in which Mr. Sydney Smirke has not only distinguished himself, but contributed greatly to the cultivation of the public taste, and, if we mistake not, given an impulse to the progress of architecture. We have our own views as to some of the measures adopted by him; but great allowance must be made for the previous condition of the building. Originally designed to be in the achromatic style, Mr. Sydney Smirke has been allowed tentatively to introduce coloured decorations. We consider the pediment of the Museum open to some objections, but then we believe this is is chiefly because the decoration is partial; and even were there nothing else to be said in his support, there is this, that he has given the first great example in England of external decoration, and which has been well followed by the magnificent railing, another work unique among many. In the interior, too, he has had to proceed step by step. First, the hall and staircase were allowed to be painted, and later, the sculpture galleries, in which he has made such an advance that the hall seems already out of keeping. In the transition of the art such occurrences as these must be treated as the result of necessity, and as productive of advantage. We look upon the works at the British Museum already executed as only the beginning; and when this building and the Palace at Westminster are more advanced, we shall have two of the finest monuments in their respective styles that the world possesses, and which alone would give distinction to any other metropolis.

We propose with this number to lay before our readers an Engraving of a portion of the iron railing in question, having selected it as a subject which would be acceptable and useful to our readers in the present tendency of their art; and it happens fortunately, that the discussion at the Institute, which we give in full, as we did Mr. Donaldson's paper last month, has given us the opportunity of discussing the system of polychromy. The example afforded by our engraving is valuable in a double point of view, because it illustrates the successful treatment of iron and the application of colour, for each of which the architect will hereafter be called upon to apply himself.

There are some remarks of Herr Licht so well expressed, that although they are to be found in the other part of our *Journal*, we cannot but repeat them. He says: "The structure which has lately developed itself in England, and announced a new era in architecture, the structure in iron, requires the aid of colour, from the very nature of the building. With our present knowledge, no safer and more convenient way of preserving this material from the effects of the weather presents itself than to recur to colour, which will certainly require often to be renewed. The field for colour which this iron architecture will throw open, cannot, indeed, be calculated."

The railing we are now considering is an iron one; but instead of being so many feet run of spiking from the founder's pattern-book, it is a special composition, and one of which no architect need be ashamed. It is, indeed, a complete illustration on a point we have often urged on our readers—the necessity of taking details under architectural superintendence. The man who can produce a work like this railing stamps himself an artist. Of the design we shall say little, because we have given it of a sufficient size to enable our readers to understand it; and it possesses such merits as win for it approbation. The height of the railing from the ground to the top of the spikes is 10 feet, and to the top of the standards 11 feet, and therefore is of such magnitude as to give a striking character to the work. The railing rests on a fine granite basis, and is connected in composition with well composed granite piers and with entrance gates, which are of themselves important works. The main rails are 3 inches diameter, and stand 10 inches apart from centre to centre. The casting is very finely executed, and reflects great credit on the manufacturer.

The colouring of the railing is a rich maroon, portions of the work being distinguished by gilding. These are the spikes of the main rails, and the spearheads of the intermediate rails, and on the standards the rim of the vase, the ornament on the necking between the two upper rails, and portions of the masques. The treatment of the colouring is the more noticeable from the free application of gilding, which, though so successfully applied on the continent, has here been wholly neglected. Mr. Smirke therefore deserves thanks for this detail likewise.

POLYCHROMATIC EMBELLISHMENTS IN GREEK ARCHITECTURE.

(*Being a Discussion at the Royal Institute of British Architects, January 26th, and February 9th, on the Explanation given by* Thomas L. Donaldson *at the Meeting of January 12th.*)

Mr. Donaldson gave a résumé of the remarks made by him at the preceding meeting (see *ante* p. 5), to explain the Polychromy of Greek Architecture, as illustrated in the work of M. Hittorff. He then proceeded to observe that M. Hittorff, in his very elaborate work, reviewed the different processes of painting which were followed by the ancients. Among these were described encaustic painting, a resinous or gummy description of painting, and two or three other kinds. The work also contained a summary of the researches of the most learned chemists on the subject, with a representation of the tomb of a lady painter, whose skeleton was surrounded by various implements of her art, as palettes, mortars, brushes, and colours; a proof that the processes of the ancients in these matters were very similar to our own. The great point of difference on the question of polychromy would be found in the opinions entertained as to the extent of its application. The pamphlet which M. Semper had presented to the Institute at the last meeting showed, he believed, that that gentleman adhered to the opinion of M. Raoul Rochette, that the paintings of the Greeks were not properly mural paintings, but paintings upon tablets, which might be removed at pleasure. M. Hittorff, on the contrary, was of opinion that all the paintings, used externally or internally (except votive offerings), were strictly mural, and formed part of the walls themselves. It was evident, from the Roman baths and the remains of Pompeii, that the Romans painted their walls very extensively; indeed, every fresh discovery showed that painting formed an essential part of their architecture. Mr. Donaldson was not aware that any remains of the supposed tablets had been found. As to external paintings, they must have been executed upon the walls. He then referred to a fragment exhibited by the kindness of Mr. Angell, being part of a plain bird's-beak moulding from one of the temples at Selinus, which had evidently been coloured blue or green, and red, the outline of the ornament being left yellow or white. In the work of the Duke of Serradifalco there were several illustrations of actual paintings upon the architectural members of the Greek temples in Sicily, especially on the sculptures from Selinus, in which the ground of the metopes was shown to have been red. Mr. Angell's work on these sculptures gave similar proofs of the employment of painted architecture. It could not, therefore, be denied that painting was applied to the external face of these temples, but the question was of course open as to interior decoration.

The subject of polychromy was not a mere question of curiosity, or pedantic antiquarian research; but it was one of great importance in their daily practice as architects, now that there was an increased demand for the employment of colour in the decoration of houses. The general use of colour by the Egyptians was well-known, and could be testified by M. Horeau, Mr. Hamilton, and Mr. Scoles, who were present. The taste of the Romans was a reflection of that of the Egyptians and the Greeks, and in their architectural remains colour was universally to be traced; whilst the vases of the ancients also afforded abundant proof of its employment in another branch of art. In the middle ages buildings were profusely decorated, not by the timid trials of inexperienced taste, but with the utmost boldness of crude but glowing colouring and gilding. A coloured monument in a mediæval building now appeared a spot upon the plain stone-work; but it should be remembered that the whole of these edifices were originally decorated with colour, so as to render the accessories in harmony with the grand mass, in order to insure the general effect. To illustrate the subject still further, Mr. Donaldson produced two small drawings of modern works of sculpture (Mercury and Pandora, by Flaxman, and a Female Sleeping, by Baily), tinted to show their appearance if painted, and said he considered that an increased degree of expression and sentiment would thus be given to sculpture. The Greeks, he believed, desired to give to their sculpture that life and sentiment, that glow of health and beauty of colour which were to be found in nature. The descriptions by classic authors of the decorated thrones and altars, &c., by which their statues of Jupiter and Minerva were accompanied, naturally led to this inference. With regard to the modern use of polychromy, Mr. Donaldson referred to the highly satisfactory instance of the British Museum, the sculptures in which had received new life and animation by the coloured backgrounds introduced under the direction of Mr. Sydney Smirke. The ceilings of the sculpture galleries in the Museum had also been skilfully decorated, in unison with the walls, and it was at length possible, in some degree, to estimate the effect of such embellishments in Greek buildings. He had never entered the cellars, so to speak, of the Vatican—its sculpture galleries—the walls of which were of marble, without experiencing a painful sensation of coldness. The background at the British Museum was not such as to distract attention from the statues, but while it absorbed the colour, it allowed all the light to play upon the marble. Mr. Donaldson here read a communication from Mr. Smirke to the following effect:—

"Were there no surviving evidences of the practice of polychromy in ancient architecture, we should be, perhaps, justified in assuming its existence, from the fact of our finding so prevalent the practice of stuccoing the exterior surfaces of ancient masonry. I can myself bear testimony to the existence of this practice at Selinus, Agrigentum, Pæstum, and Tivoli. The cold, meagre appearance of this dead white plaster would have been insupportable to the fervid eye of an architect educated amidst the brilliant profusion of painted embellishments, such as we know was lavished on every object of fictile manufacture. I beg, however, that you will note, that at all the above-named sites the masonry was executed with an exceedingly coarse material, so coarse as to render this treatment scarcely a matter of choice. The case becomes very different when the beautiful marbles of Pentelicon were used, and the Greek eye must indeed have been insatiate of colour to obliterate, without scruple or compunction, the soft crystalline translucency of that material. But you say, *ex cathedrâ*, that the whole surface of the Athenian temples was not only painted but plastered! so that Mr. Compo can claim a classic descent! However consonant this brilliant draping and jewellery may have been with the clear, sunny atmosphere of Greece and Sicily, you must pause before you advocate a similar proceeding in our cloudy zone; the tastes, feelings, and habits of men conform to the circumstances of external nature; even in the plumage of birds, and in the furs of animals, how chary of colour is dame Nature herself in our cold, grey climate, and yet how lavish in the sunny south! Mediæval artists felt this difference; whilst in India beautiful buildings were rising, radiant with coloured marbles and mosaics, we, in Europe, were raising equally stately edifices without a touch of colour, as grey and as sombre as our hills. The contrast, however, ceases at once when we enter and shut out the face of nature. No heathen artist could have dealt in blue, red, and yellow, with more gusto and profusion than the Christian when engaged on interior decorations. Whatever doubt may still hang about the question of external painting in Greek architecture, there need, at least, be none on the subject of interior polychromy. I do not suppose that any one doubts as to the lavish use of colour within the Greek temple. There was, indeed, a sort of necessity for this, in order to bring into harmony the various natural hues of the raw materials used in its construction—the wood, stone, marble, and metal; moreover, the habit of constantly burning lamps, as a religious rite, would engender so much soot that a periodic renewal of the surface decoration must have been an absolute necessity. The smoke nuisance was, you know, so great, owing perhaps to the imperfect nature of their lamps, that the atrium of a Roman's house became so named after it. I cannot imagine however we should have sunk, in these days, into such imbecility as regards the use of positive colours: in England, too, whose painters have long been the best colourists in Europe. But the eighteenth century was truly the Bœtian period of our art, and when the discovery of Greek excellence awoke in us new and higher feelings, the attention of architectural students was absorbed in the study of beautiful outlines and wonderful forms: it was not till long after that the use of colour among the Greeks became an object of particular notice and research. That we have still much to learn on this subject is obvious, from the fact that the doctors still so widely differ. You, my dear sir, who are honourably and usefully engaged in training up in the way they should go, the minds of so large a proportion of our future Phidias's and Wren's, you cannot fulfil your mission better than by fixing attention on this new branch of architectural study. In doing so, however, I trust you will not confine yourself to the consideration of ancient examplars, however beautiful and ingenious they may be. Let not the study of nature ever be neglected. She does everything infinitely better than we can ever hope to do; all the concentrated taste and ingenuity of the Crystal Palace itself could not paint the back of a beetle or the tail of a humming-bird. Yet certainly the principles on which nature has worked may be inquired into, and the very attempt to understand her must be attended with profit to the student. Let him inquire why the blossom of the rose never looks so charming as when contrasted with its own green leaves; and why the purple and yellow streaks on the corolla of the pansy make that humble little plant one of the most lovely; and let him observe with admiration the consummate skill with which the great Instructress will cause peace and harmony to prevail between the most hostile tints, and by her magic touch will convert horrid discords—the greens and the oranges, the browns and the purples—into new sources of beauty and pleasure."

Mr. Donaldson believed that what Mr. Smirke said about external painting could not be denied, after the abundant evidence supplied in the work of the Duke of Serradifalco, and the actual fragments which had been submitted to the meeting. In conclusion, he repeated his opinion of the value to be attached to the illustrations of an architect and an artist, like M. Hittorff, beyond those of a mere antiquary, however learned. M. Hittorff's work had enjoyed the highest estimation in Germany, and the author had received distinguishing marks of approbation in proof of the value attached to his labours by the Sovereigns of Germany, on the report and advice of the learned men by whom they were surrounded.

Mr. Penrose said, that although his studies at Athens had been directed rather to form than to colour, it was impossible to live, as he had, for many months under the shadow of the Parthenon and the Theseum without making some observations on the colouring of those temples. On one point in Mr. Donaldson's paper he must venture entirely to differ with him—viz., with respect to the painting of the echinus of the Doric capital. He was quite satisfied there was no painting whatever on the echinus. Then, in regard to the epitrachelium, as he would call it—not the hypotrachelium—the hollow curve above the small necking (the hypotrachelium being below it), he believed

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that that member also had not been painted in the Parthenon. He had examined all the best preserved capitals with very great attention, and found not the slightest trace of colour, or of those lines, engraved or incised, which were generally employed to determine the pattern of the colouring. It occurred, however, on the cymatium, on the bird's-beak moulding, and even on the architrave bands, these being in situations very much exposed; but the echinus and the epitrachelium, which retired, and were perfectly protected from the weather, presented a perfectly polished surface, as complete as when first formed, with a beautiful uniform tint, but without a single trace of any line to regulate the application of colour. Where the line was not to be traced, the surface very often stood raised up, about the thickness of a sheet of paper, indicating the use of colour where the actual engraved outline failed; but there was not an atom of such proof on the abacus or echinus of the Parthenon. There might be sufficient analogy for supposing those members to have been painted; indeed, there was an ornament—a little raised flower—on the echinus of the temple of Ceres at Pæstum; but he was satisfied there was not any in the capitals of the Parthenon, nor did he think there had been in those of the Theseum. M. Semper, however, was of a different opinion, and, he believed, stated that he had seen some lines upon the echinus in the capitals of the Theseum. He (Mr. Penrose) could only say that he had examined the most perfect capitals of the Theseum with great care, and had seen no such lines. If any existed, was it not possible that they had been drawn by Stuart, or some other artist, with a view to assist in obtaining a perfect measurement of the echinus? Of course, this question was to be decided by evidence; but, as a matter of argument, he (Mr. Penrose) considered that any painting on the echinus would have an ill effect. The shadow cast by the beautiful sky of Greece from the square abacus on the swelling form of the echinus was alone sufficient to make the Doric capital the most exquisitely formed surface imaginable; and its effect would be seriously injured by the suggested lines of the eggs, which would break the figure of the shadow. Mr. Donaldson thought there would not be sufficient emphasis in the capital without such ornament; but it seemed to him that the reversed curve of the epitrachelium was quite sufficient to distinguish the shaft from the parts above it, aided by that effect of light and shade which, in the latitude 36°, was so very different from that produced in the latitude of 52°. The dado, so well shown in M. Hittorff's restoration, was a feature of such importance as to have obtained a particular name in the Erectheum inscription, first published by Dr. Chandler. He agreed with Mr. Donaldson in thinking that the cases of the doors were of bronze at the Parthenon, and that the doors were of the same material. Proceeding to consider the subject generally, Mr. Penrose said that its importance was quite evident. The architecture of the Greeks could not be thoroughly understood without studying their polychromy. A considerable advance had been made in that study, especially in M. Hittorff's work. From the nature of our climate, and even from our very veneration of the Greeks, we might be loath to admit their use of polychromy. A juster feeling, however, should make us feel that they had attained the same perfection in painting as in other arts; and we should rather doubt our own knowledge of what they did than their excellence in art. As our northern climate disinclined us to believe that the Greeks used colour, so their southern climate might have led them to adopt it. Indeed, the natural background of the sky was of great importance in regard to the different effect of plain and painted architecture. The use of colour in this climate, however, need not be absolutely denied; but it should be used with moderation. The Greeks were almost necessarily, from their origin and ancestry, led to employ colour in their temples. The Egyptians universally used it; and the Assyrians (the other progenitors of the Greeks) used it also, to an almost equal extent. The remains of the temple of Jupiter at Ægina, one of the earliest Greek temples, proved that colour had been there employed. M. Hittorff had given a restoration of that temple, and he (Mr. Penrose) would refer to another restoration by himself and Mr. Willson, chiefly copied from that of M. Blouet, in his 'Expèdition Scientifique de Morée.' That colour was employed on the Greek temples it was impossible to doubt; the remains of it on the Parthenon were in such a state of preservation, and so correct in point of form, that the main fact was unquestionable. This was also evident on referring to the engravings of several coffers in the ceiling of the Propylæa, shown in the work on the Athenian remains, which had just been published by the Dilettanti Society, from the drawings and observations of himself and Mr. Willson; and the design of those paintings proved that they were either the work of the Greeks who finished the building, or that they were executed within 100 years afterwards. The decline of art after that period rendered it impossible that they could be materially later than the time of Pericles; and inasmuch as the sanctity of those edifices within 100 years after their erection rendered it highly improbable that anything was done to them, inconsistent with the feeling of the original design, he was led to conclude that the whole of these paintings were executed before the temples were finished and the scaffolding removed. It was very easy to distinguish them from the mediæval paintings which might be found upon the Parthenon. Probably the stucco which Mr. Donaldson said he had traced on the Theseum might have been prepared for mediæval paintings.

Mr. Donaldson explained, that he had observed the stucco on the external wall of the cella, and his impression at the time—for he had referred to his notes—was that the whole external surface of the Theseum, and the columns, had been covered with stucco contemporaneously with its first erection, and with a view to receive painting.

Mr. Penrose said, that as far as the columns were concerned, his impression was, that they were as perfectly polished and as highly-finished as those of the Parthenon. He proceeded to read a passage from Langhorne's translation of Plutarch in reference to the Greek temples; offering, instead of a portion of it, the following literal translation of the words:—"In beauty each was then immediately old, and in freshness till now each is recent and young." From this he inferred that when new, they were not crude, and therefore must have been in some way painted, and that the excellence of the work was such, that it had preserved its freshness for 600 years. Passages in the poets, and an inscription referring to the Erectheum, proved that gold was largely employed in the decoration of temples; but not, he thought, to the extent shown by the restoration of Mr. Owen Jones. Mr. Penrose here referred to some painted fragments discovered in an excavation made near the south-east angle of the Parthenon, and described by Mr. Bracebridge. These were coloured red, blue, and yellow, and, in his opinion, were of earlier date than the Parthenon, and, no doubt, fragments of the temples destroyed by the Persians. This might have been the site of the workshops for the builders of the present Parthenon; and, indeed, among the remains, a closed jar containing colours was found. With regard to the limits of Polychromy, he was decidedly in favour of some limits, and thought that the surfaces which were coloured were comparatively small, especially in the shade; but still, though the principal remains of colours were to be found on the soffits, there were faint lines of patterns having been used on some very exposed parts, as on the tænia and regula of the architrave—sufficient, indeed, to lead to the belief that if the abacus, or echinus, or architrave had been painted, traces of such painting also would be found. If the views of M. Semper and others, as to the use of tablets, were correct, he did not think a particular building at Athens would have been called the Pinacotheca, or the Hall of Tablet Pictures. If the cella walls were painted, which was probable, the columns would be thrown out with great brilliancy, as shown by M. Hittorff. As to the colour of the background of the sculptures, there was no evidence at the Parthenon as to whether it had been blue or red, or whether it had been painted at all. At Ægina it certainly was painted. His observation had failed to satisfy him that colour had been at all employed upon the sculpture. While positive colour was limited to small surfaces, it was probable that a general tint might have pervaded the rest of the architecture. M. Semper had given a strong red tint to the whole of the Theseum, having found, as he supposed, remains at one angle of the external architrave to warrant the application; but it was to be observed that the natural tint of the marble there employed was very remarkable, and arose from a natural efflorescence (caused by the oxidation of the iron in the Pentelic marble), which produced a magnificent warm colour approaching to red. Mr. Penrose here referred to a highly-finished original drawing by himself, to convey an idea of the present appearance of this temple, and of the colour which he had described. If the columns were slightly toned down, they would have an admirable effect in front of the dark ground of the cella. The earlier columns of Greek temples were of limestone, and these were invariably coated with a fine stucco; but when marble was used, as at Athens, of the finest and most expensive kind, it was difficult to suppose that it would have been covered with stucco. Pausanias described some temples as of stone, and others as of marble; and if the latter had been covered with stucco, he could hardly have drawn any such distinction. On the other hand, Mr. Penrose did not suppose that raw and crude white marble, like that of Pentelicus, would have been left without some toning down. The columns of the Parthenon showed some faint traces of a very thin and delicate transparent wash of ochre, or some such substance. It was not a fact of which he could be very positive, but he thought it was some kind of wash; it was, however, rather difficult to discriminate between the efflorescence he had mentioned, and the traces of actual colour. The statements of Vitruvius respecting the Attic ochre extracted from the silver mines of Laurion, and the analysis of a modern Athenian chemist, referred to by M. Hittorff, authenticated the use of ochre by the Greeks; and Pliny expressly stated that saffron was used to tone down certain statues which he specified, milk being used as the fixing liquid. This of course was negative evidence, but it was necessary that the positive and the negative should be taken conjointly. It would be a great achievement for the critical science of the age if the polychromy of the Greeks could be systematised. Considering that the works of Greek art took 500 years to attain perfection, they could scarcely be surprised that no more progress had been made in the investigation during the last thirty or forty years. M. Hittorff's work, and others, proved that they were on the right track, and if the various theories now propounded were investigated with critical discrimination, and due regard to the possible, the probable, and the true, they might hope that on some future occasion those things in relation to the subject, which were now dark, might be brought to light, and that the inquirers, like Alexander, might have cause to sigh for new fields of conquest in the realms of art.

M. Semper addressed the meeting in explanation of his drawings, which were exhibited on the wall, and referred to a passage in Herodotus, from which he deduced that the public buildings in the Island of Siphnos were of a red colour, and by analogy, those in Greece generally at the same time; though this opinion was in opposition to the interpretation put on the same passage by M. Kugler, in his work on polychromy. M. Semper had found faint traces of blackish lines on the echinus of the capitals in the Theseum, which, however, were not incised on the marble. Considering that the echinus over the caryatides in the Erectheum was enriched with eggs and darts, he had ventured to apply the same enrichment to the echinus in his restoration of the Parthenon. He had found traces of yellow red colour on an angle of the external architrave over the columns in the Theseum, but not so decided in form and tone as the artist had shown them in the drawing. He had found traces of colour on the antæ of the cella, as mentioned in his pamphlet. It was his opinion that a transparent layer of coloured enamel or varnish was laid over the surfaces generally, the colour being of an opaque nature only on the ornamented bands and mouldings.

M. Horeau, being invited by the Chairman, expressed his views on the subject, especially in reference to the polychromy of Egyptian architecture, in which, he stated, that every ornament and every colour used were symbolical, and regulated by something beyond mere caprice. Yellow was solely employed to express sentiments in connection with sovereignty, while each province had its peculiar colour. Thus there was no capricious ornament, and every part had a distinct signification, contrary to the custom of the Greeks, who painted the triglyphs, for example, blue, red, or perhaps green, at random. In modern times improvements in the industrial arts offered, here and on the continent, a wide field for architectural embellishments; as, for instance, in the various stuccoes, in the fictile wares, and in the extended application and combination of the metals.

The Chairman adverted to the fading of colour from lapse of time, both when fragments remained underground, and when they were exposed to the atmosphere, and referring to the presence of Mr. Faraday, expressed a wish that he would favour the meeting with any remarks on that, or any other point bearing upon the general question.

Mr. Faraday regretted that there was really nothing tangible yet brought forward in his department on which he could offer any remarks.

Mr. Hamilton said that his knowledge of Greek architecture referred to a period when it would have been considered absolutely sacrilege to enunciate the idea that any one of those exquisite temples could have been decorated with colour. He should himself draw a contrary inference to that of Mr. Penrose from the passage he had quoted in Plutarch. If the temples of the Greeks had been originally painted, it was hardly to be supposed that their "original freshness," which Plutarch spoke of, could have subsisted for so long a period as 600 years. He thought it very probable that the temples of rough stone were coloured, but not those of marble; or at all events not to any great extent.

Mr. Twining begged to offer a few observations on the practical application of polychromy to modern works, and to give some reasons why it should be very sparingly applied, especially in this country. If all materials, rough stone, white marble, and the more beautiful coloured marbles, such as those in the Duomo and Campanile of Florence, were to be painted, all distinction as to the relative value would be lost. Climate was also an essential consideration; and colours which would stand, and have a good effect in Greece, would not suit the climate of England. He might observe, that when he was at Athens it appeared to him, that the tint of the columns of the Parthenon was much the same as that of the exposed surfaces of the Pentelic marble in the quarry, which arose probably from the oxidation mentioned by Mr. Penrose. Another point was, that much of the beauty of Greek architecture depended on the exquisite effect of the shadows cast by its different members, and that colour would destroy the uniformity of the ground on which those shadows were cast, and produce a confused and unpleasant, instead of a distinct and beautiful effect. There was a danger, also, of painted decorations taking the place of carving and sculpture, which were so much more beautiful and valuable. He therefore thought that polychromy was only advantageous in particularly fine climates; that it should only be applied on uniform surfaces, each colour corresponding with the extent to which it was employed, and only to cover poor, coarse, and inferior materials.

Mr. Fergusson considered the subject would be incomplete without some reference to the use of colour in Assyria, where the recent discoveries had brought to light paintings, and painted architecture, to an extent not found anywhere else except in Egypt. Whilst, however, the Egyptian paintings were intended to express words and ideas, colour was applied in Assyria, as in Greece, to add to the beauty and decoration of the palaces and temples. Honeysuckles, ovolos, scrolls, and other ornaments, usually called Greek, were found in Assyria, and were coloured precisely as those given in the Greek restorations before the meeting. The specimen exhibited from Metapontum might, indeed, have come from Nineveh. The Ionic capital also, with its volutes, was essentially Assyrian, and it was coloured as the one shown. There was no trace of the Doric in Assyria; but all the Ionic mouldings and ornaments were found, and they were all coloured. Some of them were enamelled on bricks and plaster. These discoveries were of the greatest importance in relation to the question of polychromy, being in fact the authority for its employment by the Greeks; and a proper study of them would go far to throw light upon the question. Colour was used by the ancient inhabitants of India. A number of fresco paintings had recently been brought to England, in which temples and other buildings were represented as adorned with the most brilliant colours; the effect was striking, and in that country would be pleasing. The Mahometans, in India, inlaid white marble with coloured scrolls, flowers, &c., but did not otherwise employ colour. The Persians, however, from the days of Nineveh to the present time, used colour most extensively; covering their mosques entirely with painted tiles, and relying more on colour than on form for the effect to be produced.

Mr. Billings said it was an error to suppose that colour was generally applied to mediæval buildings; on the contrary, not one in fifty of them was so ornamented, and he should be very sorry to see the time when the tints of the material, stone and oak, Nature's own polychromy, were disguised by painting. He knew very little of Greek architecture, but had always looked to it for dignity and sublimity of form. He had never expected to see a brick-dust elevation of the Parthenon; and if colour of that kind were desirable, it would be easy to raise the finest temple in the world with the old red sandstone of England, which was ready coloured to the hand. The object of the present movement appeared to be to introduce colour very extensively in this country, a proceeding which he did not think at all expedient. Colour was very well in other countries, where shade was required; but here we wanted light, and must have it. As an instance of the bad effect of colour, he referred to the blue ground of the tympanum of the British Museum, which utterly failed as a representation of sky; whilst it destroyed the shadows of the sculpture, and gave the figures the appearance of exposure to cold, instead of being sheltered by the roof above. As to internal colouring, nothing could be better than the natural tints of the materials employed; and for anything more we had drawings and paintings to hang upon our walls, which the Greeks had not. No one would venture on the absurdity of painting the Apollo Belvedere, or the Elgin marbles. He protested against the theory altogether, and declared that the effect of colour would be to destroy the beautiful transparent appearance of the marble. If it were thought worth while to test it, he recommended its admirers to get permission to try it upon one-half of the marble arch in Hyde-park. He could not admit that M. Hittorff had hit upon any system, as his illustrations were merely specimens of all kinds from various places. The classic column had been taken as a perfect type of architecture; but if the capital, the shaft, and the base, were to be of different materials, and different colours, it would be a mere nondescript.

Mr. James Bell said it appeared to him that this was altogether a question of evidence; and in reference to the original remarks of Mr. Donaldson on M. Hittorff's restoration of the temple of Empedocles at Selinus, he thought he had failed to show any authority for them. The reason suggested for the highly decorated pavement was a piece of plastered floor without any colour; there was absolutely no authority for the colouring of the base or the shaft; the capital and the architrave were only restored by analogy; and the triglyphs on the faith of a passage in Vitruvius, which he found only referred to the original wooden type of the Greek temple. As to the metopes, it was doubtful whether they were blue or red; the authority for the tympanum was the temple at Ægina; and that for the wall behind the columns was derived from the domestic architecture of Pompeii. If, therefore, any conclusions were to be drawn from the brilliant illustrations to the splendid work of M. Hittorff, it was first necessary to analyse the evidence on which they were founded; otherwise such conclusions might be very erroneous.

Mr. Cockerell, V.P., who presided, said he had been requested to state the results of his investigations at Ægina in the year 1811, which he had intended long ago to make public, and with that view had caused engravings to be made, two of which he exhibited to the meeting. It would be remembered that the temple of Ægina was a work of the sixth century before Christ. It was of very small dimensions, and constructed of freestone, being a specimen of that ancient Doric which was seen in the earliest examples. The columns and entablature were covered with a very fine coating of marble-dust and pounded stalactite, as it seemed, having an effect of great brilliancy and lustre. There were no traces of colour on the columns or steps beneath them, and no part of the architrave was coloured except the tænia under the triglyphs, which was red. The triglyphs and the background of the tympanum were blue; the beak-moulding, as it was called, had the well-known leaf ornament, and within the portico a facia band of great lustre, having an enrichment highly archaic in character, coloured blue on a strong red ground, and in several parts exceedingly well preserved, was discovered over the frieze. This, which no doubt had an excellent effect in its position, on account of the great strength of the colour, was not at all correctly represented by M. Blouet's drawing, either as to the form or the colour of the ornament. The tiles were of pottery, and extremely well painted. The sculpture of the pediment, the cymatium, the griffins at the angles, and the acroteria, with the antefixæ and ridge tiles on the flank of the temple, were of the finest Parian marble, all more or less painted. The figure of Paris in the pediment was remarkable from the Phrygian dress, which had evidently been covered with scales of gold or some other material; this was shown by the greater relief of the marble, caused by the use of some encaustic material, which had protected the parts it covered, whilst the other parts exposed to the weather had been injured. The corona was also painted with an elegant ornament upon the Parian marble. The shields borne by the figures in the pediment were painted red internally, as were portions of the helmets. The pavement of the cella was a very hard stucco of a deep and rich crimson colour, and highly polished. These were the only traces of colour which he had discovered at Ægina. The ancient temple of Corinth was also covered with a very fine stucco, ⅛-inch thick, which gave to the parts the appearance of the finest marble. The same fine varnish, as he might call it, was to be found in the temple of the Giants, and other buildings at Agrigentum in Sicily. The temple of the Giants was an ashlared temple; the columns were built round a core, and the joints concealed by the stucco, the stone itself being a tufo; even the colossal sculpture of that temple was also covered with stucco. He had found many fragments in other parts of Sicily, proving the same practice of covering the temples with stucco; and the Museum of Catania contained numerous evidences of the use of polychromy. Colour was also to be traced on many remains at Syracuse; all of these were early specimens, and furnished evidences of that archaic taste which always prevailed in countries remarkable for a high patriotic feeling. He thought the attachment to what he might call excessive colouring was only to be traced in works of that early and archaic taste; and he humbly conceived, that in the marble temples of Greece, such as the Parthenon and the Theseum, which were of a more recent date, painting was employed with very great reserve. There was, however, distinct evidence that the architects of the age of Pericles employed colour—particularly crimson—and gold; and the use of crimson paintings on ceilings was constantly mentioned in Scripture. The same practice continued to prevail in Oriental countries; but, so far as his experience went, there was evidence of the use of colour on the general face of the Greek temples. The employment of colour in Greek architecture was no doubt a fashion which prevailed more at some periods than others. There was an antique and barbarous fashion of painting statues; Pausanias referred to certain terminal figures, statues of Bacchus and others, which were painted crimson. Probably, in more refined times, as under Pericles, these fashions were modified by a higher reasoning, and over-ruled by a consideration of principles which ought to be carefully regarded. The subject was important in a practical point of view, and a question arose in reference to the material itself. To attempt the application of polychromy to the exquisite marble of Pentelicus appeared, indeed, to paint the lily and to gild the rose. The excessive and painful whiteness of the new marble had been justly adverted to, but it should be remembered, that what had been well described as "Nature's polychromy" was sure to arrive in course of time. The chalky effect of new buildings was familiar to all architects; but he thought the Greeks, in such noble buildings as the Parthenon, relied upon the natural complexion given by time, and did not attempt to paint its beautiful surface. In considering the principles which governed the Greeks in the use of polychromy, he might observe that their temples were a kind of cabinet-work. The temple of Ægina was not more than 35 feet high, and the Parthenon only 60 feet; the temple of the Giants at Agrigentum—an unprecedented instance of magnitude—was 120 feet high. In the beautiful climate of Greece, he thought a natural love for these small but exquisite temples, and the ease and pleasure with which they could be minutely examined, would induce the Greeks to paint and otherwise embellish them; just as, in England, the fittings in our apartments, as bookcases and cabinet furniture, were richly decorated. Size was therefore an important consideration. The old English porches were highly ornamented, but not the upper parts of buildings; and he thought it was difficult to understand how polychromatic embellishment could be applied higher than 40 or 50 feet. Another natural argument of great importance was to be derived from the diffusion of colour throughout the works of nature, in regular gradation, from the tropics to the poles. This was observable in the animal and vegetable world, as well as in the atmosphere. The animals and butterflies of the tropics presented the most dazzling colours, whilst whites, greys, and blacks predominated at the poles. By a natural instinct, which could not be explained, mankind were led to adopt similar gradations; and the use of colour in architecture being governed by the same law, a moderate employment of it might therefore be expected in Greece. He believed that the extensive introduction of painting in English churches and cathedrals arose from pedantry, and not from the natural feeling of this country and climate. It was a practice brought from the east, and here adopted as a matter of fashion. A further consideration was the prevailing colour of the atmosphere. If an architectural drawing were placed upon a background of intense blue, the building represented would appear to be a mere ghost, unless certain colours (such as crimson and gold, which were employed by the ancients) were applied to it, to bring it into harmony with that background. With a grey background, such as that supplied by the natural atmosphere of this country, no such vivid colouring was necessary; and the natural tones of the building, with such weather stains and other tints as time produced, would suffice to give it a pleasing and satisfactory effect. He would therefore suggest, in reference to the practical application of polychromy, that it should be introduced with very great reserve in this grey climate, although it may have been happily and properly applied under a more brilliant sky.

Mr. Nelson said that in a recent restoration of the Parthenon, exhibited at Paris by M. Paccard, the walls of the cella had been coloured red; and the same was stated to have been the case at Ægina.

Mr. Cockerell stated that he had found no traces of such colouring at Ægina.

M. Servas de Jong, architect, of Amsterdam, said he thought the subject under consideration was a very dangerous caprice; and particularly so because it was brought forward and defended by a very skilful advocate. He did not believe that the colouring of buildings, termed Polychromy, deserved so much consideration, especially in England. Excepting two or three gentlemen, those who had spoken after Mr. Donaldson had generally debated whether the colour applied to one edifice or another—if there really had been any colour—was blue or red. If any one had found a red stain, then the happy discoverer of such a precious stain of evanescent and transparent colour at the extremity of one angle of an architrave in Greece, was considerably astonished at finding this stain or spot much enlarged, and of an opaque and cutting colour when submitted in his drawings here. Indeed, before concluding his speech, M. Semper had rejected the hard and solid colouring of M. Hittorff, by saying, that if the exterior of some Greek temples was painted, it could only have been done with a coat of transparent ochre. Mr. Penrose, if rightly understood, was also of opinion, that if the Greek edifices were externally painted, the colouring was rather soft than harsh. M. Horeau spoke of the colours of the lotus plant in the capitals, and of the horizontal coloured bands of the columns in Egypt, in their relation to the different divisions of that country, but he omitted to bring forward a single proof that the exterior of Greek temples was painted. Supposing that they were painted in the manner published by M. Hittorff, and not by the Arabs but by the Greeks, and that they were so painted in the time of Pericles, then M. de Jong would be very much ashamed and very sorry for the Greeks, inasmuch as he had seen from infancy this identical polychromy executed as an ornament on the little cake stalls at the Dutch fairs. He considered the work by M. Hittorff to be skilfully conceived and executed in relation to the historical and archæological portions; but nevertheless, he thought that the colouring in general was too harsh and cutting: he preferred the impressions of Messrs. Semper and Penrose as having more the air of truth, and as being more probable. As to the portions treating of æsthetical principles and the position of architecture at the present time, he thought that if colouring ever was in use among the Greeks for the external decoration of their pagan temples, it could only be considered as the expression of a frivolous and worldly, not to say physical, religion. Similar usage of colour had occurred in the interior of Roman Catholic cathedrals in the fifteenth century. But in the present day to cover the interior of an architectural work, civil or religious, with colours like the interior of a theatre, would be an imposition on the simple and modest character of the faith of the English, and an attack on the fundamental law of architecture, that the eye rests with delight, without being dazzled, upon sublime and harmonious effects, which spring from the chiaroscuro of the profiles, and not from contrasted colouring. Polychromy in moderation was acceptable for the interior of buildings dedicated to pleasure and relaxation, as well as in private houses, being carried out on information existing long before the publication of this book; but it was not adapted to the interior of public edifices devoted to study and serious business. As the opinion of M. Hittorff would lead to polychromatising every interior, whether of a church or a cirque olympique, the speaker not only saw no merit in that portion of the publication, but held it to be opposed to every element of pure and refined taste. Nor was polychromy to be adopted for the exterior of any building, whatever might be its character or destination, since the colouring would only resemble the decoration of a theatre; and as M. Hittorff advocated exterior painting, the speaker thought this portion of the work more destructive than useful. It was not to be supposed that it was possible to increase the effect of buildings by adding glaring colours. It could not be too often repeated, that a person dressed as simply as possible would create a favourable impression by an elegant and noble exterior, while another in rich and gaily coloured apparel would be really ludicrous. And whence did this difference arise, but from the fact that the one preserved harmony in his costume, while the other neglected it. The same thing occurred in architecture; we should try to be harmonious as to details in their relation to the general appearance of the whole work; and then our buildings would approach nearer to perfection, for Harmony was the mother of Beauty and the Graces. He requested those present to recollect, that especially in the fine arts, truth alone was lovely; and to resist the attempts of a depraved taste, known by the name of Polychromy, which was ready to destroy the sublime in architecture.

Herr Licht, architect, of Berlin, explained his views as to the intention of the ancient Greeks in adopting polychromy, and the reasons for decorating with colours in modern architecture. He considered that the colours were intended for ornament; that they were indispensable by reason of the taste for colour existing among southern nations; and that they were designed for protecting the material. Colour, he said, was an effective and therefore requisite instrument in the hand of the architect; but its intended effect could only be produced when the idea which the architect wished to express was harmoniously and perspicuously carried out—when the colour completed the development of the idea itself. That the Greeks, whose architecture we admired as the perfection of art, even before we knew its connection with polychromy, employed the latter, was no subject for reproach, either to the artistic cultivation of the Greeks, or to our own admiration of the beauty of their structures. It must be remembered, that our impressions of Grecian edifices were either the offspring of the imagination alone, which pictured them as existing under our gloomy northern sky in all the dazzling whiteness of their magnificent material; or they had been acquired from actual examination of the mouldering ruins, yellow with the lapse of ages, under the clear and glorious sky of Greece; in either case no inharmonious picture met the eye of cultivated taste. If we imagined, however, the temples displayed in the glittering and almost transparent purity of their white material, under the lustre of a southern sun—the piercing glare of such an object would be not merely injurious, but destructive to the sight. Such could never have been the intention of those by whom these temples of classic art were raised, who loved to celebrate their gayest festivals around these fanes with all the full feeling of innocent liberty. The annoyance and confusion which a whitewashed wall, exposed to the sunshine, inflicted on the eye were well known; how much worse would the case be if the walls should consist of white marble, with its minute crystallisation, and covered with sculptures, the thousand reflexes of which must have a distressingly glistening and oppressive effect? Could we then avoid thinking of the necessity for calling ornamental painting to our assistance to subdue the reflection of the sunlight, to soften the wild play of the rays on the forms of the capitals and frieze, and to tone down their force into tranquil harmony? The ancient Greeks did not, perhaps, even think of this necessity when they resolved on painting their temples. It was probably another, and a more powerful motive that induced them—namely, the taste for colour. Every one knows the luminous zones of the south are more productive of colours than the darker ones of the north; that from the equator to the poles, nature's wealth in colour decreases from a boundless and a lively hue to a dreary monotony of black and white, through all the degrees of organic life, and that the predilection of the inhabitant of those regions unconsciously follows the laws of nature, so long as he himself remains her simple votary. The prepossession of the Greeks for a richer scale of colours naturally led them to paint their temples, while the northern races preferred seeing theirs of one colour, black or white. Nevertheless, the northern architect should not dispense with polychromy, if it tended more clearly to develope the character and intention of his work. The use of colour, as a means of perfection against the destroying influences of the weather, Herr Licht held to be of far greater importance, as it arose from an immediate and actual necessity, though certainly the need of colour did not involve that of polychromy, which was not of practical origin, but was the offspring of taste. It led, however, to the improvement of the material; it enlivened the plastic effect, and contributed by that means not a little to the perfection of the artistic idea. A building of well burnt bricks, of hewn stone, or covered with a weather-proof cement, did not need the further protection of colour; but the structure which had lately developed itself in England, and announced a new era in architecture, the structure in iron, required such aid from the very nature of the material,—a significant, eventful form of building, in which the spirit of our age was reflected in all its greatness. With our present knowledge, no safer and more convenient way of preserving this material from the effects of the weather presented itself, than to recur to colour, which would certainly require to be as often renewed as it was in the Greek temples by the hierodules, whose sole occupation it was to restore the colours which had become destroyed or extinct. The field for colour which this iron architecture would throw open, could not, indeed, be calculated. Thus much, however, we knew; the natural colour of the material did not correspond to its adaptation to the purposes of building; and whilst by its extraordinary capabilities of formation and strength, it was fitted for the lightest constructions, and for the most elegant and minute details, the gloomy and heavy fundamental tone of its natural colour admitted as little harmonious effect in its architecture as could be produced by the material employed by the ancient architects of Greece.

Mr. Harding thought that the employment of colour by ancient architects on their buildings, had been placed beyond dispute by the observations which had been previously made, and that the point which remained to be decided was, whether the architects of the present day should follow this example, entirely or partially, or reject it altogether. Professor Donaldson had said, that we should defer to the authority of the exalted genius which had produced monuments that had been objects of admiration and text-books of study for ages; but he (Mr. Harding) could not easily agree in this opinion, unless he could previously persuade himself, that because the Greeks were great as architects, they were also great as colourists. They might, and they did possess the brightest genius for producing all that was exquisite and faultless in form, and yet be completely insensible to the true hues and associations of colour. There were not wanting instances of persons, whom the eyes as entirely misled with regard to the tones of colour as the ears misled others with regard to the tones of music. Notwithstanding the examples on the walls, which demonstrated the power possessed by the ancients in dealing with colour, he must submit that the drawings did not afford conclusive evidence that they were right. What we required was, not to know that they coloured one member of a building blue, another red, and another yellow, but evidence that in so doing they were authorised by immutable principles, whether belonging to the nature of colours, or symbolical of the purposes to which the building was applied, and the feelings and associations to which it was intended to minister and appeal. Till these laws were enunciated he could not avoid the conclusion, that it would be as unsafe to adopt the opinion favourable to the ancients as it would be unwise to refuse when they should have been irrefragably established. But many knotty questions as to the exact colours employed in various cases still remained undecided, and, even if they were set at rest, who should say which was right, or whether any one at all was right, either in the actual colour or the tone which had been used?—for there were many ways of failing in that respect. He therefore thought, that before we venture to follow these old masters in that path, opinions on the question should be as unequivocal as they were with regard to the faultless productions in form which they had bequeathed to us. With the architect, as with the sculptor, form was the great field for the display of his powers, in which he was the acknowledged teacher, and the public were his pupils; but if he touched colour, he converted his pupils into disputants, and made those who would admire his forms entirely lose sight of them in the provoked discussion on his application of colour. To some persons, cold colours, to others warm, were most acceptable; hence every beholder would persist in blaming the architect for not administering to his special gratification, and unless the building, chameleon-like, could change its hues in conformity with every varying fancy, there was no hope of its meeting with any, much less with general approbation. Even if the approval of the learned were alone to be required, he would be most reluctant to undertake the task of applying colour to a building, as he feared he could not satisfy himself, and consequently should have little hope of winning the approval of architects; while he should utterly despair of gaining the suffrages of the public, if he did not indeed incur strong censure from all, for having effectually disfigured a good production. To try polychromy by another test, he would suppose the effect it would produce on representations of architectural subjects introduced as component parts of landscape composition, and he was apprehensive that all his dreams of loveliness would be dissipated at the bare suggestion of making the glorious bits which he had culled from Greece or Rome figure in prismatic decoration. Let them imagine the effect of pictures, such as Panini or Guardi painted, which were composed chiefly of architectural remains; would they consider the merit and the value of those productions enhanced by the addition of the primary colours and their complementaries? Mr. Harding took such instances because they appeared to him to be legitimate and natural, if not conclusive; and if he might be permitted to express a strong opinion on this subject, he confessed he should not feel greater repugnance at giving up the Parthenon, the Theseum, or the temple at Ægina, to the painter, than in submitting the Apollo to the tailor, or the Venus to the marchande de modes. He admitted the greatness of the great architects, and thanked them heartily for exquisite enjoyment; but in colouring their matchless and stately creations, they appeared to him to have as entirely sacrificed all their enchanting and impressive attributes, as would the sculptors of old, could they have finished by clothing their statues in broadcloth or printed cottons. He proceeded to say, that the objections which might be urged against the application of painting to sculpture were doubly potent, and that it was a perfect negation of the art. He illustrated this position by describing a supposed colouring of the Apollo Belvedere, the ultimate effect produced being the verisimilitude of a corpse. So far as he was acquainted with the history of architecture, he believed that however long the suspicion had been entertained that the ancients coloured their buildings, the fact had only recently been confirmed. During the last half-century, many able and earnest architects had travelled from our own and other lands to behold these glorious relics of departed genius. How had they toiled to drink in all their beauty! and how many, struck with as much admiration of the colour acquired from the palette of time, or from advancing or retreating sunbeams, had tried, with the pencil, to record these evanescent beauties. Whilst thus entranced, how few had desired to see the beauty they admired otherwise painted than as they found it! Mr. Harding judged of Greece by what he knew of Italy; and often as he had sat before the buildings of Pæstum or Rome, he did not remember a single instance in which he should consider that a painter with his pots of colour could add one charm to the art which had won his admiration. He could imagine the present Houses of Parliament in polychrome attire, looking very gay in the occasional sunshine of our climate,—and that should he pass them again when a few short months of a London atmosphere had rolled over them, how sadly would all their pigmental glories have become dim! Generally speaking, it was an axiom, that such a style of architecture should be selected, and such a design composed as should be not only best adapted to the required purposes, but should announce them to the spectator. Broad distinctions, such as those between a church and a prison, were thus easily marked; but polychromy would effectually undo all which had been thus accomplished, however well done, as whatever might be the building—church, prison, bank, exchange, or college—all must figure in the same dress, subject to the limited variety producible by the self-same seven colours in all cases. He would not, however, repudiate polychromy altogether. The observations which he had ventured to make had direct reference only to the polychromy of the old masters of architecture, but with deference, he said, not masters of colour. He hoped he might be excused for this expression of his opinion, and for saying that he preferred to be guided to conclusions in theory, and results in practice on this subject, by an older, more able, and unerring teacher—Nature. Stone of any kind might be employed for the purposes of building; and, putting aside the cost of obtaining the different marbles, these presented tints of every variety, sufficient to satisfy abundantly the most craving appetite, or the most fastidious taste for colour. Here we stood in no need of evanescent pigments to decorate and deaden, and leave futurity to discover, by toil and travail, whether the architects of to-day, who would be ancient masters to posterity, were polychromists as well as architects. Nature furnished material for polychromy, whose colour was as durable as the substances in which we found it; and in the choice of the various granites, porphyries, and marbles, the architect could exercise his imagination equally in colour as in design. Every stone had its colour incorporated with its substance, not laid on as a foreign, opaque, and unnatural skin, for the conjoint influence of the winds and the rains, the sunshine and the soot, to tarnish, abrade, or obliterate,—but in ever living and enduring colours, in blocks and masses, made up of countless integers of every harmonious hue. With such materials ready fabricated, and needing only to be fashioned by the hand of art, he could easily imagine what effective results might ensue from the arrangement of these natural, delicate, and beautiful colours, and their application to the different members thus brought into delicate or strong relief, as occasion might require, skilfully harmonised and adapted to a grand whole, where the eye could easily glance over the separate members, each pleasing in its colour individually, and contributing its share to a structure sublime, consistent, imposing, and harmonious. This he should call pictorial polychromy, and it would be, according to his views, its true and indisputable application. If the cost of obtaining marbles were such as to prohibit their use, almost, if not altogether, he would submit the following for consideration. Architects constantly used, whether from choice or necessity, different kinds of stone in one and the same building. Now, as in these we had warmer and colder colours, he conceived that advantage might be taken of these differences, in the manner suggested with regard to the marbles, if not with striking, yet with very pleasing effect. When new, however, as these means of obtaining colour were confessedly very limited, the building might yet look garish, and out of harmony with all around. If in this difficulty the philosopher could suggest any means by which something like the effect derivable from the use of the marbles might be achieved, means by which to dye the tints as Nature did,—for it must be remarked, that she employed dyes, not pigments—she stained, she did not stencil,—by which to polychromatise our buildings as she eventually would by the touch of time; if he could furnish architects with such a palette, with which to work in imitation and in anticipation of her tones of colour, he would confer a valuable boon on architecture, and on the arts. Architects would be justified by the great prototype they had chosen to follow, and would meet the approval of the public. In conclusion, Mr. Harding said that his observations had been confined exclusively to the exterior, as he did not feel warranted in taxing the attention of the meeting by the expression of any opinion he might have on the application of polychromy to the interior of buildings. Here, however, as he believed, we should find its special province; and as Mr. Smirke very ably observed, whatever doubt might still hang about the question of the external painting of Greek architecture, there need, at least, be none as to interior polychromy.

Mr. Owen Jones expressed his fear that anything he could say on this intesting subject would be very unsatisfactory. The question was not altogether one of taste, or whether the polychromy of the Greeks was such as we should approve of, because we did not at present know enough about it to form an opinion on that point. Now, however, that the public attention was directed to the subject, it might be hoped that the same careful investigation would be bestowed upon the colouring on the Parthenon as Mr. Penrose had devoted to its form; and it would then be known whether the Greeks were as imperfect in their application of colour as Mr. Harding supposed. For himself he did not believe that would prove to be the case, or that a people so refined as they were could be so defective in their knowledge of a sister art. He could not, indeed, conceive it for an instant. There was already evidence which could not possibly be controverted, that the Parthenon was partially coloured, and he considered that it might be assumed, in fact, that it was entirely coloured. Not only portions of colour, but actual painted forms had been traced upon the mouldings, and he believed that the colours which bounded those forms must have been of the greatest possible intensity, as otherwise they would have been undistinguishable, and perfectly useless at the height from the ground at which they were placed. These, indeed, could not have been tints, but positive colours; and as it would be totally impossible to reconcile to the eye the appearance of bands of positive colours separated by great masses of white marble, he could never bring himself to believe that the temples were not entirely painted. He therefore agreed with Mr. Donaldson in the opinion that the Parthenon was first covered with a thin coating of stucco. Of course this would appear very frightful to those who were accustomed to look upon the white marble of the Parthenon as such a wonderfully beautiful material. He denied that the Greeks so regarded it. They used it, in fact, because they had it under their feet, and because it was the best possible material for working out those subtle modulations of form which Mr. Penrose had elucidated; and which he thought they could not have done in sandstone. He therefore believed that they did not consider it at all a crime to cover the marble with stucco. The Egyptians covered their granite obelisks with stucco; or, at all events, as we knew that they coloured the hieroglyphics upon them, we could not suppose them guilty of such discordant treatment as not to colour also the granite faces of these obelisks. They also coloured their statues, because they were emblematical, and would have been imperfect without it. He could not but feel, therefore, that the appearance of the white marble would have been excessively disagreeable, and that unless coloured throughout, it could not have been made to harmonise with the positive colours, the existence of which had been already proved. The question then was, how the Greek temples were coloured. Mr. Penrose thought the marble received a stain; but he (Mr. Owen Jones) believed it would be exceedingly difficult to give an uniform and durable stain to that material, so as to agree with the strong colours still to be traced. Others thought that the natural stains, produced by time and weather, would be sufficient to get rid of that horrid glare of the white marble, which everybody felt would be unbearable. He would ask Mr. Harding whether he could make a satisfactory picture of the Parthenon in white marble—the actual white marble of the quarries of Pentelicus?

Mr. Harding admitted that the appearance of the material would not be pictorial till nature had altered its colour.

Mr. Owen Jones remarked that it would take a very considerable time to produce that result, and it would be produced very unequally. Some parts would be strongly tinted, and others not at all; destroying that evenness of tint which it was the object to produce. The Parthenon was not complete in any way without its colour; nor were any of its mouldings perfect without their coloured ornaments. Among the questions on which there had been some doubt, was that of the colour of the background of the pediment. In one example that portion was represented as red; but considering that the male figures in the pediment may have been coloured red, as they were in Egypt, and the women yellow, he thought the fact was established that the ground of the pediment was blue. The great question of difficulty was as to the columns, which were supposed by different persons to have been left white, stained, or painted red, yellow, or even black. He remembered seeing a column in the interior of the Parthenon which had some red colour upon it, but there was good reason to conclude that that was mediæval painting. His own belief was that the columns were coloured gold. It would seem at first a very startling supposition that there should be such a mass of gold in the building; but if the fact were established that gold was largely used in the enrichments of the mouldings, he did not see how the remainder of the colouring of the Parthenon could be carried out by yellow colour; it must have been done by gilding upon the stucco. The Chairman had adverted to the small size of the Greek temples; but it might be observed, that although the temples of Egypt were of great magnitude, they were nevertheless profusely painted. The question of introducing colour in this country was altogether a distinct one. He did not think the time had arrived for us to do so; indeed, we were were not able yet to devise an architecture of our own. When we had made our own buildings, we might colour them according to our own modes of thought; but at present we transplanted a Greek temple into England; and, in his opinion, the colouring on it would be no more out of place than the building itself.

Mr. Penrose observed that a very considerable time would be necessary to give a warm tint to the Pentelic marble. The marks made by the cannon balls on the Parthenon in the last war (1820) were as white as the freshest fracture of the marble in the quarry, not having acquired the slightest tint in thirty years. Even the Venetian shot marks of 1680, though partially tinted by time, were still very white. He only contended that there had been a very delicate stain upon the columns, but thought the tone required would not have been left by the Greeks to be acquired only by time. He believed that the marble of Pentelicus had been chosen by the Greeks on account of its beauty. They rejected the Hymettian marble, which was within five miles of Athens, easy of access, and producing blocks large enough to furnish monolith columns; and on the contrary, they selected that of Pentelicus, at a distance of sixteen or seventeen miles over very bad roads, although they could not obtain blocks larger than 3 feet high from that quarry.

Mr. Harding observed, that the whiteness of the Greek marble was not more offensive than the red tiles, the new thatch, and paving employed here, until time had toned them down. Certainly, if the Greeks wished to imitate the effect naturally produced by age, they would not have coloured their temples with bright reds, blues, and yellows.

Mr. Owen Jones said, that notwithstanding the use of such positive colours, he assumed that they were so well balanced and harmonised as to produce a bloom which would be satisfactory in its effect.

Mr. I'Anson stated that in the year 1836 he was at Athens, when the remains of the temple of Victory without Wings had just been discovered, and upon the fragments of it he observed distinct traces of painting, especially in the coffers under the pediment. A beautiful instance of ancient polychromy was furnished by a small sarcophagus in one of the churches of Girgenti, the colours of which were remarkably bright and clear. As to the modern application of colour to external architecture, it was evident that the prevailing feeling had been against it. The effect of colour in the restoration of the cathedral of Spires, now in progress, was highly imposing. In the cathedrals of Coblentz and Cologne, colour was also employed, but less successfully; and even the most ardent admirers of polychromy in Germany had only partially applied it to external decoration. In France there was a beautiful example of polychromy in the monument erected to one of the French admirals, in Père le Chaise; but the architect of St. Vincent de Paul had not applied colour externally.*

Mr. W. Lloyd said the first question to settle was what the Greeks did; and the next, whether they were right in what they did. On the latter point there was much difference of opinion; but he was rather inclined to assume, as a matter of course, that the Greek architects of the age of Pericles were unquestionably right. The colour employed in the Parthenon was regulated, he had no doubt, by reference to the sculpture in the pediment. The painted mouldings, of which there was most evidence, formed a sort of frame for the sculpture. The Greeks used metallic ornaments, and probably gold upon their sculpture; and Mr. Cockerell had shown that the shields and helmets of the figures at Ægina were painted. Whether the Greeks were right in so colouring their sculpture would depend on whether they succeeded in doing it well. The Olympian Jupiter was profusely embellished with gold, silver, and painting, and that statue was executed by the brother of Phidias. It was the admiration of its time, and as there was every probability that its sculptor was also employed on the Parthenon, it was not to be supposed that he who had produced a work so perfect in one case, would produce nothing but a hideous deformity in another. We ought to hesitate in concluding that the Greeks were grossly wrong, because they must have been either perfectly right or grossly wrong. That some of the plain mouldings were painted was evident; but there was much uncertainty about the abacus and the echinus. However, he was quite ready to conform his taste to whatever it appeared that the Greeks really did; and although he should be sorry to see the echinus painted, it was necessary to guard against the rejection of evidence which did not accord with our own prejudices. As to the general tone of their buildings, he thought the Greeks preserved the pure and native colour of the marble. Classical authorities constantly spoke of buildings, monuments, and tombs of white stone. The frontispiece to M. Hittorff's work, copied from a Greek vase, represented a youth painting a sepulchral stelé. In one of his verses Pindar spoke of a sepulchral stelé as a white stone; and although the frieze and cornice might have been painted, the remainder was probably left white. On the other hand, the painful effect of a white building was familiar to the eye, even in this monochromatic country. M. Semper had used a passage in Herodotus as an argument in favour of a red tint; but it appeared to him that Herodotus clearly considered a building which he described as of Parian marble, to be a white building.

* Mr. Donaldson showed, by reference to M. Hittorff's drawings, that he had applied colour externally to the Cirque National at Paris.

Mr. Donaldson observed that the question under discussion was simply a question of research,* the object being to establish a fact; and justice should be rendered to M. Hittorff for his labours, with that end in view. No person, he believed, would attempt to deny the fact that the Greeks used colour. Even Mr. Penrose thought there had been a wash over the whole of the Parthenon. The mouldings certainly were very intensely coloured; and he concurred in the opinion that the people who produced a building so perfect as the Parthenon, would not be likely to disfigure it by unpleasing colouring: if they were capable of judging of form, it might be assumed that they could also judge of colour. Mr. Bell had objected that M. Hittorff's restoration was based on very slight authority; but his object being to carry out a system of polychromy, he had very properly avoided the Parthenon and the Theseum, and taken only a small temple at Selinus,—a temple of freestone, of which there were few remains. While guided by the principles which he supposed the Greeks to have adopted generally, M. Hittorff was not hampered in the particulars of his restoration. He had also shown very clearly the extraordinary latitude which the Greeks allowed themselves in the use of the orders, the different parts of which were often combined in the same building. Although the climate of Greece suggested the use of colour, this was not even a question of climate, because in the frozen climate of Russia the churches were covered with porcelain, and their roofs gilded and painted. Size had also nothing to do with the question. There was not in London a portico of the size of the Parthenon. As to material, the Athenians employed marble because it was cheaper than stone; and it was well adapted to show those beauties of form which was a primary object with them. Mr. Harding preferred the Apollo Belvedere as a living object, and not as a dead corpse; but surely the application of colour would produce the effect of life. He had no doubt the ancient Greeks did paint their statues; and even certain modern sculptors were endeavouring, by delicate tints upon the hair and garments, to produce the same effect. Accustomed as we were to consider a marble statue the perfection of art, it was difficult to overcome the prejudice against colour; but the more the question was studied, the more should we do justice to Greek art, and advance in art ourselves. He certainly believed that the Apollo was painted originally, or at all events toned in a delicate sensitive manner to neutralise the effect of the cold marble. In his recommendation of coloured stones Mr. Harding adopted polychromy, which was not a question of material. The marble arch in Oxford-street was a cold, dead, tasteless monument; but if marble of different colours had been employed for the columns, the frieze, and the panels, it would be more expressive and more beautiful.

Mr. Cockerell (the Chairman) congratulated the meeting on the interesting nature of the discussion. If the Greeks could rise from their graves, they would say that the various speakers had fought like Greeks, and that their respected secretary, Mr. Donaldson, contending through thick and through thin, was the best Greek among them.

* The expression λευκος λιθος (white stone), as used by ancient authors, seems to me to refer rather to the quality of the material, as distinguished from the ordinary stone, which would be of a yellower or browner tint, and not to any accidental colouring of the surface. The white fracture of marble would contrast decidedly with the yellower fracture of stone. To distinguish the quality of the marble, authors use the name of the quarry whence it was extracted. Thus Pindar, Nemea. 4. Λευκοτεραν Παριου λιθου. And Pausanias—Αχαικα .ΚΓ. Πεντελησιου λιθου· and speaking of the quarries—Αττικα, Λβ. Πεντελικον, ενθα λιθοτομιαι. It is curious that the term μαρμαρος or μαρμαρον is very seldom used. Homer, Ιλ. μ. 380, is early, and is frequently referred to by subsequent lexicographers. Strabo uses μαρμαρον λιθον and λευκολιθος. In regard to the question, whether the paintings were executed on the walls themselves, or on tablets, the expressions of Pausanias would appear conclusive. In the description of the Poikile, Attica, he says—Ενδε τῳ μεσῳ των τοιχων Αθηναιοι και Θησευς Αμαζοσι μαχονται.—"On the third wall the Athenians and Theseus are fighting with the Amazons." And the very term, Ποικελην (various coloured) indicates its origin, from being itself painted, rather than as being a mere picture gallery.—T. L. D.

Barry.—The title of knighthood has this month been conferred on the architect of the Palace of Westminster. This compliment to him will be received with gratification by the profession, they having so long expected it would be paid to one who is among the most eminent of his art in the world.

STEAM ENGINES AND GOVERNORS.

Patented by JAMES WHITELAW, *of Johnstone, Renfrew, N.B. July 31st*, 1851.

THE specification contains twenty-three separate claims, but the following description and engravings will suffice to explain the principles of the invention. Fig. 1 is a transverse section of the improved engine, which can be adapted to a screw steamer.

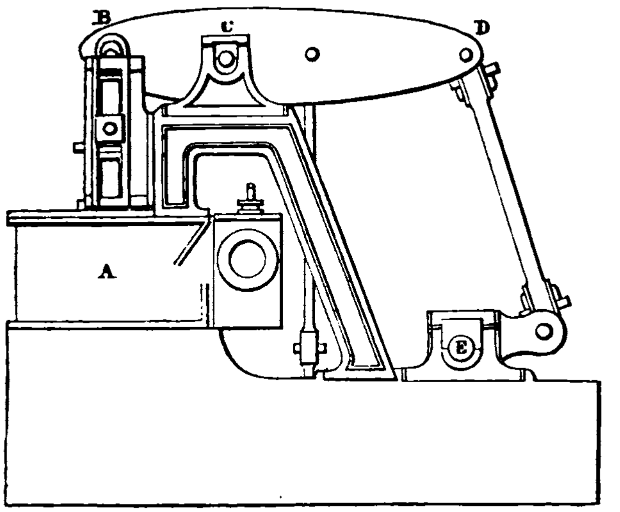


FIG. 1.

A, the cylinder, is placed on one side of the vessel, and the piston-rod is connected by links to the end B, of the working beam. This beam, in place of being set to work upon a centre equidistant from each end of the beam, is carried on the centre C, placed considerably nearer to the centre line of the cylinder than to the connecting-rod centre; the distance from B, to C, the respective centres of the piston-rod connection and the main centre of the beam is one-half that comprehended between C, and D, the main centre and the connecting-rod centre. In this way the engine has a short stroke, and therefore admits of being worked at such correspondingly high speed as may be required to drive the shaft of the screw propeller directly or without spur-wheels or other intermediate gearing, at the same time that the reduced pressure on the crank and its increased length give to this engine most of the advantages of one of the ordinary kind having a length of stroke even greater than that corresponding to the length of crank in this improved engine. It is also cheaper in construction, lighter, and occupies less room than the ordinary engine. The cylinders, instead of being side by side, may be set one on each side of the vessel so as to balance each other.

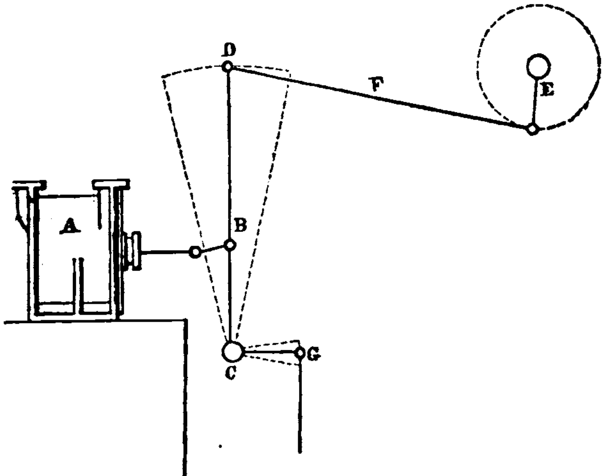


FIG. 2.

Fig. 2 is a horizontal-cylinder engine, arranged to work so as to secure the advantages of the differential or unequally-divided beam. The cylinder A, has its piston-rod connected by a link at B, nearly at the middle of the length of a lever or beam C D, which works on a fixed centre at C. In this way the end D, of the beam, by having a traverse of about double that of the piston, actuates the long crank E, by means of the connecting-rod F. The other end of the beam may be made available for actuating a pump, by an extending arm or lever G. On referring to fig. 1, it will be obvious that if the slide-valve were placed either on one side or behind, instead of in front of the cylinder as therein represented, the cylinder might be placed much lower down; this would admit of the working beam being also lowered, provided a sufficiently long connecting-rod could still be obtained.

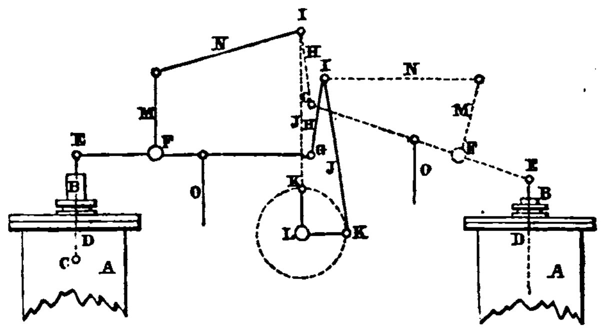


FIG. 3.

Fig. 3 shows a pair of vertical-cylinder engines with working beams brought very close down towards the crank-shaft. The cylinders A, are fitted up on the "trunk" principle, that is, with hollow trunks or rods B, attached to the upper sides of the pistons, and working through stuffing-boxes in the cylinder-covers, like the ordinary piston-rods. The pistons are jointed at C, to the lower ends of links D, which work inside the trunks B, and are jointed by their upper ends at E, to the short ends of the working beams carried on main centres at F. The opposite long ends of these beams are jointed at G, to the lower ends of the links or short lengths of connecting-rods H, which are again connected by joints at I, to the upper ends of the main lengths J, of the connecting-rods. The latter, passing downwards, are jointed at their lower ends to their respective crank-pins K, of the main shaft L. In this instance the short links H, add, in reality, so much more effective length to the main connecting-rods J. In other terms, the effective length of the connecting-rods is equal to the whole length from G, at the extremity of the long end of the working beam, to K, at the crank-pin. The upper ends of the links H, are therefore not guided in a vertical direction, but each beam is made to act as a guide to the connecting-rod of the other by means of the rocking-levers M, fastened on the main centres. The upper ends of these levers are jointed to links N, the opposite ends of which are similarly connected at I, to the joints in the connecting-rods G, I, K. By this means the action of each beam guides the connecting-rod of the opposite beam, retaining the centres I, at the proper effective angle for working; that is, the centres I, are so guided as to work nearly in the same curve through which a point at this distance from the upper end measured along a straight, inflexible rod of the length G I K, would work, so as to give the jointed rod the full working advantage of a straight, inflexible rod of about the same length. The rods O, depending from the working beams, may work air or cold-water pumps.

Fig. 4 is a Woolf's, or double-cylinder expansive engine, with the improvements. A, is the main centre of the working beam, on each side of which centre, and at suitable distances asunder, are placed the high-pressure cylinder B, and low-pressure cylinder C, their piston-rods being connected to the main beam at D, and E. From F, the connecting-rod descends to the crank-pin G. The united effect of the pressure of the steam on the two short-stroke pistons is made to act upon a long crank, as in the plans described. This action of the pressure of the steam on each piston is also balanced on each side the main centre. The steam-ways communicating between the cylinders are straighter than in the ordinary Woolf's engine, inasmuch as the steam from the upper end of the small cylinder passes directly into the corresponding upper end of the large one; and similarly the exhaust at the opposite ends passes from the lower part of the small cylinder to the corresponding part of the larger one; and one cylinder being placed near the other, the connecting steam-passages are shorter than they are in other engines of this class. Where it is desirable to avoid the use of cylinders of very large diameter, two short cylinders of small

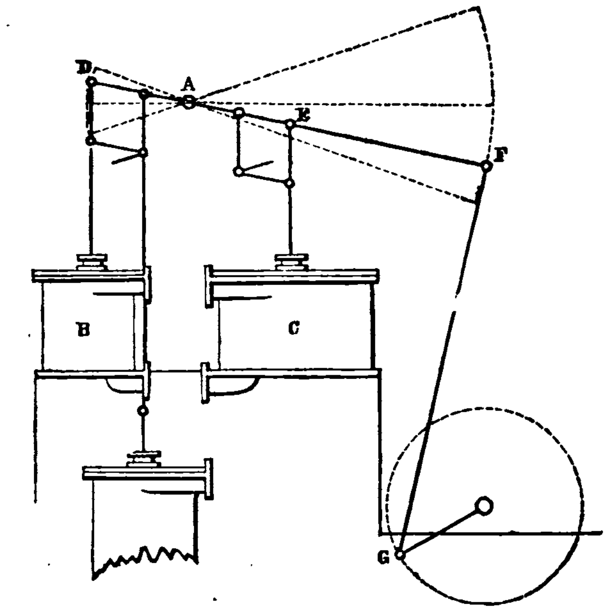


Fig. 4.

diameter, and each fitted with a piston, may be erected one upon the other, to work with one piston-rod. The effect of a short stroke of piston with a long crank may be secured by placing the cylinder between the main centre and the connecting-rod end of the beam. This arrangement is capable of easy illustration in fig. 4, where, by removing the small cylinder B, and the short end of the beam, the cylinder C, will act upon the main beam as upon a lever of the third order, giving the connecting-rod end F, the required amount of stroke upon the same principle as that of fig. 2. It will also be obvious, that the arrangement shown in fig. 4, may be modified by transposing the relative positions of the large and small cylinders, the small cylinder being placed on the connecting-rod side of the main centre.

The invention also relates to improved governors. Fig. 5, is a side elevation of one form of governor with its regulating mechanism attached; fig. 6, is a horizontal section of the spindle, with a plan of the lower sliding cross-head; fig. 7, is a plan of the expansion cam; and fig. 8, is a diagram representing the pair of adjusting star-wheels, with two of their fixed detents.

The cam A, for working the expansion-valve, is carried round by a spiral feather B, on the lower end of the governor spindle, and has a long boss C, fitting loosely to the spindle, and passing upwards for connection with the pendulum action above. Then, as the pendulum-balls expand with the increased rate of the engine, they draw the cam upwards, thus traversing it along its spiral feather B, and setting it forward to cut off the steam earlier. Similarly, the pendulum action brings down the cam again, as the balls contract on the diminution of the engine's speed, and thus the cam is set back. In this way the upward or downward traverse of the sliding tube D, of the governor, causes the cam A, to be set forward or back, as the case may be, on its spindle, altering the extent of expansion. The lower end of the tubular slide D, which fits loosely on the upright spindle linked to the pendulous arms above, is formed with a cross-head E, having an eye at each end, bored out to receive the vertical spindles of the star-wheels F, which are carried round with the governor spindle. On the two fixed brackets G, set on opposite sides of the governor spindle, are fixed two sets of stationary pins or teeth H, and I, each pair being in the same plane; and when the engine is working at its proper rate, the star-wheels F, revolve with the spindle of the governor at such a height as to work clear of the fixed teeth H, and I; but should the engine increase its speed, the interior portions of the peripheries of the star-wheels F, will come in contact with the inner and higher pair of pins H. When this occurs, the revolution of the star-wheels with the governor spindle will cause them to turn upon their own individual axes; and if the governor revolves, as indicated by the arrow in fig. 5, this action will also cause the star-wheels to turn in the direction indicated by the arrows upon them. If, on the other hand, the engine's speed should decrease, then the exterior part of the periphery of the star-wheels will similarly come in contact with the outer pins I, of the brackets G (see fig. 8), when the star-wheels will be turned in the opposite direction, as shown by the arrows in that figure.

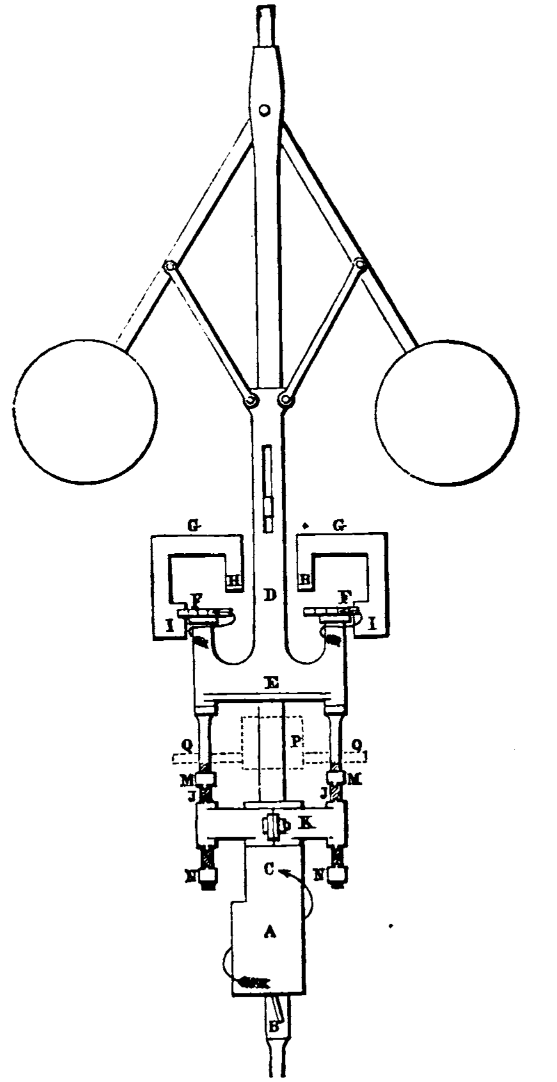


Fig. 5.

These two opposite actions of the star-wheels are made available for securing an additional power or secondary action for regulating the speed of the engine through its expansion valves, by means of the vertical spindles J, on the upper ends of which the star-wheels are fast. These spindles are screwed at their lower ends, and are passed through screwed eyes in the cross-head K, attached to the upper end of the boss of the cam A. This cross-head fits loosely in a ring-groove in the cam-boss, and carries a side projecting-piece L, which works into a short groove in the governor spindle, serving as a vertical guide for the cross-head during its traverse up or down, whilst the cam-boss works round within its collar. Similarly, the vertical traverse of the tubular slide D, of the governor is insured by a cotter, or flat stud, passed through the governor spindle, projecting on each side through a vertical slot in the slide. As the expansion cam A, has a partial turn communicated to it in either direction by the upward or downward traverse of the governor slide D, the star-wheels F, also get a partial revolution correspondingly, as they come in contact with one or other of the two pairs of fixed pins H, I, and thus a secondary action is given to the cam, setting it still further forward or backward by the revolution of the screwed spindles J, through the eyes of the cross-head K; and this will go on until the gradual arrival of the engine at its true rate of working, shall bring the star-wheels F, between and clear of the fixed teeth H, I. If the engine is exposed to varying degrees of resistance, this additional movement will give it a greater nicety of adjustment, and keep it at a more uniform rate.

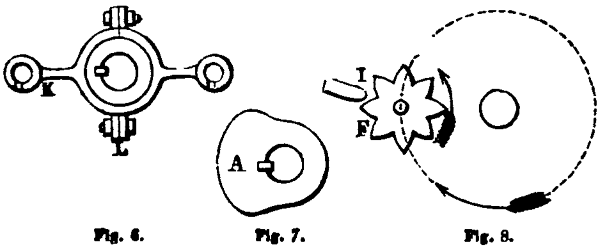


Fig. 6. Fig. 7. Fig. 8.

Provision is made for the prevention of the accidental turning of the spindles of the wheels F, too far in either direction. The wheels are attached to their spindles by stiff friction; and the eyes of the cross-head K, are furnished with inclined teeth or detents on each side, corresponding to similar teeth set in reverse directions on the lower and upper sides of the upper and lower collars M, N, fast on spindles. Thus, when the spindles have turned to the full extent allotted to them in either direction, these catches will come into action, and prevent further movement, whilst the stiff-friction connection of the wheels on their spindles will allow the wheels themselves to turn or move free when brought in contact with the fixed teeth H, I. By a slight modification one of the star-wheels may be dispensed with, a spur-pinion being placed on one of the spindles, as at O, to gear with the loose pinion P, on the governor spindle, which pinion again gears with the third pinion Q, fast on the opposite star-wheel spindle. In this way the revolution of one star-wheel spindle is communicated to the other, to give both a simultaneous movement, whilst one star-wheel only is used; or the three pinions O, P, Q, may still be used even with two star-wheels, in order to insure the simultaneous movement of the two spindles in case one star-wheel should at any time come into action before the other. Instead of having merely two pairs of fixed pins H, I, three or more pairs may be used, and set at different heights, in order, that when the engine's rate is only slightly faster or slower than it ought to be, the secondary action may come into play with greater delicacy. The same effect may also be produced by two pairs of pins, as shown in fig. 5. In working at a high velocity, where it might be injudicious to work the governor spindle at the rate necessary for the ordinary single cam (as in fig. 7), the governor may be reduced in speed, if fitted with a cam made double or triple, to correspond to this reduction in the rate. Or instead of having the cam upon the governor spindle itself, it may be carried on a separate spindle, working in connection with the engine; and if adapted to that spindle in the same way as the cam A, is connected to the governor spindle in fig. 5, the cam may be moved backward or forward as required, by means of a lever or other connection with the governor; and the secondary action may also, in this case, be applied so that the cam, if placed on a separate spindle, may be made to regulate the speed to as great a degree of nicety as if it were placed on the governor spindle. It may be adapted to work a tapering cam, or other apparatus, such as "Field's valve," where the cam is simply traversed along in the direction of the axis of the spindle on which it is carried.

NOTES ON CONSTRUCTION.

By Samuel Clegg, Jun.

(*With Engravings, Plate* VII.)

, These Notes, when completed, will be published in a separate form, as a Hand-Book for the use of the Students at the School of Construction.

Mixing Mortar.

The quicklime is formed into a bed 9 or 10 inches deep, and the sand to be mixed with it placed in a ring around it; water is then thrown on to the lime to slake it, and the whole thoroughly incorporated. The practical experience of the ordinary labourers enables them to judge how much water may be necessary to mix up the mortar to a proper consistency for use. Considerable labour must be bestowed upon working up the mass, which should be turned over and mixed several times with a species of hoe, called a *larry*, which is a half-round iron, about 6 or 8 inches in diameter, at right angles to a handle 5 or 6 feet long. It should be thus chafed up until there is no appearance of unmixed lime, the presence of which is easily detected; this unmixed lime is very pernicious, as it never sets, and is apt to swell and derange the brickwork. Mortar thus made is termed "larried mortar." A degree of beating or larrying, sufficient to give to the mortar all possible consistency, is of the greatest importance.

Another process of mixing is sometimes employed: where it is required to convey the mortar in a dry state to the work, it is done by forming a bed of lime within a ring of sand as before, throwing on the lime a sufficient quantity of water to slake it, and covering it up immediately with sand; after it has remained some time in this state, it is turned over and screened. The mixture is now in a state of dry powder, and can be carted to the work, where more water is added, and it is chafed up for use. For hydraulic limes this is the best mode of slaking, but the mixture must be used at once, and not be re-watered.

In mixing mortars, *trituration* must be avoided, as sand acts to more advantage in the state of crystals or sharp grains than as a powder, with every species of lime; trituration, therefore, kept up beyond the time necessary for perfect mixture, is only hurtful. Mortar, in every season, ought to be prepared as much as possible under cover, whether it be to avoid the rapid desiccation which takes place in summer, or to obviate the still more serious inconvenience in the rainy season. Particular care must also be taken that the mortar is not mixed on the natural surface of the ground, but on a smooth platform of paving or planking. On large works, where great quantities of mortar are required, it is desirable to mix it in a "pug-mill," turned by a horse, as it both insures perfect mixture and is economical as saving manual labour. The pug-mill shown in the engraving (fig. 3, Plate VII.) is capable of mixing 20 cubic yards of mortar in a day of ten hours, which will supply about forty bricklayers during the same period.

Artificial Hydraulic Mortars.

Naturally hydraulic mortars have been noticed in the preceding remarks, but rich limes, by the admixture of foreign substances, can be made into mortars that have the property of setting under water with various degrees of energy; indeed, they are very frequently to be relied upon, for sub-aqueous work, far more certainly than naturally hydraulic mortars. It must, however, be borne in mind, that the external joints of hydraulic mortar, however formed, will not become hard when exposed to the waves of the sea, or to *running water*, unless protected with a pointing of cement; but in still water this pointing is not essential.

Pouzzolana, tarras, and brick or tile dust, if mixed in proper proportions with rich limes, will render it an hydraulic lime; and, if mixed with a lime already possessed of hydraulic properties, will render it more energetic. Pouzzolana and tarras, or trass, are both volcanic substances; the former is brought from Italy, the latter from Holland; both are similar in their chemical composition, consisting of silica and alumina, with a trace of lime, and sometimes of magnesia; and both act, when mixed with lime, in the same manner, although pouzzolana is the most esteemed. Most clays are thus chemically constituted, and, when burned, form artificial pouzzolanas of nearly equal value with the natural.

Smeaton found that the strongest mortar he made for the Eddystone Lighthouse was produced by beating together equal measures of hydraulic lime and pouzzolana; the next in quality being composed, of lime 2 parts, pouzzolana 1 part, and sand 1 part; and he did not use more than 2 measures of mixed sand and pouzzolana to 1 measure of slaked lime powder, in any part of the work. Mr. Stevenson used the same sort of lime that Smeaton had done—the blue lias of Aberthaw—in the proportion of 1 measure of slaked lime powder, 1 measure of pouzzolana, and 1 measure of sand, which he says that he considered equally good as equal measures of lime and pouzzolana. The mortar for the front work of the Humber Dock, completed in 1808, was composed of 1 measure of ground Warmsworth* quicklime, $\frac{3}{4}$-measure of ground pouzzolana, and $1\frac{3}{4}$ measure of sharp fresh-water sand. This, when the work was pulled down twenty years afterwards, was found to be exceedingly hard, being, both in colour and hardness, like a well-burned brick.

* Described by Mr. Timperley as a magnesian limestone.

Pouzzolana communicates to common chalk lime the property of setting under water. The proportion of it used in making mortar is, 1 pouzzolana powder, 1 of lime, and, at most, 2 measures of sand. By the experiments of Sir C. Pasley, it appears that 1 measure of sand, added to 1 of pouzzolana powder and 1 of chalk lime paste, produces the strongest pouzzolana mortar with that species of lime; and the same author remarks, that pouzzolana appears to increase both the adhesiveness and resistance of the blue lias lime in so moderate a degree, as to render it doubtful whether it is worth while to use it at all with any lime possessing such very powerful hydraulic properties.

The hydraulic virtues of the pouzzolanas were, for a long time, attributed to the presence of iron. The experiments of M. Vicat, upon non-ferruginous clays, from which he produced, by calcination, artificial pouzzolanas, caused him to abandon that opinion. It would be wrong, however, to conclude that in the red coloured pouzzolanas the iron is entirely inert; but its presence is certainly not indispensable, since there are very energetic pouzzolanas which do not contain an atom of it. Captain Smith, the translator of M. Vicat's work, says, in confirmation of the above, that he has met with clay entirely free from iron, which, after calcination, formed a highly energetic pouzzolana; and, on the other hand, a stiff paste, prepared for experiment, with rich slaked lime and the washed peroxide of iron, was perfectly soft after several weeks' immersion. The mortar used for the Ramsgate Harbour new works consisted of lias lime 3 parts, sand 4 parts, coal-ash 4 parts, and of pouzzolana 2 parts, mixed thoroughly in a pug-mill.

In Holland, trass mortar is very much used in sub-aqueous constructions. M. Weeninck, a Dutch architect, states that there are four kinds of trass mortar, depending on the different proportions of lime, trass, and river sand, of which the mortar is compounded. But it is to be observed, that sand is never added when the strongest trass is used, as it tends to dilute its strength.

	Lime.	Trass.	Sand.
Strong trass	6 parts	...... 5 parts	...... 0 parts
Strong bastard	6 ,,	...... 4 ,,	...... 1 ,,
Bastard	2 ,,	...... 1 ,,	...... 1 ,,
Slack bastard	3 ,,	...... 1 ,,	...... 2 ,,

When the lime is produced from calcined shells, the proportions are as follows:—

Strong trass	2 parts	...... 1 part	...... 0 ,,
Strong bastard	6 ,,	...... 3 ,,	...... 1 ,,
Bastard	5 ,,	...... 1½ ,,	...... 1½ ,,
Slack bastard	5 ,,	...... 1 ,,	...... 2 ,,

Trass does not suck up the water, it resists its action; but it is affected by dry air and by frost. In the erection of walls exposed to cold and damp, the bastard trass should be used: sand gives strength, and the trass repels the damp. It is also used for exterior walls exposed to south-west winds, in damp soils, quays, &c. Strong trass is used for all sorts of work which it is desirable to render waterproof, as close cellars, reservoirs, cisterns, and the like. In hydraulic works, when the closeness of the work is not absolutely requisite, or which are more or less exposed to the air—like quay walls—and which are often above high-water mark, the strength of the mortar may be diminished, by taking 5 parts of lime to 2 of trass; but for constructions almost always above water, and only now and then wetted, such as those portions of a sea wall above high neap tides, 3 parts of lime to one of trass are sufficient.

The following notice of tarras is taken from Mr. Smeaton's essay on Water Cements, in his work on the 'Eddystone Lighthouse':—"Although really endowed with those qualities which have justly obtained it [tarras] a reputation for water building, yet it is generally admitted to have some properties that for our use were not quite eligible. In the first place, though it will cause most kinds of lime to set and become hard under water, as we have seen by several examples, yet, if the cement grows dry by a gradual exposure to the air, it never sets into a substance so hard as if the same lime had been mixed with good, clean, common sand, but it is very friable and crumbly; and if, after it has acquired a considerable degree of hardness by immersion in water, it is then exposed to the air, it loses a considerable part of its firmness, and also becomes crumbly, though, according to my observation, it never becomes so much so as if it never had acquired a greater hardness by a submersion in water. In a state between wet and dry, or of being wet and dry by intervals, tarras is known not to answer well." Mr. Smeaton also says, that when tarras mortar is kept always wet, and consequently in a state most favourable to its cementing principle, it throws out stalactites from the joints, which, in time become so extuberant as to deform the face of the wall. But Sir C. Pasley believes this growing out of the joints to have arisen from the fact of too much chalk lime having been mixed with the tarras—viz., twice its own bulk; and he apprehends this is not peculiar to tarras, but would take place with pouzzolana also, if it were mixed with so great an excess of lime. The brick wharf-wall of Woolwich dockyard, removed some time ago, was built with mortar composed of 1 measure of Dorking lime, 2 measures of sharp river sand, and ½-measure of tarras; and was found to be everywhere very hard, except in a small portion exposed to the action of running water from a culvert.

Artificial Pouzzolana may be made by calcining certain clays; indeed, nearly all clays that do not contain too much sand and lime, become, by roasting, more or less active agents in the preparation of hydraulic mortar. The Dutch are in the habit of burning a clay found under the sea on their coast, for the purpose of forming an artificial pouzzolana, which has often been sold for tarras, being so good an imitation of it. Sir C. Pasley found that the blue alluvial clay of the Medway, moderately burned, reduced to a fine powder and mixed with chalk lime putty in the proportion of 1 lime to 2 burnt clay powder, so as to form a stiffish paste, set nearly as quickly under water as the best natural pouzzolana. The brown Upnor-pit clay was not so good, and when sand was added to the mixture its properties were less hydraulic. The value of any clay for forming an artificial pouzzolana may be easily ascertained by experiment: burn the clay in small lumps, so that it may be reduced to a fine powder; mix it into a paste with slaked lime of the description most easily obtained, immerse it beneath still water, and note the time it takes to set. For practical purposes the clay may be burned in a brick or lime kiln.

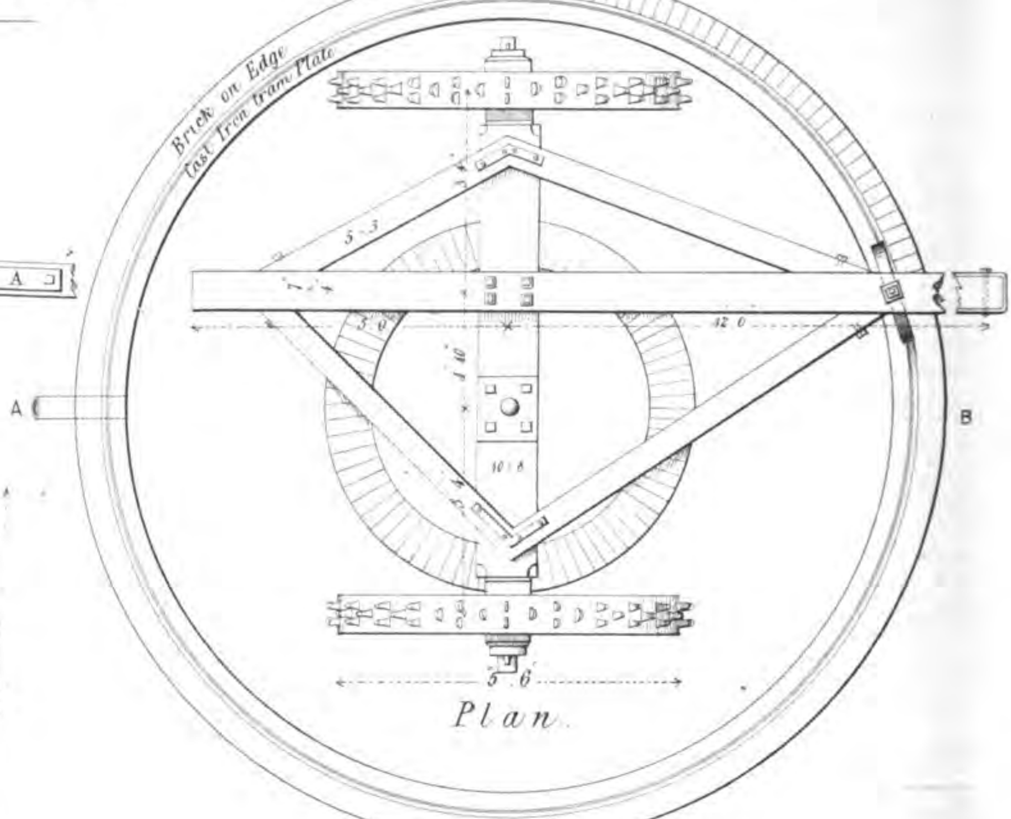
M. Vicat says: "All clay, principally composed of silica and alumina, and moreover fine, soft to the touch, and which contains more or less of the oxide of iron, and little or none of the carbonate of lime, will give a very energetic pouzzolana when calcined." Five per cent. of carbonate of lime will produce vitrification of the clay in the kiln; but the use of such a clay is not to be prohibited on this account, as it is easy to moderate the heat, and its presence enables the clay to be more easily reduced to powder. The presence of oxide of iron is, as has been before mentioned, not essential.

Brick or tile dust, when mixed with about half its bulk of slaked lime gives hydraulic properties to the resulting mortar, and is, in fact, the same thing as burnt clay. The proportions of lime to any kind of artificial pouzzolana must be obtained by experiment. As a general rule, one measure of rich lime paste and two measures of burnt clay, will make a mortar that will set beneath still water; if employed in running water, the joints must be pointed with cement. For a weather lime, equal measures of rich lime, artificial pouzzolana, and sand, may be used; if the lime used, instead of being rich, is already a weather lime, these proportions will produce an hydraulic mortar. It is necessary that the pouzzolana should be ground into a fine powder before being mixed up with the lime, as an intimate combination is essential. In fixing proportions, it is better to err from a deficiency than an excess of lime, when making mixtures of rich lime and any kind of pouzzolanas; and *vice versâ* in the case of hydraulic limes mixed with sand. Captain Smith makes the following note: "With an eminently hydraulic lime found in the neighbourhood of Masulipatam, I found that the mixture of two parts of a highly energetic artificial pouzzolana produced a much inferior cement to a like mixture of the same pouzzolana with rich slaked lime. I did not find the time of *set* to differ much, but the cement containing the hydraulic lime was meagre and friable, and soiled the finger on touching it, for a few days after solidification: that prepared with rich lime formed a compact, perfectly hard mass, with clean surface and conchoidal fracture, and so homogeneous in texture and closely united, as to be superior to many substances which had undergone the action of heat, such as bricks, tiles, &c."

Artificial Hydraulic Limes are made by calcining together rich slaked lime and clay, or pure limestone and clay, and the result is generally more satisfactory than when the natural or artificial pouzzolanas are mixed with the slaked lime as simple mortar, for the combination of the ingredients is more intimate and the

CHALK WASH MILL.

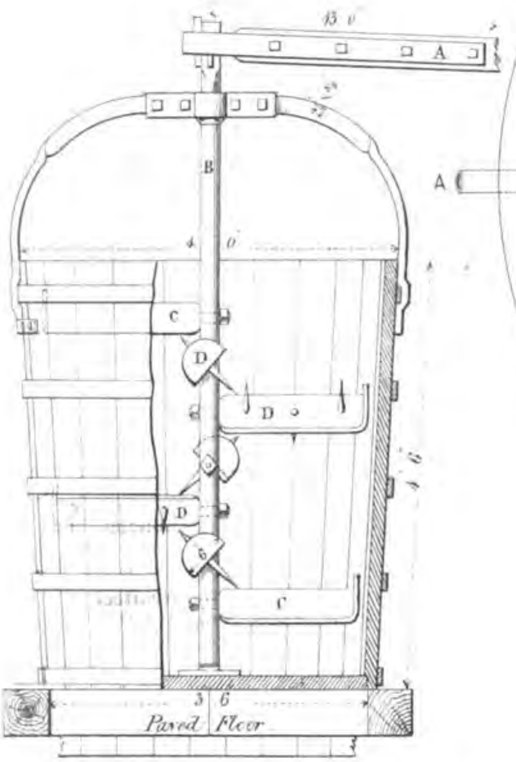
Fig. 1.

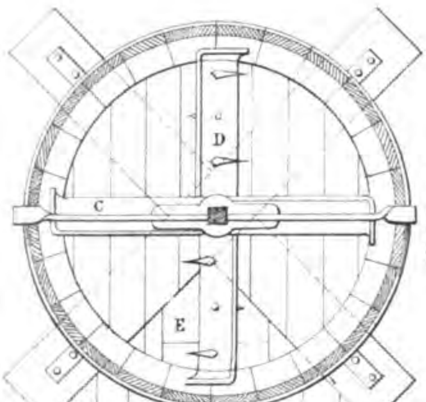


Plan.

PUG MILL

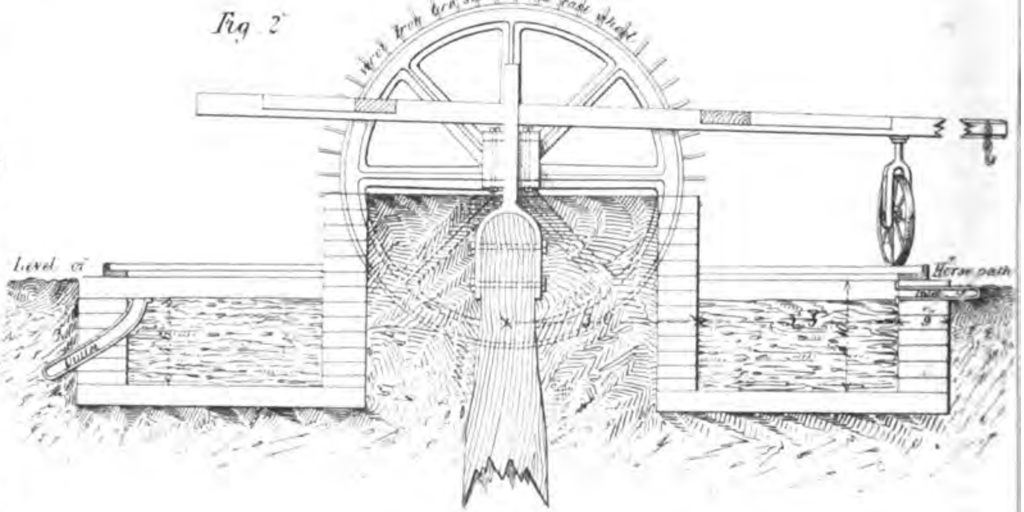
Fig 3





Section thro' A. B.

Fig 2



A. Yoke Arm

B. Shaft on which knives are fixed

C. Forcing knives

D. Cutting knives

E. { Hole in bottom of Mill thro which the mixed Mortar is expelled

Scale to Figs. 1 & 2

0 1 2 3 4 5 6 7 8 9 10 ft

Scale to Fig. 3

0 1 2 3 4 5 6 7 8 ft.

C. Bagster.

chemical changes more certain. The most perfect method is the first, and is called "twice kilned," and may be employed when the limestone procurable is too hard to crush and form a perfect mixture with the clay; when, however, chalk, coral, or sea shells are to be used, they may be mixed with the clay without first having been reduced to quicklime, and then only one burning is necessary. The proportion of clay to lime may be regulated so as to give to the artificial lime any degree of energy we please; for instance, 13 measures of clay added to 100 measures of chalk, ground well together and burned, will produce a lime similar in its properties to the *blue lias* of Aberthaw; and by a further addition of clay, say 48 measures to 100 of lime, a *cement* similar to the Sheppy is produced. But here again the engineer must have recourse to experiment, in order to fix upon the exact proportions, when new materials are to be employed. Particular attention should be paid to the amalgamation of the materials, and the degree of calcination best suited to it should be carefully observed, before attempting to imitate the process on the large scale.

M. Vicat describes the method of manufacturing artificial hydraulic lime adopted at Meudon, near Paris, which I give in his own words. The materials made use of are, the chalk of the country and the clay of Vaugirard,* which is previously broken up into lumps of the size of one's fist. A millstone set up edgeways, and a strong wheel with spokes and felloes, firmly attached to a set of harrows and rakes, are set in movement by a two-horse gin, in a circular basin of about 6 ft. 6 in. radius. In the middle of the basin is a pillar of masonry, on which turns the vertical arbor to which the whole system is fixed; into this basin, to which water is conveyed by means of a cock, is thrown successively 4 measures of chalk and 1 measure of clay. After an hour and a-half working, they obtain about 53 cubic feet of a thin pulp, which they draw off by means of a conduit, pierced horizontally on a level with the bottom of the basin. The fluid descends by its own weight, first into one excavation, then into a second, then a third, and so on to a fourth or fifth; these excavations communicate with one another at the top; when the first is full, the fresh liquid, as it arrives, as well as the supernatant fluid, flow over into the second excavation, from the second into the third, and so on to the last, the clear water from which drains off into a cesspool. Other excavations, cut in steps like the preceding, serve to receive the fresh products of the work, whilst the material in the first series acquires the consistency necessary for moulding. The smaller the depth of the pans in relation to their superficies, the sooner is the above-mentioned consistency obtained. The mass is now subdivided into solids of a regular form, by means of a mould; this operation is executed with rapidity. A moulder, working by the piece, makes on an average 5000 prisms a-day, which will measure nearly 212 cubic feet (English). These prisms are arranged on drying shelves, where in a short time they acquire the degree of desiccation and hardness proper for calcination, which may be effected in a common kiln, as described in a previous chapter. It is necessary that the prisms be thoroughly dried previous to calcination, as experience shows that if subjected to heat while retaining any moisture, it may deprive them almost if not entirely of their hydraulic properties.

Cements differ only from water limes in containing a greater proportion of clay (silica and alumina) and a less proportion of carbonate of lime in their composition, than any of the water limes; and the term "cement" is merely used to distinguish them from these. Practically, cements differ from water limes in several particulars: first, they will not slake unless previously ground to powder, which is therefore always done in preparing them for use; secondly, when mixed with water, they set under water in a much shorter time than the strongest lime mortars do even above the surface of the water; thirdly, they are always weakened by the addition of sand, nevertheless equal measures of cement powder and sand set more rapidly and harder than any lime mortar; fourthly, when "gauged" up for use, it must be applied in work before it becomes warm, after which it must not be disturbed, so that any portion of it that could not be used immediately must be discarded.

Natural cement is made by calcining certain stones, such as those found off Harwich, in the Medway, on the Yorkshire coast, and in various other places, and such cements are named after the places from whence they are furnished. A cement stone may be distinguished and roughly tested by the engineer in the following manner. In colour, the stone should be of a bluish grey or brown, or of some darkish colour, as *white* indicates pure limestone; touched with the tongue, a cement stone, from its containing clay, will adhere to it slightly; they only dissolve partially in diluted acids, and leave a greater residue than any of the limestones. When by these rough tests the stone is presumed to be fit for making cement, it may be burned, pulverised, and then tested by its "set." When burned at a red heat in a crucible for about three hours no effervescence should take place in acids; if, however, any effervescence is visible, the carbonic acid of the lime has not been completely driven off, and it must be again subjected to heat; but it must not be burned too much, or its properties will be destroyed, and it will become of a dark colour. After the burnt stone has become cold, reduce it to a powder, mix it with water, and knead it into a ball; if it be a good cement stone it will soon become warm, and not only hard in the heating, but if put into a basin of water it will continue hard, or even become harder beneath the water.

Cement powder, by exposure to the air or to moisture, always recovers back some of its carbonic acid, and when long kept it is termed "stale." It is always sold and kept in casks, and if stored in a dry place may remain good for a long time; and if it has lost its properties, it may be reconverted into good cement by re-burning. If any considerable quantity of damaged cement should require to be restored in this manner, as it could not conveniently be burned in a kiln whilst in the state of powder, it would be necessary first to mix it up well with water into balls or lumps of a convenient size, which, if allowed sufficient time, will probably set so far as not to fall to pieces. If, however, the cement powder should be too stale for this purpose, let a small proportion of fine clay, not exceeding one-tenth part by measure be added to it in making these lumps, which will cause them to hold together in the kiln, without materially injuring the quality of the cement. It would not be worth while to take so much trouble in this country, but in the colonies the knowledge of this expedient may be useful.

Artificial Cements may be manufactured with as great facility as artificial hydraulic lime; and the following is the description of the process:—

The first ingredient is chalk, or such other pure limestone that may be ground dry to an impalpable powder, or into a fine paste with water; all impurities must be carefully discarded. *The second ingredient* is the blue alluvial clay of lakes or sluggish rivers, fine, and free from sand; that procured from rapid rivers is generally mixed with sand, and is not therefore fit. The brown surface with which alluvial clay is usually covered must be rejected, and care must be taken not to allow it to become stale by exposure to the air, which generally robs it of its blue colour, and, at the same time, of its virtue as an ingredient for water cement. When alluvial clay is not to be had, fine pit clay will answer the same purpose; but the cement they produce is much harder, and therefore more expensive to pulverise than that made from the alluvial clay.

The best proportions of these ingredients (when pure chalk and blue alluvial clay are used) are 1 cubic foot of stiffish chalk paste to $1\frac{1}{4}$ cubic foot of the fresh clay; but different materials require different mixtures.

To grind the chalk, it must be broken into moderately small pieces, and placed in a mill, such as represented in Plate VII., figs. 1, 2,—which consists of a circular trough of brickwork, in which heavy spiked wheels, revolving on a horizontal arm, are made to turn by a horse: this arm turns loosely on a pivot, made of such a length as to allow the arm, and consequently the wheels attached at each end, to adjust themselves to the height of the chalk in the trough. The wheels are placed at unequal distances from the centre, so that they act upon the whole breadth of the chalk contained in the trough. The yoke-frame is attached to the axle by staples and pins, to allow it to move radially up and down with the fixed wheel (running on the tram fixed on the outer edge of the trough) as a centre. The chalk, as it comes from this wash, or grinding-mill, will be too thin for immediate use, although the superfluous water is drained-off through gratings at the bottom of the trough; it must therefore be suffered to dry, until it is of the consistency of ordinary mortar, when it may be mixed with the clay. To effect this, two measures must be provided, of the respective capacities of 1, and $1\frac{1}{4}$, the former for the chalk, the latter for the clay (and the smaller these are the better will the mixture be). Let the contents of these measures be thrown alternately

* 100 parts of this clay consist of—silica 63, alumina 28, oxide of iron 7, loss 2.

into a pug-mill, until it is full; the first filling, as it is ejected, must be passed through the mill a second time. To prepare this raw cement mixture for burning, it must be kneaded by hand into balls about 3 inches diameter, and dried, under cover, for about forty-eight hours or so, that they may not stick together or crush in the kiln; when thus ready, they should be burned as soon as possible, exposure to the air being detrimental to their after-cementitious properties.

The kiln for burning this mixture may be the same as for common lime; but a kiln described by Sir C. Pasley (p. 284) is more simple, and quite as efficacious: it is in form a double truncated cone, their bases being about two-thirds from the bottom. The dimensions may be 21 feet high, 5 ft. 6 in. diameter at bottom, 8 feet at two-thirds of the height, and 6 feet at the top; the chamber must be lined with fire-bricks, and the whole structure firmly bound together by four hoops of iron, 3 in. × ⅝-in. The external diameter of the kiln should be uniformly about 20 feet. A kiln of these dimensions will contain nearly 30 tons of broken cement, measuring about 26 cubic feet to the ton, together with the whole of the fuel necessary for burning it, which varies according to the management of the workmen. The bottom of the kiln is first filled with wood and shavings, after which coals and cement stone are laid in alternate layers, the coals being broken so small that they occupy very little more space than is necessary for filling up the interstices between the strata of the cement, each of which is usually 1 foot in thickness. Three days after the kiln is lighted, the workmen may begin to draw the calcined cement; whilst, by laying on more coals and raw cement stone at the top, so as to keep it continually burning, they may afterwards draw the kiln once in every twenty-four hours. Every ton of cement stone is said to produce 21 bushels of cement powder.

The usual method of grinding the cement into powder differs in no respect from the mode of grinding corn and sifting the flour, the same sort of hoppers, mill-stones, and bolting apparatus being used for both; but it may be ground beneath heavy edge-stones—at all events, at first—and then passed through the mill-stones, if found necessary, to produce extra fineness. The cement powder is packed away in casks, for use when required. Where hard limestone, instead of chalk, is to be used, it must be burned before being ground; with this exception, the process of mixing and preparing the cement is similar to that just described.

Before using any cement supplied by a manufacturer, it is necessary to test its quality; and the best way of doing this is to mix it up into a few small balls, about 1 inch diameter, with water; allow them to become cool, which will be in about half-an-hour, place them beneath water, and if, in the course of a day or two, they have become hard inside and out, the cement may be pronounced good. If they do not set, the cement is either stale or adulterated, and in England both may be rejected; but if abroad, it may probably be worth while to reburn the cement, in a small crucible, in the manner before described at page 602, Vol. XII.: if, after this process, it will not set, it is adulterated, and worthless.

CONCRETE.—For foundations and similar work the use of concrete, as a substratum in dangerous soils, has almost entirely superseded every other method; and as it offers so valuable a resource in so many different situations, I shall here give the rules for its composition and preparation, and in the chapter on Foundations give as many examples as will be useful of its successful adoption. Concrete is a composition of clean gravel stones or rubble, and sand, with fresh-burned stone-lime ground to powder without slaking. The stones may be considered as the substance of the mass: the sand answers the double purpose of filling-in the interstices between the stones and uniting with the lime to form mortar; the quantity of sand should therefore be proportioned to the quality of the lime, as in ordinary mortar, and to the size and shape of the stones. For Dorking, Merstham, Halling, or limes of such quality, 3 measures of sand to 1 of lime is, as I have before stated, the general proportion used for mortar; and suppose we had to make concrete with this lime and the black Thames ballast, from between London and Westminster bridges, which consists of 2 of stones to 1 of sand, it would seem that the proper proportions for concrete would be 6 stone, 3 sand, 1 lime; any excess of lime must remain free, and as soft, useless matter. When broken stone is used, the size of the stones should be as various as possible, and none larger than a hen's egg; and coarse sand should be added, to make as nearly as possible artificial Thames ballast. Angular stones are better than rounded stones, for the same reason that sharp sand makes the best mortar. Ordinary pit gravel must be washed, if at all mixed with clay, &c., but not screened. If perfectly incorporated the proportions for concrete may be—

Broken stone.	Sand.	Lime.
6	3	1 for Dorking or similar lime.
4	2	1 for lias limes.

But the difficulty of incorporating these ingredients renders it advisable to increase the proportion of lime, not more however than about 25 per cent. These ingredients should be placed together *dry* upon a platform, as small a quantity of water added as possible, and the mixture being turned over two or three times with a shovel, it must be put into barrows and thrown into the situation it has finally to occupy as speedily as possible from a height of 8 or 10 feet. It sets very quickly, so that it is desirable that the mixture should be made at or close to the place from whence it is thrown, and after being expeditiously spread and brought to a level, it must not be again touched. The whole surface to be concreted should be got to its proper depth in uniform layers of about 12 inches in thickness. In setting it expands in the same manner as hydraulic lime, which renders it very valuable for under-setting walls and similar purposes. This increase of dimensions amounts to ⅜-inch in a foot in height on the first setting of the concrete, and it continues to expand insensibly for a month or two afterwards, the time of course depending upon the weather or upon its position. This expansion follows a previous condensation of about one-fifth in bulk by which the ballast and lime are found to be contracted after being incorporated together.

GOTHIC ARCHITECTURE.

(*With Engravings, Plates* VIII. *and* IX.)

Details of Gothic Architecture, Measured and Drawn from Existing Examples. By JAMES K. COLLING, Architect. London: David Bogue. Parts II. III. and IV.

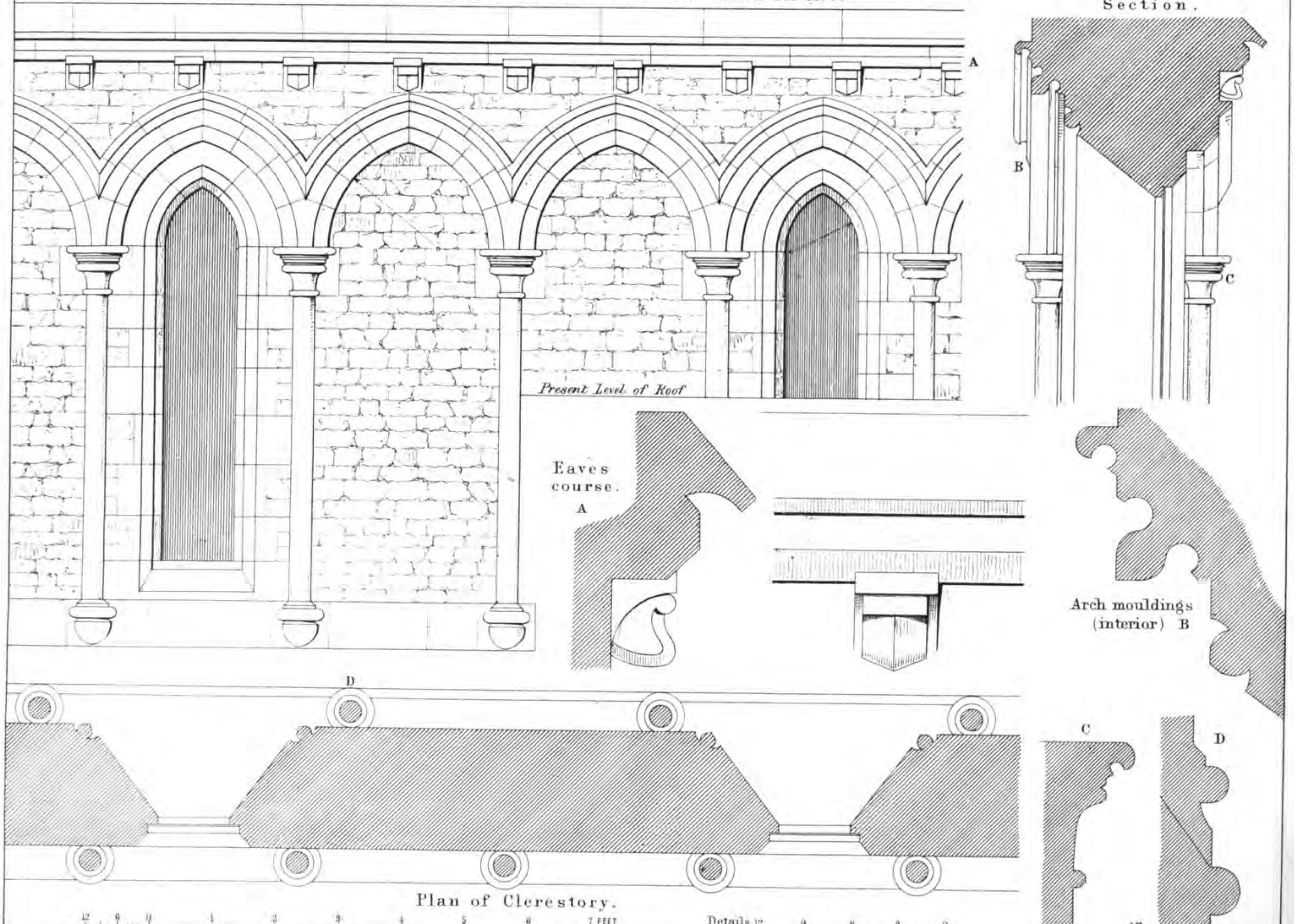
WHEN the first number of this work was produced, we felt it our duty to point out its great value, as furnishing the architect with examples on those details which, being now brought within his domain, are expected to receive special attention from him. Patrons are more exacting now, and are not contented without their buildings are carefully finished within and without. A chance font or pulpit will not pass muster with a public as well read in mediæval lore as the architect himself. This is all the better, for the architect is now more appreciated, and has gained in dignity by the extension of his functions to smaller labours. For assistance in these studies the works of Mr. Colling, called 'Gothic Ornaments,' and that now in progress, will be found most valuable. Mr. Colling has taken as his basis the reproduction, accurately, and in all their particulars, whether of form, construction, or measurement, of existing examples of the several mediæval styles. The churches from which they are derived are chosen with judgment and discrimination, as affording good examples, and therefore the value of individual drawings is enhanced. These are not chance sketches made here and there, an omnium gatherum, or an archæological album, but a collection of practical works calculated to be of use to the architect.

We have availed ourselves of the opportunity to give two plates, each referring to West Walton Church, in Norfolk. One of these (Plate VIII.) shows the exterior of the clerestory; and the other (Plate IX.) the nave, piers, and clerestory. These satisfactorily exhibit Mr. Colling's arrangement of his work. The plates are produced by Mr. Jobbins, the lithographer, and are fine specimens of the art.

Tables of Discount on Simple Interest. By T. GOMERSALL. Eighth Edition. London: Effingham Wilson. 1852.

ALTHOUGH there are several interest tables, yet much is still wanted to supply all the details of calculation required by the public. The present book is one which will be found very useful, because it has exclusive features which are likely to make it popular, while great care has been bestowed on the correction of the figures. Each page is complete in itself, and the discount of any amount, from one pound up to twenty thousand, for any number of days, may be obtained by simple addition.

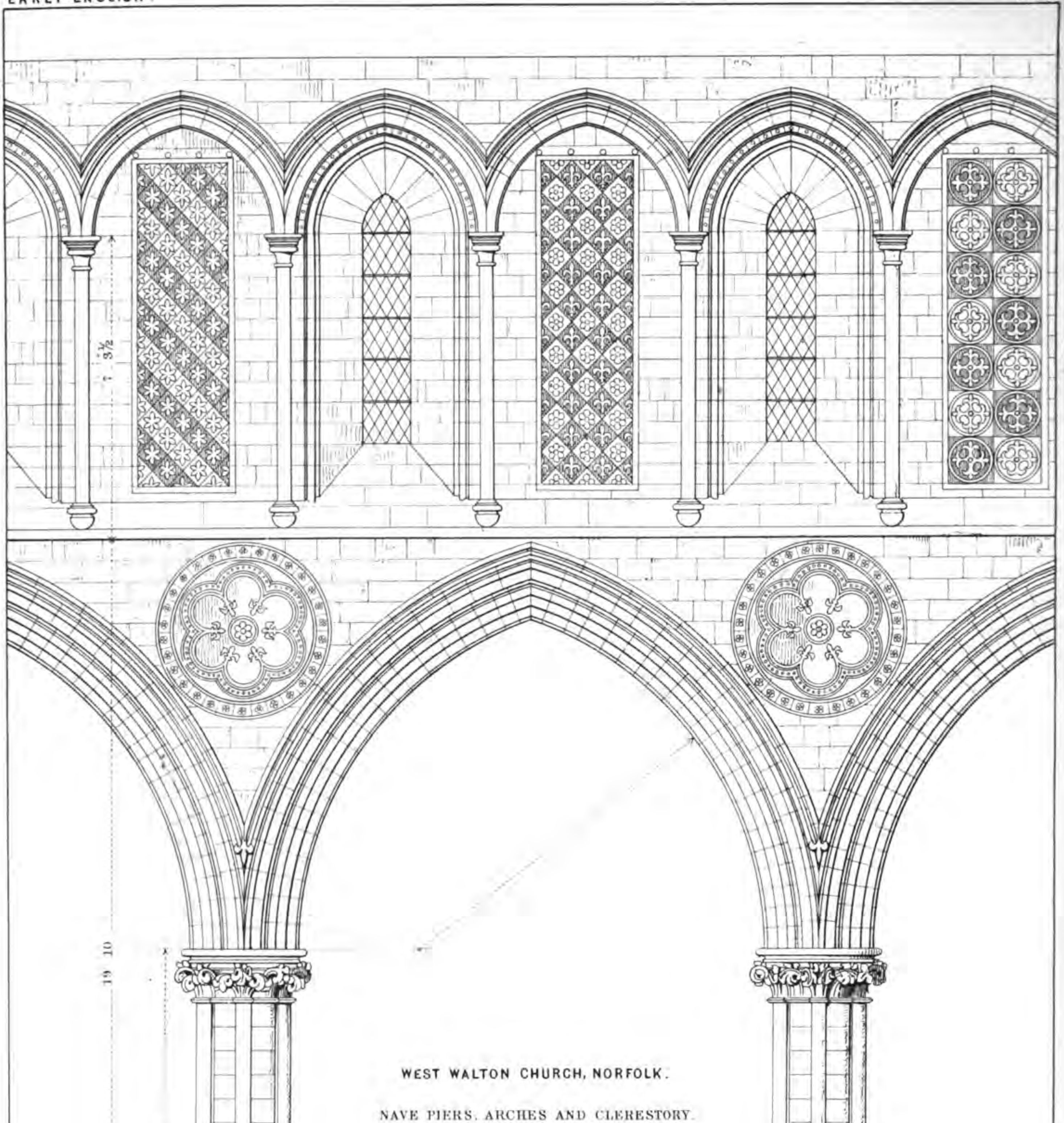
WEST WALTON CHURCH, NORFOLK. EXTERIOR OF CLERESTORY. For interior see Pl. 9.



J. K. Colling. del.

Pub.d by D. Bogue, 86 Fleet St. Nov.r 1. 1851.

J. R. Jobbins.



WEST WALTON CHURCH, NORFOLK.

NAVE PIERS, ARCHES AND CLERESTORY.

J. K. Colling del. Pub^d by D. Bogue 86 Fleet S^t Sep^t 1 1851 J. K. Jobbins

CONSTRUCTION OF THE BUILDING FOR THE GREAT EXHIBITION OF 1851.

By Matthew Digby Wyatt, Assoc. Inst. C.E.

(*Abridged Paper read at the Institution of Civil Engineers.*)

[Although the more immediate events connected with the Great Exhibition have passed away, and although we have at different times described the mode of construction of separate portions of the Building, yet the many clever inventions and appliances brought to bear in its erection are so valuable to the profession, that we may be excused giving a more authentic and continuous account of them,—rendered the more valuable as coming from the pen of Mr. Digby Wyatt, the indefatigable Secretary to the Commissioners, prepared by him during the progress of construction of the Building, and read at the Institution of Civil Engineers.]

The Area Covered.—The building, as now erected, provides an area, upon the ground-floor, equal to 772,784 square feet, and upon the level of the galleries, 23 feet from the floor, an area equal to 217,100 square feet, making a total area of available space of 989,884 square feet.

The General Features of the Design.—The combination upon so vast a scale of the materials, glass, wood, and iron, of which alone the building is constructed, and the care which has been taken not to exaggerate the proportions of form in which those materials may be best and most economically used, will probably tend to counteract conventionality of style in architecture, and may be expected to produce, hereafter, important changes, alike in the construction and appearance, of many extensive buildings throughout the country. The general distribution of the design recalls the system of a cathedral structure—a vast nave, 72 feet wide, rises to a height of 64 feet above the soil. This is crossed by a transept 408 feet long, equally wide and lofty, but with the difference that it is crowned by a wagon vault, increasing its height to 104 feet at the centre. On each side of the nave and transept a series of aisles, 24 feet wide by 44 feet and 24 feet high, spread out to a total width of 456 feet. Some idea may be formed of the leading peculiarities of the building, by recalling the fact, that its main avenue, between the columns is nearly double the width of nave of St. Paul's Cathedral; while its length is more than four times as great. The walls of St. Paul's are 14 feet thick: those of the Hyde-park building are 8 inches. St. Paul's required thirty-five years to erect; the building will be finished in about half that number of weeks.

The Drainage.—It may be conceived that the arrangements for carrying off, rapidly, the entire roof-water of 17¾ acres, involved considerable preparation. Six rows of cast-iron pipes, each 6 inches diameter, communicating with the hollow columns supporting the roof, follow the fall of the ground from west to east, and convey the water to three drains running north and south. The latter, communicating with sewers running east and west outside the building, convey the water to the lowest points, at the east end of the site, from which it is discharged into the main sewer in the Kensington-road, by an egg-shaped culvert of 4 ft. 8 in. sectional area. A datum line having been assumed, the level of the flooring of the whole area was arranged to incline 1 inch in 24 feet, approximating to the fall of the ground.

The Flooring.—The floor was arranged to consist of boards 1¼ inch thick, laid half-an-inch apart, upon joists 7 inches by 2½ inches, bearing upon sleepers 13 inches by 3½ inches, at intervals of 8 feet apart. The interstices were left between the boards to permit the passage of dust and dirt. This method of flooring has been found to answer well at Chatsworth and in other localities.

The Foundation and Base-Plates (Figs. 1, & 2).—It would have been difficult to have found a better foundation than that which extends over the whole area of the building, with the exception of a few "faults" here and there. Good gravel is reached at a depth of about 3 feet below the surface of the ground, and excavations have been made, in all cases, sufficiently deep to lay bare the gravel. The extent of the horizontal area of the excavation has been determined by a rule, that, making allowance for possible contingencies, the gravel cannot be exposed to a greater load than 2½ tons per superficial foot. The cavities thus formed have been, in all cases, filled up with solid concrete, finished with fine mortar. On the surface of this mortar are bedded "base-plates," or foundation pieces, consisting of a horizontal bed-plate, at right angles to

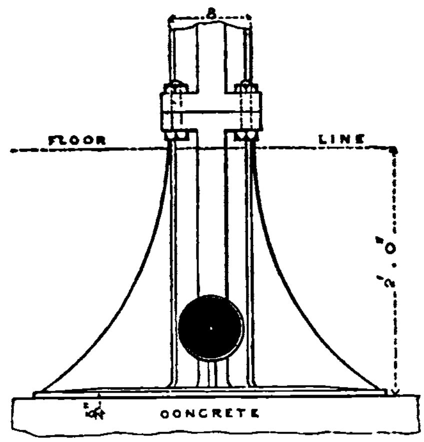


Fig. 1.—Elevation of Base-Plate, showing connection with Column above it.

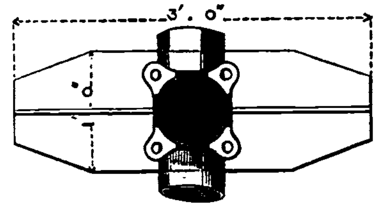


Fig. 2.—Plan of Base-Plate.

the vertical lines of the building, strengthened by shoulders, uniting the horizontal plates to the portion of the base-plate the section of which corresponds with that of the columns. The exact height, from the top of the concrete foundation to the plane of the junction between the base-plate and the column, has been so precisely calculated, and the casting of the base-plate has been, in all cases, so perfectly performed, that the snugs, cast on the upper portion of the base-plates, have exactly met and corresponded with those on the lower portion of the superincumbent columns, without leaving any interstice, or requiring any packing. From the vertical portion of the foundation pieces, which carry columns, through which the roof-water passes, sockets branch out, into which are fixed the ends of the cast-iron pipes, for conveying the water descending from the roofs to the transverse drains.

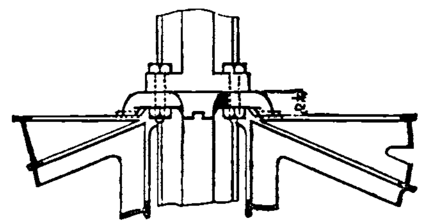


Fig. 3.—Elevation of Upper Portion of Connecting Piece, &c.

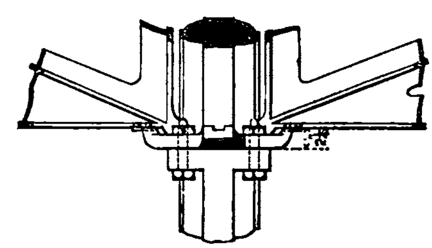


Fig. 4.—Elevation of Lower Portion of Connecting Piece, showing its attachment to a Column below, and to the Girders at the sides.

The Columns and Connecting Pieces (Figs. 3, 4, & 5).—The form of the supporting columns bearing upon the upper face of the base-plates was suggested by Mr. Barry. The horizontal section is a ring, of which the external diameter is uniformly 8 inches; and the substance of metal is proportioned to the various areas of roofing, &c., to be supported at each point on the plan. The minimum thickness of the columns thus varies from $\frac{1}{2}$-inch to $1\frac{1}{8}$ inch; but the sectional area is increased by the addition of what would be equivalent to four fillets $3\frac{3}{8}$ inches by $\frac{5}{32}$-inch, cast upon the opposite portions of the ring, and facing, when fixed *in situ*, north, south, east, and west. Four snugs are cast on the top and four on the bottom of the columns, between these fillets. Corresponding snugs are cast on to connecting pieces, the snugs alternating upon the same plane, with the projections on the connecting piece which serve to carry the girders. Bolt-holes are cast in the snugs of the columns, and in those of the connecting pieces. All the bedding surfaces are accurately faced in a lathe, and are then fitted together, so as to enable four bolts to pass through the holes in the snugs of the columns and connecting pieces, which exactly correspond to one another. Nuts then secure the bolts in their places. By these arrangements, connecting pieces may be placed on, and attached to columns; and columns may, in turn, be placed on and attached to connecting pieces, the rigidity of the whole being secured by fixing girders, at right angles to one another, on to the projections cast on the connecting pieces. The detail of these projections will be described in connection with the roof-trusses, which they serve mainly to keep in their places. The largest number of columns fixed in one week was three hundred and ten.

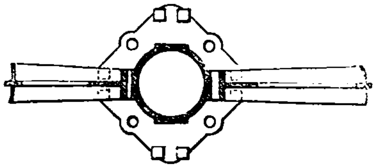


FIG. 5.—Plan of Connecting Piece, with Girders, &c.

Various Heights of portions of the Building.—Facilities are thus obtained for varying the dimensions in height of portions of the building, and at the same time for preserving lateral stiffness. The main arms of the cross on plan—that is, the avenues 72 feet in width, or the nave and transept, together with their aisles 24 feet wide—rise three stories in height; an avenue 48 feet wide, and an aisle 24 feet wide, on each side of the three-story building, rises two stories in height, and the whole of the remainder of the covered area is one story only in height. The gutter level of the three-story portion is 62 ft. 2 in. from the floor; that of the two-story, 42 ft. 2 in.; and that of the one-story, 22 ft. 2 in. As a description of the varieties of structure, induced by these several altitudes, necessarily involves an outline of the whole skeleton of the building, it will be well to consider each separately. The horizontal planes, or strata of the building, from the ground-floor upwards to the roof, in the three-story work, will be found to consist—first, of base-plates, the upper bearing surface of which rises $3\frac{3}{4}$ inches above the ground-floor; secondly, of columns 18 ft. $5\frac{1}{2}$ in. long, fixed on the base-plates; thirdly, of connecting pieces 3 ft. $4\frac{3}{4}$ in. deep, to which are attached cast-iron girders, 24 feet long, serving to support a gallery-floor, at the height of 23 feet from the ground-floor; fourthly, of columns 16 ft. $7\frac{1}{4}$ in. long; fifthly, of connecting pieces 3 ft. $4\frac{3}{4}$ in. deep, to which are attached, transversely in one direction, and longitudinally in two directions, cast-iron girders 24 feet long, of similar form and scantling to the roof-girders, in order to retain all the columns in their places; sixthly, of columns 16 ft. $7\frac{1}{4}$ in. long; and lastly, of connecting pieces 3 ft. $4\frac{3}{4}$ in. deep, to which are atttached the roof-trusses and girders. The corresponding horizontal strata of the two-story portion of the building consist—first, of base-plates, the upper bearing surface of which rises $3\frac{3}{4}$ inches above the ground-floor; secondly, of columns 18 ft. $5\frac{1}{2}$ in. long, fixed on the base-plates; thirdly, of connecting pieces 3 ft. $4\frac{3}{4}$ in. deep, to which are attached cast-iron girders, 24 feet long, serving to support a gallery-floor, at the height of 23 feet from the ground-floor; fourthly, of columns 16 ft. $7\frac{1}{4}$ in. long; and fifthly, of connecting pieces 3 ft. $4\frac{3}{4}$ in. deep, to which are attached the roof-trusses and girders. The horizontal strata of the one story-portion consist—first, of base-plates, the upper bearing surface of which rises $3\frac{3}{4}$ inches above the ground-floor; secondly, of columns 18 ft. $5\frac{1}{2}$ in. long, fixed on the base-plates; and lastly, of connecting pieces 3 ft. $4\frac{3}{4}$ in. deep, to which are attached the roof-trusses and girders.

The Galleries (Figs. 6, 7, 8, & 9).—From these dimensions it will be apparent, that at 23 feet above the floor level, galleries are inserted, which form striking features of both the two and the three story buildings. These galleries, in two widths of 24 feet each, with frequent connecting galleries, extend entirely

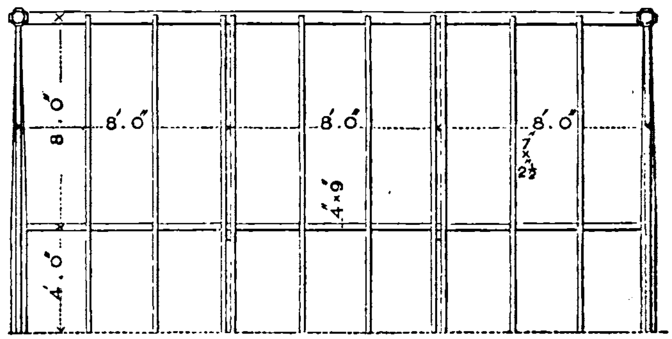


FIG. 6.—Plan of half of a 24-feet Bay of the Gallery Floor.

round the upper portion of the building, and are supported by cast-iron girders 23 feet long, similar in form to those which support the roof, but of somewhat heavier scantling. These single castings, 3 feet deep, are divided into three parallelograms of 3 feet by 8 feet, by vertical struts connected at the top and the bottom by diagonal ties and struts. The sectional areas of their top and bottom flanges, in the centre of the length of the girder, equal respectively 5·31 inches, and 7·64 inches; those of the diagonal struts and ties average 3·50 inches. All these girders are proved, in the building, to a strain of 15 tons, and in exceptional cases, with extra scantlings, to 22 tons. Their breaking weight is calculated, and has been proved by experiment, to be not less than 30 tons. The binders, which serve to support the

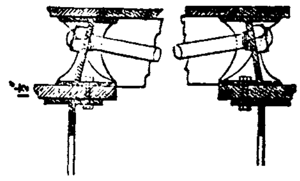


FIG. 7.—Details of Elevation of Truss of Gallery Floor.

FIG. 8.—Sections of the Truss.

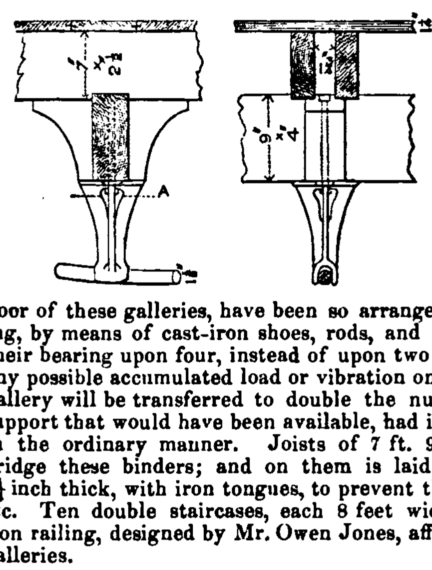


FIG. 9. Plan of cast-iron Standard to Truss.

floor of these galleries, have been so arranged by under-trussing, by means of cast-iron shoes, rods, and struts, as to take their bearing upon four, instead of upon two girders; and thus any possible accumulated load or vibration on a portion of the gallery will be transferred to double the number of points of support that would have been available, had it been constructed in the ordinary manner. Joists of 7 ft. 9 in. clear bearing, bridge these binders; and on them is laid a floor of boards $1\frac{1}{4}$ inch thick, with iron tongues, to prevent the passage of dust, &c. Ten double staircases, each 8 feet wide, inclosed by an iron railing, designed by Mr. Owen Jones, afford access to these galleries.

The Facework (Figs. 10, 11, 12, & 13).—Next to the internal supports of the building, the external inclosures present themselves for consideration. It is obvious, from the widths and heights given, that the north and south elevations, with the exception of the transept front, must consist of three stories, set back at various distances from each other. These three stories are, the first, or ground-floor; the second, or gallery-floor; and the third, or clerestory-floor. On the ground-floor, the cast-iron columns which carry the transverse roof-girders of the one-story building, constitute vertical divisions, at 24 feet from centre to centre; two wooden columns of precisely similar form, placed between the cast-iron ones, divide the 24 feet space into three bays of 8 feet each. The first horizontal line above the ground is a cill 9 inches by 3 inches, and $1\frac{1}{4}$ inch above the floor level; beneath this cill an inclosure of boards forms a plinth, against which rests a slope of turf, at an average level of 2 feet above that of the adjacent ground line. A second cill, 9 inches by 4 inches, is placed at a clear height of 4 ft. 3½ in. from the lower one, the space between forming a kind of dado, and being filled in with louvres, which will be described under the head of ventilation. At 10 ft. 6 in. from the upper surface of the second cill is the springing line of a light cast-iron arch, which spans from column to column, and assists in supporting the "filling-in frames." These frames, sufficiently deep to supply the idea of an entablature, and yet so light and open as not to appear to overload the slender proportions of the columns, are 3 feet high, and are backed with louvres similar to those in the plinth. The parallelogram, bounded by the sides of the columns, the top of the dado, and the underside of the filling-in frame, is filled in, on an inner plane, behind the arch pieces, with ploughed, tongued, and beaded boarding, stiffened by stout ledges on the inside. Small castings, spanning the inner face of the column, screwed to these ledges, connect them together; and are themselves fixed to the columns by bolts, passing completely through. On the top of the filling-in frame runs a boxing, with external mouldings, and behind the boxing is a small gutter. The whole is surmounted by a cast-iron ornamental cresting, 1 ft. 6 in. high, attached to the boxing.

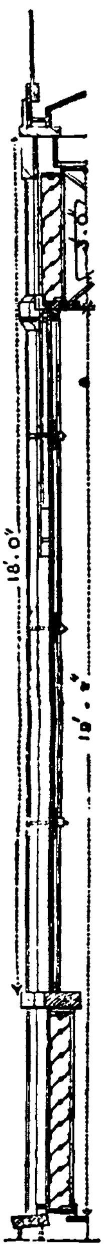


Fig. 13.—Vertical Section of the Facework of the Lower Tier.

Fig. 10.

Fig. 11.

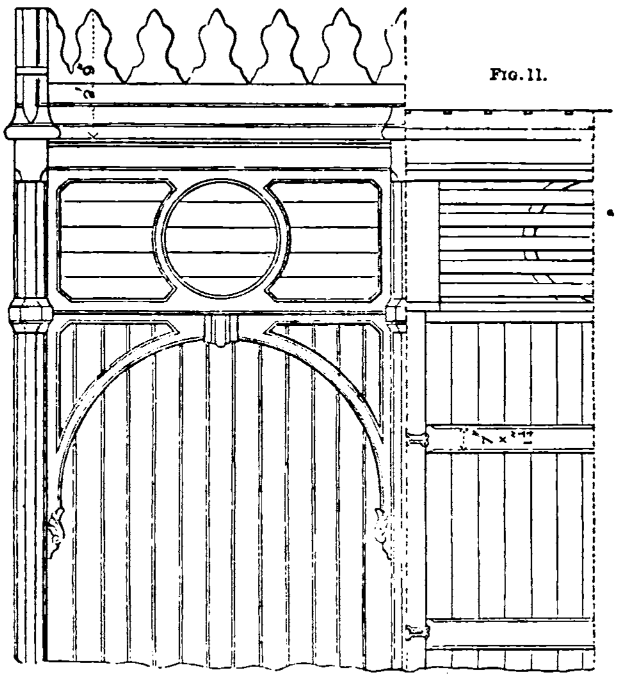
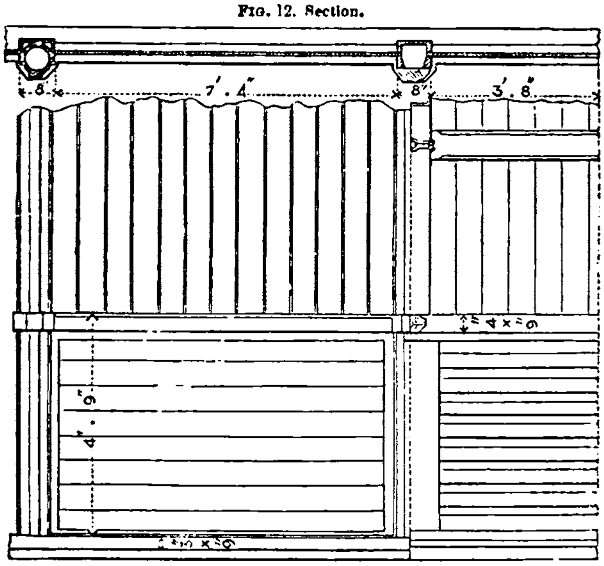


Fig. 12. Section.



External Elevation of an 8-feet Bay of the Facework of the Lower Tier. Half Internal Elevation of the same.

On the gallery-floor the upper parts of the columns supporting the two-story roof, constitute the main vertical lines. The space between is divided and filled up in a similar manner to that of the ground-floor, with two exceptions—first, that there is no dado, and secondly, that for the vertical boarding of the ground-floor a glazed sash is substituted. The frame of the sash is fixed to the columns by castings, similar to those which secure the ledges. As these sashes form an important portion of the building, no fewer than 1500 of them being required, a short description of them may be given. The sash-frames are 2¼ inches thick, with seven bars in their width; the sash-bars are 2⅝ inches deep, double-grooved for the glass; three bolts, ⅜-inch diameter, pass completely through the bars and frames, at the points where they are attached to the columns, and thus a chain tie is kept up all round the building, in order to prevent the displacement of the sashes, either bodily or in portions, by the pressure of the wind. To further guard against the same action, timber bridges, 3½ inches by 1½ inch, in the centre, are fixed across the middle of the length of the sash; and at the internal angles, where the wind will exert its greatest force, iron rods, ½-inch diameter, are fastened from column to column, pressing against the wooden bridge, and converting it into a continuous strut, bearing up against any force applied to the exterior of the sash. In order to glaze the sashes, the glass is slipped down between the bars, and provision is made for the repairs by causing one groove to be cut deeper than the other, so that the glass may be slipped in from either side, and puttied into its exact place. Similar provision is made for mending the roof-glass.

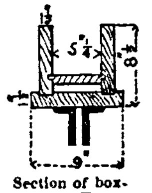
On the third, or clerestory-floor, the external main vertical divisions are formed by the upper portion of the three-story columns, and the filling-in between them corresponds exactly with that of the gallery-floor.

The east and west elevations are simply vertical sections through the main building, filled-in with facework similar to, and ranging with that of the three stories of the north and south elevations. The elevations of the transept ends correspond with those of the east and west, with the exception of the addition of a semicircular head filled-in with concentric and radiating tracery.

The Exits.—In the circuit of the whole building there are fifteen exits, symmetrically disposed; wherever they occur, a pair of doors, 8 feet in width, occupy the centre of the space, and the two bays of 8 feet each, on either side of the doors, are glazed instead of being boarded.

The Roof-Girders and Trusses (Figs. 14, 15, 16, 17, 18, 19, & 20).—The net-work of girders and trusses immediately supporting the roof next demands attention. The main gutters, run transversely, spanning the various avenues leading from end to end of the building, except where it is crossed by the transept. These avenues are all either 24 feet, 48 feet, or 72 feet wide; of these avenues there are six 24 feet wide, five 48 feet wide, and one (the central) 72 feet wide. To span these widths at least three kinds of trusses are necessary. All the trusses, with the exception of four, are 3 feet deep, and have perpendicular struts of cast-iron, fixed at distances of 8 feet from centre to centre, connecting the top and bottom bars. The whole parallelogram, formed by the length

Fig. 14.



Section of box-gutter on Truss.

and width of the trusses, is thus divided into smaller parallelograms of 8 ft. by 3 ft., the four angles of which are diagonally connected by various materials, but of uniform width on the face, and thus regularity of form is obtained. The trusses of 72 feet and 48 feet span consist of cast-iron standards and vertical struts, an upper portion formed of two pieces of angle-iron, set 1 inch apart, a bottom portion of two bars, increasing in sectional area as they approach the centre of the bearing, and tie-bars which, passing diagonally between the two pieces of angle-iron in the upper portion and the two bars in the lower, are rivetted to them, and form a complete suspension truss. The remaining diagonals in the opposite direction, which would, if in action, be under compression, are constructed of wood, and are only inserted for appearance, it being thought better to resist the diagonal strains by tension bars alone, rather than partly by diagonal suspension bars, and partly by diagonal struts. The girders of 24 feet long are single castings, corresponding in form to those which support the galleries, the arrangement and scantlings of the various parts of which have been elaborately studied and balanced. Every one of these trusses has been proved, in the building, with a strain of nine tons.

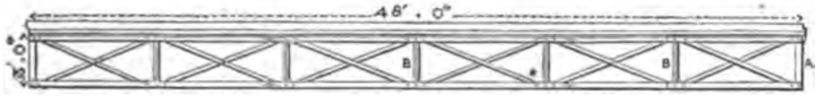


FIG. 15.—Elevation of ordinary 48-feet Truss.

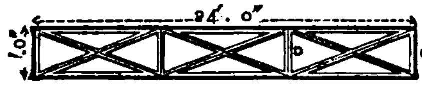


FIG. 18.—Elevation of 24-feet cast-iron Girder.

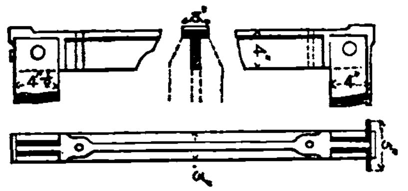


FIG. 16.—Front and Side Elevations of End Standards to 72-feet and 48-feet Trusses.

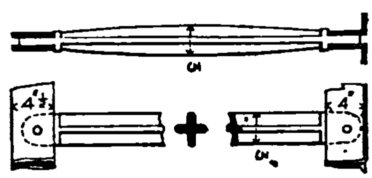


FIG. 17.—Front and Side Elevation of Vertical Struts, or Intermediate Standards, to 72-feet and 48-feet Trusses.

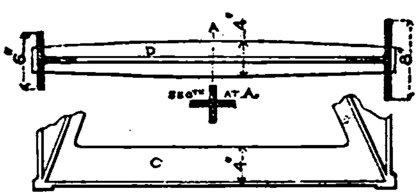


FIG. 19.—Front and Side Elevations of Ends of cast-iron Girder.

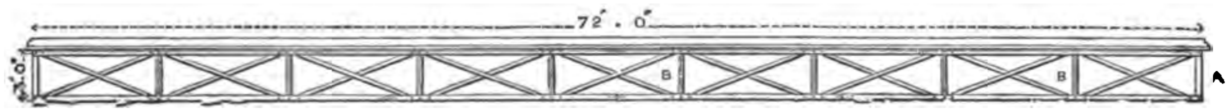


FIG. 20.—Elevation of ordinary 72-feet Truss.

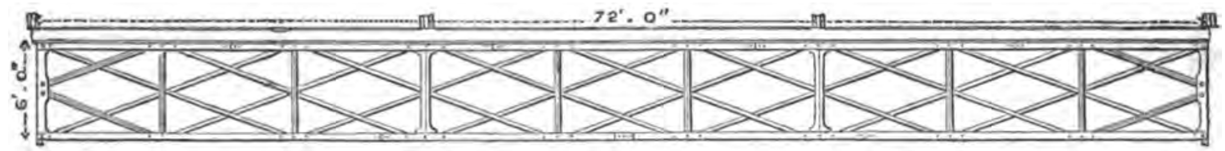
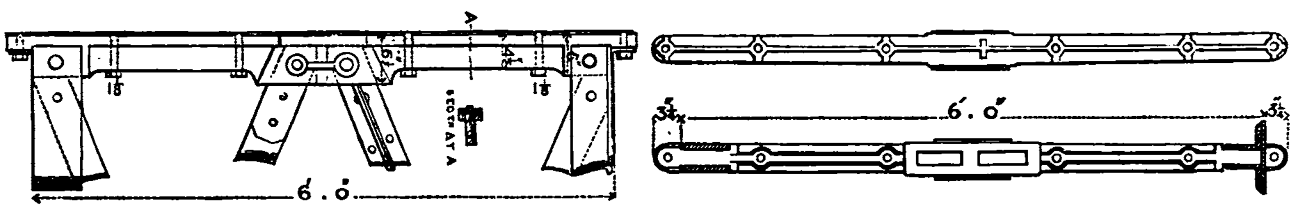
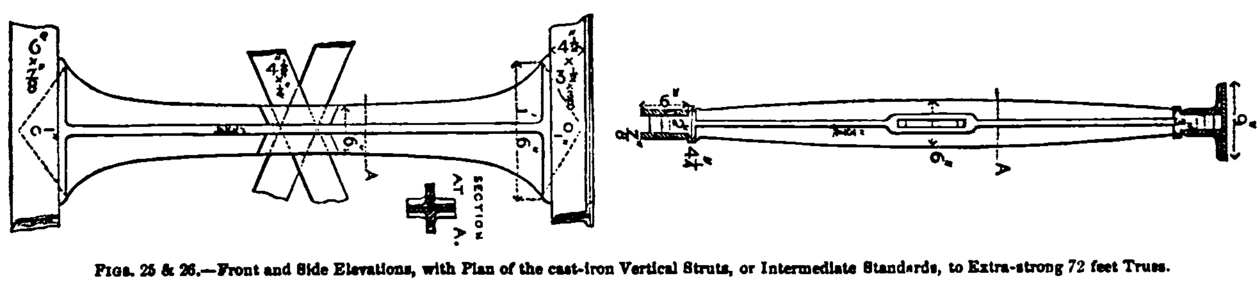


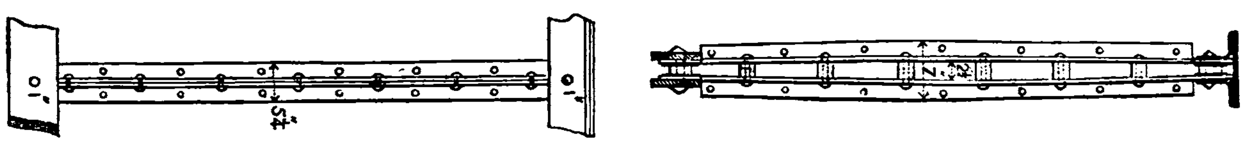
FIG. 21.—Elevation of Extra-strong 72 feet Truss.



FIGS. 22, 23, & 24.—Side, Front, and Back Elevations of the End Standard to Extra-strong 72 feet Truss.



FIGS. 25 & 26.—Front and Side Elevations, with Plan of the cast-iron Vertical Struts, or Intermediate Standards, to Extra-strong 72 feet Truss.



FIGS. 27 & 28.—Elevations of wrought-iron Vertical Struts, or Intermediate Standards, to Extra-strong 72 feet Truss.

The Extra-strong Trusses (Figs. 21, 22, 23, 24, 25, 26, 27, & 28). The four 72-feet trusses which have been alluded to, as differing from the others in depth, perform such important functions, and are consequently so different in form, as to warrant a separate notice. They support the lead flat, covering two bays (each 24 feet by 72 feet) of the main avenue, where it abuts upon the eastern and western sides of the transept, and a pair of them carry, in addition, the two semicircular ribs, which, at 24 feet from centre to centre, form the main beams on which the semi-cylindrical roofing rests, over the square where the transept roof crosses the main longitudinal avenue. These trusses are made twice the depth of all the others, and the scantlings are considerably increased. In this extra depth the vertical struts remaining at 8 feet from centre to centre, and the tension bars continuing the same in number, and being set at the same angle as those in the ordinary trusses of 72 feet span, the lines arrange themselves into a lattice-form two diamonds in depth, the intersecting diagonal bars passing through slots cast for them in the middle of the cast-iron struts. Although the form would appear to be that of a compound truss, the strength of all the parts is calculated so as to render these trusses suspension trusses only. In order to relieve the ordinary columns of much of the weight which is supported by these trusses, additional columns are placed beneath their two ends, secured, at frequent intervals, to the ordinary columns by wrought-iron clips.

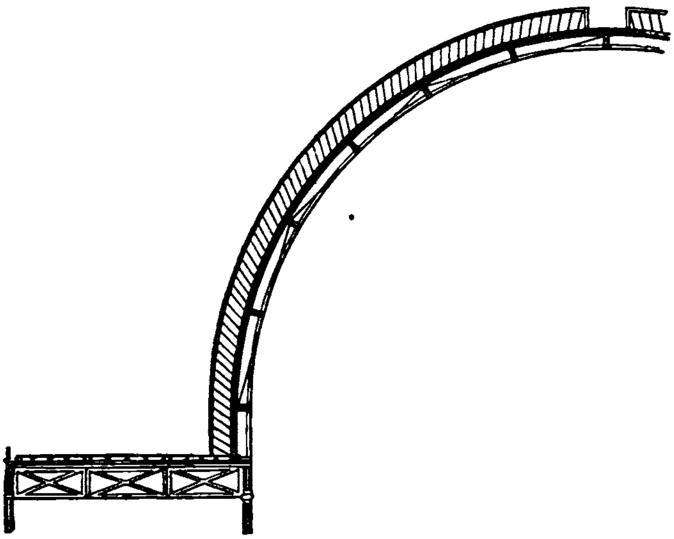


FIG. 29.—Half-Section of Arched Roof to Transept, with the lead Flat.

The Semicircular Ribs (Figs. 29, 30, & 31).—In order to form an idea of the nature of the work the extra-strong trusses have to perform, the structure of the semicircular ribs must now be defined. They are made in three thicknesses of timber, each 9 ft. 6 in. long, cut into segments of a circle 74 feet extreme diameter, the central thickness being 4 in. by 13½ in., and the outer flitches, breaking joint with the centre, being 2 in. by

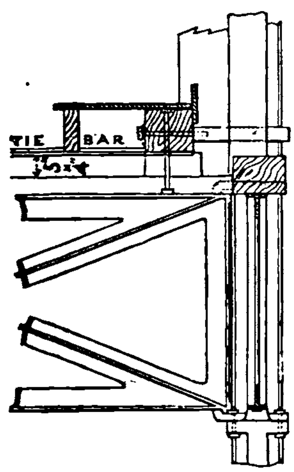


FIG. 30.—Detail of the Foot of Arched Rib on Column, and adjoining parts.

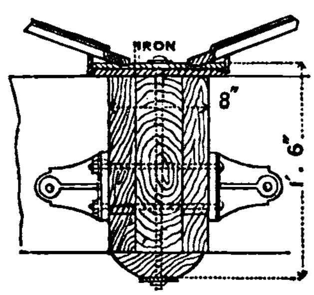


FIG. 31.—Section of Arched Rib, showing attachment of the purlins, &c.

13½ in. The flitches are nailed to the centre thickness, and bolts ⅝-inch diameter, and about 4 feet apart, traverse and bind together the three thicknesses; on the extrados of the wooden arch thus formed, two planks, serving as the gutter-board, each 11 in. by 1 in., and a bar of iron 2 in. by ⅜-in., are bent to the curve; and on the intrados a piece of timber 7 in. by 2 in. moulded to correspond with the form of the columns, and a bar of iron 3½ in. by ⅜-in., are also bent to the curve; bolts passed through the depth of the rib, at intervals of 2 feet from centre to centre, unite these additions to each other and to the main rib, which thus increased in scantling, measures when complete 8 in. by 1 ft. 6 in. The ends are stepped down upon a plate 9 in. by 6 in., bearing on the top of the two trusses, on each side of the transept.

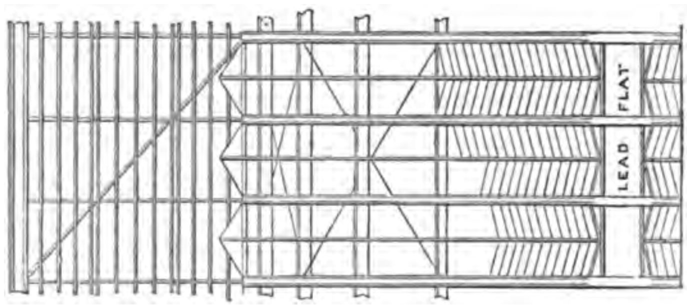


FIG. 32.—Half Plan of a 24 feet Bay of the Transept Roof.

The Transept Roofing (Fig. 32).—In order to steady the ribs, purlins 4½ inches by 9 inches to 13 inches, and 9 ft. 2 in. apart, are introduced between them; and on the top, from end to end, a narrow path of lead flat runs the whole length of the transept, for the purpose of affording convenient access for any repairs which may be necessary. Diagonal rods, intersecting each other in planes parallel to a tangent to the curve, also connect the ribs, and serve to bind every portion together; while, at the same time, their lines form reticulations over the surface of the vault, producing an agreeable effect in perspective.

The Experiments tried on the Roof-Trusses and Girders.—Previous to deciding upon the scantling of the trusses to be used in the building, Mr. C. H. Wild and the contractors entered into an elaborate series of calculations, as to the adjustment and proportions of the various parts. These calculations were submitted to the President of the Institution of Civil Engineers, and their correctness was so completely justified by the results of some experiments on the trusses and girders, made in his presence and in that of the author, that a summary must be interesting.

A 72-feet truss, cambered 4½ inches, and weighing complete about 35 cwt.,

The maximum sectional area of the two top angle-irons being	5·71 inches.
The maximum sectional area of the two bottom bars being	6·75 "
The maximum sectional area of the principal diagonal tie being	3·38 "

when loaded with a weight of 4 tons, deflected 1¼ inch; 6 tons, 2¼ inches; 8 tons, 3⅜ inches; 10 tons, 4½ inches; 12 tons, 5 inches; 14 tons, 5⅜ inches; 16 tons, 6¼ inches.

A 48-feet truss, cambered 4 inches, and weighing complete about 13 cwt.,

The maximum sectional area of the two top angle-irons being	3·0 inches.
The maximum sectional area of the bottom bars being.	3·38 "
The maximum sectional area of the principal diagonal tie being	2·75 "

when loaded with a weight of 2½ tons deflected ½-inch; 5 tons, 1¼ inch; 7½ tons, 2⅛ inches; 8¾ tons, 2⅜ inches; 10 tons, 3 inches.

A 24-feet girder, weighing complete 11 cwt. 3 qrs., exactly similar in construction to the 24-feet roof-girders, but being 2 cwt. 1 qr. heavier, bore 30 tons, but broke down with 30½ tons, flying so completely to pieces that doubts existed as to the point at which fracture commenced.

The Connections of the Roof-Trusses, &c.—Having indicated the general construction of the roof-trusses, there remain to be noticed the arrangements for fixing and for steadying them longitudinally. In the 72-feet and 48-feet trusses, respectively, the standards forming their ends are cast with a projection on their top and bottom faces, and with a bolt-hole through the upper portion of their length; a hollow "connecting piece," corresponding in the form of its section to that of the columns, and 4¾ inches longer than the height of the truss, pierced through with a bolt-hole to agree with that of the truss standard, has cast upon its upper and lower ends a projection corresponding with those cast on the top and bottom faces of the truss standards. The truss being hoisted above its ultimate position, is lowered down until it can be slipped between the projections on the connecting piece, when the projections on the bottom faces of its two standards take a bearing, and clutch on to those cast on the lower ends of the connecting pieces. A screw bolt, 1 inch in diameter, passed through the bolt-hole of the standard, and completely through the connecting piece, secures the upper part of the truss from lateral motion, and, together with the stiffening of the "Paxton-gutters," counteracts any tendency to buckle. The means provided for fixing the cast-iron roof-girders of 24-feet span into the connecting pieces, are precisely similar to those above described; but the mode of securing them from lateral movement is somewhat different. Instead of the bolt-fastening of the trusses of 72-feet and 48-feet spans, a groove is sunk in the middle of the top and bottom projections of the connecting piece, and a corresponding tenon is cast on the bottom of the standard of the 24-feet girder. The bottom of the truss is thus held in its place, by the fitting of its tenon into the lower groove of the connecting piece; while the upper projection of the truss, having a groove cut in it, to correspond with that on the underside of the upper projection of the connecting piece, is secured by the insertion of a wrought-iron key, which acts as a dowell, and prevents the surfaces from sliding laterally upon one another.

The Provisions for Stiffening the Building.—In order to maintain the stiffness and steadiness of the building longitudinally, girders 24 feet long are inserted between the connecting pieces, in the direction from east to west, and are attached to them in a similar manner to the other girders. Of these there are eighteen rows on the various levels of the building. The influence of the "Paxton-gutters," and of the facework giving additional stiffening to the whole, adds considerably to the good results obtained by the insertion of these longitudinal girders. In thus providing for the rigidity of the connections of the various portions of the building, care has been taken, by the substitution, in certain places, of oak for iron keys, to provide for the play of the metal, incident to any sudden variation of temperature. In the transverse direction, it was determined that the whole of the keys should be of iron, for two reasons—first, because the length, divided into two portions by the nave, was not sufficiently great to render the probable amount of expansion or contraction of any practical importance; and secondly, because it was upon the side of the building that the currents of wind would impinge with the greatest force. In the longitudinal direction, iron keys are inserted for six bays from the extreme east and west ends, and for six bays east and west of the transept, the intervening girders being keyed-up with oak keys: and thus rigidity was maintained in those parts exposed to strain, whilst elasticity was provided in the portions of the building least subject to strain from without. Twenty-two sets of horizontal, and two hundred and twenty sets of vertical diagonal bracing, consisting of wrought-iron rods secured by wrought-iron links to the columns and connecting pieces, and meeting in adjustment-plates, are inserted as a measure of extra precaution, tying the main masses of the structure together.

The "Paxton" Roofing (Figs. 33, 34, 35, 36, 37, 38, & 39).—The roof of the building is perhaps the most novel and interesting portion of the whole structure, and exhibits in a remarkable manner the ingenuity of Mr. Paxton's design. In order to convey the rain-water to the hollow columns, transverse gutters 24 feet apart extend the entire width of the building. These transverse gutters are capacious wooden boxes, strongly framed and attached to the upper flange of the main trusses, which cross the building, false bottoms being, in some cases, inserted to assist the flow of the water. At intervals of 8 feet from centre to centre, with their ends resting on the box-gutters, are fixed those ingenious contrivances known as "Paxton-gutters" for conveying away simultaneously the rain-water falling on the roof, and the condensed vapour formed inside the building, and of them a length of 24 miles is required. Each one of these consists of a piece of the best crown timber, 5 in. by 6 in. and 24 feet long. The form is given by passing it through an ingenious machine, worked by Mr. Birch, of the Phœnix Saw-mills, Camden-town. At one operation, this machine scoops from the middle of the upper surface of the timber, and throughout its whole length, a nearly semicircular groove about 1$\frac{3}{8}$ inch radius, and at the same time cuts two smaller, grooves downwards at an oblique angle to its sides; the object of the larger groove being to receive and convey to the box-

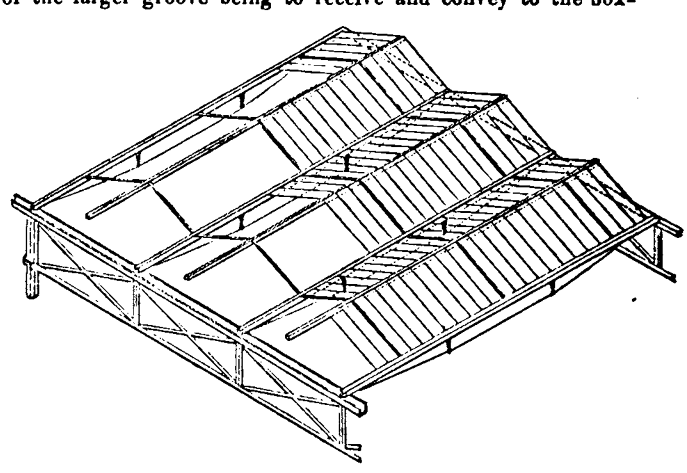


Fig. 33.—Isometrical View of one 24 feet Bay of Roofing, partly glazed.

gutters the roof-water, and that of the smaller grooves to receive the moisture, which, condensing upon the inside of the roof, would trickle down, adhering by capillary attraction, and finally deposit itself in the smaller grooves, by which it would be conducted to the box-gutters. On leaving the machine, the "Paxton-gutter" is too slight for a bearing of 24 feet, and is

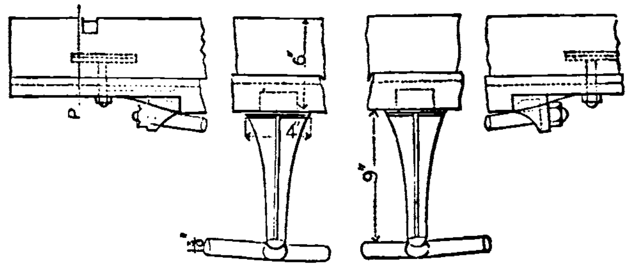
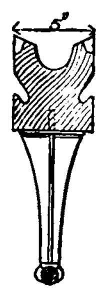
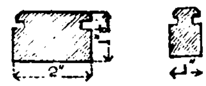


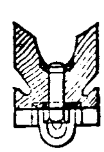
Fig. 34.—Elevation of portions of a "Paxton-Gutter."

straight, so that the water in it would not have any fall: both these defects are remedied by trussing it into a curve, by means of a wrought-iron bolt, $\frac{13}{16}$-inch diameter, threaded at both ends, and bent so as to pass under and press up, to the underside of the wood, two cast-iron struts 9 inches long, the ends of the bolt being passed through holes in the two cast-iron shoes, fixed at the ends of the gutters, and the nuts on the ends of the bolts being screwed-up, the bolt is tightened, and a camber of 2$\frac{1}{2}$ inches is given to the gutter, so that the whole becomes a truss, requiring a weight of 1$\frac{1}{2}$ ton to break it. A semicircular





Figs. 35, & 36.—Sections of Extra-strong and Ordinary Sash-bars.



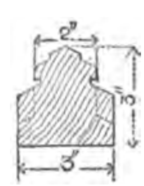


Fig. 39.—Section of the Ridge.

Fig. 37.—Section of "Paxton-gutter" through Centre.

Fig. 38.—Section of "Paxton-gutter" at the End.

cut is then given through the depth of the gutter at both ends, so that when two are placed end to end the water will flow down into the box-gutter through a circular cavity, two oblique cuts being also made, to connect the condensed water with this cavity, and twenty-seven notches are marked from a template, and worked on each side of the upper edge of the "Paxton-gutters," whose ends are then attached to a flanged plate bolted on to the edges of the box-gutters. Of the notches on each side of the "Paxton-gutter," three are larger than the others; and on them bars of wood 2 in. by 1½ in., grooved for glass on both sides, are notched down; these bars form principal rafters, and being set at a pitch of two and a-half to one, are fixed to a ridge 3 in. by 3 in. grooved for glass on both sides: the long edge of a sheet of glass 4 ft. 1 in. by 10 in. is then inserted into the groove of the principal rafter, and a sash-bar 1 in. by 1½ in., also doubled-grooved, is then put on to the other long edge of the glass; the sash-bar is then brought down, and secured to the ridge, and to the edge of the gutter; the lower edge of the glass, bedding on putty about ⅜-inch wide, a little force applied at the lower end brings the upper edge of the glass home into the groove in the ridge. The glass being then pressed down, the putty is made good in the grooves externally, and thus simply is this system of roofing put together. Its lightness is one of its remarkable qualities, since the entire weight of one superficial foot averages only 3¼ lb. The largest quantity of "Paxton-gutter," each 24 feet in length, planed and grooved by one machine in one week, was four hundred and forty-two.

The "Paxton" Roofing over the Transept.—The area of 29,376 feet, forming the transept, is covered with roofing, similar in many particulars to that adopted by Mr. Paxton in the great conservatory at Chatsworth. The width which is spanned by the semicircular ribs, at intervals of 24 feet from centre to centre, is 72 feet. Purlins 9 ft. 2 in. apart connect the semicircular ribs, and between them, at distances of 8 feet from centre to centre, are framed smaller ribs, the backs of which, as well as those of the main ribs, form water-courses, and convey the rain on to the lead flat running 24 feet in width, on each side, at the base of the semicircular ribs of the roof. These latter, which stand at 8 feet apart, are then connected by ridge-and-furrow roofing, the construction of which is nearly identical with that previously described as employed in the smaller roofs. Beneath the lead flat is constructed a horizontal truss consisting of bars, calculated to transfer the strain to the points most securely tied and abutted, and thus to counteract any tendency of the ribs to spread, or to shift under the action of wind.

In connection with the design for the building, there are still three important items to be considered:—the mode to be adopted of tempering the intensity of the sun's rays, the ventilation, and the supply of water immediately available for the extinction of fire.

The Canvas Covering.—In order to diminish the intensity of the light and heat of the sun's rays, it is proposed to cover the whole of the roof and of the south side of the building with canvas, which will be attached to the sashes on the side, and span from ridge to ridge on the roof, the seam being arranged to occur directly over the gutters.

The Ventilation (Figs. 40, & 41) is obtained by means of louvres set in boxings, inserted behind the "filling-in" frames

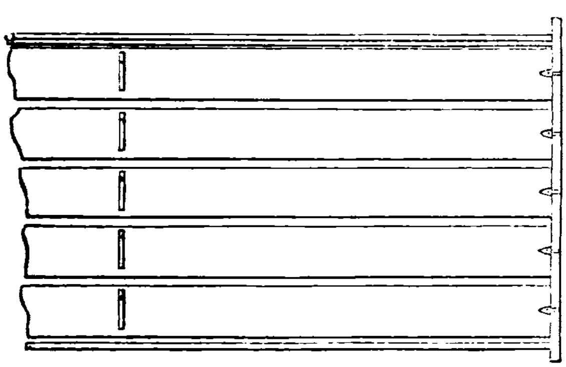


FIG. 40.—Part Elevation of Louvre Frame.

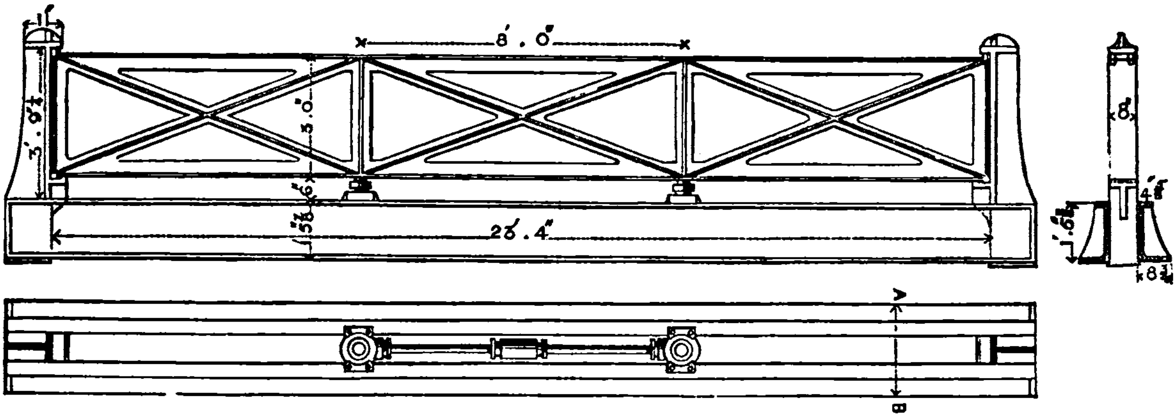
of each of the three stories of the building,—and in the dado, between the upper and lower cills on the ground-floor. At the springing of the transept roof, a line of louvres is inserted on both sides, 3 ft. 8 in. high, running the whole length of the transept; and at the very summit of the curved roof, ventilation is obtained in the gables of the roofing, where it is interrupted by the narrow path of upper lead flat. The total quantity of ventilating area in the louvres equals about 45,000 feet, in addition to which, large volumes of air will necessarily be introduced at the numerous doorways. The louvre-frames on the ground-floor consist of boxes, in which eight louvre-blades of galvanised-iron, 6½ inches wide, are fixed on pivots at 6 inches from centre to centre, and so curved as to offer the minimum interruption to the ingress or egress of air when open, compatible with keeping them weather-tight. Small iron brackets attached to the centre of each blade, are furnished with eyes, through which are inserted pins, passing also through holes bored at equal distances from one another, in a species of rack; by drawing these racks up and down, the opening and closing of the ventilators is effected. A number these racks will, of course, be attached to levers, and set in motion by rods and cranks; Mr. Fox has designed an ingenious method of producing simultaneous action of a considerable number, and at the same time of securing the uniform position of the louvre-blades at any desired angle. Should it ever be found necessary to reduce, by artificial means, the internal temperature of the building below that of the exterior, Mr. Paxton has proposed a system of cooling, applicable to these ventilators, somewhat on the principle of the Indian "tatties."

FIG. 41.—Section of Louvre Frame.

The Water Supply.—The water is supplied by the Chelsea Waterworks Company, through a main-pipe 9 inches in diameter, bracing into three pipes 6 inches in diameter, at the centre of the building, on the south side, at about 35 feet from the entrance. These latter pipes go entirely round the building, and across the centre; twenty cocks of 3 inches diameter are attached to these pipes externally; eight pipes, 4 inches diameter, branch from the pipe of 6 inches diameter, at eight points on each side of the building, and run inwards to a distance equal to one-fourth the width of the building. On the ends of these pipes fire-cocks, with waterways 3 inches diameter, are fixed in such situations, that circles drawn from them as centres, with a radius of 120 feet, would intersect one another, and pass considerably without the limits of the building. From the pipes, 6 inches in diameter, crossing the building, it is proposed to draw the principal supply for the fountains, which will probably be distributed along the central nave and line of the transept. An ample supply of water, connected with efficient drainage, will be provided for the steam-boilers, which will be fixed in a detached building at the north-west angle, and for the refreshment-rooms, &c., which will be placed in immediate proximity to the trees beneath the transept.

The Execution of the Works.—In proceeding to the third part of the subject, the power and dexterity with which the design has been realised, or, in other words, the feature that first claims attention is the celerity with which the various operations have proceeded. When it is remembered that Messrs. Fox, Henderson, and Co.'s tender was only verbally accepted on the 26th of July, 1850—that possession of the site was only given on the 30th of the same month—that the first column was fixed on September 26th, exactly two months after the acceptance of the tender—and that at the present moment but little of this vast building remains to be finished—it must be felt, that England possesses mechanical appliances and physical energies, far exceeding those which gave form and being to the most celebrated monuments of antiquity. The total number of men employed in each week varied from thirty in the week ending August the 3rd, to two thousand two hundred and sixty in the week ending December the 6th.

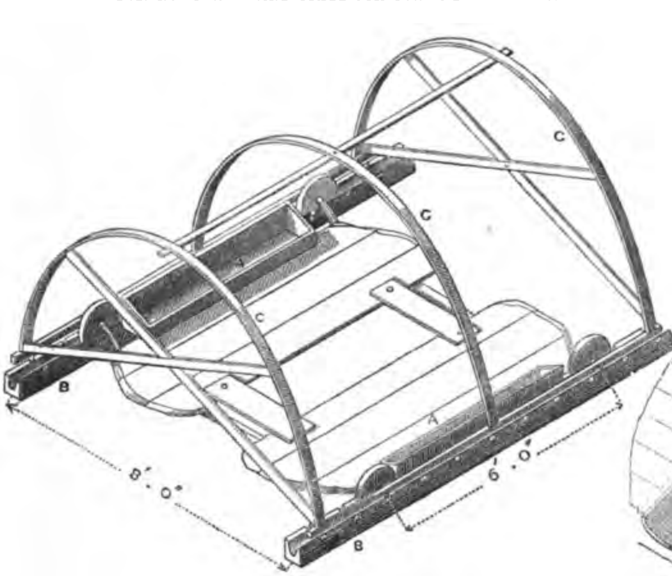
The Proving of the Girders (Figs. 42, 43, & 44).—To prove the girders, a very ingenious apparatus, connected with an hydraulic press and register, was contrived by Mr. Wild, by means of which the girders are perfectly gauged, and in which they are retained in an inverted position. Pressure is then applied upwards from two pistons, at the points in the upper table of the girders upon which, in the roof-girders, the "Paxton-gutters" will bear, and in the gallery-girders, the binders, and thus the proof is applied in a similar manner to that in which the girders will be eventually loaded. One of Mr. Henderson's patent cranes, and a weighing-machine, have been so conveniently arranged, in connection with this apparatus, that a girder has been lifted from the wagon, deposited for weighing, weighed, lifted up again, conveyed to the proving machine, slipped into its place, and secured,—proved, released, taken up again, deposited on the ground, and stacked, in less than four minutes. The whole of the light iron-work, with the exception of some of the gallery railing, has been cast by Messrs. Fox, Henderson, and Co., at their works, near Birmingham; and the principal castings, consisting of the columns, girders, &c., were supplied, all ready turned and fitted, from the works of Messrs. Cochrane and Co., of Woodside, and Mr. Jobson, of Holly-hall, both near Dudley. The wrought-iron has been principally supplied by Messrs. Fothergill and Co.; the glass by Messrs. Chance, Brotherton, and Co., of Oldbury; the timber by Messrs. Dowson and Co.; and the machine cutting of the "Paxton-gutters" at Messrs. Fox, Henderson, and Co.'s mills at Chelsea.



FIGS. 42, 43, & 44.—Plan, Elevation, and Section of the Frame in which the Cast-iron Girders were fixed for Proving by the Hydraulic Press.

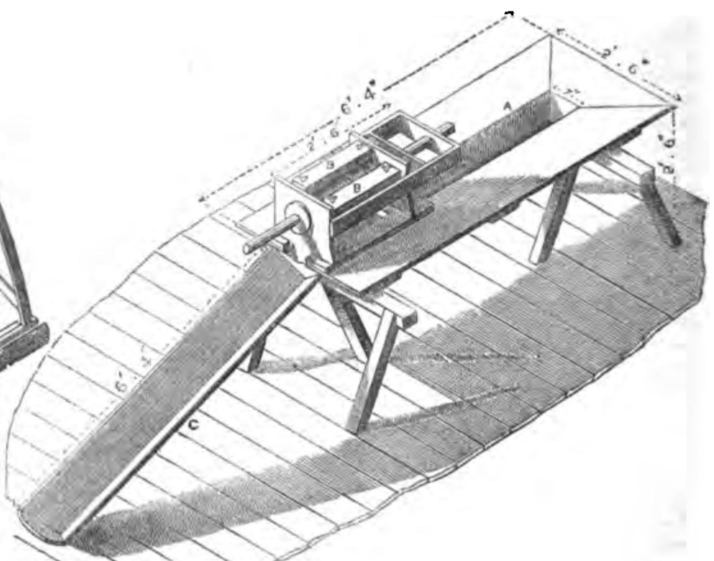
The Setting Out and Progress of the Work.—The perfection with which the lines of the building were set out by Mr. Browngar will be easily tested in the building, by remarking the precision with which the columns range and cover one another diagonally as well as rectangularly. To this correctness, and to the careful setting of the base-plates (of which one thousand and seventy-four were required), may be attributed, in a great measure, the uniformity of the lines exhibited by the columns from whatever points they are viewed. One of the most striking peculiarities of this building is the skill with which it has been arranged, so as to form the scaffolding for its own construction. The columns were raised by a fall descending from shear-legs, steadied by guy-ropes; so soon as two columns were fixed, two falls, descending from two pairs of shear-legs, raised a girder with the connecting piece attached; then, when four columns, four connecting pieces, and four girders had been raised, the whole became self-supporting, and the tackle and apparatus, used to erect it, could be moved off to do its work in constructing a similar bay elsewhere. The raising of much of the upper tiers was effected by suspending falls from poles lashed to columns. The trusses of 48-feet and 72-feet spans were raised by means of derricks, steadied by guy-ropes, the derricks being moved on from spot to spot in a perpendicular position. The way in which the men managed to retain the derricks in a perpendicular position, by alternately tightening, slackening, and shifting the guys, was really admirable. By this means as many as seven of the great trusses of the nave have been raised in one day; the derricks (for one was at work at each end of the building) thus travelling 168 feet. The active superintendence and direction of the whole of the labour devolved upon Mr. John Cochrane, Mr. Earee acted as clerk of the works to the Commissioners, and Mr. Harwood as their surveyor. During many weeks upwards of two thousand men were constantly employed upon the ground, four steam-engines assisting in the various operations, and affording motive power to a variety of machinery for facilitating production. Ingenious arrangements of circular saws, and revolving gouges, &c., cut and bored different portions of sash-bars, ridges, and "Paxton-gutters." Huge shears, and punching and drilling machines combined to prepare the truss-bars for being rivetted, and portable forges supplied the means of heating the rivets for the three hundred and seventy-two wrought-iron trusses.

FIG. 45.—TRAVELLING STAGE FOR GLAZING THE ROOFS.



A, Box for glass. B, Trussed girder. C, Frame to support the covering.

FIG. 46.—MACHINE FOR PAINTING THE SASH-BARS.



A, Trough for holding paint. B, The brushes. C, Spout for waste paint.

The Glazing Machines (Fig. 45).—It was of great importance that arrangements should be made for carrying on the glazing of the roofs independently of weather. To effect this purpose a travelling stage was devised by Mr. Fox, which superseded the necessity of any scaffolding for glazing, and by means of seventy-six of these machines nearly the whole of the work has been executed. The stage is about 8 feet square, and it rests on four small wheels, which travel in the "Paxton gutters." It thus embraces one bay of a span of 8 feet of the roof, with one ridge and two sloping sides; each bay in width requiring a separate stage. The stage, occupied by two workmen, is covered by an awning of canvas, stretched over hoops to protect them in bad weather, and is provided with two boxes to contain a store of glass. The sash-bars and other materials are piled upon the stage itself, the centre of the platform being left open, for the convenience of hoisting up materials. Whilst working, the men sit at one end of the platform (the ridge having been previously placed in position by means of the extra-strong sash-bars), and fix the glass in front of them, pushing the stage backwards as they complete each pane. On coming to the strong sash-bars previously fixed, they temporarily remove them, to allow the stage to pass: in this manner each stage travels uninterruptedly from the transept to the east and west ends of the building. The average amount of glazing hitherto done by one man per day has been fifty-eight squares, or about 200 superficial feet, and the largest amount done by any one man in a working day has been one hundred and eight squares, or about 370 superficial feet. The largest amount of work done in one week was by eighty men, whose time amounted to 309 days, and who put in 18,392 squares, containing 62,584 superficial feet. The machine for glazing the transept roof was also designed by Mr. Fox. It consists of a kind of long wooden box, with wheels running against the semicircular ridge. In each of these boxes eight glaziers can stand at their work. The machine is lowered and raised by means of ropes attached to the purlins at the summit of the roof. A platform, with wheels also travelling upon the ridges, has been contrived for the performance of any repairs that may be necessary after the flat roofing is completed.

The Painting Machine (Fig. 46).—An ingenious machine has been adopted for painting the sash-bars. A trough being filled with liquid colour, the sash-bars are dipped into it, and when taken out are passed through a series of brushes set at such angles to each other as to entirely remove the superfluous paint, and to leave the sash-bar as neatly finished as it could have been by hand.

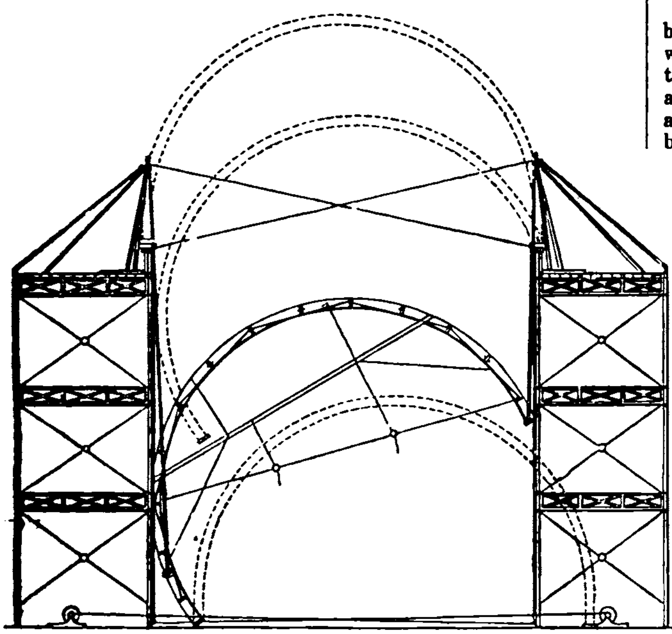


FIG. 47.—Section through the Transept, showing the arrangements for Hoisting the Semicircular Ribs. The dotted lines indicate the various Positions of the Ribs during the Hoisting.

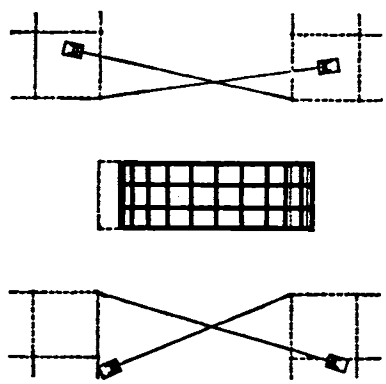


FIG. 48.—Plan of Centre of Transept, showing the Position of the Crabs for Hoisting the Ribs.

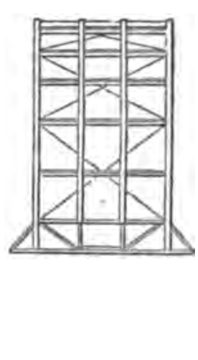


FIG. 49.—End View of a Pair of Ribs, framed together, previous to being Hoisted.

Mode of Raising the Transept Ribs (Figs. 47, 48, & 49).—The operation about which most anxiety had been felt was the hoisting of the arched ribs of the transept. These ribs were constructed horizontally on the ground, and when completed with all their bolts, two of them were reared on end, and maintained in a vertical position, at a distance of 24 feet from each other, by guy-ropes. As the ribs possessed little lateral stiffness, they were framed together with the purlins, intermediate small ribs, and diagonal tie-rods, forming a complete bay of the roof, 24 feet long. Two complete sets of temporary ties were also introduced, to provide for the strains incident to the variations in position of the ribs during the hoisting: the feet of the ribs were bolted on to a stout cill, and the lower purlins were strutted up from it. The whole framework was then moved on rollers to the centre of the square formed by the intersection of the transept and the main avenue, whence it was hoisted: all the ribs were landed over this square, and were afterwards moved on a tramway to their permanent positions. This tramway, formed of half-balks, was constructed over the columns on each side of the transept, at a height of about 4 feet above the lead flat. The hoisting tackle consisted of four crabs, each one being placed on the side of the transept opposite to the part of the ribs to be lifted by it, so that the men at the crabs might watch the effect of their exertions with greater convenience. The hoisting-shears were placed on the lead flat, immediately over the deep trusses of 72 feet span; each set consisted of three stout scaffold-poles, lashed together at the top, bearing on planks laid across the flat, and secured by the necessary guy-ropes. The hoisting rope passed from each of the crabs, across the transept to a leading block attached to the foot of the column in the opposite angle of the square; it then passed up to a treble block attached to the shears, and from thence down to a double block, secured by chains, to the bottom part of the ribs. The extreme width of the framework to be hoisted was 74 feet, and the clear width apart of the trusses, above which it had to be hoisted, was only 71 ft. 4 in.; it was therefore necessary to raise one side to a height of 35 feet, before lifting the other, so as to diminish the horizontal width. The diameter of the semicircle being maintained at this angle, the whole was then hoisted, until the highest end could clear the tramway. The foot of the ribs was then passed over the tramway, high enough to allow the other side of the ribs to clear the truss, after which the whole was hoisted to the full height, and rested on rollers and hard wood, placed between the cills attached to the framework and the tramway, by means of which it was moved to its permanent position. There it was again raised by another set of shears, while the cill and tramway were removed, and the ribs were then lowered into the sockets prepared for them, which, in fact, formed a continuation of the columns above the level of the lead flat. Each successive pair of ribs was fixed at a distance of 24 feet, or one bay from the preceding one, and the purlins, &c., were placed in this space by means of jointed ladders, which were adjusted to the form of the roof, and thus all scaffolding was avoided. The first pair of ribs was hoisted the 4th of December, 1850, and the eighth pair on the 12th of the same month. It took about one hour to raise each pair, from the ground to the level of the lead flat, and the whole was completed without the occurrence of any accident. About sixty men were employed in the hoisting, there being eleven men to each crab, and the remainder engaged on the lead flats.

VALUE OF AN EXTENDED KNOWLEDGE OF MINERALOGY AND THE PROCESSES OF MINING.

By Warrington W. Smyth, M.A., F.G.S.

[*Introductory Lecture to the Course of Mineralogy and Mining, at the Museum of Practical Geology.*]

An extended knowledge of mineralogy and the processes of mining are essential to those interested or engaged in mining.

In the commencement of an inquiry into the infinite variety of objects surrounding us in the natural world, presented, it would appear, for the purpose of inducing the most attractive and holy exercise of our observing and reasoning powers, it is obvious that three principal assemblages are to be discriminated. These divisions are the animal and vegetable kingdoms, characterised by organic structure, and the wondrous phenomena of life; and the inorganic or mineral kingdom, comprising that far greater proportion of the materials of the planet in which no traces of organic structure are observable. This last assemblage of objects has been generally understood to form the province of mineralogy, which thus in its most extended sense would include all the aëriform and gaseous bodies occurring in nature, and could hardly venture to exclude the multifarious substances produced under similar chemical laws by the agency of man.

But since, amid the daily increasing accumulation of new and unexpected combinations, the domain of the inorganic kingdom appears unlimited, and many of its phenomena must be investigated by special departments of science, it becomes necessary to draw a boundary line around that portion of it which is to be embraced in modern mineralogy; and where we can find no logical distinction between the actual products of similar bodies and similar laws, as seen in nature or in art, we must, for the sake of convenience and utility, rest our criterion of separation upon the different conditions of their origin.

Under this point of view mineralogy has for its object the consideration of the natural inorganic materials of our globe, fluid and solid; the physical phenomena which they present, their chemical constitution, their modes of occurrence, the methods by which they are distinguishable from each other, their classification, and the uses to which they may be made subservient.

Now it is evident that, as the characters of minerals are dependent partly on their form, partly on their chemical, and partly on their physical properties, mineralogy must be based upon geometry, chemistry, and natural philosophy; and the history of the science affords the best proof that no branch of knowledge can rise towards perfection till the conterminous sciences have, after due cultivation, been brought forward to aid in its development.

It may at first sight appear trivial and unnecessary to insist on the definition and objects of mineralogy; but, in addition to the importance of a clear understanding of the purport of any branch of education, there are in the present case special reasons for adopting such a course. This science has in Britain, for many years past, been cultivated by so small a number of investigators, that by the public at large it has been almost lost sight of, and is not unfrequently confounded with chemistry, geology, or metallurgy. Nay, there are not wanting among scientific men those who assert, that as a mere department of chemistry it can hold no independent place, nor offer a foundation for a special course of study. The above definition, however, may aid in fixing its true position, and will show, that whilst we contend with such opinions on the one hand, we would oppose on the other the vain struggles of those who have endeavoured to disconnect the science from that chemical aid which has so much advanced its progress and heightened its interest.

The prime and grand interest attached to our studies of the products of the earth is to be found in the fact that the mineral properties of different lands, in conjunction with their geographical features, have determined the distribution, the physical and social character, and the well-being of the various races of man. Whether we examine the vestiges left by the peoples of gray antiquity, or study the modifications produced in branches of the same race located in regions of different aspect, or inquire into the origin of the chief seats of modern civilisation, we shall be assured that most of these phenomena are dependent immediately, or through the medium of vegetation, on mineral produce, and the particular conditions under which it can be made available to human convenience.

In the remains of ancient Egypt we learn how a stupendous architecture arose by the aid of the soft yet massive sandstones piled by nature on the banks of the Nile, and how monolith statues and obelisks were suggested by the presence of a syenite capable of taking a high polish, and admitting of the sharpest intaglio tooling. In Attica the marble of Pentelicus and the silver of Laurion combined to develope that high state of art which, exemplified in the Parthenon and the sculptures of Phidias, has never since been equalled; whilst the abrupt limestone ravines of Lycia and Arabia Petræa gave rise to a description of architecture peculiar to itself.

As examples of the second point, call to mind the different occupation and character of the dwellers in the Spanish peninsula,—the active mining and mercantile population of Gallicia, Asturia, and the Basques on one hand, the indolent Castilian and Portuguese on the other.* Or compare the torpid millions of the Slavic race in the plains of Russia with their industrious relatives and co-religionists in Servia and Bulgaria.†

Lastly, in furtherance of the third inquiry, we need only to examine the beautiful population map of the British Islands by Petermann, which shows at a glance that besides the conditions requisite for the purposes of shipping, it is coal and iron and lead and copper that mainly influence the increase of our towns. Nor can we omit to refer to the amazing process by which the discovery of gold is at this day pouring a new tide of population over parts of Siberia, to Western America, and to the Antipodes.‡

Such general views are, however, somewhat foreign to my purpose, for the main question which lies before me is the importance of mineralogical knowledge to those engaged in technical avocations. Enormous as is the interest at stake in connection with this science, it is obvious that a more or less profound acquaintance with its facts must be productive of considerable differences in the progressive development of the national wealth. It is surely patent to all that the miner ought to be thoroughly acquainted with the nature of those substances which it is his daily task to seek in the recesses of the earth, as well as with those which exert a favourable or a pernicious influence either on the abundance or quality of the objects of his search. No less should he be prepared to recognise those which, although unusual in the spot where he has commenced his career, may be thrown in his way either in another part of the same vein, or in neighbouring veins of the same district, or even in other lands, to which, by the varying demands for mining skill, he may so probably at some time be transplanted.

Supposing even that our miner had perfected himself in a science requiring far more close application to books and in-door study; supposing that he were an expert chemist, I venture to assert, that although in many cases highly serviceable to him, this rare acquisition would not make amends for an ignorance of mineralogy. Were he, each time that he required to know the nature of a substance, obliged to enter upon its chemical analysis, his days and years would be passed in endless labours often repeated and sometimes fruitless. If we concede that after twice or thrice analysing the same ore, for example, he were to recognise it the fourth time by some less laborious test, we allow, in other words, that he has acquired a mineralogical knowledge of that single substance: and thus we arrive at the conclusion, that the methods of mineralogy are those which a man must employ, if, in relation to the natural inorganic bodies, he desire to reap the advantages offered him by previous investigations.

There exists, it is true, in practice a source of difficulty which has probably gone far to prevent the spread of our science. Whilst many of the more abundant and valuable productions of the mineral kingdom are met with in such a state of impurity from mechanical aggregation and admixtures, that the particular minerals of which they are composed are not separable by physical means, others occur only in an amorphous or irregularly shaped condition. Now scientific mineralogy bases its descriptions on the most perfect individuals, or crystals, of each species, bodies which are comparatively rare; and treats with but little respect those which are never crystallised, and of which the distinguishing characters are less definite. It stands

* Le Play, Ann. des Mines, 1834.

† C. Weerth, 'Die Entwickelung der Menschenracen durch Einwirkungen von aussen.' Lemgo, 1842.

‡ Virlet, 'Coup d'œil statisque sur la Metallurgie dans ses Rapports avec l'Industrie, la Civilisation, et la Richesse des Peuples.' 1837. Ami Boué, 'Der ganze Zweck und der hohe Nutzen der Geologie.' Wien, 1851.

to reason that in an institution of a practical tendency the strictness of such rules must be relaxed, and that greater weight must be attached to those substances, chemically impure though they may be, which are abundantly yielded by our mines and quarries, and yet scarcely constitute true mineralogical species.

We shall thus, for example, study the characters of the pure carbonate of iron in the crystals occasionally lining the cavities of our lodes, in the masses which exert so powerful an influence on the industry of Nassau and the Austrian Alps, and again in those indefinite mixtures which as nodules and continuous beds have, from their geological position and abundance, contributed in a high degree to raise Great Britain to her present pinnacle of manufacturing power.

But the cause of such a preference in mineralogical works is at once evident, on comparison of the objects described with those of the other classificatory sciences.

In the animal and vegetable kingdoms the naturalist traces, in successive groups of animals and plants, a descending scale of lower and lower organisation, till at last, in the most rudimentary forms of life, individuality is lost in an assemblage; yet down to this point each species presents none but forms complete in themselves, and almost unvarying. In the mineral kingdom, on the other hand, we are obliged to seek out for description the most perfect specimen, because it is not a succession of species, but the same species which offers a never-ending diversity of aspect. The mineral species may indeed occur in every state of development, from the symmetrical crystal, composed of definite constituents, passing through every grade of incompleteness of form or admixture with foreign substances, till we reach the lowest step of the scale, where the individual is so merged in the mass that form is destroyed, and the other characteristics are no longer discernable to the sense. How striking is the parallel in human societies, where the development of mind and resources unmistakeably accompanies such arrangements as lead to the self-reliance and importance of the individual, whilst as surely the crippled freedom of action, caused by merging individuality in the crowd, is attended by deterioration and destruction of all healthful prominences of character!

But besides the miner, there are hundreds and thousands amongst us whose pursuits, bearing on the practical purposes of life, render a knowledge of mineralogy an element of success. The geologist, the engineer, and the architect must have recourse to mineralogy to gain acquaintance with many of the materials which they employ; nor, even if they possessed unlimited time and means for the acquisition of chemical analyses, could they afford to overlook the physical properties which are often chiefly instrumental in fitting those substances to their several applications. The agriculturist, if he wish to modify and improve the condition of his soils, must become familiar with the appearance and qualities of the marls, limestone, gypsum, phosphorite, and other minerals, which are now beginning to exert a remarkable influence on his art. The antiquary, without a knowledge of the stones from which the ancient inhabitants of the earth sculptured their idols, reared their temples, or fashioned their rude implements, and of the ores from which they produced their metals and alloys, can draw no sound conclusions as to the comparative civilisation of distant epochs, nor guard himself from the blunders consequent on faulty observation or crude description. Who, again, that is not insensible to the varied beauties of the brilliant gem, would hesitate to prefer to determine its nature by the methods of mineralogy instead of intrusting it to the chemist, who, with ruthless hand and devouring acids, must destroy its substance ere he can pronounce upon its character?

Other and numerous mineral productions there are for a decision on whose value we are dependent on the aid of analysis. Among the irregularly mingled bodies to which I have before alluded are many which, like the iron ores lately discovered in the oolitic formation, can only be determined as to their importance by accurate assay. Few among the crowds who at the late Industrial Exhibition swept by the series of iron ores brought together from all parts of Britain by Mr. Blackwell, could have prophesied that the collection of half-a-dozen of those sombre stones would give rise within a few months to an active industry, which bids fair to develope a new phase in the gigantic phenomenon of the British iron trade. An example, this, of the mutual dependence and assistance of three sister sciences, where geological reasoning had to point out the tract in which a given formation was to be found, mineralogical observation to discover the actual deposit, and chemical analysis to determine the value of the ore.

The mining districts of Great Britain are so utterly destitute of the means of mineralogical education, whether in schools or suitable collections, that it need be no source of wonder to find the most intelligent miner acquainted only with some two or three of the substances which in the routine of his employment have been brought prominently before him, and often neglecting others from ignorance of their nature, or dangerously confounding things which are totally distinct from each other. It is matter of history that the copper ores of Cornwall were recognised as useful only at a comparatively late date, the miners having concentrated all their attention upon the tin with which that county was so plentifully supplied. More wonderful does it appear, that even at the commencement of the last century, when the yellow ore or pyrites had been long appreciated, the far more valuable redruthite, or sulphide of copper, was thrown as worthless rubbish over the cliffs of St. Just into the Atlantic; and Pryce informs us, that "many thousand pounds worth of the rich black ore, or oxide of copper, was washed into the rivers and discharged into the North Sea from the old Pool mine."*

These might be considered as the errors of a past age, but we may recollect that they occurred at a time when the value of the same substances was understood in other countries; and by mere accidental rencontres similar cases are still not unfrequently brought to our notice.

During a visit, three or four years since, to a mine which was supported chiefly by raising blende, the sulphide of zinc, my attention was attracted by a lump of white mineral lying on the window-cill of the office, a single glance at which was sufficient for recognition; and I put to the agent a few questions regarding its nature and occurrence. He replied that it was nothing but "spar," and that in working a particular part of the lode they had met with many tons of it, which, however, had been all, except this accidentally preserved specimen, irretrieveably mixed with the rubbish heaps. The surprise of my informant was not small, when he learned that the so-called "spar," confounded by him with quartz, was calamine, an ore containing in its pure state above 60 per cent. of oxide of zinc. Not to leave the same metal and its ores, which put on a great variety of characters, I have known zinc blende taken for lead ore, and honoured with the erection of a smelting furnace, when, to the chagrin of the manager, the volatile metal flew away up the chimney, leaving only disappointment and loss behind. Again, from a faint resemblance which some of the varieties bear to certain iron ores, a resemblance which would at once disappear before accurate observation, a considerable quantity was bought, not long since, by one of the greatest iron-masters in this country. It was carried to the furnaces, duly mingled with fuel and flux, and after a strenuous effort had been made to get it to yield iron, it all, as the proprietor naïvely remarked, "went off in smoke."

Blunders of this kind are more excusable when made in regard to some of the minerals of comparatively rare occurrence. An active agent of my acquaintance, a man of high character, was requested by a couple of his friends, who gave themselves credit for uncommon sagacity, to join them in forming a company to work a deposit of an unusual ore which they had lately found. Already they had referred it, for corroboration of their opinion, to a person at Birmingham styling himself a mineral chemist, whose report set forth that the specimen shown him was, as the others had suspected, an ore of molybdenum, and that it was worth 8*l*. per ton. This was sufficient to induce the agent to join the discoverers in a journey to the place in question, and at the head of a remote valley, embosomed among the ruggid hills of Cambria, he was gratified with the view of such a mass of the same substance that it was evident that thousands of tons might be quarried at a mere nominal price. Specimens were broken, the party returned to consider the preliminaries of their adventure, and it was agreed that the mineral corresponded pretty nearly with the description of sulphuret of molybdenum in some book, which was at hand. Still, the more cautious manager feared that the prospect was too bright to be real, and without consulting the others, expended a fee in sending for a good analysis to a scientific chemist in London. The result was, that the substance in question proved to be a shining, black, slate-clay, not applicable to any use, except perhaps to make bricks.

* Pryce, Mineralogia Cornubiensis, 1778.

Within a gunshot of the place where the above-mentioned agent related this anecdote, the appearance of some rather ferruginous slate rock attracted the attention of a party of credulous speculators, who believing they had discovered a rich iron ore, actually built a blast-furnace, erected the necessary machinery, and continued for some time to carry out their vain attempt, deluded by the fraudulent practices of the workmen. As might, however, have been predicted, the undertaking soon ended in abandonment and ruin.

In other mining districts I have known persons, who although possessed of great general intelligence, have collected blue stones (generally ores of copper) for cobalt, ignorant of the fact that none of the natural combinations of this valuable metal possess a blue colour.

The sulphate of baryta has for a few years past borne a certain value for manufacturing purposes; and an instance was brought to my notice, where a ship-load of what was supposed to be this mineral was obtained by surreptitious means, and sent from a distant part of the country to London. But the biter was bit, for his observation was faulty, and his cargo, proving to be calcareous spar, was worthless. It would tire out your patience to enumerate the cases in which mica or iron pyrites have been mistaken for gold. From the anxious country gentleman in our own land, to the disappointed Californian gold seeker, and to the solemn Turkish Bey mysteriously unwrapping from many a folded rag the specimen of his expected wealth, such victims of mineralogical ignorance are frequently presented to those whose pursuits bring them into a position for advising on similar points.

But there is another and a wider field far more important than the correction of isolated mistakes, in which mineralogical research has yet to be largely employed, and in which the connection of this subject with mining is no less grave than intimate. The principles by which the accumulation of ore in lodes or metalliferous veins has been regulated are to this day so enveloped in mystery, that the prosecution of mining enterprises is almost as much a matter of chance as it was with our forefathers three centuries ago. Nor can we wonder that this should be the case, when we regard the peculiar difficulties by which the subject is beset. Not only is the progress of the operations so slow that the observation of one set of phenomena may extend over many years, but the examination of some points, unless made at the time of first opening, is precluded by the discolourations of water and powder smoke, or by the means adopted to secure the works. Then, according to the conditions under which the lode is placed, a combination of problems, geological, physical, and chemical, are presented for solution, and the thoughtful mining agent, left to consider them only by the light of a partial experience and natural shrewdness, is commonly led to see them through a peculiar medium, and to fall into the numerous errors resulting from unsound premises. Copious stores of knowledge have, it is true, been acquired by many of the captains and tributers in Cornwall and elsewhere; but besides the difficulty, according to the various views of individuals, in collating them, they have generally, from want of early educational opportunity, been accumulated upon an unsafe basis; finally, the experiences perish with the men, leaving society no richer for their acquisition.

Nowhere is there more room than in the study of this subject for accurate mineralogical observation,—nowhere is the prize offered more inviting; for the resolution of some of these questions must tend to acquaint us with the probability of finding remunerative ores in certain directions, either in depth or on the course of the lodes, and must, therefore, be instrumental in discovering untold sources of wealth. Nor need we despair, when we remember the confused state of all the natural sciences a little more than a hundred years since, that at some future day a more systematic cultivation, by rigorous induction, founded on close observation, will clear away the weeds, and cover with plenteous crops this hitherto barren field.

We are thus naturally led, by the contemplation of the objects to be sought for, to the second part of our subject—the Art of Mining: and here it will be necessary to dwell at greater length on the character of the studies which it is desired to embrace, inasmuch as no course of instruction in them has yet been attempted in this country; and, strange to say, not a single book exists in the English language in which they are comprehensively treated. Among the Germans many excellent works on mining have appeared from time to time during the last three centuries; and even in France, a country comparatively so poor in mineral productions, treatises have been published, in which many of the divisions of the subject have been skilfully discussed, whilst the periodical literature of both those nations is rich in detailed descriptions of the natural phenomena and the working processes of mines in all parts of Europe. Nor are we unindebted to the Russians, whose well-educated officers of mining engineers, sent at the public expense to investigate various mineral regions of the continent, have carried back with them a treasure of valuable information, which has been in a great degree instrumental in advancing, to a high grade of perfection, the mining and metallurgical operation of the Ural and of Siberia. In Britain, however, we have little else than two or three treatises on the working of coal, and a few isolated papers on other parts of the subject; and hence it will be needful, in a series of Lectures, to depend in great part on personal experience, and to indicate, in exceptional cases, the sources whence a knowledge of details may be obtained.

But it would be an injustice to the many thinking and enterprising spirits among our British miners not to express our admiration for the skill and ingenuity which they have brought to bear on particular portions of their art. Surrounded by difficulties and dangers, they have won enduring triumphs; and in some of their applications have, by the force of persevering industry, advanced their experience with such rapid steps, that science has been glad to follow in their wake, and reap new facts to aid her further progress.

The first great feature which strikes the attention in approaching this subject is the enormous value of the mineral productions of Great Britain, amounting to the sum of 24,000,000*l.* annually in the rough state. So bountifully, indeed, has our country been enriched by Providence with these sources of wealth, and in a degree so much higher than any other region in Europe, that it need excite no surprise if those natural gifts which even aroused the industry of the early Britons, and excited the cupidity of their Roman conquerors, yield at the present day an amount of riches far greater than those produced by any other nation. Let us, then, consider the great population supported directly by the extraction of these minerals, and indirectly by their application to the arts,—the maintenance of hundreds of thousands of men by these not inexhaustible stores,—and the entire dependence of our whole manufacturing and commercial system on the supply of fossil fuel; and we cannot fail to arrive at the conviction, that in exercising the stewardship of such gifts of heaven, the nation has a high and responsible duty to perform, that waste and improvidence are a national sin, and that it behoves all who are in any way connected with the working of our mines to lend their best endeavours to the perfecting of the most economical and efficacious means of rendering all the products of our mines available to the uses of mankind.

It is not pretended that by any plan of education it is possible to make a miner, or in other words, to prepare a man for taking charge of a mine as soon as he has left our walls: not more reasonably should we expect that a lad drilled in the classes of a naval college were at once metamorphosed into a sailor, fitted at once to take command of a ship. Yet surely no one will deny, that if in that school he has learnt to box the compass, to knot and splice, if he has worked out problems in navigation on sound mathematical principles, if he has been taught by descriptions how to handle a vessel at anchor in a tideway, or on a lee-shore, he will be infinitely more ready to take advantage of circumstances, and to make rapid progress, than if he had been sent on board unknowing of these things and their principles. No "royal road" to learning, no legerdemain of "cramming," can make amends for the want of time and pains bestowed on the acquisition of practice; and as with the seaman so should it be with the miner.

By description, by drawings, and by models, it will be our endeavour to make the student familiar with the chief phases of the operations practised in various regions, and under different conditions. He will have, each year, the opportunity of closely inspecting the mineral features and particular mining processes of the districts under examination by the Geological Survey; and, when furnished with this preliminary knowledge, will, I doubt not, pass to his sphere of probation better qualified to observe and to compare; whilst the practical experience which he must afterwards acquire will be superadded to what he has already benefitted from the labours of others.

Before we proceed to examine farther into the general question of the importance of endeavouring to establish in Britain, a system of technical education for this department, let us consider the definition and principal heads of the subject before us; and, whilst so engaged, let us take an instance from each division, illustrative of the gain to be derived from an extended acquaintance with the modes of treating it.

The art of mining comprehends all the processes whereby the useful minerals are obtained from their natural localities beneath the surface of the earth, and the subsequent operations by which many of them must be prepared for the purposes of the metallurgist.

In the first place, among these processes must be mentioned, the search for localities in which we may reasonably hope to meet with the minerals occurring either in beds or lodes. It is obvious that a combination of geological and mineralogical knowledge is requisite for success, and that a mere empirical tact obtained in a given district may lead to fatal mistakes in another. Amid the phenomena of the lodes, their frequent heaves and dislocations, and their different appearance when bounded by different rocks, call for close attention; and although from lack of sufficient and well recorded observation, the principles upon which a criterion should be founded are far from fixed, we often find that a superior degree of general experience has been rewarded by success, when mere unintelligent working had been completely foiled.

Among the methods of proving the existence of useful deposits, none has yielded greater results, or is more capable of extended application than the art of boring. For ascertaining the position of coal-seams, and for obtaining a supply of water, bore-holes are frequently sunk in many parts of the country. But we have yet, by a comparison of the practice of different countries, and the adoption of a more economical mode of sinking, where need be, to greater depths, to increase their sphere of utility. At Neusalzwerk, near Minden, a bore-hole has lately been pierced through the trias formations, to the depth of 2300 feet, for brine springs; and another, at Mondorf, in Luxembourg, to near 2400 feet, which, though unsuccessful in discovering salt, has supplied a spring of above 21 cubic feet per minute. At these and various bore-holes of less depth in Germany and France, a variety of apparatus has been employed, a complete study in itself, much of which has been serviceable in greatly reducing the time and cost of such operations. We may instance the ingenious instruments of M. Degousée, the "free-falling" cutter of Herr Kind, and the hollow iron rods of Von Œynhausen, as a few of those which are well worthy of attention for the good service rendered in the execution of great works. Again, we know far too little of the routine of the Chinese well-borers, who have succeeded, according to the detailed statements of Father Imbert, in attaining the extraordinary depth of 3000 feet, by their simple and inexpensive apparatus of rope-boring, an example which has been successfully imitated in the chalk districts of France.

The next division of importance embraces the tools used in mining. One of the greatest advantages which we enjoy over our forefathers is the use of gunpowder in rending a path through the harder rocks, which they with enduring and patient labour were obliged to cut away with hammer and wedge. But the implements employed in various districts differ not only in form and weight, but in their material and useful effect. Let me only allude to one point: in scarcely any of our mines, whether in the north or south, has it been attempted to use borers of steel; iron is almost universally, with us as in most parts of the continent, the material of which the shank of the borer is composed. Yet in Saxony, for many years past, as also in Derbyshire, and at Ecton, the work has been advantageously carried on with borers of steel alone. Accurate experiments made and recorded at Eschweiler, and at Mansfield in Prussian Saxony, have been attended with favourable results; and Mr. Rogers of the Abercarn Collieries has succeeded in proving, whilst sinking a large shaft in hard rock, the value of steel tools, a set of samples of which were placed in the Great Exhibition, and afterwards presented to this Museum. Although the suitable tempering of cast-steel is attended with some difficulty to the inexperienced, the following reasons for its preference to the ordinary material have been established—viz., the great saving in wear and tear; the reduction of original outlay, since the stock of steel borers may be smaller than that of iron in a lower ratio than that borne by the price of iron to steel; the diminution of smith's costs for sharpening, and of time lost by boring with a blunted edge, and the greater convenience of carriage in and out of the mine. Farther, the superior compactness of the material transmits the force of a blow more efficaciously to the required point, a fact corroborated by the observation that an iron borer will cut less ground with the same number of blows when new than after being for some time in use; and it need hardly to be added, that in the questions of time, material, and cost, connected with the breaking of ground, we touch on some of the most important elements of economy in mining.

I will not detain you with an enumeration of the points to be dwelt upon in the form of the excavations by which we enter into the earth, whether by the driving of levels or the sinking of shafts under different circumstances; nor, from among the modes of securing them by timbering, masonry, or ironwork, shall I do more than bring to your notice one ingenious application of physical science to these purposes. It is well-known that the sinking of a shaft through loose sand or watery rock often besets with great and sometimes with insurmountable obstacles the approach to the useful minerals which lie in firm ground below. On the banks of the Loire repeated efforts to reach the coal measures through a thick bed of alluvial sand had failed, overcome by the great influx of water and loose material; when M. Triger bethought him that the simplest mode of vanquishing the difficulty was to dam back the water, to employ a constant resisting force which might be maintained at small expense, in place of a moving power of enormous cost. It was, in fact, to pump into the iron cylinder which formed his shaft such an amount of air that the pressure on the bottom from within should be equal to the pressure from without; and the water was thus prevented from rising above a given height. Placing a cover on the cylinder, through which two pipes are inserted, one conveying the compressed-air into it, the other dipping into the watery stratum, he found a stream of water and sand poured through the latter whenever it was unable to escape rapidly enough elsewhere. Then, in order that the men might enter upon or leave their working place without disturbing the equilibrium of the forces, he applied the principle of the canal-lock, fitting an upper chamber in his shaft, where, when the upper door was closed and the lower one opened, all was filled with the compressed-air; when the lower one was closed and the upper opened, the air-lock was relieved from its superabundant air, and men or materials might be introduced. Pages would be filled with the details of the difficulties met and overcome, and of the successful adoption of the principle in the sinking of larger and deeper shafts; suffice it to say, that M. Triger succeeded, surrounded by water, in joining his cylinder to the solid rock at a depth of 82 feet from the surface, having proved that human life could be supported, and work done, for many hours together under a pressure of 3¼ atmospheres. His procedure is marked by manifold advantages, and admits of various applications;—witness the removal of rocks in the harbour of Croisic, on dry ground, whatever the state of the tide. Verily, if Canute had possessed a Triger among his courtiers, he might, to better purpose, have defied the rising flood to touch his royal foot!

We shall be unable here to glance even rapidly over the many systems devised for working out the minerals attained by the foregoing operations: let us only scan an isolated case. The magnificent seam called the "thick coal" of Dudley has been worked throughout the entire field on a principle which by taking the whole height, 30 feet, at one time, has been attended with such danger as to cause almost weekly some frightful and fatal accident, and to exercise morally a pernicious influence on the character of the colliers; whilst it has necessitated the leaving of so large a proportion in "pillars" and "ribs," that only from 11,000 to 15,000 tons of coal have been obtained out of 40,000 contained in the acre. Here then is a loss to the national wealth of useful life, and of about two-thirds of the finest fossil fuel in Britain, the money value of which would amount to many millions. Yet for twenty years past, in that very district, one group of pits has been worked on a system by which the coal is taken in two successive stages, where the men work in comparative safety, and where, instead of 11,000 or 15,000, 26,000 tons are realised per acre, although the seam is there of less than its average thickness. Consider only for one moment the beneficial effects of improved means of extracting the coal from our mines: it is supposed that the total quantity annually brought into use amounts to above 30 millions of tons; and if an economy of but 3*d*. per ton were effected, by reducing friction, ineffective labour, or other sources of wasted power, a sum of nearly 400,000*l.* per annum would be saved to the country.

We must omit to speak of the modes of transport along the underground roads, of raising the minerals to the surface, and of pumping the subterraneous water, accomplished by an amazing variety of apparatus and machines. Nor can we dwell upon that important subject of ventilation, to which our attention is so often and forcibly called by the fearful catastrophes occurring in our mines from its absence or mismanagement. I would only call attention to the rude method of dispersing noxious gases figured by Agricola 300 years ago, and in some of our districts still adopted, under the term of "brushing out the sulphur," as the only means of rendering a place safe for the men to work in. But although even at that early day more refined processes had been introduced, as evinced by his description of the ventilating fans, let us compare all those puny means, and the efficiency of ventilation in the great bulk of our collieries with the skilfully applied and fiercely blazing furnaces of some of the great northern mines, where a current of 150,000, or in one case near 200,000 cubic feet of air in one minute are circulated through the devious passage, and rush to the upcast shaft with the velocity of a hurricane.

Nearly related to this division, as regards the question of humanity, is the true construction and the preservation of mining plans. Take an instance in which the loss of 100 lives may ensue from the ignorance of a physical fact. Those familiar with the mining districts are well aware that the great majority of their maps are laid down without any reference to the phenomenon of magnetic variation. If, then, a colliery be in operation on the dip of old workings filled with water, the tapping of which would be death to all employed in the pit, and the maps had been constructed some years previously with respect to the magnetic meridian alone, the variation may in the meanwhile have so far changed that the exploring drifts supposed by the manager to be going clear of the known danger may, in reality, lead him straight to destruction. The art of surveying is, however, too important and extensive to be included in the lectures on Mining, and will ultimately, we hope, form the subject of a separate course.

The last group of operations to be included is the dressing of ores, on the efficient conduct of which the success of many a mine may depend. Whilst the Schemnitz miner is able to work actual gold ores broken from great depths, which, besides a little lead, contain no more than one part of gold in 228,000 of stone,* and whilst the Russians wash in their stream-works sands containing only one part in half-a-million, we learn from description that the Californian and Australian are employing processes more rude than what they might have copied from the miners of three or four centuries since, and that (inasmuch as the poorer can only be profitably worked in conjunction with the richer) they are actually losing for ever a large proportion of the riches showered by nature upon those lands.

Such are, in few words, the processes which will form the substance of a course of instruction in the art of mining; and it need scarcely to be observed that a preparatory acquaintance with physics, geology, and practical mechanics is indispenably necessary. For this reason it is proposed that the Lectures on Mining shall be given to the students of the second year, already provided with the preliminary studies, some of which have been commenced; but in order to obviate misconstruction, it is proposed during the present season to deliver a concise course, intended simply as an outline of the subject, leaving the more detailed treatment for the ensuing year.

Amid the entire circle of the sciences we can hardly mention one which the accomplished miner may not at some time call to his aid, from the science of numbers, on which all his other knowledge should be based, up to astronomy, which may assist in the construction of his maps. We cannot, indeed, expect that many will become, like Humboldt (who was educated, and for some time practised as a miner),† master in several sciences; but when we add to these the acquaintance with business routine and commercial queations which the manager of mining property ought to possess, is it not clear as the noon-day that for those who desire to excel in this profession a special education ought to be superadded to the training of our schools and colleges? And is it not equally clear that with so vast a field of investigation before him the intelligent inquirer must ever remain a student, whilst only the shallow pretender can affect to be the arbiter of the difficult problems which daily present themselves?

From the examples above adduced I trust that I shall be justified in asserting, that a communication of knowledge, whether of the principles or of the practices involved in mining, must be attended by great pecuniary gain to the country at large. We shall be met, in the outset, by the argument more suited to the Cape Boer or the Chinese than to the progressive Anglo-Saxon, that because our fathers have done very well without it we may easily dispense with any such innovation; and that the immense mineral production of Britain is the best proof that we need not to follow the example of nations unable, with all their schooling, to rival us in that respect. But let us not overlook the great natural advantages with which we have been favoured, nor forget, that although individual perseverance has done much, very much, among us, we must still depend for advancement in a great degree on the experience of others. In good truth "he that neglects the culture of ground naturally fertile is more shamefully culpable than he whose field would scarcely recompense his husbandry: and it is as rational to live in caves till our own hands have erected a palace, as to reject all knowledge of architecture which our understandings will not supply.*

Taking even the present state of our knowledge as a standard, let us balance the argument on such crucial questions as the following. Do cases occur in which mineral substances are neglected from ignorance of their nature? Is it true or not, that others are wasted and lost to the nation by the character of the present operations? Do not crowds of well-meaning adventurers rue their introduction to the mining schemes of impostors? Are not hundreds of human lives sacrificed to a want of precaution and prudence? Is not the condition of machinery and apparatus in a great part of the country very inferior to certain now existing models? Are there not numerous sources of wealth lying unemployed from the uncertainty consequent on a want of former records or present knowledge? No one, I am confident, acquainted practically with our mineral districts, will hesitate in replying, that in all these points great and salutary changes may be made, and that enlarged opportunities of learning accorded to the mine agents must produce their fruits in due season.

As for the miserable plea of ignorance, that the country cannot fail to prosper, in whatever degree her sons may squander the stores of nature deemed inexhaustible,—it but leads the mind back, through many centuries, to an instance of similar reckless boasting, followed by a warning fate. In the palmy days of Athens, when the silver mines of Laurion were vivifying art, commerce, and luxury, Xenophon asserted, in a formal treatise on the revenues of the state, that "whatever number of men had been employed in those silver mines, no diminution had been practically effected in the quantity of the ores;—that there was no limit to the productiveness of the veins, either in depth or in extension, and that their riches, in fine, were inexhaustible." Let any one contrast such assurances with the beggared state of the land ever since.

I would be far from strictly comparing the conditions of Attica or its people with our own; but we must bear in mind, that in all our mining districts the minerals are extracting at a fearful rate, and each year in an increasing ratio, and that after a certain lapse of time scarcity and increase of price must necessarily follow. In the meanwhile, we have numerous rivals in other and less favoured lands, doing their utmost to make up for natural disadvantages by fostering education and acquiring a sound knowledge of the principles on which they act. In this race they have often been checked by political troubles and peculiarities in their social relations; but, having so thoroughly secured each onward step as to be comparatively independent of the fleeting skill of individuals, they nevertheless press forward again in the same path; and when the day comes that our preponderance in natural treasures is reduced to something nearer equality,—when deeper and thinner coal seams must be wrought, when poorer ores of the metals must be more highly prized, and when the products of our manufactures can only be brought into commerce at higher prices,—then must the star of England's

* In 1841-2, when I passed some months among the mines of Hungary, much had been done and was still doing by my friends the late Oberstkammergraf von Svaiczer and Mr. Rittinger, the Inspector of Stampworks, for the improvement of the dressing of gold and silver ores; and the works at Antal and Illia, near Schemnitz, were well worthy of admiration for their scale and economy.

† Alexander Von Humboldt was a student at the mining academy of Frieberg, in Saxony, in 1791, with von Buch, Preiesleben, and other coryphæi of mineralogical and geological science.

* Johnson. Rambler, No. 154.

prosperity decline, unless we keep our vantage ground by the superior skill and knowledge to which technical education must greatly contribute.

Thus far we have directed our attention almost exclusively to the material advantages, or, in other words, the pecuniary returns to be expected from the cultivation of these subjects. I have dwelt so long on such topics because the main object of the foundation of this course of instruction has reference to that point of view.

But I should ill appreciate the character of this audience, and do violence to my own feelings, were I not, in conclusion, to protest againt that debasing spirit which would decry all branches of knowledge except those which are at once commercially profitable, and which would practically inculcate a belief that the acquisition of money is intended to be the great end and aim of human existence. Shall we, for their own sake, examine the works of the architect, the painter, or the poet, and analyse the rules upon which his art is founded, whilst we yet remain indifferent to any one department of the rich storehouse of nature, opened for man's inspection by the Author of all things?

Believe me, that the phenomena of mineralogy, and the principles which regulate them, are, though different in their kind, no less beautiful than those of animal and vegetable life; and they possess the additional source of interest, that they may guide us to the wider sphere of speculating rationally on the constitution of the orbs which roll with us through endless space.

With reason has Nabi Effendi, a Turkish author said, "Consecrate, O my son, the aurora of thy reason to the study of the sciences; in the vicissitudes of life they are an infinite resource, they form the mind, they polish the understanding, they instruct man in his duties, they delight and amuse us in prosperity, they become our consolation in adversity." Indeed, to the student in his cabinet, no less than to the traveller through Alpine passes, or over regions explored by the skill of the miner, the study of minerals offers at the same time an attractive recreation, and an efficient method of disciplining the faculty of observation. The closer we investigate the principles on which their constitution and their physical properties depend, the more are we startled by new and convincing proofs that it is only the imperfection of our knowledge which as yet prevents us from seeing more than the glimmering outline of that harmony which pervades all the works of nature. The system of law, the νομος ο παντων βασιλευς of Pindar, working as surely in the particle which vanishes from our power of sight, as in the loftiest mountain mass, reveals itself with more distinctness the farther we advance; and although the difficulties of inquiry are heightened, so are its pleasures also increased by the ties of brotherhood, which springing hence unite our pursuits with the other natural sciences.

Nor let it be supposed that the details of mining are unproductive of advantage to any but the professional miner. Deep in the bowels of the earth the labour of generations has wrought out edifices no less worthy of admiration than those which the skill of the architect has reared upon her surface; and if, in the latter case, we esteem it desirable to learn so much of the principles of the art as may enable us to appreciate the design of the craftsman, so in the former shall we find in the magnitude of the operations, in the diversity of the natural appearances brought to light, and in the ingenuity of the processes adopted for the maintenance and extension of the works, a harvest of facts no less interesting than suggestive of farther inquiry.

Whatever may be the imperfection of the teacher of these subjects, there is in themselves so much that is exact, so much that is vast, so much, in fine, that is most worthy of man's highest powers, that we may hope, out of the number who will enter with us on the curriculum, to see some few, at least, who will not stop short at that point whence they may obtain their worldly ends, but will persevere towards that goal of higher knowledge which has been, and always will be, the object of the noblest of mankind.

The Board of Health.—It has been stated in the House of Commons that the total expense of the surveys made by the Board of Health, with respect to the supply of water to the metropolis, was 674*l.* 19*s.* 3*d.*, and the Parliamentary expenses 6000*l.*, besides the cost of certain chymical inquiries.

THE MANCHESTER CORPORATION WATERWORKS AND RESERVOIRS.

[The following description of the reservoirs now in progress for the Manchester Corporation will, we are sure, be read with great interest by the profession, knowing the perilous position of the works during the late heavy rains. We are indebted to the *Manchester Guardian* for the information, which, be it observed, was collected on the spot within a day or two after the heavy fall of rain on Sunday the 8th February last.]

The reservoirs of the Manchester Corporation Waterworks in the valley of Longdendale, which stood admirably the great floods of Wednesday and Thursday, 4th and 5th February, had a yet severer test in the continued heavy rains of the three following days, till on Sunday the 8th some of the reservoirs were within seven hours (supposing the rain had continued to fall in equal quantity during the whole of that time) of being brim-full; and there was consequently considerable anxiety on the subject, especially amongst the millowners and other inhabitants of the valley within a little distance of and below the three great reservoirs of these works. This anxiety was of course greater than would otherwise have been the case, from the vivid remembrance of the recent horrors attending the bursting of the Bilberry Reservoir, near Holmfirth, in Yorkshire; though there is no analogy in the nature and character of the works to warrant any apprehension of the one, because the other had failed, as for years past all conversant with it had expected it to do. In order to enable our more distant readers to comprehend the general character and vast extent of the Manchester Corporation Waterworks, and the circumstances which led to their position on Sunday the 8th February, we must enter a little into detail.

Though in two instances perhaps (one in Scotland and one in Ireland) there are single reservoirs larger than any of those of the corporation waterworks, yet, taken as a connected series or chain of artificial lakes, constructed for the storage of water, those in the Longdendale valley have the largest aggregate capacity of any artificial sheets of water in the world. The great Croton Waterworks, which supply the city of New York with water, give a daily supply of 35 million gallons. The Manchester Corporation Waterworks, including the 17 million gallons with which they are bound by their act to supply the millowners on the streams, before they can send a gallon to Manchester, yield a daily supply of 45 million gallons, or 10 million gallons daily more than the Croton Waterworks. This will give some idea of the extent of the corporation waterworks, which collect the rain from a drainage area of some 18,900 statute acres, or 29¼ square miles of high ground, amidst the moors and mosses of the Pennine hills.

These works, which were commenced at the Woodhead reservoir in October 1848, though now rapidly approaching completion, are by no means finished. When completed they will comprise (besides weirs, lodges, watercourse, conduits, and tunnels) eight reservoirs, having an aggregate area of more than 420 acres, and an aggregate capacity of 611,872,607 cubic feet. The three highest of these reservoirs, in the main valley of the Etherow, are also the largest storage basins of the whole works, and it is from these that any great disaster is to be looked for, if such should ever occur. The highest is the Woodhead, the second the Torside, and the third the Rhodes Wood reservoir; and the following will be, when completed, their respective dimensions and capacities:—

Reservoir.	Embankment.		Reservoir.			
	Greatest Height.	Contents.	Area. A.	R.	P.	Capacity. Cubic feet.
Woodhead	90	152,707	131	2	25	187,949 092
Torside	100	899,129	158	1	38	240,251,983
Rhodes Wood	80	263,248	54	0	16	79,705,806

The present state of the works, especially the embankments, of these three reservoirs, may be generally stated as follows:—The embankment of the Woodhead reservoir is completed to its full height of 90 feet; but operations are now in progress to render some portions of it perfectly water-tight; and these operations are by no means finished. Of the Torside embankment of 100 feet, about 60 feet in height is completed; but here also the operations in progress to secure the watertightness of every part, only allow of the water being impounded in this reservoir to a depth of about 30 feet. Of the Rhodes Wood embankment of 80 feet, from 50 to 60 feet is completed; so that it only allows of impounding water to a depth of somewhat more than 40 feet. In the commencement and earlier period of the construction of any one of these embankments, it is necessary to make temporary provision for the passage of flood waters. Accordingly, temporary watercourses are constructed above the top-water level of the reservoirs, or otherwise gaps are left in the embankments themselves, until they reach a certain height, when these gaps are closed, and the floods must afterwards be either impounded in the reservoirs, or passed through the large discharge pipes. All the three large reservoirs we are now describing had, before the late floods, reached a point at which it became necessary to dispense with these temporary watercourses, and to place reliance solely on their powers of impounding and discharging any flood waters that could by possibility come down. In the various stages of the work, of course, every successive step has to be taken with direct reference to the amount of flood water which is expected to pass down the river Etherow; and these reservoirs have at all times been in a condition either to pass downward, or to impound, a quantity of water at least equal to a fall of rain of three inches on their collecting ground during the 24 hours. In this state, then, the floods of February found the reservoirs. But, in order rightly to appreciate the nature of these floods, we must look to the records of the fall of rain in the district, as registered by improved rain-gauges under the direction of Mr. J. F. Bateman, C.E., the engineer-in-chief of the Manchester Corporation Waterworks.

Taking the rain-gauge placed at the foot of the hills in the Crowden Valley, which joins the main valley of the Etherow, below Woodhead, which is in the very centre of the drainage grounds, we shall give its registers of the fall of rain; premising, however, that it must indicate a much less quantity than that which actually fell, either on the summit of the hills, or over the whole district. In January, then, the rain which fell in the Crowden Valley was 5 inches. This, though considerable, is not a very unusual quantity for that district in that month; but the following will exhibit the daily quantities during the first nine days of February:—Sunday, 1st, 0·5 in.; Monday, 2nd, 0·4 in.; Tuesday, 3rd, 0·5 in.; Wednesday, 4th, 1·1 in.; Thursday, 5th,* 1·2 in.; Friday, 6th, 0·8 in.; Saturday, 7th, 0·2 in.; Sunday, 8th,† 1·3 in.; Monday, 9th,‡ 0·5 in. Here, then, we have in the first nine days of February, no less than 6·5 in. of almost incessant rain; and although there have been heavier floods, nothing like so continuous and protracted a fall of heavy rains has been known within living memory in that district. As to the rain which produced the floods on Wednesday and Thursday, the 4th and 5th February, the fall from 11 a.m. on the 4th, to 11 a.m. on the 5th, was 2·1 in.; and in the same period, 2·4 in. of water flowed off the ground and was impounded in the reservoirs, or was passed through the discharge-pipes. The quantity of water which still remained due to the fall of rain during that period, and which flowed off the ground before the streams were reduced to the same volume at which they were when the floods commenced, was about 0·3 in.; making the whole quantity coming off the ground in the twenty-four hours, 2·7 in. That must, therefore, have been the mean rain over the whole district, and the rain on the summit of the hills must consequently have been considerably upwards of 3 inches in the same twenty-four hours; and the rain that fell in the first nine days of February—viz., 6·5 in. rain, would probably upon the summit of the hills be not less than *ten inches*. Referring to Mr. Bateman's paper on the measurement of rain, read in April 1848 to the Manchester Literary and Philosophical Society, and printed in the last volume of their memoirs, we observe that the fall of rain in the four wet months of the winter of 1846-7, as registered by the rain-gauge at Crowden-hall, was as follows:—1846, November, 2 in.; December, 2·8 in.; 1847, January, 2·2 in.; February, 4·3 in. So that the fall of rain in the first nine days of February 1852, equalled the entire aggregate fall of the two months (59 days), of January and February 1847.

The following table, which has not been published before, exhibits the quantity of rain that fell in each month of the three years 1849, 1850, and 1851; as registered by a rain-gauge placed in a field at Crowden-hall, a fold of houses, situated at the junction of the Crowden and Longdendale Valleys:—

	1849. Inches.	1850. Inches.	1851. Inches.
January	8·2	3·8	2·5
February	2·4	4·4	3·0
March	1·5	1·1	4·1
April	3·0	4·0	1 8
May	2·8	2·0	3·0
June	1·7	3·4	6·3
July	7·8	4·8	3·8
August	5·4	3·2	4·2
September	4·7	1·8	3·0
October	7·0	6·5	4·9
November	5 1	7·8	2·7
December	5·1	1·3	0·8
Total for year	54·4	44·1	40·1

In January 1852, as we have stated, the fall was 5 inches; in the first nine days of February it was 6·5 inches.

To return to the working of the waterworks reservoirs, under the pressure of floods such as have just been indicated,—we learn that on Wednesday and Thursday, the 4th and 5th February, flood water to the extent of 2·4 in. in the twenty-four hours was safely passed or impounded in the reservoirs,—with a considerable space still remaining for storing additional water. But before the stored water could be discharged from the reservoirs, a succession of other floods, especially during Saturday night and Sunday, nearly exhausted the storage powers of the reservoirs, and on the evening of Sunday the 8th, there remained provision only for the safe passage of heavy rain (which had then been continuing for some time) for a further period of six or seven hours. With some amount of risk, though probably not very great, the continuance of rain for even twenty-four hours might have been provided for. Under these circumstances, however, the excitement of the millowners and residents in the valley below the reservoirs became very great during Sunday, stimulated of course by the recent catastrophe at Holmfirth, so that the whole valley was thronged by persons, many of whom came from some distance, notwithstanding the heavy, continuous, and beating rains, to see the reservoirs, examine into their state, and speculate as to the possibility of some of their embankments giving way. A little inn, which, from its usual quietness and loneliness, has for its sign "The Quiet Shepherd," was thronged from morning till night with people seeking shelter and refreshment; its stable and outbuildings were filled with guests, and the utmost excitement prevailed. On Sunday morning the rain continued to fall heavily from an early hour till about two o'clock p.m. without intermission. There was then a lull for nearly two hours, when it again commenced raining as heavily as ever, with a prospect of continuing during the night. Under these circumstances Mr. Bateman, who had been on the spot almost constantly from the morning of Thursday the 5th, feeling the very great and solemn responsibility that would attach to him, in case of any accident, even of a trifling nature, occurring to an embankment, without any notice to the inhabitants below, thought it prudent, about half-past three o'clock on Sunday afternoon, to dispatch messengers to the parties immediately on the river, for some distance below the reservoirs,—stating that, should it continue to rain heavily all night, some danger might be apprehended after the lapse of six or seven hours, and that it would therefore be prudent for them to prepare for the possibility of such a contingency. Of course this intimation spread great alarm throughout the valley, and the most vigorous efforts were made by some of the millowners and others to remove valuable property without delay; the occupants of cottages and other dwellings along the stream, also hastily removed their furniture to the houses of relatives and friends at some distance from the course of the stream. Thoughout the little village of Valehouse the inhabitants were thrown into a state of the utmost excitement, for in the event of the bursting of the embankment, a large number of the houses must have been swept away. Some houses at Bottoms Mill would also have been in imminent danger; as would others occupied by operatives employed by Messrs. Sidebottom, at Waterside Mill. All these removed their furniture. Mr. H. Lees, who resides between five and six miles below Torside, had several carts and wagons constantly engaged for several hours in removing his household and other property. At Glossop the alarm was very general, and much damage was done to furniture during its hasty removal.

* On the night of Thursday the 5th, between 4 p.m. and 8 a.m. of the 6th, there fell 0·7 in. of rain.

† This was between 4 p.m. Saturday, and 4 p.m. Sunday.

‡ This was from 4 p.m. Sunday, to 12 noon on Monday.

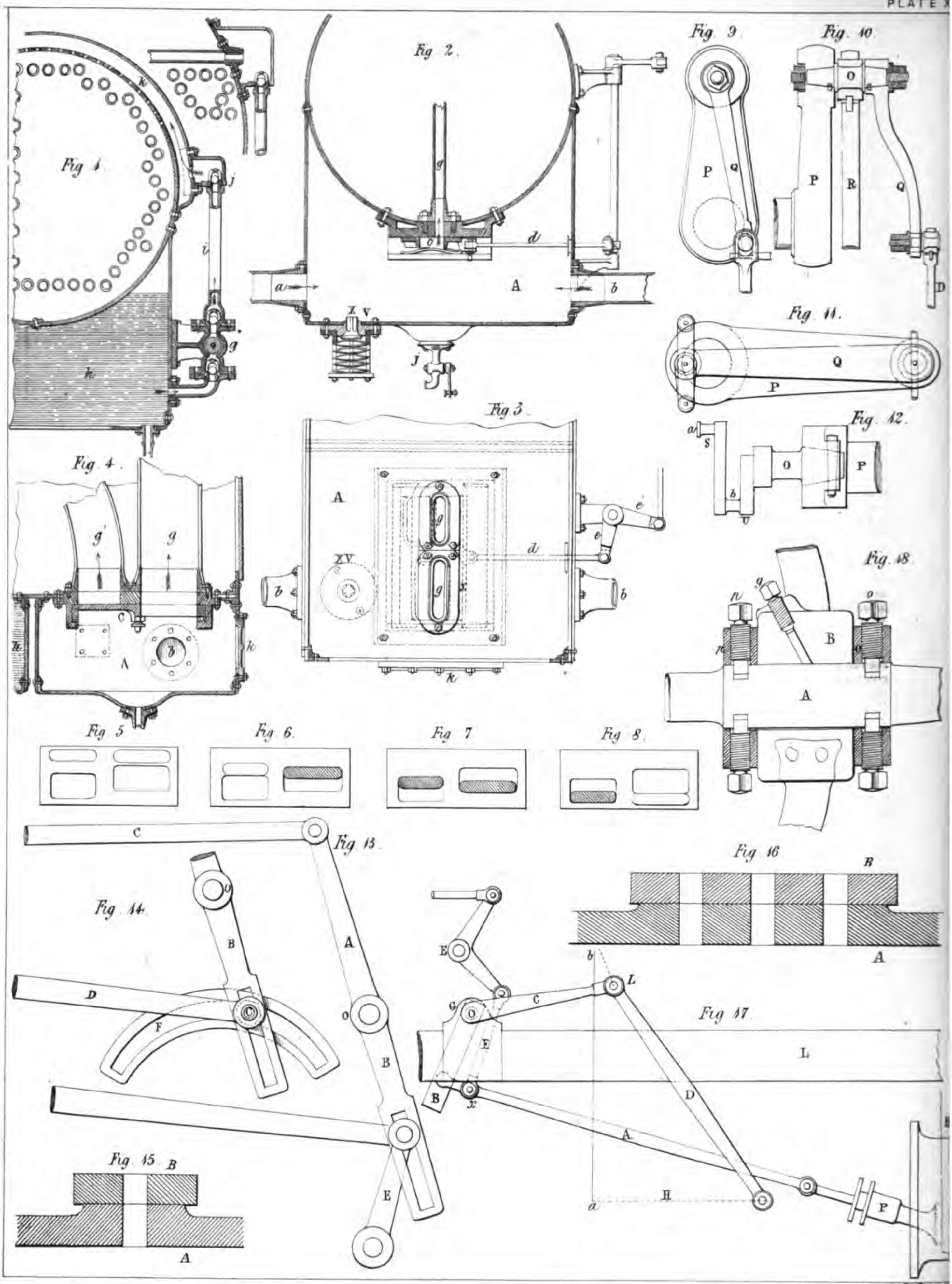


Fig 1
Fig 2
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Fig 11
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Fig 14
Fig 15
Fig 16
Fig 17
Fig 18

C. Bagg

Fortunately, however, for all concerned, in the course of rather more than an hour after this intimation had been given by Mr. Bateman, the weather cleared up, and as it promised well for the remainder of the night, and as the heavy flow of water during this interval had materially abated, he felt so confident of the perfect security of the works, that he dispatched other messengers, about half-past five, p.m., to reassure the inhabitants, and to prevent or allay all unnecessary apprehension and alarm. The weather continued fine; the streams abated, and on Monday afternoon, the water within the reservoirs had been considerably diminished in quantity by the action of the discharge-pipes.

From what we have stated, we think it will be understood that an occasional flood of 3 inches or more in the twenty-four hours would be a matter of very little consequence, inasmuch as it could always be passed off in perfect safety. But a rapid succession of floods, one occurring before the effects of the previous one had ceased, must occasion such an accumulation of water in the reservoirs, that after a certain period they would no longer be able to hold any additional water, without running some risk in the present unfinished state of the embankments and other works. The rains during the week and of Sunday were of this description, and the result was a constant succession of heavy floods, such as no previous calculation could have provided for. But the result has been satisfactory, as showing that even that quantity might have been passed with perfect security. We have mentioned the discharge-pipes, and we may explain that each reservoir is provided with two of these pipes. Each pipe is 4 feet in diameter; and besides these, when the works are completed, the reservoirs will also be provided with waste-weirs of great capacity. These discharge-pipes are closed by valves, which are opened for the passage of the water. The quantity discharged will of course vary with the amount of pressure, or, in other words, with the height of water in the reservoir above the pipes. The quantity of water which can be discharged by one single pipe (the mouth of which is below the bottom of the reservoir), *under full pressure*, is from 500 to 600 cubic feet per second. The pressure varies from 80 to 100 feet. At the Rhodes Wood reservoir, the lowest of the three, the pipes are closed by valves of three feet in diameter; in the two higher reservoirs the valves are each four feet in diameter;—it being the intention, when the works are completed, to pass off the flood waters of the two higher reservoirs by a waste-water course, above the level of the Rhodes Wood reservoir, and to use that reservoir as a store for pure water for the supply of the inhabitants of Manchester. In the present unfinished state of the works, the water from the Woodhead reservoir flows into the Torside reservoir, uniting with the waters of several large streams, the whole of which waters must pass from the Torside into the Rhodes Wood reservoir, from which they are discharged into the valley below, by the two pipes with their valves, already mentioned. With the pressure which can be brought to act upon these pipes, in the present state of the works they would discharge between 500 and 600 cubic feet of water per second. On Wednesday, the 4th, the flood water poured into the reservoirs averaged during the twenty-four hours, no less than 1730 feet per second, and deducting as discharged 500 feet per second, it follows that the remaining 1230 feet per second had to be stored in the reservoirs, to be gradually discharged thence on the subsidence of the flood. From eleven a.m. on Wednesday the 4th, to nine p.m on Thursday the 5th, the water impounded in the Woodhead reservoir gradually increased from a height of 47 feet below top-water, to 19 ft. 9 in. below top-water, or the level of the waste weir, over which the water will flow, or run to waste, when the reservoirs are completed. The water in the reservoir continued to rise with greater or less rapidity till about nine p.m. on the 5th, when it stood at the high level already named —19 ft. 9 in. below the waste weir. From that time it gradually lowered, by the discharge of the water from the reservoir by the pipes, till Sunday morning, when it stood about 9 feet below the highest point it had attained on the 5th. On Sunday morning, the water again commenced rising as the rain fell heavily, and in the evening of that day, the water in the reservoir had attained a greater height than it had previously reached, by nearly 2 feet—standing at that time at a level of 17 ft. 6 in. below what will be the top-water of the reservoir when it shall be finished. At the commencement of the flood on Wednesday, the 4th, the Torside and Rhodes Wood reservoirs were both quite empty; but during that flood, the water rose in each to within a few feet of the full height to which water can at present be impounded therein. This was drawn off again by the discharge pipes on the following days, till on the morning of Sunday, the 8th, the water stood, on the average of the two reservoirs (Torside and Rhodes Wood) about 5 feet lower than it did on Thursday, the 5th. But during Sunday, the flood of that day raised the water within both these reservoirs to a level several feet higher than it had ever previously attained. The greatest height to which the flood attained at any one time, appears, from such observations as could be made, to have been from 3600 to 4000 cubic feet per second. The collecting ground from which this vast volume of water was derived is about 16,000 statute acres in extent: and, in ordinary times, when its river and streams are unswollen by rain, the volume of the stream that comes down is not more than from 15 feet to 30 feet per second. This will convey some idea of the enormous quantity of water which is suddenly collected and sent down the great natural conduit of the Etherow during heavy and continuous rains.

A further precautionary measure to provide additional means for the safe discharge of the water in the reservoirs, in case it should rise to a greater level than those reservoirs would safely hold, must not be overlooked. Provision has been made for passing the water in such case, over the embankment of the Rhodes Wood reservoir—the lowest on the river—by a large wooden shoot or trough, which is of capacity sufficient to pass several hundred cubic feet per second. It was found, however, unnecessary to employ this shoot on the Sunday, as there still remained abundant storage for six or seven hours; and only in case the rain had continued to fall with equal heaviness for a period exceeding that time, would it have been necessary to bring this shoot into action.

No damage whatever has been sustained, except some unavoidable injury to the unfinished masonry, and the giving way of some slopes above the level of the Hollingworth water-course, which is for the conveyance of pure water to Manchester. On the completion of the works, when all the waste weirs, and other apparatus for discharging the water are finished, the most ample provision, we are assured, will be made for the passage of flood waters; and it is only so long as the works remain in their present unfinished state, that any danger, even from excessive floods, can possibly arise. It is anticipated that in the course of the autumn of this year, or at all events before the close of 1852, the whole of the works will be completed. To show the extraordinary character of the recent floods, we may mention a computation carefully made, that the water which has flowed down the valley of the Etherow since the 1st of January last—a period of forty days—would have more than filled every one of the reservoirs of the corporation with water, had they been utterly empty on New Year's Day. The appearance of the Woodhead reservoir on Sunday the 8th, though only partially filled, was exceedingly beautiful; having all the appearance of a natural lake, a mile and a-half in length, winding around the foot of wild and steep hills, in the midst of scenery of a strikingly romantic character.

The stability of the works has now been put to a most severe and unusual test, while in an unfinished state, and they have stood that test in a way that cannot fail to redound to the credit of Mr. Bateman, as an hydraulic engineer, and to the great satisfaction of all those (including the ratepayers of Manchester) who would suffer in person or property from any serious failure in these extensive works.

REGISTER OF NEW PATENTS

LOCOMOTIVE ENGINES, BOILERS, AND CARRIAGES.

(*With Engravings, Plate* X.)

Charles Cowper, of Southampton-buildings, Chancery-lane, for *improvements in locomotive engines, boilers, and carriages, part of which improvements are applicable to other similar purposes.* (A communication.)—Patent dated July 31, 1851.

Claims.—1. For a mode of applying a lining of fire-bricks, or firestone, in the lower part of the fire-box, to defend that portion from the full action of the fire, thus rendering the combustion of the fuel more perfect, and preventing the sides of the fire-box from cooling the fuel. By this means coal may be employed as fuel.

2. For constructing the ash-pans of a curved or dished form

by which means they are less liable to warp, and applying two or more dampers in the bottom of same. The ash-pans in present use are of a flat form. The inventor considers the new form will prevent their warping. Two sheet-iron valves, or dampers, are placed on the underside of the ash-pan, turning upon centres, each carrying an arm, to which is jointed a T-ended rod by which the dampers are closed or opened. By employing two dampers the risk of warping is diminished.

3. For a mode of constructing the fire-box and body of the boiler, when the body of the boiler is completely filled with tubes. Also, in applying two or more boiler bodies in connection with a single fire-box. The interior fire-box is made of equal width with the steam-chamber and the body of the boiler, while the exterior casing of the fire-box is made wider than the other parts. The top of the interior fire-box is of the form of a quarter-sphere, united to a cylindrical portion, so as to admit of the whole of the body being filled with tubes. In another arrangement, the upper part of the interior fire-box is of the same width as the body of the boiler, and it is curved at the top to allow the whole of the body to be filled with tubes. The lower part of the interior fire-box is made narrower, and the exterior casing is made to follow it, so that the latter may be at that part of the same diameter as the body.

4. For a mode of applying a steam-channel of a suitable form on the top of the body of the boiler, for the exit of the steam. The channel communicates with the body by perforations, and the steam passes through the channel, one end of which communicates with the steam-chamber, and the other with the pipe leading to the cylinders.

5. For modes of introducing the feed-water through several perforations at the end of the boiler furthest from the fire.

6. For a mode of applying partitions in the body of the boiler, so to cause a circulation and gradual heating of the feed-water; also the carrying of these partitions into the steam-channels, so as to stop the passage of the steam.

7. For a mode of applying an air-vessel to receive the water from the tender, and supplying the feed-pumps of locomotives. Fig. 1, Plate X., is a vertical transverse section of a portion of the body of the boiler, showing the feed-pump *g*, and pipes. The feed-pump draws the water from the chamber *h*, which is connected by a pipe to the tender. The chamber is placed under the smoke-box, and is closed at the top, so as to inclose a portion of air; it thus serves as an air-vessel to regulate and render nearly uniform the flow of the water from the tender. Where there are two pumps they may each be provided with a separate air-vessel, or both may be connected to the same air-vessel. The water is thrown by the pump *g*, through the pipe *i*, and stop-valve *j*, into the semi-annular pipe *k*, which is rivetted on the body, and communicates in a similar manner with the pump on the opposite side of the boiler. When two pumps are employed a series of perforations are made through the top of the boiler into the pipe *k*, so that the water may enter at several different places. The water injected by the pump being at a lower temperature than that in the boiler, descends among the tubes towards the bottom of the boiler; by this means the cooling effect of the water is distributed and divided among the tubes, and the risk of leakage is diminished. When the boiler is only partially filled with tubes, the feed-water may be distributed among the tubes by means of a perforated pipe passing from side to side above the top row of tubes of the boiler, and opening on each side into a small chamber or valve-box containing the stop-valve *j*, which communicates with the pump by the pipe *i*. The underside of the pipe *k*, is perforated.

8. For placing beneath the boiler a mud-chamber divided into compartments. Each compartment is of an unequal size, and furnished with a separate blow-off cock at the bottom, so that the smaller one can be blown off while the engine is at work; each communicate at the top with two of the boiler compartments, and contain a quantity of substances, for the purpose of facilitating the deposition and ready removal, through doors, of the sediment.

9. For applying two or more chimneys to the boilers, with a blast-pipe to each chimney.

10. For applying to the chimneys a disc-damper, turning on a spindle, and entering a slit or notch in the side of the chimney.

11. For constructing the chimneys of various forms, and the application of a lining to certain spark arresters.

12. For applying to the blast-pipes, a slide or other valve capable of closing them air-tight, and the adaptation of the same to open or close any one or more of the two or more blast-pipes, and the making them of unequal size. Fig. 2, is a transverse section through the eduction-pipes *b*, *b*, leading from the cylinder; and fig 3, is a plan of the lower part of the smoke-box. Fig 4, is a longitudinal section through the blast-pipes *q*, *q'*, and the centre of the smoke-box. A, is a chamber which receives the steam from the two cylinders of the engine, and being of large capacity, serves to regulate and equalise the flow of the steam up the blast-pipes. C, is a sliding plate or valve, having two apertures, in the positions shown by the black lines at *u*, *u*, in figs. 5, 6, 7, and 8, which are plans of the valve, moved by the rod *u*, and levers *e* and *e'*; the two blast-pipes, *q*, *q'*, are of a flattened form and of unequal size. When the valve is in the position shown in figs. 2, 3, and 4, the larger blast-pipe *q*, is open, while the smaller one *q'*, is closed by the valve. If the valve be drawn forward by means of the rod *d*, the blast-pipe *q'*, will also be opened, and the steam will escape at both blast-pipes. If the valve be drawn still further forward, it will close the larger blast-pipe *q*, the smaller one *q'*, remaining open; by reversing the operation the blast pipe *q*, will be and remain opened, while the further motion of the valve closes the blast pipe *q'*; still further continuing the motion, the blast-pipe *q*, will be closed, arresting altogether the escape of the steam, and by placing the valve in the intermediate positions, any intermediate arc of opening may be obtained if required, and the blast-pipes may be closed altogether when necessary. The chamber A, renders the blast much more regular; *v*, is a safety-valve to prevent any danger of the chamber A, being burst, by the valve *c*, being completely closed while the engine is working; *j*, is a cock for drawing off any water which may condense in the chamber A. When the chamber is suddenly reversed while in motion, a vacuum is formed in the blast-pipe, which has a tendency to draw in dust and ashes from the smoke-box; closing the valve *c*, entirely prevents this; *k*, is a door for cleaning out the chamber A. In figs. 2, 3, 4, the chamber A, is made of wrought-iron plates, rivetted together; and at *h*, in fig. 4, is shown a portion of a wrought-iron air-vessel for the supply of the feed-water, as before described with reference to fig. 1. The steam-chamber may be made of cast-iron, and in one piece with the air-vessel *h*.

13. For the application of a steam-chamber on the escape-steam pipe, for the purpose of regulating the blast, and separating the water, grease, and other impurities from the steam.

14. For application in the steam pipe leading from a boiler of a regulator or valve, which closes in proportion as the slide-valve opens, for the purpose of cutting the steam off more regularly.

15. For the application of a steam-chamber between the regulator and the cylinder, so as to render more uniform the flow of steam from the boiler, and to render the steam more free from water.

16. For the application, between the boiler and cylinder of any engine, of one or more regulating chambers, in entering each of which the pressure of steam is diminished, so as to regulate its flow from the boiler.

17. For a mode of applying superheating steam-engine chambers, or superheating and regulating chambers in the smoke-box or flue of a steam-boiler, and a mode of applying superheating chambers to tubular boilers.

18. For a mode of packing a spindle, by making a part thereof of a tapering or conical form, and causing it to be forced into a corresponding hole by the pressure of a spring, assisted by the pressure of the steam or other fluid to which it is exposed.

19. For a mode of applying, in lieu of an eccentric, a counter-crank, adjustable in length and position, for the purpose of varying the stroke and lead of a slide-valve, and reversing its motion.

20. For a mode of applying a counter-crank parallel with the main crank, but longer or shorter than it, and carrying another small moveable counter-crank, capable of being adjusted and secured in any required position, for the purpose of working the valve, and varying its stroke and reversing its motion.

21. For the application of a double counter-crank attached to the main crank-pin, for driving and reversing the slide-valve.

22. For the application of a counter-crank, fixed to the main crank-pin, and carrying small additional counter-cranks for working the slide and expansion valves. Some of these arrangements are intended to lessen the friction of the valve gear by reducing the diameter of the rubbing surfaces, which in the ordinary eccentrics is very considerable. Fig. 9, is a front view

of a main crank P, with a fixed counter-crank Q, for driving the slide-valve. Fig. 10, is a section of the same, together with a detached view of a portion of the main crank. The main crank-pin O, is cylindrical in the centre, where the connecting-rod R, is fitted to it, and made conical at the two ends where it enters the main crank and counter-crank. It is fixed in the main crank by a key and a nut, which is let into the back of the crank; the other end of the pin O', is fixed in the counter-crank by a key and a nut, over which is placed a set-nut to secure the first from becoming unscrewed. The pin O, is fixed in the end of the counter-crank by means of a nut and set-nut, and the rod D, for working the slide is fitted to it. The counter-crank Q, is bent so as to enable the rods D, and R, to clear the nuts and set-nuts. Fig. 11, is a front view, and fig. 12, an end view of a main-crank P, and counter-crank Q, carrying a double counter-crank S, U, which serves as a substitute for the eccentrics, and may be employed for driving a link, or other motion driven by eccentrics; rods are fitted to the pins *a*, *b*, in lieu of the eccentric-rods ordinarily employed. In this arrangement, the counter-cranks are all forged in one piece of iron with the main crank-pin O', which is turned conical at the end, and keyed into the main crank P; these counter-cranks may also be made of separate pieces of metal fixed together by screws or nuts, or otherwise. Fig. 13, shows an arrangement by which the velocity in the centre of the stroke is increased, and at the ends of the stroke diminished. A, B, is a lever turning on the centre or way shaft O, and working the slide-valve by a rod. D, is the eccentric-rod, or a rod attached to a crank or counter-crank, driven by or attached to the main shaft of the engine; it is jointed to a pin on the end of the lever E, which pin is capable of traversing in a slot in the arm B. When the lever E, is in a line with the slotted arm B, the effective length of the slotted lever B, is a minimum, and consequently the velocity of the slide-valve is a maximum; when on the contrary, the eccentric-rod D, is at either end of its stroke, the lever E, is nearly at right angles to the slotted lever B, whose effective length is then a maximum; and as the motion of the eccentric-rod-end is nearly in the direction of the slot in the lever B, it follows, that the latter remains nearly stationary; by this means the variation of the velocity in the motion of the slide-valve is much increased—the difference between this motion and that of the common eccentric is obvious. Fig. 14, shows a modification of this arrangement, in which a fixed, curved slotted-frame F, is employed, in lieu of the lever E; a pin *c*, at the end of the eccentric-rod D, works in this curved slot, and also in the straight slot in the lever B.

23. For a mode of working the slide-valve and expansion-valve by means of the same rod, driven by the link motion, and the making of the expansion-valve in two pieces, which are capable of being brought nearer together or removed further apart by means of a grooved plate, for the purpose of varying the expansion.

24. For a mode of increasing the variations of velocity in the motion of the slide-valves and expansion-valves. Fig. 15, shows an expansion-valve, consisting of a plain slide B, with one passage working over a face A, with a single passage or port. Fig. 16, shows another expansion-valve, in which several passages and ports are employed. By adopting this last arrangement the motion required for opening and shutting the passages may be reduced, as several narrow passages may be used in place of one wide one.

25. For a mode of regulating the supply of feed-water by working the feed-pumps by a variable lever, driven with a reduced motion from the cross-head.

26. For the construction of the variable lever last mentioned, with a flanged slot to receive a small sliding-block, carrying a pin on which is jointed the connecting-rod which drives it; and the making of this lever with a catch or catches for retaining the block in various positions. Also, the application of this arrangement to the slotted levers or links used for driving slide-valves. Fig. 17, is a side view of an arrangement of levers and other parts adapted for regulating the supply of water by varying the length of stroke of the feed-pump, or by arresting its motion altogether. P, is the feed-pump, mounted on the frame of the engine, or on the vessel R, before described, and shown at *h*, in fig. 1. A, is a connecting-rod, by which the pump is driven; the end of this rod is jointed to a pin *x*, on a block of metal sliding in the grooved lever B, which is fixed to the spindle O, on which is a lever C, the end of which is connected by a connecting-rod D, to the cross-head of the piston-rod of the engine, which moves in the line H, as far as the point *a*; the motion of the cross-head thus gives motion to the lever C, and B, and through the rod A, to the pump P; a link F, connects the rod A, with a lever on the axis E, which carries another lever and a rod, by means of which it can be moved by hand. By raising the rod A, by means of these rods and levers, the pin *x*, may be brought into a position concentric with the spindle O, and the motion of the pump will then be altogether arrested; by lowering the rod A, into other positions intermediate between the centre O, and the end of the lever B, the length of stroke of the pump will be varied, and the quantity be thus regulated.

27. For constructing axle-guards with flexible plates, or with plates jointed and provided with springs, for the purpose of diminishing lateral concussions.

28. For constructing axle-boxes and bearings, so that they may bear on the collars at the ends of the axles as well as upon the ordinary bearing surface or journal. Also a mode of constructing the axle-boxes and bearings, so that they may bear against the end of the axle and the nave of the wheel.

29. For constructing the axle-box and cross-boss of the driving-wheels with external cranks, so that the axle-box may bear partly upon the boss of the crank. Also the combination of this arrangement with dished driving-wheels.

30. For constructing the cranks and counter-cranks, by making the crank-pin of the main crank in one piece with the first counter-crank; the first counter-crank pin in one piece with the second counter-crank; and the second counter-crank pin in one piece with the third counter-crank, when three are used. Also the application of loose rings with spherical peripheries on the crank and counter-crank pins.

31. For a mode of fitting one wheel loose upon the axle, and securing it by a ring and shoulder, or by two rings, while the other is fixed upon the axle in the ordinary manner, as shown in fig. 18, which is a section of a portion of one of a pair of railway wheels mounted upon an axle. A, is the axle; B, is the nave, loose upon the axle, capable of turning independently of it; *o*, *p*, are two rings, secured to the axle by the screws *o*, and *p*, which are screwed through the rings into cavities formed in the axle to receive them. Holes are formed in the nave, which are closed by screw stoppers *q*, for the introduction of oil or grease.

32. For packing stuffing-boxes with a collar or bush of hard or soft metal, capable of being compressed and squeezed up when worn. Also the application, for a similar purpose, of two or more metallic rings forced in opposite directions by springs, and confined by a plate pressed up by a spring.

33. For constructing springs so that the weight comes upon the plates successively, in lieu of simultaneously. Also the making of the lower plates progressively thicker than the upper ones.

34. For jointing a fore-carriage by means of two pins working in transverse and longitudinal slots at the front and back.

35. For constructing a break with a block or shoe without flanges, which is capable of being brought down quickly upon the rail by a grooved disc or cam, or a pinion and racks, and then forcibly pressed down by a screw, with the intervention of a spring to prevent concussion.

36. For constructing tender locomotives with the driving-wheels behind the fire-box, and a bogy frame in front of the smoke-box, and without any wheels between the fire-box and smoke-box; by which means the centre of gravity may be brought very low, notwithstanding that large driving-wheels are employed. Also the application of two or more pairs of coupled driving-wheels behind the fire-box of a tender locomotive, or the placing of some of the driving-wheels before and some behind the fire-box, and coupling them together. The exterior cylinders are placed horizontally, or nearly so, by the side of the smoke-box.

37. For a mode of roofing over the tender and part of a locomotive, to protect the driver and coke from the weather.

38. For a mode of constructing the wheels with tyres of a conical form, having an inclination to the horizontal of not less than 1 in 4, and with or without flanges.

39. For the application of wheels with conical tyres, so that some of the wheels may have their tyres inclined in contrary directions to those of other wheels on the same engine or carriage.

40. For a mode of applying, on the driving-axle, a pair of wheels, one of which is loose upon the axle and the other fixed,

so as to facilitate the passage of the engine round curves. Also applying two or more such pairs of wheels to the same engine, and the coupling together of those wheels which act as driving-wheels.

41. For constructing the wheels with grooves in their tyres, of such form that the sloping sides of the grooves may bear upon the rail, while the deepest part of the groove is out of contact with the rail.

42. For causing a portion of the weight of a tender to rest upon a pulley or roller on each side of the framework of a locomotive, and the application of a stud or tooth entering a hollow, for preventing side oscillation between the engine and tender.

43. For applying steam jackets to the cylinders, cylinder covers, and valve-boxes of steam-engines.

44. For a mode of constructing metallic pistons, more particularly adapted for small engines, or those which run at high speeds.

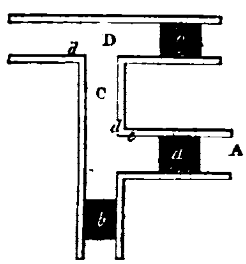
45. For a mode of applying the governor to regulate the degree of expansion, by means of valve gear driven by counter-cranks.

GLASS FLATTENING.

JAMES TIMMINS CHANCE, of Birmingham, gentleman, for *improvements in the manufacture of glass.* (Partly invented and partly a communication.)—Patent dated July 28, 1851.

Claims.—1. The employment, in connection with the same flattening kiln, of more than one flattening stone or bed, the same not being connected together by a common supporting framework or base, and in such manner that two flattening beds or stones can be interchanged without one having to pass directly over or under the other.

2. The combination of rollers with the implement used for transferring plates of glass. In the annexed engraving, *d*, and *e*, are rails on which the travelling beds *a*, *b*, *c*, run. A workman stands at the opening A, and when the sheet of glass on the bed *a*, has been sufficiently prepared, he removes the bed *a*, on to the rails *d*, in the kiln C, and traverses it towards the annealing chamber *d*, it taking the place of the bed *c*. The bed *b*, by levers, is then traversed towards D, until it is opposite the rails *e*, when it is traversed on to them, and occupies the original position of the bed *a*. This system obviates a great number of defects that existed in the old plan.



The implement for removing the glass consists of a fork having two prongs; on each of these prongs, on the underside, are affixed rollers on which the implement may run; these rollers project slightly above the prong on the upper side.

GLASS FURNACES.

EDWIN DEELEY, and RICHARD MOUNTFORD DEELEY, of the Dial Glass-houses, Stourbridge, Worcestershire, for *certain improvements in the construction of furnaces for the manufacture of glass.*—Patent dated August 6, 1851.

Claim.—The construction of furnaces (for the manufacture of glass) with grates having inclined bars or perforated plates, situate and arranged, as hereafter described, so that the flame may play directly upon the pots.

The method heretofore practised in constructing furnaces used in glass-making has been to carry the grate, with horizontal bars, through the centre of the seige, or bed of the furnace, between the pots, or to carry the grate from each end of the furnace, part of the way through the seige, leaving a portion of the seige called a bridge, in the centre, the grates being constructed with bars placed in a horizontal position. The flame ascends in the first instance to the crown of the furnace, and then, being driven down upon the top of the pots, acts upon the metal contained therein. The engraving represents a sectional view of the improved furnace with the grates attached. *a*, is the floor of the glass-house, *b*, is the seige, or bed of the furnace, bevilled off next the grate. This bevil saves the wear and tear of that part of the seige next the grate, which abrupt or acute edges would have the effect of causing. *c*, is a pot in which the glass is melted; *d*, is the wall of the furnace, with the working holes *d'*, over each pot; *e*, are the tunnels or chimneys for acquiring a better combustion, and drawing the flame around the bottoms of the pots; *f*, are the horizontal bars forming the bottom of the grate, which bars are sustained by cross-bars or sleepers *f'*;

Fig. 2

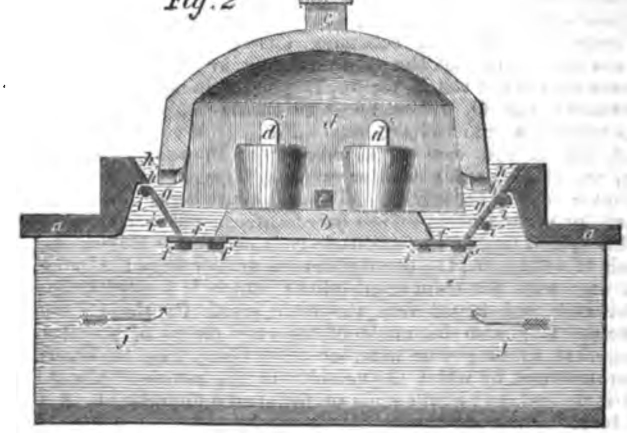
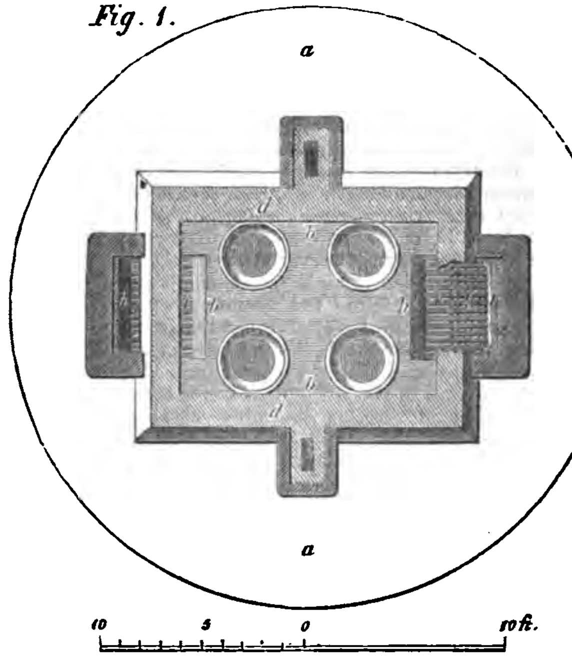


Fig. 1.



g, are the inclined bars forming the grate of the furnace. The upper parts of the bars may be made with a hook; they hang on a cross-bar *i*, in which may be either fixed into the wall on each side of the fireplace, or may be placed in slots fixed at each side. Various modes of suspending this bar may be adopted; and as it is moved higher or lower in the slots, a greater or less inclination of the bars *g*, would be the consequence. It is preferred to have the upper cross-bar fixed as first mentioned, taking care to have the bars *g*, placed at a proper inclination, and which is preferred to range from 35 degrees to 55 degrees. The lower parts of the inclined bars *g*, are sustained by, or rest upon, the cross-bar or sleeper *i'*, each end of which cross-bar is also fixed into the side walls of the fireplace; or such lower cross-bar *i'*, may, if desired, be made to work, or be placed in slots fixed at the sides of the fireplace in a similar manner to the above description of the upper cross-bar. The cross-bar *i*, may be made with grooves upon it, corresponding to the number of inclined bars used in constructing the grate; and such inclined bars, instead of being hooked at the upper end, may be straight, and rest in the grooves, such inclined bars being sustained either by having a hook to catch on the lower cross-bar *i'*; or if preferred, it might be made to clip the cross-bar or sleeper *f'*, which supports the horizontal bars *f*, such clip being made to act upon the said cross-bar *f*, between each of the said horizontal bars; *h*, is the hopper into which the slack or fuel is placed, and which slack or fuel descends through the opening *h'*, on the inclined bars, thus affording a regular supply of fuel to the grate. The hopper may be formed of brick or iron: *j*, is the cave or ash-pit, which passes under the whole length of the furnace, and communicates with the open air outside, and by means of which cave sufficient draught is obtained for the due combustion of the fuel. The inclined as well as the horizontal bars hereinbefore described, may be either of round, square, or other shaped iron, or may be made of flat plates perforated with holes, so that such perforations be sufficiently numerous to admit sufficient draught, and also the grate be constructed so as to admit of the cleansing of the grate from burrs or clinkers; or instead of the bars or perforated plates forming the bottom or lower part of the grate being placed horizontally, as above described, they may be placed at a slight inclination either way, so as to form an acute or obtuse angle with the larger or upper inclined bars. The inventors do not confine themselves to the relative lengths which the lower (firstly described as the horizontal) part of the grate bears to the upper or inclined part of the grate; but care should be taken to have the top part of the bars *g*, about a foot or 15 inches above the level of the seige or bed of the furnace, as by this means the flame acts directly upon the pots. The proposed application of the incline bars of the grate places the fire in such a position (a portion of such fire being raised about a foot higher than the seige) as to cause the flame to play more directly upon the pots. The seige itself is not so destroyed by the action of the fire as it is in the furnaces of the old construction, consequently, the furnace and pots stand longer. Small coal or slack can be consumed in these furnaces, but a considerably less quantity of fuel is consumed. For a four-pot furnace, having a seige of about 11 ft. 6 in. by 10 feet, the inventors recommend a grate about 5 feet wide, the inclined bars about 2 ft. 6 in. long, the horizontal or lower bars about 18 inches long, and the seige about 18 inches deep. The invention may be applied to all forms and descriptions of furnaces which may be used in the melting or manufacture of glass.

PROCEEDINGS OF SCIENTIFIC SOCIETIES.

INSTITUTION OF CIVIL ENGINEERS.

Feb. 3.—James Simpson, Esq., V.P., in the Chair.

In the renewed discussion on Mr. Jee's Paper "*On the Cast-iron Viaduct erected at Manchester, forming part of the Joint Station of the London and North Western, and Manchester, Sheffield, and Lincolnshire Railways*," Mr. Hawkshaw described a nearly similar structure which had been erected at Salford, in 1842, forming a junction between the Liverpool and Manchester, the Manchester and Leeds, and Manchester and Bolton Railways. In this structure the columns were placed in pairs, and, instead of planking between the transverse girders, flat brick arches, set in cement, were introduced. Some interesting experiments on the strength of the girders were given, and the ingenious steelyard lever testing machine was described.

The question then turned upon the peculiar form of the wrought-iron girder bridge over Store-street, and on the manner in which the experiments had been made, for ascertaining its strength. From minute calculations which were given, it appeared that this bridge was foot for foot as strong and stiff as wrought-iron, cellular-top, tubular girders of the ordinary form; and though, in this instance, the size of the cylindrical top, which was required to be large enough to admit a man for painting the inside, and for necessary repairs, might seem disproportioned to the depth of the girder, yet this would not be the case if the span and depth of the girder was increased, as the cylindrical top might still remain of the same size. By some speakers, however, it was contended, that in applying wrought-iron to girders of comparatively small span, there really was no necessity, nor was it advisable, either as regarded strength or convenience, to adopt the cellular form, but that the girder should be of the ordinary, simple, double T section, with the bottom flange, and the middle web of wrought-iron, and the upper flange either of wrought or of cast iron, the latter being the best suited for resisting the compressive strain to which that part of a girder was subjected; and it was thought that both of these forms would be a more economical application of material for girders of limited extent than cellular tops. A modification of these different plans was described to consist in a kind of flattened, triangular top, of which the base was uppermost, and the plates were thickest, representing the upper flange of the ordinary girder, the two sides being merely thin plates, to prevent the edges of the upper flange from buckling under the compressive strains.

Doubts were also raised, as to whether painting was the best mode of protecting wrought-iron from oxidation; and it was suggested, as an improvement, that the iron should, in the first instance, be thoroughly cleaned and plunged at a low heat in common oil, and then dried. An alloy of cast-iron, containing a small portion of tin, was also said to prevent, effectually, the injurious effects of oxidation.

The method of combining wrought with cast-iron, by Stirling's process, was also described, and the great tenacity and strength of the metal was fully admitted.

Feb. 10.—James Meadows Rendel, Esq., President, in the Chair.

The Paper read this evening was "*The Construction and Duration of the Permanent Way of Railways in Europe, and the modifications most suitable to Egypt, India, &c.*" By W. B. Adams.

This paper was an historical record and critical examination of the various parts, together forming the "Permanent Way," and of the numerous changes that it had undergone. The requirements that had been gradually developed, as necessary for accomplishing this object, were enumerated, and may be concisely stated to consist in a well-drained substructure, regulated, as regards strength, according to the weight of the engines and the amount of the traffic, firmly seated in the ballast, the rails being stiff enough to resist deflection, sufficiently hard not to laminate, and so broad as not to crush;—smooth, so as to offer the least friction, and properly inclined, especially on curves, so as to fit the wheels, and the joints so arranged as to make the bars continuous, and yet to admit of contraction and expansion.

The different kinds of rails, from the flat tyre-bar and edge-rail, used on colliery lines at the time of the introduction of railways—to the parallel and bridge-shape rails now generally adopted, were examined; and also the girder-rails, for doing away with the sleepers and other extraneous means of support, in the hopes of effecting a saving in the cost of maintenance. Of the girder-rails, the saddle-back pattern, introduced by Mr. William H. Barlow, was the one most generally known; but it was suggested, there would be some difficulty in the packing of this rail, and if, as was asserted, it really was a rigid girder, though the draught might be lessened, the tyre of the wheels would roll down the rails to a corresponding angle with themselves. The mode of connection of this rail, by a piece of nearly similar section, to which it was firmly rivetted, was objected to, on the ground of there being no allowance for expansion and contraction; the strength of the joint depending entirely upon that of the rivets. Many modifications in the form of the girder-rail was suggested; among them a T section, with a rail, or rib, on the upper surface, and a vertical portion below, giving stiffness, and forming a solid web for ramming the ballast against.

The supports for the rails were next considered, and the reasons for abandoning stone blocks were attributed, in some degree, to their hardness and rigidity, which caused much noise, but principally to the difficulty of packing and maintaining the way, owing to their depth, to the chairs cutting into the stone, and the spikes working loose. The adoption of timber sleepers, first on newly-made embankments, afterwards universally—their size and number to each length of rail, and the proportionate area to the length of bearing—to the necessity for their being sunk into the ballast, and yet to have such an amount under them as to prevent their being depressed in the ground, was also treated of, and a comparison instituted between cross-sleepers and longitudinal timbers, from which it appeared, that when their bearing surfaces were equal the quantity of timber used in each would be the same, and, provided the quality was similar in both cases, which it ought to be, the cost of this portion of the way would also be the same. The longitudinal system certainly afforded great stiffness to the rail, and offered greater facilities for packing; but, on the other hand, the timber was more crushed than in the cross-sleepers, the fastenings were less effectual, and were more difficult of access. For the purpose of obtaining greater durability in this portion of way, and, at the same time to preserve the elasticity afforded by the timber substructure, Mr. Reynolds had designed a combination of wood and iron, the wood, to which the rails were attached, being placed in a cast-iron trough, triangular in section, with the apex downwards. This system, however, did not meet with much favour, and more recently various contrivances had been suggested, and in some instances tried successfully, for doing away entirely with the timber work in the substructure. In the "dish-cover" cast-iron sleeper, invented by Mr. Greaves, of Manchester, and now, it was said, about to be used in the Egyptian Railway, the packing was accomplished from the surface, through two small holes; and in the system introduced by Mr. P. W. Barlow, the rail was held in two cast-iron vices, which formed so rigid a road, that there was not the slightest elasticity in it. A modification of this plan by Mr. W. H. Barlow, in which the sleeper was cast in one piece, with a chair-head on it, and into which the rail was secured by a wooden key, was a slight improvement on the previous method. Mr. Samuel had proposed that the rail should be held in a compressed wooden cushion, or vice, set in a cast-iron sleeper, or trough, but not continuous; and Mr. Hoby, that the sleeper should consist of an elongated chair of the ordinary form, the rail being fastened in it by means of a pair of folding wedges. From what had been done, it might safely be concluded that cast-iron might be advantageously employed, provided it was in large masses, and formed a continuous support; unless, indeed, the rails were so strong in themselves as to be non-deflecting.

The different modes of fastening the rails in the chairs at the joint, so important to prevent *déraillement*, were then alluded to, and the failure of the wooden keys, at first used, was attributed to their being ridiculously small; iron spikes were substituted for them, but they also were obliged to be abandoned, when larger wooden keys were again adopted; in some instances they were compressed, like the treenails, by the process of Messrs. Ransome and May, who likewise had introduced a chair to be used with them.

The last point to be noticed in the formation of permanent way, was the establishment of a firm connection between the rails, so as to form them into one continuous bar, and to remove all the evils attending bad joints. On the Blackwall Railway the ends of the rails were originally scarfed—that was previous to the use of locomotives on this line—but this weakened the ends, and reduced the available length of each rail. Subsequently the addition of fishes on both sides of the rails was proposed; various modes of accomplishing the same object were given; at first of cast, afterwards of wrought iron, and then only to touch at the top and bottom; these fishes were laid in the channel of the rail, and, in the first place, were supported at the ends by chairs; but as fresh castings had to be made to receive them, it was thought better to have holes in the rails and fishes, and to pass a bolt through all, the holes in the rails being made larger than those in the fishes, so as to allow of expansion and contraction. To meet the objection to the increased cost of this plan, Mr. Samuel, in 1849, proposed that a chair should be cast with only one jaw to fill one channel of the rail, the other being occupied by the fish.

In Egypt the dry heat of the atmosphere was fatal to timber, and the soil along which the line would be carried, would vary from the extreme moisture of irrigated land to parched dust. Therefore the deeper the foundations of a discontinuous sleeper-road could be placed, the better chance there was of their remaining firm. In the flat parts of India two evils had to be guarded against; the one, the floating up of a line during rainy seasons, if much timber was used; the other, the ravages of the white ant, which might possibly be prevented by creosoted timber; but this, in dry weather, would be liable to be fired either by hot coke or the burning sun. And in both these countries, as well as in the Australian colonies, where fences and police could not well be maintained, an absence of anything which could be easily pilfered, was a great desideratum; there should be few parts, and easily put together, so as to require little skilled labour, where such labour would be dear.

Under all these circumstances, it was submitted that an iron girder-rail, of simple construction, hollow, so as to preserve as nearly a uniform temperature as possible, under the extreme variations of temperature between day and night, would be the most efficacious, the simplest, and eventually the cheapest.

Feb. 17 *and* 24.—Robert Stephenson, Esq., M.P., V.P., in the Chair.

The discussion on Mr. W. B. Adams's paper, "On the Permanent Way of Railways," occupied the whole of these evenings.

The importance of diminishing the cost of maintenance of way was admitted by all the speakers, and numerous improvements introduced for that purpose were mentioned. Those which appeared to have obtained the most general approval, were Mr. Fowler's long chair; Messrs. Adams' and Richardson's fished joints; Mr. Samuel's fished chairs; Mr. P. W. Barlow's cast-iron sleepers; and Mr. W. H. Barlow's self-supporting, broad-flanged, wrought-iron rails. Each of these systems were shown to possess peculiar qualities, but it appeared to be admitted, that the latter combined the greater number of advantages, now that the more powerful machinery of the iron works enabled heavy rails to be rolled with greater facility, and at a less cost. The asserted rigidity of the iron lines, without timber sleepers, was combated; and it was stated that, from the evenness of the joints, the wear and tear of the rolling stock would be diminished, the cost of maintenance of the permanent way would be materially reduced, and that provision against the effects of the contraction and expansion of a long length of rails rivetted together, need not be made, as in practice the anticipated effects were not experienced.

It was stated, that the system of fishing the joints had been practised in Germany for some time, and that as far back as 1838, rails with a hole at each end had been exported from this country; it appeared, however, to be the general opinion, that these holes were not intended for fishes, but for traversing pins to hold down the ends of the rails in the joint chairs; however, within the last few years the system of fished joints had been introduced with great advantage in Germany.

The numerous varieties of form proposed by Mr. Adams, for inflexible girder-rails, for hollow iron sleepers, for a combination of timber and stone bearings, &c., were discussed; the system of accumulating all kinds of assumed forms, was censured as having a tendency to retard the introduction of improvements by practical engineers; and the compound rails were objected to as being less substantial at first, and more expensive to renew than Barlow's rail, which, when exfoliated on the surface could be again rolled, at a cost of less than 2*l.* per ton; the other modifications were not considered to be required, as with the present experience in railway affairs, with good materials, care in putting them together, and keeping the whole in order, a good travelling road might be made and maintained on any of the usual systems. Up to the present time, a strong bridge-rail, firmly secured to a strong longitudinal balk of timber, soundly packed with dry gravel ballast, and well drained, had been admitted to be, if not the best, to be one of the best kinds of permanent way. It remained to be demonstrated by time, what amount of improvement was introduced by the continuous broad-flanged rail, which it was admitted did appear to be well adapted for foreign lines, but with respect to them it was contended, that in almost all the tropical climates there were some kinds of timber which resisted the white ant, and those would necessarily be used; but it was probable that the use of iron might be found ultimately more economical, even if it were more costly at the outset.

On the question of stone block railways, it was urged, that on several lines so constructed, where the traffic was considerable, but the velocity did not exceed ten or twelve miles per hour, the rails lasted well, and the cost of maintenance of way was light; but that where the velocity was great the rigidity was objectionable, and caused too much wear and tear of the rolling stock.

In the various statements of the cost of maintenance of way, it was essential to specify what items were included in each, in order to arrive at any comparison. When iron was cheap, and timber comparatively dear, the proposed system of cast-iron sleepers and of very heavy continuous rails might be advantageously adopted; but in countries where timber was abundant and iron must be imported, the system of longitudinal sleepers and light rails would of necessity be adopted.

With respect to the cast-iron sleepers on the South Eastern Railway, it was stated, in reply to questions, that there was not a greater amount of breakage than with ordinary cast-iron chairs, although the system had been principally tried on a part of the line where the traffic was very heavy and the ballast was very bad, and that the offer of Mr. Taylor, the contractor, to maintain and renew those parts of the line laid with cast-iron sleepers, for twenty-one years for 100*l.* per annum, sufficiently proved the fact.

It was urged also, that it was impossible to draw any accurate deductions from the expenditure in maintaining a wood-sleeper line for six months, as it might appear in the next half-year that an apparent saving had been made at the expense of increased deterioration.

It was urged, that the duration of rails must depend on the quality of the iron, the proportion of its weight to the traffic, and the velocity and amount of that traffic. That the question of the cost of maintenance of way was, up to the present time, almost an insoluble problem, the elements being inconstant, no absolutely parallel cases being in existence, and unless all the conditions were distinctly given, no comparison between different systems could be established.

The paper announced to be read at the Meeting of Tuesday, March 2nd, was "On the Electric Telegraph, and the principal improvements in its construction," by Mr. F. R. Window, Assoc. Inst. C.E.

ROYAL SCOTTISH SOCIETY OF ARTS.

Feb. 9.—Dr. Lees, LL.D., President, in the Chair.

"*On the theories of Galileo and Leibnitz, touching the Strain and Strength of Material, on the position of the Neutral Axis in Beams, and their actual strength in reference to the resisting forces of Compression and Extension on opposite sides of this line.*"—By G. Lees, LL.D., President.

Dr. Lees, after adverting to the several ways in which a beam may be strained, proceeded to say that neither the theory of Galileo nor that of Leibnitz, were consistent with the real condition of the material when under transverse strain, to which alone he now proposed to call the attention of the Society. It required but little reflection to see that when a beam is strained transversely, its fibres were compressed on one side and stretched on the other, and that therefore, there must be some *line* within the beam where the compression ends and the extension begins. Here the material will neither be compressed nor extended; this lines takes, accordingly, the name of the *neutral axis.* Although the existence of this axis was long maintained, its real existence was first approximatively determined by Barlow. From his experiments, it appeared that in wood, to which they referred, the neutral axis divides the depth of the beam, so that the square of its depth, reckoning through the area of tension, was equal to three times the square of its depth, reckoning through the area of compression. On this principle, it easily followed that the position of the axis was ·6 and ·4 of the depth nearly. The real position of the axis might be determined, provided we knew the tensile and compressive force of material. These being understood to be given, he then proceeded to the mathematical consideration of the question, deducing formulæ, not only for the position of the neutral axis, but also for the strength of beam of any given material. In applying these to cast-iron, which has a compressive strength of 49 tons per square inch, and a tensile strength of 9 tons, it appeared that the neutral axis was at ·7 of the depth, reckoning through the area of tension; and ·3 of the depth, through that of compression; that a beam of the same material, 12 inches deep, 8 inches thick, and 10 feet long, would bear a weight of 28 tons at its extremity, or, taking its own weight into account, a weight of 26 tons.

"*Description of a Cast-iron Swing Bridge, constructed for Peterhead Harbour by Messrs. Blaikie, Panmure Foundry, from designs by Messrs. Stevenson, Civil Engineers.*" By J. Lawrenson Kerr, C.E.,

The swing bridge, erected in 1850, over the canal, which was cut through the isthmus separating the north and south harbours of Peterhead, is of cast-iron, and consists of two compartments or leaves. The span is 41 ft. 6 in.; rise, 5 ft. 6 in.; breadth over all, 20 ft. 5 in.; and total length, 99 ft. 6 in. The depth of the exterior girders at the crown is 15½ inches, and of that of the interior 11¼ inches. The weight of each leaf is 91½ tons, of which 13 tons are ballast. A man with one hand can easily work the gearing which causes the leaf to revolve; and, considering this great weight (91½ tons), it testifies the quality both of the design and execution. The work reflects great credit on the Messrs. Blaikie, of the Panmure Foundry, who were the contractors. The advantages which have resulted from the communication between the two harbours were stated to be great, as vessels can now enter or leave either harbour in every state of the wind.

NOTES OF THE MONTH.

Architectural Conversazione.—A step in the right direction was taken when it was determined to hold a conversazione in the gallery of the Architectural Exhibition. At this conversazione, on Wednesday the 18th, the Earl de Grey gave in his adhesion to the Institution, and inaugurated its permanent establishment in a speech which came home to his hearers, and was well calculated to enlist the sympathies of the profession.

The Builders' Ball.—It is one instance of advancement, that organisation is advancing among the members of the engineering and architectural professions, and of those classes closely connected with them. It is in this light that we look with gratification on the annual celebration of the Builders' Benevolent Institution Ball, which passed off most successfully, on the 19th ult., at Willis's Rooms; and the more particularly, as a benevolent purpose was associated with it. Upwards of six hundred persons were present.

Affiliation of Literary and Scientific Institutions.—The council of the Society of Arts has under its consideration a very important proposition made to it by Mr. Harry Chester, and which contemplates the affiliation of the literary and scientific institutions, the mechanics' institutes, and other similar bodies throughout the country. Since the close of the Great Exhibition the society, which contributed so largely to the realisation of that display, has greatly strengthened its popularity and means of usefulness. Every week large accessions are made to the number of its members, while the series of lectures delivered on the suggestion of H. R. H. Prince Albert have proved eminently successful. These are still in progress every Wednesday evening, and draw crowded audiences. The extensive range of subjects treated unfits them for being made the materials for a newspaper report, but the council has undertaken the publication of them in a separate form; and as the lecturers are men of the highest eminence in their respective departments, there cannot be a doubt that their treatises will receive a wide circulation, and be highly appreciated. From those which have already been delivered, we are disposed to think that this course of lectures will be found in no respect inferior, either in interest or value, to the long-promised and long-delayed jury reports, the formal character of which, combined with other circumstances, places them at a disadvantage in many respects when compared with productions the authors of which were in a freer and less embarrassed position to write as they thought. The names of Dr. Whewell, Sir H. De la Beche, Professor Owen, Mr. Jacob Bell, Dr. Playfair, Dr. Lindley, Professor Solly, Professor Willis, Mr. Glashier, Mr. Hensman, and Dr. Royle, are sufficient guarantees of themselves for the manner in which their respective tasks have been performed; and the subjects still to be treated before all the sections of the Great Exhibition have been reviewed, will no doubt be confided to equally competent and able hands. Under such circumstances, and seeing the usefulness of the society and its vigour daily extended, it occurred to Mr. Chester to lay before the council his proposition. He points out in his letter, that the literary and scientific institutions which now exist in almost every town throughout the country are at present for the most part in a languishing condition, that they are isolated and possess no means of co-operation for the common good, and that they have no connection with the great central associations which pursue under national auspices the objects of literature, science, and art. To infuse new life into these local bodies, and to found a well-organised system, whereby industrial knowledge may be cheaply and conveniently diffused, are the ends which Mr. Chester aims at. He points out the many social questions apart from politics which might with such a machinery at command be thoroughly ventilated, and he gives examples in which the principle of association recommended by him partially developed has been attend with beneficial results. The council of the society seems disposed to act upon his suggestion, and there cannot be a doubt, that if by the measures adopted, a character of greater practical utility is imparted to the local institutions, a public good of no small importance will have been achieved. While the fate of the Crystal Palace remains doubtful, and the Royal Commission shows no sign of returning energy, the Society of Arts, by carefully sustaining the organisation of the Exhibition, and by fostering the impulse which it gave to industrial knowledge, may quietly take possession of a field of usefulness, for which its popular constitution and its independence of government control admirably adapt it. In all that relates to the progress of the arts, facilities of communication between kindred institutions must be extremely desirable, and the benefits to be derived by following up the scheme now contemplated, will be better understood when it is remembered how little information on industrial subjects had been popularised, even in England, before the great display in Hyde Park, and how vast an extension it received from that remarkable event.—*Times.*

Patent Law Amendment.—Lord Brougham's new bill on the Patent Laws, has just been printed. It contains fifty-eight sections. Empowers Her Majesty to grant letters patent for inventions. Certain commissioners are to be deemed commissioners, and they are to appoint examiners, make rules and regulations, and to report annually to Parliament. Inventions provisionally registered are to be protected under the new act. An appeal is given to a law officer, and from him to the Lord Chancellor. By one of the provisions the courts of common law may grant injunctions in cases of infringement of patent. The stamp duties payable under the act are given in the schedule annexed. Her Majesty it is proposed to empower by an Order in Council, so as to authorise letters patent to be granted for the colonies. The bill is waiting in the House of Lords for further consideration.

Rochester New Bridge.—Messrs. Fox, Henderson, and Co., invited the wardens of Rochester Bridge, and a number of engineers and other gentlemen, on the 26th ult., to witness the arrangements for sinking, by means of the newly invented pneumatic process, the last of the cast-iron cylinders employed in the construction of the foundation of the new bridge over the river Medway. After an examination of the finished portions of the work, the company witnessed with great interest the operations for expelling the water from the cylinder by means of atmospheric pressure, and of passing the workmen and materials in and out of the cylinder under pressure, by means of the air-locks, several of the gentlemen present entering and remaining some time in the cylinder. The party consisted of Lord Darnley, Col. Sandham, R.E., Capt. Simmons, R.E., Mr. T. Brassey, Mr. J. Martin, M.P., Mr. C. May, Dr. Fox, Dr. Black, and Mr. C. H. Wild, C.E., with Sir Charles Fox, one of the contractors of the bridge, Mr. John Hughes, superintendent of works, and Mr. John Wright, resident engineer, acting under Sir W. Cubitt.

The Marionette Theatre.—This little house continues to attract public attention, and deserves a slight notice from our hands, for the ingenuity displayed in working the little puppets who contrive to amuse so many people. The action of walking and moving the arms caused some difficulty at first; but the figures are now much improved, and could the appearance of the line that suspends them be made less prominent, would approach much nearer to reality. The scenery is pretty, and the ballet-dancing well contrived. The theatre has been formed out of the late Adelaide Gallery, and contains a neat little stage, orchestra, and pit; also reserved seats, which are placed behind the pit, a few private boxes across the end, and two tiers of balconies ranged on each side, which render on the whole accommodation for about 400 persons.

LIST OF NEW PATENTS

GRANTED IN ENGLAND FROM JANUARY 22, TO FEBRUARY 14, 1852.

Six Months allowed for Enrolment unless otherwise expressed.

Thomas Richardson, of Newcastle-upon-Tyne, for improvements in the manufacture of magnesia and some of its salts.—January 23.

George Stacey, of Uxbridge, Middlesex, machinist, for certain improvements in machinery for reaping, mowing, and delivering dry or green crops.—January 24.

William Pidding, of the Strand, Middlesex, gentleman, for improvements in the manufacture, preparation, and combination of materials or substances for the production of fuel, and for other useful purposes to which natural coal can be applied.—January 24.

Frank Clark Hills, of Deptford, Kent, manufacturing chemist, for improvements in manufacturing and purifying certain gases, and in preparing certain substances for purifying the same.—January 24.

Joseph Jones, of Bilston, Stafford, furnace builder, for an improvement or improvements in furnaces used in the manufacture of iron.—January 24.

Richard Ford Sturges, of Birmingham, Warwick, manufacturer, for an improved method or improved methods of ornamenting metallic surfaces.—January 24.

John Hinks, of Birmingham, manufacturer, and Eugene Nicolle, of the same place, civil engineer, for certain improved machinery to be used in the manufacture of nails, rivets, bolts, or pins, and screw-blanks.—January 24.

Peter Armand Le Comte de Fontainemoreau, of South-street, Finsbury, for certain improvements in lithographic, typographic, and other printing presses; which improvements are also applicable, with certain modifications, to extracting saccharine, oleaginous, and other matters, and to compressing in general. (A communication.)—January 24.

James Gathercole, of Eltham, Kent, envelope manufacturer, for improvements in the manufacture and ornamenting of envelopes; parts of which improvements are applicable to other descriptions of stationery; and in the machinery, apparatus, or means to be used therein.—January 24.

Arad Woodworth 3rd, and Samuel Mower, of Massachusets, United States of North America, for certain new and useful improvements in machinery for manufacturing bricks, tiles, or other articles of a similar character.—January 24.

Alfred Richard Corpe, of Kensington, Middlesex, gentleman, for improvements in trowser-strap fasteners.—January 24.

George Kent, of the Strand, Middlesex, patentee of the rotary knife-cleaner, for certain improvements in apparatus for sifting cinders, and in apparatus for cleaning knives.—January 24.

Joseph Maudslay, of the firm of Maudslay, Son, and Field, of Lambeth, Surrey, engineers, for improvements in steam-engines, which are also applicable, wholly, or in part, to pumps, and other motive machines.—January 26.

Edward Simons, of Birmingham, tallow-chandler, for certain improvements in lighting.—January 27.

William Brindley, of Queenhithe, for improvements in the manufacture of flocked fabrics, and in the manufacture of buttons.—January 27.

William Dray, of Swan-lane, Upper Thames-street, City, London, agricultural implement maker, for improvements in reaping machines. (A communication.)—January 27.

George Duncan, of the New North-road, Hoxton, and Arthur Hutton, of Herbert-street, New North-Road, Hoxton, for improvements in the manufacture of casks.—January 27.

Nelson Smith, of New York, United States of America, gentleman, for improvements in the construction of violins and other similar stringed musical instruments. (A communication.)—January 27.

Jean Benjamin Coquatrix, of Lyons, in the Republic of France, merchant, for improved apparatus for lubricating machinery.—January 27.

James Joseph Brunet, of the Canal Iron-works, Poplar, Middlesex, engineer, for certain improved combinations of materials in shipbuilding. (A communication.)—January 27.

Alexander Mills Dix, of Salford, brewer, for certain improvements in the method of ventilating apartments or buildings, and in the apparatus connected therewith.—January 27.

Thomas Lambert, of Hampstead-road, Middlesex, piano-forte manufacturer, for certain improvements in piano-fortes.—January 27.

Julian Bernard, of Guildford-street, Russell-square, Middlesex, gentleman, for improvements in the manufacture or production of boots and shoes, and in materials, machinery, and apparatus connected therewith.—January 27.

Joseph Vincent Melchior Raymondi, of Paris, France, machinist, for certain improved statistic and descriptive maps.—January 27.

Isaac Lewis Pulvermacher, of Vienna, engineer, for improvements in galvano-electric, magneto-electric, and electro-magnetic apparatus, and in the application thereof to lighting, telegraphic, and motive purposes.—January 29.

François Jules Manceaux, of Paris, France, gun-manufacturer, for improvements in fire-arms, and in instruments and apparatus used in connection therewith.—January 29.

Joseph Maximilian Ritter Von Winiwater, of Surrey-street, Strand, Middlesex, Doctor of Law, for certain improvements in the locks of fire-arms and cannon; and in gun-matches, or in the mode of igniting gunpowder used in guns; and in machinery for manufacturing the same.—January 29.

William Smith, of Kettering, Northampton, agricultural implement maker, for improvements in apparatus for cutting or breaking lump-sugar and other vegetable substances.—January 29.

Alfred Vincent Newton, of 66, Chancery-lane, Middlesex, mechanical draughtsman, for improvements in the manufacture of pigment or paints. (A communication.)—January 29.

Edward Highton, of Clarence Villa, Regent's-park, Middlesex, civil engineer, for improvements in electric telegraphs.—January 29.

Isham Baggs, of Liverpool-street, Middlesex, electrical engineer, for improvements in crushing gold quartz and metallic ores.—January 29.

William Longmaid, of Beaumont-square, Middlesex, gentleman, for improvements in obtaining gold.—January 30.

Owen Williams, of Stratford, Essex, engineer, for improvements in preparing compositions to be used in railway and other structures, in substitution of iron, wood, and stone. (A communication.)—January 31.

Martyn John Roberts, of Woodbank, Gerrard's-cross, Bucks, Esq., for improvements in agricultural instruments.—January 31.

Alexander Hediard, of 25, Rue Tait Bout, Paris, France, gentleman, for improvements in propelling and navigating ships, boats, and vessels by steam and other motive power.—January 31.

Joseph Haythorne Reed, late of the 17th Lancers, Harrow-road, Middlesex, gentleman, for improvements in propelling vessels.—January 31.

Richard Archibald Brooman, of Fleet-street, London, for improvements in the purification and decoloration of oils, and in the apparatus employed therein. (A communication.)—January 31.

William Squire, of High-Holborn, late of George-street, Euston-square, both in Middlesex, piano-forte maker, for improvements in the construction of piano-fortes.—January 31.

Charles Cowper, of Southampton-buildings, Chancery-lane, Middlesex, for improvements in multiplying motion applicable to steam-engines, saw-mills, and other machinery in which an increase of velocity is required. (A communication.)—January 31.

Alfred Vincent Newton, of Chancery-lane, Middlesex, mechanical draughtsman, for improvements in machinery for weaving coach lace, Brussels tapestry, and velvet carpeting, and other piled fabrics. (A communication.)—January 31.

Frederick Philip Thompson, of Waterworks-chambers, Orange-street, Trafalgar-square, engineer and surveyor, for improvements in filtering and preserving water.—February 2.

George Spencer, of Lacey-terrace, Islington, engineer, for improvements in the springs of railway-carriages, trucks, and wagons.—February 2.

Samuel Cunliffe Lister, and James Ambler, both of Manningham, Bradford, York, manufacturers, for improvements in preparing and combing wool and other fibrous materials.—February 2.

Emanuel Charles Theodore Croutelle, manufacturer, of Rheims, for certain improvements in machinery or apparatus for preparing woollen threads and other filaments.—February 3.

Robert Hesketh, of Wimpole-street, St. Marylebone, Middlesex, for improvements in apparatus for reflecting light into rooms and other parts of buildings and places.—February 3.

Peter Claussen, of Gresham-street, London, gentleman, for improvements in the manufacture of saline and metallic compounds.—February 3.

George Torr, of the Chemical-works, Frimley's-lane, Rotherhithe, animal charcoal-burner, for improvements in re-burning animal charcoal.—February 3.

John Feather, of Keighley, York, worsted-spinner and manufacturer, and Jeremiah Driver, of the same place, iron and brass founder, for certain improvements in screws.—February 9.

Auguste Neuberger, of Rue Vivienne, Paris, France, lamp manufacturer, for certain improvements in lamps.—February 9.

William Becket Johnson, of Manchester, Lancaster, manager for Messrs. Ormerod and Son, engineers and ironfounders, for improvements in railways, and in apparatus for generating steam.—February 9.

Sanders Trotman, of Clarendon-road, Middlesex, civil engineer, for improvements in fountains.—February 9.

John Dennison, of the firm of John Dennison and Son, of Halifax, York, and David Peel, of the same place, manufacturers, for an improved lubricating compound.—February 9.

Ralph Errington Ridley, of Hexham, Northumberland, tanner, for improvements in cutting and reaping machines.—February 9.

Martyn John Roberts, of Gerrard's-cross, Bucks, Esq., for improvements in galvanic batteries, and in obtaining chemical products therefrom.—February 10

John Smith Hutton, of Bolton-le-Moors, Lancaster, bleacher, and Joseph Mutgrave, of the same place, engineer, for a certain improvement or improvements in apparatus used in the bleaching of yarns and goods.—February 12.

Christian Schiele, of Oldham, Lancaster, machinist, for certain improvements in obtaining and applying motive power.—February 12.

William Edward Newton, of Chancery-lane, Middlesex, civil engineer, for improvements in the heddles or harness of looms for weaving, and in the machinery for producing the same. (A communication.)—February 12.

John Stephens, of Kennington, Surrey, Esq., for improvements in obtaining and applying motive power.—February 12.

John Mollady, jun., of Denton, Lancaster, hat manufacturer, for certain improvements in machinery or apparatus for manufacturing hats or caps.—February 12.

Charles Louis Barbe, of Mulhouse, France, for improvements in the re-producing of drawings, and in the mode of obtaining designs, to be principally used in the engraving surfaces for printing fabrics.—February 12.

Annet Gervoy, of Lyons, France, director of the Lyons Railway, for means to prolong the durability of the rails on railways.—February 13.

Edmund Morewood, of Enfield, Middlesex, and George Rogers, of the same place, for improvements in the manufacture, shaping, and coating of metals, and in the means of applying heat.—February 13.

Hermann Turck, of Broad-street buildings, London, merchant, for improvements in the manufacture of rosin-oil. (A communication.)—February 14.

Arthur Wellington Callen, of Peckham, Surrey, gentleman, and John Onions, of Southwark, Surrey, engineer and ironfounder, for improvements in the manufacture of certain parts of machinery used in paper-making, and certain parts of railways, railway and other carriages.—February 14.

TO CORRESPONDENTS.

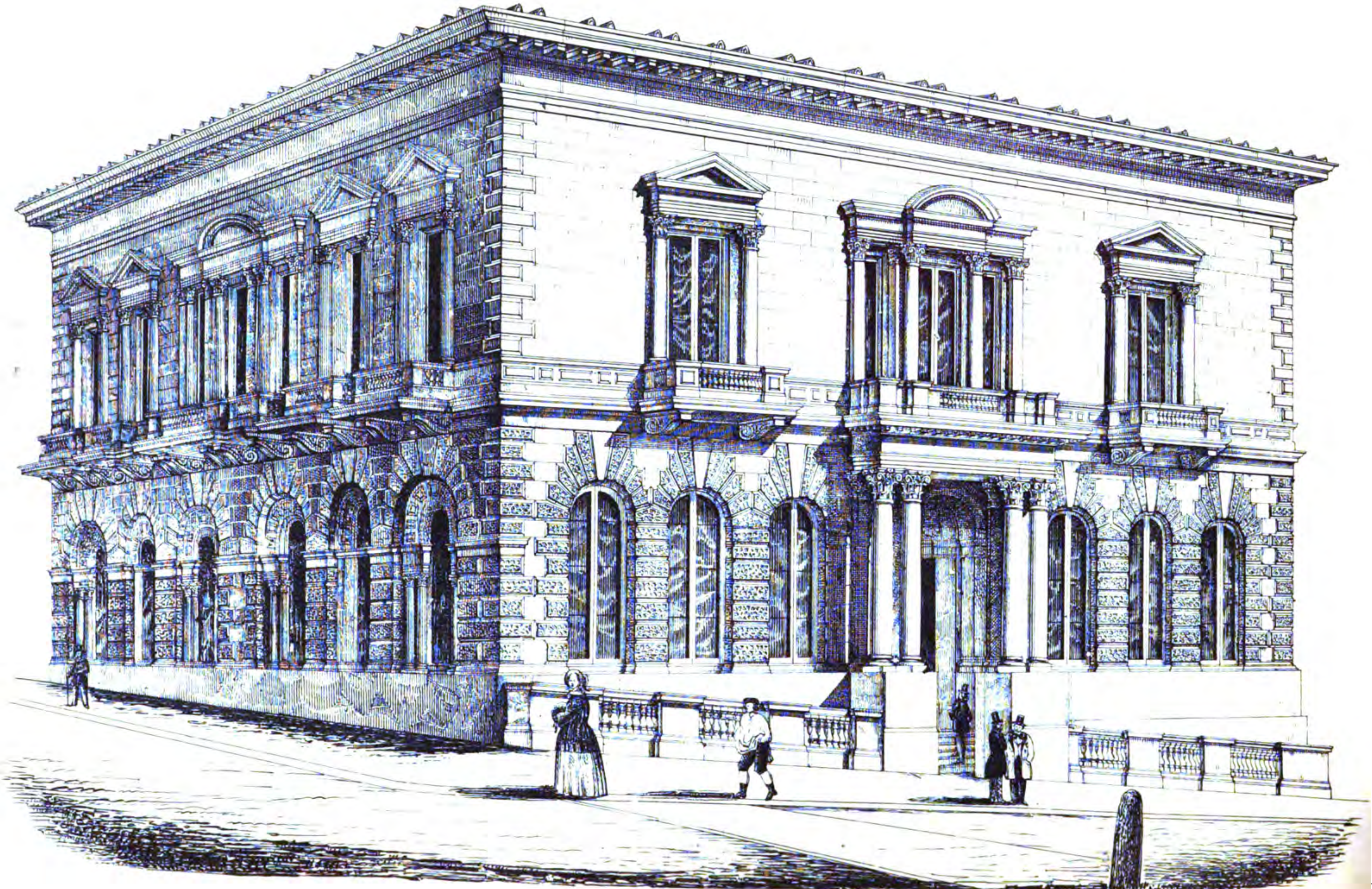
AN AMATEUR asks "whether a bridge, built of stone or brick, would be secure, supposing it to be built at an angle of 40°, and to have a pointed Tudor arch springing from the abutments;" and states: "This being what is commonly called an askew bridge, is there no error in principle?—would it not have to be groined?"

Answer.—An askew bridge of stone has been built at Bristol, over the Float, to carry the Great Western Railway, at angle of 60°, or thereabouts. And another Tudor bridge, askew, has been built on the Chester and Holyhead Railway at Conway; but this latter has been built by a series of ribs. We can see no difficulty in building a brick arch askew at an angle of 40°, if there be introduced at the intersection of the point of the arch a continuous key-stone, serrated on each side, to receive the abutments or ends of the bricks; or the bricks might be cut at the intersecting point and set in cement.

A CORRESPONDENT requires some information for calculating the time for emptying a reservoir having four sluices.

Answer.—Supposing the water is stopped from running in, the following formula will give the result:—Multiply the square root of *half* the height above the centre of the sluices to the surface of the water in the reservoir by 8, which will give the mean velocity in feet per second; then, if this velocity be multiplied by the area of all the sluices, it will give the theoretic quantity in cubic feet *per second* that will be discharged through the sluices. In practice, it has been found that only two thirds of this quantity will give a correct result, on account of the friction of the water passing through the openings of the sluices, and the *vena contracta*. A short rule will be, to multiply the square root of half the height by 320, which will give the velocity per *minute*; and this, multiplied by the total area of the sluices, will give the quantity discharged per *minute* in cubic feet: then, if the cubic contents of the reservoir be divided by the above result, it will give the number of minutes that will be required for emptying the reservoir.

FLOODS.—This winter has been signalised by most destructive floods, which have in many cases swept away important works. Engineers will, from the evidence in some cases, see the necessity of paying particular care to the facings, as well as the inside of the dams and weirs they set up, because, as will be observed, the destruction took place in consequence of the water passing over the brim of the reservoir and washing away the external face of the embankment. The inside held well enough to allow the water to rise so high; but the outer works, it too often happens, are less carefully finished. With regard to the Holmfirth catastrophe, it is a signal disgrace on the legislation and legal administration of the country, that an important work should be allowed to be ruined because it was said an act of parliament was of doubtful meaning.



James Green Arch[t]

BURNLEY MECHANICS INSTITUTION.

NEW MECHANICS' INSTITUTE, BURNLEY.

James Green, Esq., Architect.

(*With an Engraving, Plate* XI.)

The site selected for this building is at the junction of two streets, Market-street and Yorke-street, to both of which the principal fronts will be presented. The nature of the site admits of two stories below the level of Market-street, the lower of which will be used as store vaults, and will be built fireproof, with brick arches on iron beams; the entrance to the vaults will be from a back street. The second basement story will be occupied by large class rooms and porter's living and lodging rooms. The ground or principal story will be approached from Yorke-street by twelve steps, and will have a portico with four coupled, disengaged Corinthian columns, supporting entablature and balustrade. The hall and principal staircase will be spacious and well lighted; and opening from it, right and left, are—news room, 36 feet by 28 feet; reading room, 28 feet by 28 feet; library, 30 feet by 19 feet; committee room, 30 feet by 22 feet; and two shops or offices fronting Market-street, each 28 feet by 18 feet. The first story above ground floor will be occupied entirely by the assembly and lecture room, 72 feet by 52 feet, inclusive of ladies and gentlemen's ante and retiring rooms, over which will be a gallery for orchestral and other purposes, and which will be separated from the main room by twelve coupled Corinthian columns supporting entablature, &c. The walls of assembly room will be decorated with coupled Corinthian pilasters supporting entablature, with modillion cornice, from which springs a coved-and-panelled enriched ceiling, with large circular dome of stained glass in the centre, over which on flat of roof will be a lantern light. It is intended to have a circular chandelier of gaslights in the roof above glass dome, which, besides lighting the room, will also assist in the ventilation. The total height of this room will be 26 feet clear. The building will be heated throughout with hot water, and provision made in every room for ventilation.

The style of the exterior is Italian, and, as will be seen from the engraving, the windows of the first floor are enriched with Corinthian columns and entablature, with alternately segmental and triangular pediments; all the windows will have projecting balconies. The two principal fronts are finished by a bold, Italian trussed cornice and frieze, which is to contain an inscription. The whole will be built of polished ashlar, of very good quality, from the Catlow Quarry, in the neighbourhood. The contractors are—for the masons' work, Mr. R. Smith; for the carpenter and joiners' work, Mr. W. Parker; for the plastering and internal decoration, Messrs. Beevers, all of Burnley.

The total cost of the building will be about 4500*l*., which it is proposed to raise entirely by subscription, and of which about 3000*l*. is at present subscribed. The first stone was laid on the 25th of November, 1851, by the President of the Institute, Charles Towneley, Esq., of Towneley, and in the presence of the Earl of Carlisle, Earl Sefton, Sir J. P. Kay Shuttleworth, Sir Charles Barry, the Hon. Colonel J. Yorke Scarlett, the members of the county, and a large concourse of people.

NOTES OF A TOUR IN BRITTANY AND NORMANDY.

By John P. Seddon, Architect.

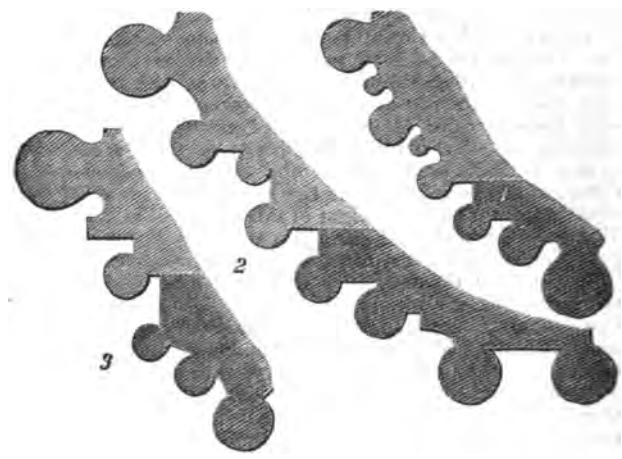
Evreux.—The cathedral of the city of Evreux is an important and highly interesting building, comprising several different styles of architecture. Its general outline is exceedingly irregular, far more so than any which I had met with in this portion of France; although the excess of the height of the choir above that of the nave may he often noticed in other parts of that and neighbouring countries, and sometimes it produces an exceedingly striking and picturesque effect, though it must be considered as detrimental to the unity and beauty of a building. The western towers and central spire are abominably ugly. The northern tower is Renaissance and very massive; the others are capped by ugly wooden spires. The nave is Norman in the lower part, with a clerestory of Early Gothic; its proportions are narrow and lofty, while the choir, which is of rich Flamboyant workmanship, is wider than it on plan, so that the arches next to the crux are set obliquely to meet the width of the nave. This choir is very elegant, and has a fine, luminous triforium, with narrow gallery, the inner screen to which is filled with flowing tracery, and the outer one glazed with stained glass. The transepts are most elaborate and beautiful specimens of the Flamboyant, literally covered with foliage of the thistle type, and this both internally and externally; the façade to the north transept is perhaps the richest portion, and exceedingly imposing. The veils of detached tracery which cover these Flamboyant buildings of France have not the wiry, cast-iron effect of the German cathedrals, such as Strasburg, but there is so much of breadth and fullness retained in the other parts which gives to them their due relief. The details and treasures of the cathedral contain a mine of elaborate ornament, both in stone and metal. Adjoining the cathedral is the episcopal palace, of the same style of architecture, and interesting as showing its application to civil buildings; it has an external polygonal staircase tower and lofty dormer windows, with pediments crocketted and filled with flowing tracery.

Louviers.—In the centre of the city of Louviers, and with its southern aisle fronting the main street, stands its principal church, an irregular, fantastic, but imposing and picturesque pile; the road being divided by it at this point, passes on either side of it with rather a rapid turn. This peculiar position of the site has, as it will be explained, considerably influenced its architecture. It stands, however, a melancholy instance of the ravage of modern restorers, who have in their stupidity done that which scripture tells us no man (*i. e.* in his right senses) would do, namely, "patched an old garment with new pieces," and rather scraped the old to match their clumsy new work, than tempered the new to match the old; and thus all the fine colour and the stamp of antiquity which ages had wrought upon its surface has been obliterated. This, indeed, is no slight loss, not only in an antiquarian point of view, but also in actual beauty; but yet, to be candid, as far as may be gathered from its present appearance, the operation has been conducted with more care than at Lisieux, where I myself watched closely the fearful mischief of the masons. The old work here has generally been left (I know not how scraped or if yet to be *restored*) where not much decayed, and the spirit of the ornament has been somewhat followed, for it is of a far coarser description than that of Lisieux, being almost Italianised in detail, and lumpy in comparison with the pure Gothic. It *can* be followed, and time will restore the colour, and no great damage will have been done: whereas that at Lisieux it is out of man's power to copy or of time to redeem. The south aisles and porch are marvellously rich and fantastic; the energy, vigour, and life in the Flamboyant, even where the detail is coarse and purity had vanished, is very striking. The south-west corner of the aisle is rounded off to allow the road to pass round it, and the end flying buttress to the clerestory, after spanning the first aisle, is swept round the corner, as if it had been driven by the blast of a tempest abruptly through all the niches and tracery that are clustered together at that point, in very luxury of confusion; while of these, some of the smaller canopies to the niches are set within and at right angles to the larger ones, in place of a statue; the finials piercing the canopies above, and the whole of the pediments pushing forward the foliated cusps of their tracery into the light, the leaves bending back upon them as if they would shield them from a rude touch. To the northern aisle there is a doorway, *luckily not restored*, the pinnacles to the buttresses of which actually impale the grinning demon gargoyles of the aisle roof. These gargoyles themselves are very fanciful, though hardly equal to those at Evreux, among which is to be seen a hissing serpent coiled around the stump of a tree, whose roots plant themselves firmly into the buttress behind; and others are grisly dragons, whose scaly folds are writhing all along the parapet on either side. The whole architecture of this period resembles some geologic strata, laid at first, indeed, in ordered level, but raised with sudden fault, and, while still pliant, tossed in wild confusion amid the convulsions of the world. But little like this can be seen in the empty, frittered work of our cotemporary Perpendicular style. We need not, however, fear a comparison with their modern taste, for in this church the east window has been knocked out to admit a plastered semi-dome, which pushes through the carved window-head like the hood of a bathing-machine, the upper part of which is glazed with a deal skylight. Inside, it contains some gewgawed relics, and an altar flanked by two marbled Doric pillars supporting nothing.

From Louviers the route passes by the modern burial-ground outside the town, and, Roman catholic though it be, it might put to the blush many of our protestant cemeteries, seeing that therein it is *the cross*, though in but lowly form, which is pre-eminent, gleaming white in the sunshine on the broad hill-side,—and not a row of empty jars, and pompous pagan monuments, such as those which disfigure and desecrate our own. Such thoughts suggested themselves to me as I passed around the base of this modest cemetery and through a lovely and varied country, at that time glowing in all the radiance of an autumnal sun, which, although it was late in the season, still found a glad company of golden leaflets, fluttering on the slender birch-trees which fringed the road, for it to burnish with its beams; until the blackened air warned us that we were approaching the busy manufacturing city of Elbœuf. In that place is nothing of interest to delay one to whom stocking-looms and pale faces are no attraction; and as the posting steamboat and the memory of the Rouen towers were inviting me onwards, I seized the opportunity offered. It was then evening: the scarped hills, past which we glided swiftly, rose, like the bleached cliffs of England's shores, as a wall on the one side, their bases being all fringed by the graceful willow, as were also the numerous islands that slept on the broad bosom of the Seine. And these, again, were reflected sweetly on the calm surface of the water, which—save where, being ploughed by the paddles of the boat, the waves caught the gold of the setting sun—was spread like a purple mirror beneath us; nor did the varying splendour cease until we reached the broad quays of Rouen.

Rouen.—The cathedral, although it has been erected at different periods, is a noble building, both as a whole and in its several portions and details. It is so built against and hemmed in by houses and narrow streets, that it is difficult to obtain any general view of the exterior from below. From S. Ouen tower, however, or the heigths to the east of the town, the general plan and outline may be well seen, and hence its form is almost unequalled. The plan is the Latin cross, with each arm well developed and equal in height; the picturesque façade, with its western towers, alone being somewhat irregular. The transept ends are each flanked by square towers with lofty, open windows; and these, though equalling in dignity most west fronts of cathedrals, are yet properly subordinated, as their position requires. The choir, terminated by a polygonal apse surrounded by a clustering crown of chapels and flying buttresses, completes the building, since the horrible modern iron spire, for ever suggesting the idea of a huge gasworks, may not be considered a part of it. The interior and the choir, and the substratum as it were of the west front, are of the Early Gothic, massive and grand in proportion and simple in detail. The transept ends are noble, and perhaps unequalled, specimens of complete Gothic. The Tour de Beurre is still later, and coarser in detail though fine in mass; while the magnificent western portal and the overlaying screen of decoration of the west front is a *chef d'œuvre* of the Flamboyant, although in parts somewhat Italianised. The series of art is further continued by the rich Renaissance tomb of the Cardinal d'Amboise, within the choir; but this, compared with the earlier work of the building, appears so false and degraded in feeling, as scarcely to attract attention or deserve notice.

The nave has eleven arches in length and four divisions in height, an arcade being open to the aisles, which are very lofty. Over the main arches above is a shallow triforium, forming almost one feature with the clerestory, and typifying the luminous triforia, the pride of the Flamboyant churches, as S. Ouen, Rouen, and Évreux cathedrals. The effect of the aisles, from their height, is fine, but injured by the curious cage-like projections round the upper part of the vaulting shafts; the appearance, however, of the two arcades being open to the aisles is disagreeable when viewed from the side of the nave.



The clustering of the shafts to the nave piers is simple and bold: five shafts, diminishing in gradation from the centre, rise to the vaulting (usually only three); the same number support the arch mouldings, but are divided by slenderer shafts whose capitals nestle under the larger; this arrangement (fig. 1) is particularly effective and harmonious, but is confined to the nave. The mouldings of crux pier (fig. 2) are not equally simple, and far inferior to those of Coutances crux. In the transepts (fig. 3) five rise to the vaulting, and three only, divided by square fillets, to the arches. In fig. 1, it is the central vaulting shaft which predominates, as it ought, being the most important; but in fig. 3, it is the central arch shaft—and far too much so in relation to the rest. In the choir, the piers are massive, circular columns, with lofty, foliated capitals, from which the three vaulting shafts rise. This arrangement is bold, and the choir has a grand simplicity produced by reversing the means by which the extreme elegance of Coutances choir is gained: for there the aisle piers are low, massive, and circular, those of the choir lofty and shafted, their elegance enhanced by the contrast; here, the slender-shafted aisle piers and the sparkling tracery of the lady chapel seen through the giant choir apse, gives to its sweep of massive columns a noble grandeur. The transepts have a chapel at the angle of junction with the choir, which is not usual. The choir has only two polygonal chapels and the lady chapel, roofed with a canopy over each window,—a beautiful method, and far superior to that used at S. Ouen, where each chapel has an ugly, pyramidal, sugarloaf roof, much to be regretted, as otherwise its circlet of apse chapels would have been strikingly beautiful.

The tracery throughout the cathedral is varied and beautiful, particularly in the transept rose windows, which are continued down with a sort of luminous triforia with screens of tracery before them. There is much excellent stained glass, but the carving of the interior is not remarkable.

The side portals of the west front are simple and grand Early Gothic, with great richness of bold sculptured foliage and animals, full of feeling—but the feeling of a truly Doric mind, in sympathy with which the very stone seems to have turned into iron. I may refer to the character of this foliage, as bearing upon the discussion which has lately taken place upon Gothic ornament. The contour of the ornament is similar to and not distinct from the contour of the mouldings beneath.

The central portal, with its soaring arch and fretted buttress flanking piers, encrusted over with delicate carving, cannot fail to impress every spectator with awe at the transcendant power and infinity of design displayed in them; yet the loss of the true spirit of Gothic art is but too evident in the foolish Renaissance conceits of naked children and the statues of knights and dames in the quaint costume of the period, which have supplanted the angel host, the more fitting occupants of the canopies of a christian church.

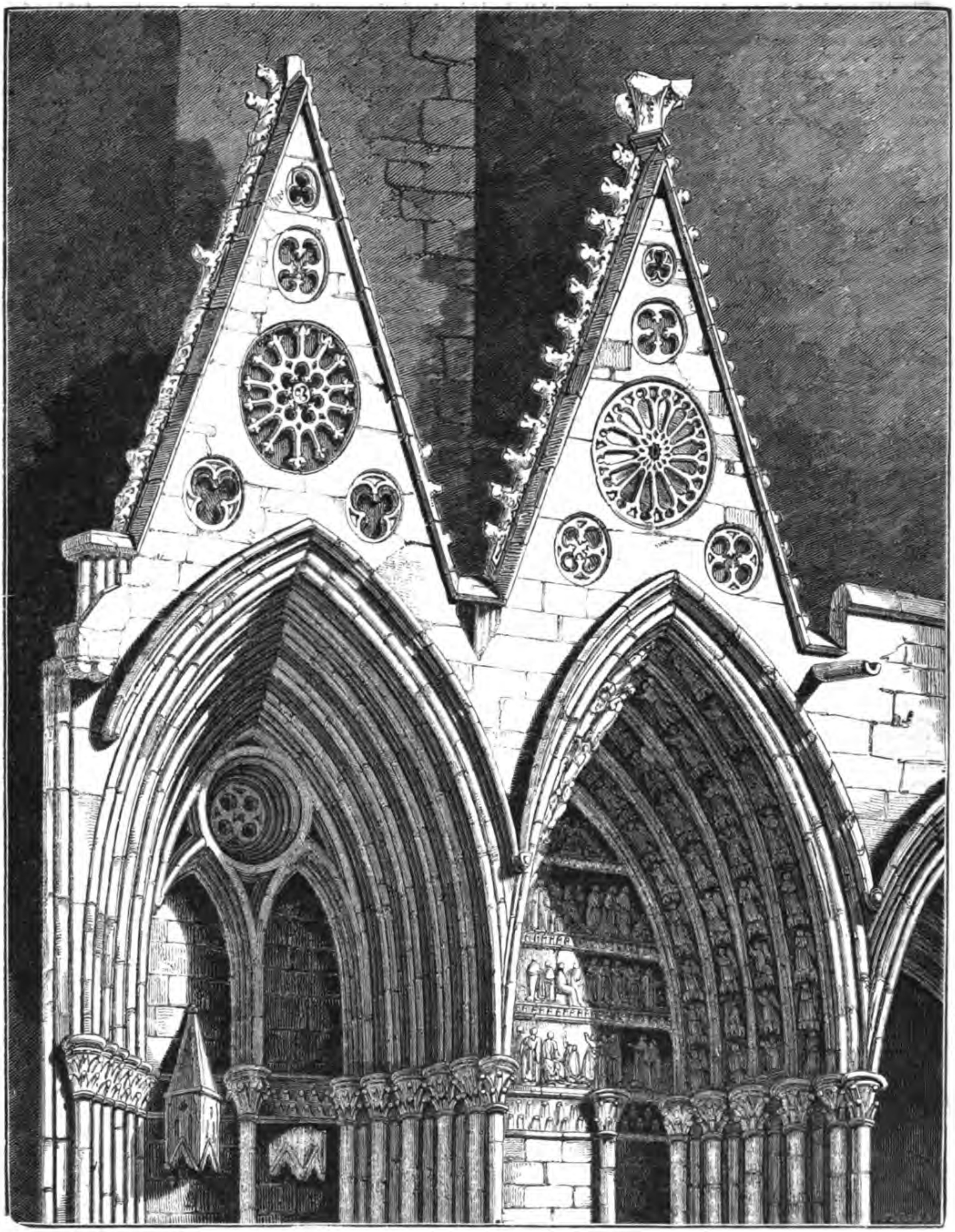
The transepts are by far the purest and most beautiful portions of the cathedral. They are of the complete Gothic, simple in design, each feature being well marked and possessing all requisite enrichments, yet properly relieved by plain broad surfaces between; the mouldings are bold, as those of the earlier Gothic, but rendered delicate as well, by small fillets and beads between the principal members,—and this, together with their exquisite proportion, forms their peculiar excellence. The sculptured bas-reliefs which cover the sides—to such height only as they can be well seen—are of good composition and execution, and wonderful from their fanciful variety.

The Abbey Church of S. Ouen, from its completeness and uniformity, being finished in the same style throughout, and there being nothing to obstruct the view externally or internally; from its lofty proportions, the fine colour of the stone, its luminous triforium, and the quantity (not quality) of stained glass,—is certainly an elegant and striking building. But this general effect is too superficial: the details show neither the study, feeling for proportion, nor variety of the earlier Gothic: no part, when examined, can be pronounced first-rate, or seems to be endued with any feeling; it looks like the work *of a system* (to which some would now reduce Gothic, if they could), and not that *of a man;* and the whole is infinitely inferior to the better portions of the Cathedral. Its very elegance becomes wearisome, for the same monotonous, lengthened, tapering form pervades every pinnacle or projection of the church, down to the modern extinguisher-like towers of the west end. The plan is a Latin cross, the nave having nine arches and aisles of great width, without chapels; the transepts, two compartments and aisle to either side; the choir, three arches only, with an apsidal end, five narrower ones, an aisle all round, and a range of polygonal chapels beyond; the crux is vaulted over level with the rest of the church. The great height of the interior—three and a-half to one of its width—and the luminous triforium continued round the whole of the building, form its peculiar beauty. The tracery of the choir and transepts is of one pattern (Geometrical) and of marvellous lightness; that of the nave is Flamboyant, and poor. The rose windows are fanciful and varied, but inferior to those of the Cathedral; their glass is crude and ugly in colour; some of the other glass is pretty, but not first-rate. The mouldings of the piers consist of circular shafts set in curved hollows, and do not show a gradation like those of the Early Gothic. The nave vaulting shaft preponderates too much over the rest, and produces a clumsy appearance; while two pilasters break into the mouldings on the side of the aisles and pierce their vaulting without any capitals, in the ugliest manner conceivable; and in the shafts of main pier to crux, in addition to the above errors in proportion, the small shaft which bears the crux vaulting is pushed before the others and has its capital lower than the rest, producing great confusion: all breadth is thus destroyed, as it is also in the pier bases, where each minor shaft has its mouldings at different heights. There is no carved work upon this church which is tolerable. The south porch, much vaunted by the local antiquaries and others, though intended to be exceedingly rich, is simply detestable; its details are copied from the Cathedral transepts, but their refinement and proportion have been omitted,—the crockets and cusps having the same form, but stupidly magnified to four times the size of the original, and thus rendered coarse in the extreme; the bas-reliefs have neither merit of conception or execution. The crown of the lantern over crux is elegant, but the buttress is useless and too heavy in effect, rising to such a height that the crown seems pushed down among them. In power it is not to be compared to the crown of the Tour de Beurre of the Cathedral.

The Church of S. Maclou, the third in order of importance, though, in parts, superior to S. Ouen in merit, is of the complete Flamboyant style, compact and pyramidising in outline. It is almost a Greek cross in plan, the nave having only three compartments, the transept two, and the choir two, with an apse of five arches. There is an aisle and row of chapels all round; the flying buttresses which span these, and which are set closely together, have a peculiar and good effect. The porch, with its five arches and their lofty pediments, united by a rich traceried screen, is a *chef d'œuvre* of this style—it serves as a frame to the magnificent sculpture of the Last Judgment, which I have described at length, from a minute examination, in a former paper (p. 121, Vol. XIV.) It is almost impossible to obtain a view of this front, from the narrowness of the street. The money now being actually wasted in spoiling the church would have been far better spent in clearing a space in front of it. In the interior the mouldings are somewhat liny and effectless, being continuous. The bases to the piers are interpenetrating and confused.

It may thus be seen, from what has been said above, that in Rouen, while the remnants of its fine domestic architecture are fast disappearing, to make room for more comfortable modern monotony, there are still congregated characteristic and fine examples of the several periods of Gothic ecclesiastical architecture, which—until the *blight of restoration*, which has already fastened on them (as it has fastened likewise upon many, while it threatens others, of our own priceless mediæval heirlooms), shall have proceeded too far — afford an admirable opportunity for the study of the comparative merits of the several styles. It is also nearly upon the extreme limit of the locality where are to be found the buildings of the Norman-French Gothic, combining, as has been explained, the features of the English and Continental styles—uniting the unity and completeness of the former with the vigour and feeling in detail of the latter; and here, therefore, for the present, I take leave of the cathedrals and churches of France, hoping, however, at some future period, to renew my researches among them.

JOHN P. SEDDON.



West Front, Bayeux Cathedral.

WESTERN FRONT, BAYEUX CATHEDRAL.

The western front of Bayeux Cathedral, (described page 577, Vol. XIV.), of which the accompanying engraving shows the two northern arches, is an exceedingly noble conception. There are five arches in all. The central one has been at some time destroyed by lightning, and tastelessly restored. Those on the southern side correspond generally with those shown in the engraving, having the same lofty pediments, with their peculiarly bold and effective perforations. The outer arch in each case has its tympanum filled with blank tracery, those next the central one have groups of sculpture and rows of saints and angels under canopies in the mouldings. The piers throughout are clustered with shafts alternately of slenderer dimensions, their capitals being united into bands of flowing foliage; the whole is executed with remarkable freedom. The lines of the moulding bend and wave, as may be seen in the engraving, the original sketch for which was taken with scrupulous exactness. Some of the arches which correspond in position vary considerably in their span, while the pediments are of the same dimension, so that the apex of the gable is not in each case over that of the arch beneath, nor are the perforations at all arranged in exact order; yet the effect produced is by no means unsatisfactory, for, as I have before stated, a certain amount of life and vigour appears to be even gained by these irregularities. In the design for the front of a cathedral, which was exhibited at the late Architectural Exhibition, the general arrangement of that at Bayeux was followed; to the central arch, however, a similar gable as to the others was given, whereas that of Bayeux has a horizontal gallery above it, while the depth of its recess was greatly increased. Lancet arches also were placed, with statues on pedestals, on either side of the arches shown in the engraving, in order to extend the façade, and give a greater variety, while most of the details, for which I did not possess the authority, were my own design, together with the idea of the introduction of mosaics and colouring.

John P. Seddon.

THE POETRY OF GOTHIC ART.

By David Duthoit, Jun.

[Paper read at the Architectural Association, Jan. 30th.]

All who have studied architecture, even in the most superficial manner, must have observed that a building displays something more than mere constructive ability; that in its advanced state is possessed what has been termed *expressiveness*; and that the kind of expression exhibited is of a different character in different styles and in different countries. In the present paper I have thrown together a few remarks upon the kind of feeling which we perceive in the Gothic, and this expression or feeling manifested I shall term, in the course of this paper, its Poetry.

No one will for a moment contend that architecture is merely a useful art: it is something beyond it, and possesses a higher character than can belong to anything of mere utility. So long as architecture was confined to the erection of wooden huts or mud-walled houses, its classification with the useful arts would undoubtedly be correct; but when the ideas of man began to expand, and besides improving his own dwellings, he began to erect temples for his gods, the art of building assumed a very different aspect. It then required for its practice a previous amount of study, and the attention of the architect was necessarily turned to the adaption of scientific principles in the construction. This was one step forward, and it was quickly followed by another. The architect began to see the necessity for some kind of decoration; and as his ideas enlarged, the decoration which he introduced would partake of a higher character. Still advancing, he would at length see of what architecture was capable; and as his experience increased, he would throw into his composition an amount of feeling, and bring to bear upon it a fertility of imagination, which would at once raise it from the position of a mere useful auxiliary to the comfort and convenience of man, to the rank of a fine art. It was at this point that the poetry of the art was developed; and it will be here proper to explain what we intend when we speak of the poetry of architecture.

The term poetry, as usually applied, belongs to metrical composition, though it does, in reality, possess a much more extended signification; and the term poetical may very properly be applied to the thoughts and feelings, as well as to the expressions of the poet. It does not at all follow that because a piece of composition is written in verse that it is therefore poetry, whilst on the other hand there is much poetry that is expressed in prose. If this be admitted, it will be easily seen that the term poetic will as properly apply to the feelings of a painter or a sculptor as to the author of an epic. The sculptor, for instance, so long as he confines himself to copying the objects exactly as they are placed before him, must be a skilful artist, but nothing more; but so soon as he abandons the idea of being a copyist, and attempts to depict in stone some form or expression which his own mind has created, that moment he becomes a poet. The same will, of course, apply to the painter. Rafaelle and Rubens were poets of the highest order; in fact, the feelings which give rise to what is popularly termed poetry to sculpture and painting, are in all cases precisely the same—they merely develope themselves in different directions.

We must not, therefore, limit the application of the term poetry to what is only one form of expression of a similar class of feelings; and if we examine the claims which architecture has upon our attention in this respect, we shall find that it is the result of the same species of feeling which we see exhibited in verse, painting, and sculpture. It will be a part of our task to see where and how this poetical feeling is developed in Gothic architecture.

Let any one for a few moments contemplate some one of those ancient churches or cathedrals which adorn our country. The longer he gazes upon its lofty tower or spire, its many turrets, pinnacles, and buttresses, as they all point upward to the sky, the more he becomes convinced that he is not looking upon a dead pile of stones, heaped together for some merely useful purpose. The impression which they at once convey to his own mind convinces him to the contrary. He feels that he is gazing upon something in which thought and feeling are everywhere visible; the minutest object upon which his eyes rest embodies some element of the poetic and the beautiful. The building before him is the product of the imagination of its designer—it embodies his feelings, and expresses his sentiments; it tells at once, by the aspiring tendency of the whole, that it was created in homage of the Creator, and raises in his mind ideas as grand and as sublime as any which have been excited by the highest flights of poetical genius. Does a poem display imagination and beauty, sentiment and feeling? Not less does a Gothic cathedral; nor can we suppose that the most successful poem which was ever written ever suggested more sublime or more heavenly thoughts than the simple expressiveness of an early English cathedral.

Let us for a moment enter its precincts. We pass in at the western entrance, and the whole beauty of the nave, with the retiring splendour of the distant choir, are at once before us. The deep and still solemnity of the place, as it steals over the senses, at once tells us that we have entered the temple of the Deity, while the beautiful harmony of the several parts which catch the eye, together with the appearance of firmness and indestructibility of the whole, present to the mind a fit emblem of the temple not made with hands. The long vista of receding arches, and the continuous vaulting above gradually diminishing to the eye till it is almost lost in the distance, is a picture so enchanting, and at the same time so grand and elevating, that we feel it at once to embody the true principles, the real feeling, of the highest species of poetry. And when we call to mind that the vast building before us has been placed there especially for the worship of God—that it stands a mighty offering in acknowledgment of the goodness of the Creator—that it has been hallowed by the worship of succeeding generations—and that it has seen kneeling upon its pavement a throng who have passed from the scene for ever, the effect is overpowering. How can we say that any composition of man ever awakened such holy emotions or such a noble enthusiasm?

The great charm of a Gothic building is its religious character. It is a *sacred* poem. Its peculiar style of architecture was invented and developed in the service of the church; it was carried out upon Christian principles, by professedly Christian men: and the aid which it lends to religious worship has never been questioned. It is this sacred character of Gothic architecture that breathes over it a hallowed charm, which we may look in vain for elsewhere. No poem, perhaps, ever suggested more sublime ideas of the heavenly regions than the Paradise Lost; but does not the interior of a Gothic cathedral produce a precisely similar effect? It may be that it is less defined, but it is all the more intense. Milton himself—though living in an age when ecclesiastical architecture was least of all valued, and though belonging to a party the most professedly hostile to anything like taste or beauty in religious worship—was not ashamed to avow his attachment to the ancient architecture of England, or to bear the following testimony to its suggestiveness of the glories of heaven:—

"But let my due feet never fail
To walk the studious cloister's pale,
And love the high embower'd roof
Like antique pillars massy proof,
And storied windows richly dight,
Casting a dim, religious light.
There let the pealing organ blow
To the full voiced choir below,
In service high and anthem clear,
As may with sweetness through mine ear
Dissolve me into ecstacies,
And bring all heaven before my eyes."

It is this suggestiveness of Gothic architecture to which the poet thus beautifully alludes that forms one of its chief characteristics, and places beyond dispute its poetical spirit.

And here we notice the difference between the power of expression in architecture and in that of the other fine arts. In verse or painting the ideas conveyed are in general of a definite character—everything is minutely described, and the picture brought before the eye should be in every respect complete. In architecture, on the contrary, we see nothing defined—the ideas it expresses are not particularised. It rather produces feeling than displays it; and while poetry and painting may be said to feed the imagination, architecture excites it. In this respect it is akin to music, the great charm of which lies in the effect which it produces upon the senses without presenting to the mind any abstract ideas. Yet is its effect no less enchanting—no less intense. Every one has experienced the thrilling emotions which it excites, and the state of feeling into which it throws us. It has brought up before us scenes which have long passed away; it has carried us to the remotest corners of space, and has opened to our astonished gaze the glories of heaven itself. Nor is it unworthy of notice that architecture alone, of all the arts, has the power to collect within itself every element of poetry in existence. The other fine arts (which we must consider as the forms of expression which poetry assumes) stand more or less by themselves, excepting in the case of song, in which music and verse are combined. But during service time, in a Gothic cathedral, we find all the elements of poetry collected together, and exerting their influence at the same moment. The mind, when we enter the sacred pile, is at once under the combined influence of the architecture of the building, the painting of the glass, and of the sculpture of the various figures. But this is not all, and when the solemn tones of the organ are heard, and the "service of song" floats along the vaulted edifice, every avenue of the senses is assailed at once, and how overpowering is the effect: fired with the enthusiasm which the whole scene creates, our thoughts wander from earth to heaven, till we think we hear the song of the heavenly choir above; and when the music ceases, and the chaunt dies away, the mind reverts to its usual channel as if awoke from some delicious dream.

From all this it follows, that a Gothic architect to be successful, and to exercise his calling in anything of an efficient manner, must necessarily be, in a certain sense, a poet. This may be demurred to; but, if there is anything of poetry in Gothic, it must be the case. How is it possible for an architect to exhibit feeling or imagination in his productions, if he does not possess them himself? The inspiration of genius is as necessary to an architect as to a poet or a painter, and those who do not possess it cannot expect to succeed.

Here, I think, we discover the cause of those abortive attempts at church architecture which we have so often to deplore. Men have attempted to build churches with no other idea of Gothic than that it consisted of the pointed arch, and holding the somewhat curious opinion that any building, so long as it contained doors and windows with the pointed addition, must therefore be Gothic. But many even of those who have been pretty well acquainted with Gothic detail, have been utterly destitute of its spirit, and have but put together a fixed set of forms upon a fixed set of principles. As well might some foolish schoolboy, who, because he had become acquainted with dactyles and spondees, imagine that he was then competent to commence writing poetry, and would be able to produce something analogous to the authors he had been reading Yet such has undoubtedly been the case; and all the failures that have of late been made may be traced to this one fact, that the architect has forgotten that he ought to be a poet, and that a building is destitute of the first principles of Gothic art that does not embody the highest species of thought and feeling.

Let us compare for a moment the architects of the present time with those of the middle ages, with whom Gothic originated. The comparison (with respect to the poetry of art at least) is manifestly to our own disadvantage: for, however much our architects may study ancient examples, however well they may become acquainted with them—however able they may be, had they the means, to produce a work equal in point of execution to any old one that exists, we must recollect that the great charm, the great value of a work of art—its novelty, and its originality—is gone. At the very best, our modern works in this style are little better than copies. The mediæval architects, on the contrary, invented and developed their own architecture, and its history is one continued series of progression. There was no standing still, no copying of what had gone before; each new church that was built had in it something different to the last, and their works therefore exhibit that great essential of true art and true poetry—originality. This is what the architect of the present day cannot, or rather does not, possess. He may not certainly descend to dead copying—he may show a certain amount of originality in adaptation, or introduce novelties of design in the more minute parts of the edifice—but the general features remain the same, the essential characteristics are all borrowed. Thus, though a modern architect might show himself imbued with the poetic spirit of art, yet, so long as he will continue to adhere in every important feature to the old models, he can never arrive at perfection. He is, in fact, in a similar position to some poet who takes some author who has gone before him, and does everything in exact accordance with the tutor he has selected. It is obvious, that whatever natural genius such a person might possess, that he would never rise to eminence, and could never produce anything worthy of preservation. Poetry, if it would be poetry, must be original. What should we think of a man who produced an exact parody of the Paradise Lost?—or one who should take book after book, and, appropriating every incident, put it all into his own words? The man might be clever, and his book might be admired as a literary curiosity, but it would want that which is the life and soul of Milton, it would want the one quality which has placed him upon his pedestal of fame—his rich and copious imagination. Our modern architect is exactly in this position; he does not copy we will say each part separately (though even this is done to a great extent), but he appropriates the leading features of those works which have come down to him: and unless he will throw off the trammels in which he has thus voluntarily placed himself, and will attempt to develope a style for himself and for his age, I do not see how he can ever expect to be placed alongside with the great architects of antiquity, as being equally a poet with them.

Assuming for a moment that the cultivation of Gothic art is both desirable and possible at present, we must recollect that circumstances have greatly altered since it was first introduced, and, with respect to architecture, have altered very much to our present disadvantage. The mediæval architects were placed in a position peculiarly favourable to the growth of their art, and very different from that in which our modern architects find themselves. No doubt a considerable portion of those who designed our ancient churches, besides being members of the society of freemasons, were also ecclesiastics; and their position with respect to the church they served, in a double sense would be very different from that of our present secular architects, who in general pursue their calling as a matter of business. This fact is obviously against the development of the poetry of architecture; and it can hardly be expected that a man sitting in his office, and designing as many churches as he can obtain orders for, with the comfortable prospect before him of being handsomely paid for each, can exhibit the true feeling of art, and that art especially of a Christian character. Poetry results from inspiration, and cannot be made to order "on the shortest notice." I do not certainly profess to be acquainted with the secrets of an architect's office, but if I might reason from analogy, I should say that he cannot be less ready than others to accommodate himself to his customers; and I can easily imagine an architect who wishes to increase his connexion, taking into account when getting out his design whether the clergyman in question is puseyite, low church, or anything else, and designing the building accordingly.

Allow me again to express my regret that a country like ours, so pre-eminent for its rapid advancement in the arts of civilised life, should not at the present moment possess a style of architecture peculiarly its own, and developed from its own resources. The architecture of a people should always be the reflection of their habits and feelings; and this is of course impossible with those who borrow from others. This is the grand secret of the success of the mediæval architects: their architecture embodied their own feelings, and was the effect of the peculiar spirit of their age—a spirit which we see to pervade also their poetry, their literature, their painting, and their religion.

This tells us why it is not to be expected that we should succeed in rivalling our ancestors in the walk of Gothic art. We live in a different age; we do not possess those ideas and feelings from which Gothic took its rise; we do not breathe the same atmosphere; we do not live for the same purpose: and it is but folly to attempt to express feelings to which we are strangers, and which are incompatable with the genius of the present age. It matters not how skilled in design an architect may be; if he does not possess the feelings of the ancient designer, it is impossible he can succeed in the same walk with him. Nor do I think it desirable that he should. The spirit which we see in a Gothic building belongs to a past era, to one which I trust we have exchanged for a better; and the present rage for the revival of ancient art, though very alluring, does yet appear upon closer examination to be founded upon false taste and upon false principles.

There is, however, one exception to this rule. There are some people, possibly some architects, who appear so absorbed in the study of the mediæval period, and to be so often poring over the dusty volumes of ancient lore, that they seem at last to have imbibed the spirit and ideas of the age which they study, and to be all but unconscious that they are living in the nineteenth century. These are the men who will probably succeed with the Gothic: but the exception proves the rule, and shows how absurd is the attempt for men mixing in everyday life, and joining in the prevailing sentiments of their age, to hope to succeed in producing similar works of art to those which a preceding generation have left us.

No other proof, I think, is needed, of the inconsistency of Gothic art with the present advanced state of society, than the incongruous effect which is produced when modern sculpture or decoration is introduced into a Gothic church. We see at once that it is out of place; for while painting and sculpture have gradually advanced, till they have almost arrived at perfection, architecture has long since come to a stand-still. The consequence naturally is, that a statue by Chantrey, or a painting by West, however excellent they both may be in themselves, and however superior they undoubtedly are as works of art, they yet produce a jarring sensation in a mediæval building. We feel that they speak a different language, display a different and even opposite spirit, and produce a similar effect upon the eye to that which discordant notes produce upon the ear; while, on the other hand, the painting of the patron saint, with his stiff neck and sprained ancle, or the cross-legged effigy of the crusader,

> "With his mailed hose,
> And his dogs at his toes,"

however imperfect they may be when judged upon anatomical principles, are still felt to be quite in harmony with the rest of the edifice: and it is one of the great evils attendant upon the revival of mediæval architecture, that it necessitates our going back to a stage in art when it was (with respect to sculpture and painting) really in its infancy, and compels us, in order that the accessories of the church may be in keeping with the whole, to adopt the wry faces and uncomfortable positions of the thirteenth and fourteenth centuries!

Still we are placed in a somewhat peculiar position—we do not possess a style of our own, nor can we invent one at a few moments' notice. We have, therefore, no alternative left—we must choose something from what is already in existence; and this is the only excuse which we can plead for the adoption of Gothic. This state of things is nevertheless unnatural, and the sooner it is altered the better it will be for the success of the art; but we must make the best of our present position, and select that description of architecture which is most suited to our wants. I the less regret the alternative, because I feel how well suited is a Gothic building for Christian worship; but I cannot at the same time forget, that had not the development of our own style been checked by the unfortunate introduction of Classic in the sixteenth century, that we should probably have developed a kind of architecture which might have been as well adapted for worship, while at the same time it would have had the advantage of being stamped with characteristics of the existing period, and might have been even more suited for the requirements of modern worship.

It is not yet too late to amend; and it should be our endeavour, by being more original, by throwing off those conventionalities which at present so fetter design, to strike out a path for ourselves. Until this is accomplished, we never can expect to see the true poetry of art developed. And if the present system of borrowing and copying is continued, the art will sink lower and lower in the public estimation.

ON SOME PRINCIPLES TO BE OBSERVED IN ORNAMENTING CHURCHES.

By Rev. T. Chamberlain.

[*Paper read before the Oxford Architectural Society, Feb. 4th.*]

The paper commenced with disclaiming any intention of vindicating the practice of ornamenting churches, and assumed that there being certain parts of a church, as walls and windows, roofs and floors, which admit of decoration, it must necessarily be an object of consideration with every one who desires to promote God's glory, how he may best adorn them. The modes of ornamenting in common use were said to be—1, illuminated lettering; 2, symbolical devices; 3, colouring for its own sake; 4, pictorial representation of persons and events. Of these, Mr. Chamberlain objected to the one first named in every place, save that where it is ordered by the canon—that is, for exhibiting the decalogue over the chancel arch, where, he observed, it is really used *symbolically*, as suggesting the thought of the general Judgment, which used of old to be represented there in a picture—a custom which was probably ordered to be discontinued, mainly on account of the gross manner in which in a corrupt age it had come to be caricatured. The present indiscriminate use of the sacred monogram, the evangelistic and other emblems, the writer also very strongly deprecated, recommending in all cases where it can be resorted to—as in windows, frontals of altars, and walls—designs of figures; and where this is beyond the reach of the artist, or the means of the church builder or restorer, the employment of colour for its own sake, in diaper or arabesque, or even the use of hangings of cloth. These principles he then applied to the several parts of a church which are most commonly destined to receive ornament. For an east window he recommended the Crucifixion as the best design; for side windows figures of saints or other subordinate subjects; for an altar-cloth, *Agnus Dei;* for a dorsal behind the altar, a slab of slate to be painted in rich colours. Of this kind one had been recently put into the church of Kidlington, which, though with some fault of detail, was spoken of as very effective. Commendation was also bestowed on a large triptych, or frame of oak, recently erected in Merton College Chapel for the reception of an ancient altar-piece representing the Crucifixion. The use of plates of zinc here, as in all other parts of a church, was strongly protested against; as also of niches and arcades containing nothing. Attention was also drawn to the very poor effect produced by delicately-chiselled stone (as in St. Giles's Church, and Garsington), or by encaustic tiles (as in the new church of St. George), in all of which, at a very little distance, the pattern is lost in a general indistinctness. In tiles for the floor, as well as carpets, kneelers, and other common ladies' work, the sacred emblems should be used, it was suggested, very sparingly.

At the conclusion of the paper, Mr. Parker rose to suggest the employment of the revived art of mosaic-work for providing dorsals to altars. He also noticed that in parts of France great use was made of different coloured stones—a practice in which, it was observed by some one present, that Mr. Parker's recommendation had been anticipated by the distinguished architect of All Saints', Marylebone.

It was announced that several communications had been received by the secretaries, among which a letter from the Rev. T. Woodrooffe was read, announcing that the desecration of one of the chapels of Winchester Cathedral, which has obtained some notoriety, was about to be in part, at least, if not wholly removed by the Chapter.

APARTMENT HOUSES.

A House, to be let out in Apartments for Families, Hotel non Garnie,—at Vienna.

Professor C. F. L. Förster, Architect.

(*With an Engraving*, *Plate* XII.)

The abolition of the window-duties has, as we have already pointed out, opened to architects the opportunity of raising large structures in the streets of our great towns, similar to the hotels of Paris and Vienna. Formerly such structures were impossible, as the increase *pro ratâ* of the window duties gave a premium to the construction of single, or, as they are called in Scotland, self-contained dwellings. Thus, even in Edinburgh, with the example of the old large houses before them, the modern town is chiefly constructed on what may be called the English plan. A change is, however, at hand, more particularly in London, where ground-rent in the best situations being very high, and shop-frontage valuable, it will become desirable to raise large houses of several stories, having a common staircase and approaches, by which space may be economised.

The towns of middle and north Germany possess many remarkable examples of domestic architecture in various styles; but it is otherwise in Vienna, one of the oldest and principal German towns, where the Romanesque and Gothic styles are so well represented by St. Stephen's Cathedral, the Maria Steigen Church, and monuments in the neighbourhood at Klosterneuburgh, Tuln, Wiener Neustadt, and Petronell (Carnuntum). Vienna, however, has no domestic example of the several styles till the end of the seventeenth century: even from that time till the middle of the eighteenth century, the architecture of Vienna is chiefly represented by its palaces. Continual war, and other political events, frequent conflagrations, and even earthquakes, but principally the condition of Vienna as a fortified town, were the chief causes of this state of affairs. In 1814, Francis I. relieved Vienna from what may be called the state of siege.

It must, however, be borne in mind, that formerly dwelling-houses, unless favoured by a good situation and fitted like barracks, did not give a good and safe return on the capital; that the circumstances of the citizens, which formerly were very narrow, did now allow of considerable enterprises; and that the architects of the day did not extend their studies much beyond a little mathematics, and learning by heart the rules of Vignola, —and with such practice as they got, their utmost achievement was a massive palace covered with incongruous stucco ornament.

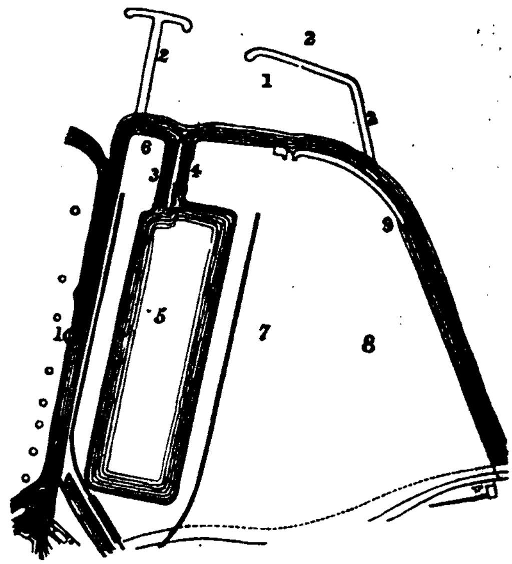
A chief cause of improvement was a new building law for Vienna, defining the requirements for fire-police and sanitary purposes, and, like our building acts, giving directions as to the several parts of the structure. It resulted, however, in a very favourable effect on house property as an investment, and greatly improved the town. The fire assurance is provided for, rent is payable half-yearly in advance, or in some suburbs quarterly, with the right of the landlord to levy a distress on the goods of defaulters. Other circumstances were likewise favourable to improvement, as the increasing wealth of the citizens, the establishment of large brick manufactures in the neighbourhood of Vienna, whence 130 millions of bricks are yearly produced, ready access to materials of all sorts, and the introduction of a better taste in architecture and greater constructive knowledge. These latter branches of education were much behind in Vienna, when in 1818, Peter Nobile introduced in the Academy a profound study of the classic antique, and of the period of the Renaissance, and contributed essentially to the encouragement of the plastic arts. The Viennese too having a susceptibility for art, the result has been a very great progress in architecture, and a material improvement in the aspect of the town, which greatly impresses the beholder. Much has been likewise done for widening narrow streets, for extending the drainage, laying down pavements, and supplying the town with water and gas.

Notwithstanding this progress, there was still wanting a consistency of treatment, and a solidity of character, for, except the Gothic churches, which show the material throughout, the buildings are in a mixture of styles with stucco ornamentation. It is not, however, to be denied that there is some character in the mass of the structures, and that the interiors present some excellent arrangements, while great constructive skill is displayed and the solidity of the edifice secured.

Of late a desire has arisen for higher artistic treatment and a more monumental character, and a decided improvement is to be noticed. The work we present to our readers is remarkable for simplicity and breadth, with a degree of ornament which greatly contributes to its graceful appearance. It shows the elevation of a house at Vienna, constructed by Messrs. Förster and Hansen, the ground-floor to be occupied as shops, and the other floors as private dwellings. We purpose next month presenting our readers with the plans, which will better display the extent and arrangement of the building.

GREAT GRIMSBY DOCKS.

After six years of arduous labour these works are nearly brought to a completion. No fewer than 140 acres of land have thus been added to the occupation of man; and there, by the happy union of science, capital, and labour, has been founded the finest harbour of the eastern coast of England. Our readers will be able, by means of the annexed engraving, to form an estimate of the immensity and importance of the undertaking.



1, entrance basin, of an area of 19 acres

2, 2, are piers which protect it, and on which vessels, which do not require to enter the docks, may at any time land passengers. This entrance basin will be accessible at all times of the tide, for the largest vessels, and will afford the most complete security.

3, is a great lock, 300 feet long and 70 feet wide, made purposely to allow the largest war steamers to enter the dock. This lock was made by special stipulation with the Admiralty.

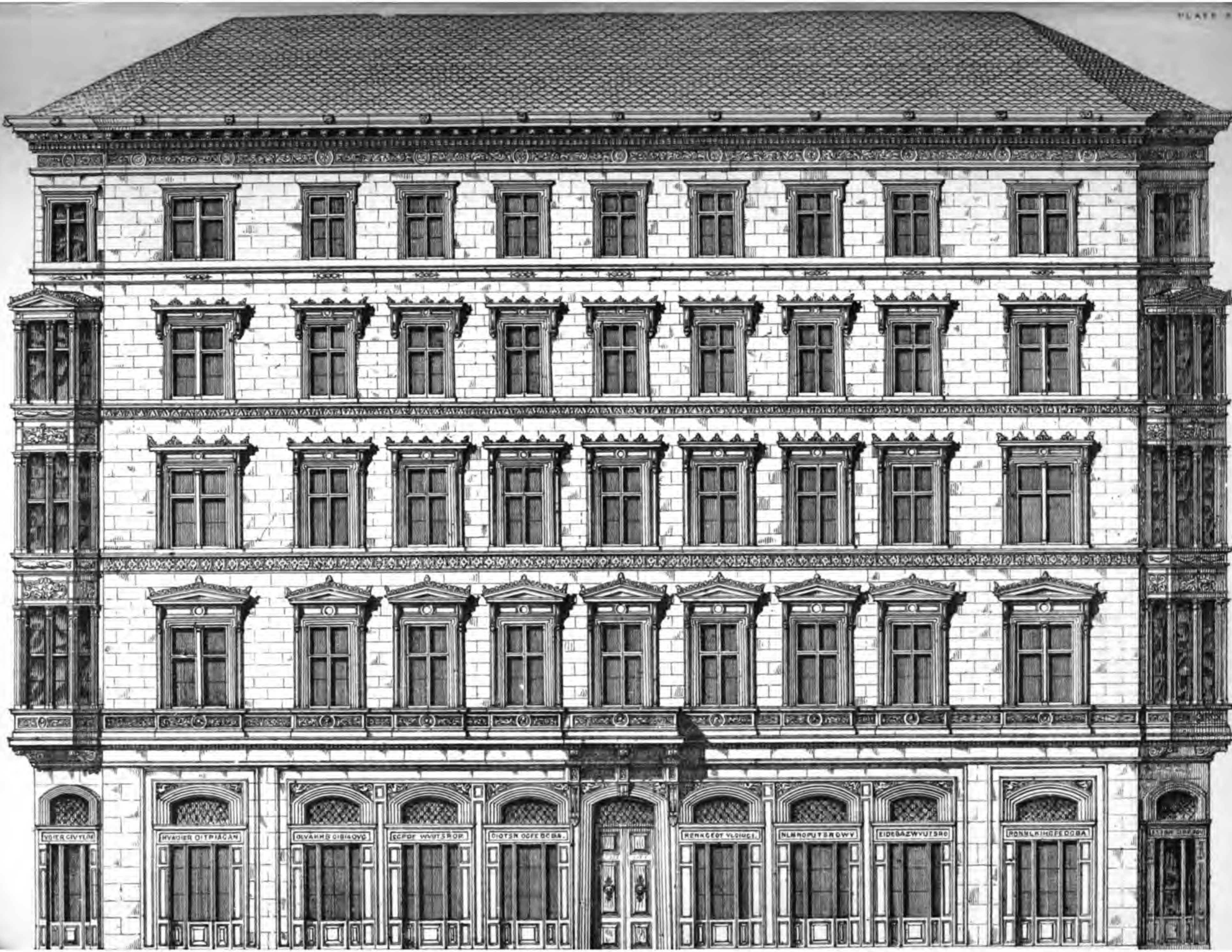
4, is the smaller lock, 200 feet long and 45 feet wide, which will admit into the dock all ordinary vessels.

5, is the great dock, 2000 feet long by 580 feet wide. Its area is 29 acres. The depth of water at its gates is such, that the largest steamers employed in the coasting trade may enter or leave it in any state of the tide. The largest war steamers may go in and out during twelve hours out of the twenty-four, and may here obtain ample supplies of the purest fresh water, which rises in the utmost abundance from the chalk formation. This is a consideration of the highest importance to all steam vessels. In this dock steamers will be two hours nearer the sea than at Hull, and merchant ships of the largest burden may come in with the first of the flood tide, and leave at high water with the ebb tide, which will carry them well out to sea. In contrary winds the contiguity of the docks to the sea will economise the cost of steam tugs. The docks, as a railway station, are more valuable than any inland station can possibly be, for by means of them, all Europe as it were is made a part of the terminus of the railway.

6, is the west wharf, 200 feet wide, with rails laid down to its extremity. The area of this wharf is 12 acres.

7, indicates the east wharf, 2000 feet long, and 670 wide; on this wharf, also, rails are laid. This wharf has an area of 42 acres. It is occupied by warehouses and a goods station.

PLATE XI



8, the one-third of the area inclosed reserved by the Crown is on this side, which the company now proposes to buy.

9, represents the eastern wharfage and embankment against the sea.

10, is the line of access to the old docks.

Sheds are close to the quays 750 feet in length, and 50 feet in breadth, affording a covered area of 4000 feet; and a vaulted warehouse 150 feet square, for free and bonded goods. The arrangements for the passenger traffic and light or perishable merchandise are on the most complete scale, the railway extending to the edge of a low-water landing-stage in the outer tidal basin, where a station is built, provided with accommodation for passengers, who, without leaving the cover of the station, may be carried by trains in attendance, as goods also may, to any part of England or Scotland. For the transit of passengers, a pier, 1500 feet in length, to the end of which the trains run, extends into the river; passengers can descend on a covered platform, and passing through two iron tubes to a floating iron pontoon, go on board steamboats fitted, after the American fashion, with decked saloons, which lie alongside.

The most complete arrangements are made for the convenience of business at the wharfs. A striking feature is a tower called the Lighthouse tower, the principal purpose of which is to furnish a column of water for the hydraulic machinery, to work the dock gates, cranes, &c., and to display lights for the benefit of the seafaring man. It is a square, red brick tower, to be raised to a height of 300 feet; at a height of 230 feet a tank is placed, holding 49,000 gallons of water. The walls of the tower are 4½ bricks thick.

So little now remains to be done, that the piles of the cofferdam, which interpose between the lock-gates and the sea, only require to be removed to give access to the dock. While this is being performed, the dock will be filling with fresh water from the springs in the chalk, and the purity of this source of supply will be found to be an immense advantage in keeping the dock free from mud.

The Great Grimsby roads afford the only refuge between the Thames and the Frith of Forth. The old dock was purchased by the Manchester, Sheffield, and Lincolnshire Company, when they decided on their "water terminus." It has an entrance-lock of 150 feet in length and 37 feet in width, with 18 feet on its sill at high tide. In 1845 they obtained an act for the new dock, and the first stone was laid by Prince Albert on the 18th of April, 1849. The undertaking has been carried out from the beginning by Mr. Rendel, engineer-in-chief; Mr. Adam Smith, the resident engineer; and, for the last three years, by Messrs. Hutchings, Brown, and Wright, the contractors. The principal portion of the stone used has been brought from the Auston quarries. The total cost of the docks will be 750,000*l.*

THE NEW NORTH DOCKS, LIVERPOOL.

The works attending the construction of the Huskisson and other docks on a large scale are, the *Liverpool Albion* states, fast approaching to a state of completion. The Huskisson Dock, which is one of the largest in the world, is constructed for the accommodation of ocean steam-ships. The locks at the south end are finished. The dock itself is ready to receive vessels, water having been let in at the last spring tides; and workmen are busy paving the pier and parts of the quay, and constructing the locks at the north end. Large as are the Bramley Moor, Nelson, and other of the north docks finished in 1848, they are outrivalled by this new evidence of what the genius and enterprise of Liverpool can effect. The width of the east lock-gates is 80 feet—10 feet wider than the lock-gates of any dock hitherto constructed at this port; the west lock-gates, 45 feet. The water area of the dock, 14 acres 3451 yards, with quay space to the extent of 1122 yards. The water area of the east lock, 4682 yards, with quay space of 342 yards; and water area of the west lock, 3650 yards, with quay space of 330 yards. No sheds have at present been erected on the dock quay, which is still in an unfinished state; but sheds have been constructed on the lock quay, where arrangements have been made for unloading vessels, and for the reception of cargoes. A large space of the west end of the lock quay is set apart for a timber-yard, and the remaining portion, by the side of the lock, will be used as the sites for sheds for the reception of dry goods.

The total water area of the wet docks, along the margin of the Mersey, belonging to the corporation of Liverpool, is now 177 acres 3684 yards, with a quay space of 12 miles and 1412 yards; and of dry basins, an area of 20 acres 892 yards, with quay space of 1 mile 712 yards; making a total of 197 acres 4576 yards of water area, and 14 miles 712 yards of quay space; with a length of 5 miles and 20 yards of river-wall. The extent of these docks, the gigantic nature of the works, and the approved principle of their construction, have obtained a world-wide fame, and our transatlantic neighbours deem it no dishonour to apply for a plan of our dockyards, of the principle and construction of which they express their unqualified admiration. But dock building here has not ceased; others are yet to be formed. The appearance of a considerable extent of land, north of the Huskisson Dock, and stretching some distance beyond the Bootle landmarks, is to be changed, not by the mutations of time, but by the scientific energy and laborious application of man. Dock after dock will be constructed, until the unrivalled line is completed. The piece of land to which the next dock to be built is to give "a local habitation and a name" is already distinguishable by an extensive excavation.

The walls surrounding the Huskisson Dock, as well as the other north docks which have recently been constructed, and the Norman-like towers, to serve as offices for the gate-keepers, are built of granite, and combine considerable beauty and neatness with extraordinary durability and strength.

On the large tract of land in the neighbourhood of the new docks, buildings of various description are rapidly springing up, and excellent shops, private dwellings, and public-houses, in a half-finished state, may be seen in progress in almost every direction. Not the least interesting feature of that locality will be the new fort, in the course of erection.

REVIEWS.

FIREARMS AND PROJECTILES.

1. *Observations on the Past and Present state of Firearms, and on the Probable Effects in War of the New Musket.* By Colonel Chesney, D.C.L., F.R.S., Royal Artillery. London: Longmans. 1852.
2. *Projectile Weapons of War and Explosive Compounds.* By J. Scoffern, M.B., F.S.A. Second Edition. London: Cooke and Whiteley. 1852.

Events of recent occurrence, but which we are not called upon to discuss, have caused the earnest attention of all classes of this empire to be directed to the efficiency—or rather non-efficiency, we should say—of the weapons with which we arm the defenders of our liberty and nationality. The full light of public scrutiny which has thus been brought to bear upon what may be termed the mechanical engineering of military boards, has demonstrated, most conclusively and painfully, that in spite of the immense sums annually expended—directly under the head of Ordnance, and indirectly in numerous other channels—the arms of our troops are worse, in every important respect, than those of any civilised nation;—that while France has been carefully testing her Minié rifle and adopting it among her soldiery, Prussia her Zündnadelgewehr, America her revolvers, Austria her rockets, and even little Norway her Jäger rifle,—the three kingdoms, or rather those who are entrusted with and paid for their defence, have remained stationary amid the general progress of other nations; or, if any slight improvements have been adopted, they have been with evident distaste, and so dilatorily that before they have become general they are superseded by fresh ones: so that a British soldier in face of any one of his continental rivals, during the last thirty years, would find himself as inferior in the means of attack and defence as were his ancestors before the warriors of Louis XIV. armed with the invention of Marshal Catinat—fixing the bayonet as at present instead of in the muzzle of the musket.

To account for the dislike to improvements and the apathetic indifference to the fatal consequences of neglecting them which pervade the councils of our military authorities, is a psychological problem beyond our powers to solve—unless, indeed, it springs from an exaggerated feeling of *esprit de corps*, which, in moderation, is to be encouraged and commended. Whatever may be the origin of the sentiments which induced the shameful neglect of the security of England, we shall not pause to determine. It is sufficient to record the fact, which doubtless many of our readers can corroborate from personal experience. But, conscious as we have long been of the indifference with which military gentlemen have invariably treated suggested improvements of civilians, we were certainly not prepared to hear that they exercised as great indifference and contemptuous disregard for improvements submitted by brother officers. The author of the work that heads this notice—Colonel Chesney—whose previous writings upon the subject, and exertions in the Euphrates expedition, entitle him to a patient hearing, and his opinions to respectful attention, was summoned before a House of Commons' committee in 1849, and, as in duty bound, stated what alterations he deemed needful in the regiment of Artillery. That no improvements might be effected, and the evidence of an able and studious officer deprived of whatever weight it otherwise would have, Sir H. D. Ross, K.C.B., did not hesitate to say that "he [Col. Chesney] has had no experience in the field, and therefore, I presume, is not very competent to give his opinion against those who have." As if the mere act of smelling gunpowder, fired in earnest, made a man competent to decide in matters purely within the domain of physical and administrative sciences. Hear this, inventors; waiters on the decisions of military boards of examiners!

So patent to all people have now become the supineness of our authorities, and the inefficiency of the arms of our soldiery, that the press is teeming with publications suggesting the reorganisation of our military system and the improvement of our arms, so at least as to put us upon an equality—not numerically, but in every other respect—with whomsoever may presume to disturb the peace of Europe. From the numerous works on this subject we have selected for review the "Observations," by Col. Chesney, and the *brochure* by Dr. Scoffern; not only because they treat more fully than the others of matters that come more immediately within our province—the mechanical construction and nature of firearms—but also because they bear unmistakeable evidence of being written in an earnest spirit, and display a thorough knowledge of the subject.

Into the antiquarian portions of both works, which are well written and contain a variety of interesting and carefully collected details, we do not propose to enter, but will content ourselves with taking, as a *point de depart*, that state of efficiency to which the British musket (and its ounce ball ranging to 150 yards) has been brought after thirty years' peace, and contrasting it with the more recently improved "projectile weapons" of our neighbours — the Minié rifle-musket and the Zündnadelgewehr.

The Minié Rifle-Musket.

The construction of this weapon presents no essential difference from the ordinary rifle, with the exception of the sights, which are calculated for distances of 800 yards, and even beyond up to 1000. This enormous range is attained by the peculiar construction of the ball, which Col. Chesney thus describes.

"The ball is rather smaller than the bore, and consists of a cylinder having three channels cut round the surface near the extremity, the other end of the missile being like a fir-cone. A cylindrical hollow orifice is cut into the centre of the ball, which extends from its base almost to the apex. Before placing the ball into the piece, a small capsule or thimble of sheet-iron is placed in the aperture level with the base of the ball, and paper being rolled over it, this end of the cartridge, with the ball in it, is dipped in grease about half-an-inch. When loading, the soldier bites off the end of the cartridge, shakes the powder into the barrel, reverses the cartridge, and puts the ball with the thimble-end downwards into the muzzle as far as the upper channel; tears off the paper, throws it away, and then rams the ball (with the greasy part of the paper on it and the iron thimble inside) down on the powder, which is as easily done as with the common musket. In firing, the explosion, as a matter of course, forces the iron thimble up into the conical hollow in the ball, before the *inertia* of the ball itself has been overcome, and thus, by increasing its diameter, forces the lead into the grooves of the bore so completely that the whole base of the bullet is exposed to the action of the powder without allowing the slightest windage, or any diminution of the explosive force of the powder, by which so much of the impetus is lost in common rifles.

"Paixhans, in his 'Constitution Militaire de la France,' gives the following as the result of extensive experiments with the new rifled carbine, which only requires $4\frac{1}{2}$ grains instead of 9 of powder to propel a ball nearly double the weight formerly used.

"At a distance of $218\frac{8}{10}$ yards, it was found that a target of rather more than 2 yards square was struck one hundred times in succession with the new musket, and only forty-four times by the old weapon, out of the same number of shots.

"Again, at $655\frac{6}{10}$ yards, which the common musket did not reach, the same target was struck twenty-five out of one hundred shots by the new musket; whilst a field-piece firing the same number only struck it six times.

"And at 1093 yards, when a field-piece usually diverged 6 or 8 yards from the target, the new musket struck it six times out of one hundred shots; and even at this enormous distance, it was found in the case of an experienced marksman that three of his shots out of four took effect on a moderate-sized target, so that in this case art did more than nature, for at 1000 yards none but a good sight could distinguish the object which the musket hit so accurately."

The Zündnadelgewehr.

"The progress of the Zündnadelgewehr, or needle-igniting musket, was, however, slow at first, but the fusiliers being so armed, it gradually became general; and it will probably be used ere long throughout the Prussian army. It combines the use of percussion with that of a particular kind of ball, which being conical at the point, cylindrical in the centre, and round at the larger end, is, as in the case of the French projectile, a good deal heavier than a sphere of the same calibre. It becomes rifled as it passes through the barrel, and is propelled with much greater force than the ordinary rifle-ball, owing to two causes—viz., a suitable centre of gravity, and the more perfect ignition of the powder, which takes place in front, instead of being as formerly at the other end of the charge. This advantage, one of the greatest belonging to the change, is accomplished by means of a metal needle and a spiral spring. The spring serves the purpose of a lock, and by forcing the needle through the charge, the fulminating powder explodes it in a way which will be better understood from the following details.

"The barrel of the Zündnadelgewehr is 34 inches long, and is rifled with four grooves, taking $1\frac{1}{2}$ turn in the length, and has a high backsight; it is screwed into the end of a strong open guider or socket; the chamber properly so-called is bored out in a slight degree conically from behind, so that when the cartridge is placed in it the shoulder of the ball (which is of a particular shape) shall meet, and be stopped by the projections of the ribs of the rifling, the body of the ball being of sufficient diameter to fill the full depth of the grooves. Inside the guider slides an iron tube, with a strong helve or handle attached, and having a space at the front end next the barrel of about $1\frac{1}{2}$ inch in length; in the middle of this space is the needle-conductor, which is pierced with a small hole in its entire length, through which passes the needle that is to ignite the charge. This needle-conductor is screwed from behind into a solid plate of iron left in the tube; and this plate it is which (like the breechpin-piece of the ordinary musket) receives the whole reactionary force of the charge. Behind this plate, again, there is a second tube of iron, having a spring with double-catch attached, and carrying within it an inner small tube, which has two projecting-rings on one moiety of its length, and a spiral spring on the other; and through this tube passes the *needle*, which is a thin steel wire pointed at the end destined to ignite the charge, the other end being screwed into a brass-head, which again screws into the interior tube that carries the spiral spring. The trigger is of peculiar form, with a straight spring having two knuckle-movements acting upon a ball; the first movement fires the gun, and the second admits of the whole mechanism being taken out behind, when the parts can be taken to pieces, cleaned, and put together by a soldier in two minutes, there being no pins whatever, and no screw except that by which the needle is connected with the inner tube, and this is never disturbed except when the needle has to be replaced by a new one.

"The cartridge is made of one thickness, of thin but strong paper. The ball has a paper bottom, with the indentation in its lower end for the priming composition, below which is the powder. The end of the cartridge is formed also of a single thickness of paper; through this the priming-needle is forced by the spiral spring. The needle passes through the whole length of the charge of powder, and penetrates the primer, which it ignites, and consequently the charge is lighted in front, instead of the other extremity as usual; and behind the charge there is an empty space in the sliding-tube of $1\frac{1}{2}$ inch long. To these two circumstances the Prussians attribute the additional range and the slightness of recoil.

"Besides celerity in firing, which without over-exertion extends to about six rounds in a-minute, and entire freedom from windage, by which a range of 800, or, according to some, even 1200 yards is obtained, there are several advantages attending the use of this weapon.

"As already mentioned, a ball, for the same bore, is much larger than that of an ordinary musket, and being formed by pressure, it is more solid, and has, at the same time, a more correct position of the centre of gravity. Having the advantage of being rifled also, it is truer in its flight than the round bullet, especially as the powder is not crushed, as is frequently the case in ramming down an ordinary musket or rifle. Added to these advantages, it receives a greater impulse; and the pasteboard-wadding, which is a part of the cartridge, assists in clearing the barrel from the effects of the previous discharge; and as the soldier can load almost as easily in a recumbent as in an upright position, he need not, when once behind cover, allow any part of his body to be exposed to the enemy's fire. In addition to the preceding considerations, the recoil is less violent, and owing to the simpler and more delicate motion of the trigger, there is much less to prevent a correct aim, so that a very accurate fire is the consequence.

"The objections which have hitherto been imagined are—the liability of the spring to get out of order, the divergence to the right or left to which the steel needle may be liable in passing through the powder, and the probability of missing fire when the needle gets dirty; likewise the escape of gas through the apertures after firing has been continued for any length of time, and finally, the wear and tear of the barrel from the smoke and burnt powder issuing through the apertures at the place of the junction of the cylinder with the barrel.

"The diminished power of the spring by constant use, and the divergency which may be caused to the needle, are serious, but it is hoped not irremediable evils, since both spring and needle may be renewed at a trifling expense. By having a few spare needles and springs, as one of each for eight or ten muskets, or in any other proportion that may ultimately appear desirable, the defects in question would probably be remedied, and efficiency secured; for the liability of the piece to miss fire, and the more serious defect of the escape of gas, only take place (extensively, at least, in the latter case) after some fifty or eighty discharges, so that a general action might be fought before the piece even requires to be cleaned. It is true that the gas escaped with sufficient force to remove a trifling weight placed on the aperture, but this should not be a fatal objection to an instrument of undoubted power and precision of range. Even with a piece from a flint-lock, the escape through the vent is considerable, and at any rate the evil may be lessened if not entirely removed; for since American and other pieces have close fighting breeches, as was shown lately in the Great Exhibition, it cannot be doubted that the skill of our workmen will overcome the difficulty in the case of the Prussian musket."

We have been led to quote the above passage *in extenso*, not only from a desire to afford our readers an opportunity of judging for themselves of the very fair and impartial spirit of Col. Chesney's criticisms and the perfect mastery that he has of the subject, but also because we believe that when the objections to the use of the Zündnadelgewehr, as at present constructed, are fully known, the inventive genius and mechanical aptitude of Englishmen will enable them to overcome or reduce to their minimum effect the difficulties which have prevented the adoption of this otherwise efficient weapon. And we certainly do think that the public are entitled to have submitted to them the reasons which induced the Ordnance to give the preference to the Minié rifle. As regards the latter, we believe it would be materially improved by adopting an invention patented some four years since by Mr. Needham, the gunmaker, which consists in a self-priming apparatus, capable of being adapted to any description whatever of percussion-gun. A water-tight tube-chamber is fitted into the underpart of the stock, in which are contained a hundred or even more percussion-caps. The lock is fitted with self-acting mechanism and a primer, something like the hammer, only that it has a hollow head and interior groove communicating with the tube-chamber. The action is extremely simple. After loading the gun, all that is required is to elevate the muzzle, which causes one of the caps to fall down under the hollow of the primer, which is next brought down upon the nipple (by half-cocking the piece), whereby the cap is projected up the hollow of the primer and deposited upon the nipple, in which position the cap is protected from damp and from accidental explosion. Full-cocking the piece draws the primer back out of the way, and leaves the cap ready to receive the blow of the hammer. By the adoption of this improvement, the objections to percussion-caps would be entirely removed. They would not be liable to corrode from wet or perspiration of the body, as was the case in the Guards lately; nor would soldiers, when their fingers are benumbed and insensible to touch, find any difficulty in priming, as at present is often the case.

There is one point—the usefulness of horse artillery—in which we differ from Col. Chesney. We believe this branch of the service to be very costly, and, in case of future wars, incapable of producing any important effect when opposed to infantry armed with the Minié rifle or the needle-gun; and this belief is borne out by the contradictory evidence of the author himself, for he concurs in the opinion (p. 191) that "recent experience has shown that the requisite speed *cannot be maintained* with heavier guns than 6-pounders. This is also the opinion of a distinguished officer, Sir Robert Gardiner, who has set this question at rest by saying 'that the necessary quick movements of the horse artillery could not be attained by 9-pounders; the telling effect of 9-pounders could not be expected from horse artillery;'" and at page 305 states "that field artillery should mostly consist of 9-pounders, with a proportion of 12-pounder howitzer batteries and some rockets, in order to produce a decided effect on the enemy when still at a distance."

The portions of Dr. Scoffern's treatise which will prove most interesting are those in which he discusses the nature of explosive compounds, and the probability of discovering some new composition which will project a ball further than gunpowder. This he does not deem possible, and ably confutes many of the erroneous opinions respecting the applicability of gun-cotton and fulminating silver, by showing that there is a point where the resistance of the atmosphere will equal the projectile force of the ball; and that, to attain the enormous range of which we have heard some six years since—the long range—it will be necessary to obtain not only gunpowder of the requisite degree of force, but "cannon strong enough to withstand this projectile effort—ball strong enough to resist the shock without breaking." In this respect we conceive the Doctor has done good service, by directing public attention to those points in which improvements can be effected, and which are purely of a mechanical nature—the diminution of windage by the adoption of the expansive ball, as in the Minié rifle-musket; and burning the whole of the charge of powder by igniting it at the top, as in the Zündnadelgewehr, instead of at the bottom, as in other guns, so as to obtain successive increments of force in driving the ball from the gun. We are at a loss to conceive why these two desiderata were not combined in the new army musket, unless it be from the dislike to improvement and progress to which we have before adverted, but which the ex-secretary at war, Mr. Fox Maule, approved in terms which showed his contempt for inventive genius, by designating its productions *new fangled!**

* See debate in the House of Commons on the Ordnance estimate, March 26th.

A Theory of the Negative Sign. By Henry B. Browning, St. John's College, Cambridge. London: Simpkin and Marshall. 1852.

In this case, as a new system is propounded, we shall throw on the author the responsibility of explaining it. He says:—

"The usual method of teaching algebra is first to lay down definitions, purely arithmetical, of the symbols and operations to be employed; symbolical rules founded on these definitions are then deduced and exhibited in their most general form, but the exceptions to their arithmetical application, arising from the limited character of the principles involved, are either concealed or insufficiently explained: thus, in processes having a show of demonstration, the student is led unconsciously to violate the rules of reasoning; and when with notions purely arithmetical he looks for intelligible results, or seeks to verify results obtained, *negative quantities* appear, and he learns, for the first time perhaps, that addition does not necessarily imply increase, that subtraction does not necessarily imply diminution, and that other quantities besides numbers are to be treated by arithmetical rules. Some rough idea of the meaning of isolated negative quantities is then given, and perhaps particular examples to teach the general mode of interpreting negative results, and he is told, and required by experiment to convince himself, that the unconscious use of negative quantities in processes supposed and intended to be arithmetical, does not vitiate the results. He is thus led to regard algebra as a science in which, by some imperfectly understood properties of the symbolical rules, contradictions produce consistencies, and errors in reasoning produce true results; and thus conviction arising from logical deduction is replaced by faith. The object of this work is to lay down definitions at once simple and general, which will not be contradicted by processes afterwards employed, and so place algebra, as far as positive and negative quantities are concerned, on the same logical footing as geometry, or any other science in which no idea or process is admissible which the first principles do not include."

The Art of Figure Drawing, containing Practical Instructions for a Course of Study in this branch of Art. By Charles H. Weigall, Member of the New Society of Water-Colour Painters. London: Winsor and Newton. 1852.

The great fault with most of the authors of elementary works is, that they take for granted that the student knows something of the subject they treat of; but this cannot be said of Mr. Weigall. The little work before us is what it professes to be—a book for the beginner, and as such is very valuable, for the lessons it gives, unlike those found in most books of this class, are not rendered useless nor superseded by advanced study and increased knowledge. We can confidently recommend Mr. Weigall's treatise: he has completely succeeded in his object—not that of giving all the instruction necessary to form a figure painter, but of producing a sound and excellent elementary work.

Railway Machinery, a Treatise on the Mechanical Engineering of Railways; embracing the Principles and Construction of Rolling and Fixed Plant in all Departments; illustrated by a series of plates on a large scale, and by numerous engravings on wood. By DANIEL KINNEAR CLARK, Engineer. London: Blackie and Son.—Parts 7 & 8.

We have already spoken of the meritorious design of this work, and are glad to report its satisfactory progress. It takes a very practical character, and none the less so in discussing some very important points in the theoretical working of the locomotive, in which experience is ably brought to bear. The engravings in these numbers chiefly relate to Crampton's locomotive and Adams's composite carriages, and the text to what is called the Physiology of Locomotives. In this the actual working of several locomotives is resorted to, to afford information; and not merely varied results are given, and tabulated observations, but numerous curves and diagrams showing the operation of each several part of the engine under various conditions. This mode of treatment is entitled to the more respect on account of the evident desire of the author to insure accuracy, so that some slight error having found its way into a portion, the whole of the text in question has been reprinted and supplied to the subscribers.

The Machinery of the Nineteenth Century; illustrated from original drawings, and including the best examples shown at the Exhibition of the Works of Industry of All Nations. By G. D. DEMPSEY, C.E. London: Atchley and Co. 1852.

With the progress of engineering science and its application to many branches of industry, an increased demand has sprung up among the public and professional men for drawings and illustrations of varied machinery. Works on particular departments, as railways, have supplied a great extent of information, but still much ground is unoccupied, and Mr. Dempsey has come forward usefully to meet a great public requirement. The nature of the work will be well enough seen by a reference to its contents. Thus, one of the parts includes Fowler's Patent Drain Plough, Samuel's Patent Locomotive Feed Engine, Sandford and Owen's Double Wheel Lathe, Hopkinson and Cope's Two-Horse Table Engine, and Speller's Artesian Well-Boring Tools. All these are fully illustrated, so that the constructions and working of each part may be well understood; and it will be seen how well this work is calculated to serve the practical man, while it supplies the student of mechanical engineering with copious materials. It is likely to be advantageous to this work that it will meet with purchasers among many of the public interested in special machinery.

Lecture on Electro-Metallurgy, delivered before the Bank of England Library and Literary Association. By ALFRED SMEE, F.R.S., Surgeon to the Bank of England. London: Horne, Thornthwaite, and Wood. 1852.

WE feel that we cannot do better than recommend this book to those of our readers who take an interest in the subject of which it treats. It will afford them the fullest information, together with a considerable amount of amusement. Its literary, apart from its scientific merits, are of a high order, and the illustrations, of which there are many, are of a superior kind.

A Guide to Photography. By W. H. THORNTHWAITE. Twelfth Edition. London: Horne, Thornthwaite, and Wood. 1852.

THE above is the title of a work which has lately appeared, and which is likely to prove very valuable both to those commencing the study and practice of the art and to those who are more advanced. It contains an introductory chapter on optics in its relation to the science of photography, is copiously illustrated with diagrams, and is, moreover, deficient in those technicalties which so often disfigure and render useless works of an elementary nature.

The British Journal. London: Aylott and Jones. 1852.

This is a new magazine, brought out with great spirit, and contributed to by first-rate writers. It will prove a great boon to numbers among the reading community who cannot afford the orthodox price of half-a-crown. It well deserves success, and we venture to predict it will obtain it.

MACHINES AND TOOLS FOR WORKING IN METAL, WOOD, AND OTHER MATERIALS.

By Rev. ROBERT WILLIS, M.A., F.R.S.

[*Exhibition Lecture delivered at the Society of Arts, Jan. 28th.*]

THERE are two very desirable objects which I shall proceed to develope, and which, if we take advantage of the interest excited on the subject of manufacturing science and art by the Great Exhibition, we may possibly succeed in bringing to bear.

The first object is to effect a more intimate union and greater confidence between scientific and practical men, by teaching them reciprocally their wants and requirements, their methods and powers, so that the peculiar properties and advantages of each may be made to assist in the perfection of the other.

The second object is to promote a more universal knowledge amongst mechanics and artizans of the methods and tools employed in other trades than their own, as well as of those employed in other countries in their own and other trades.

With respect to the first object, it is no secret that there has always existed an unfortunate boundary wall or separation between practical and scientific men, a mutual distrust or misunderstanding of their relative values, which has deprived them of many great benefits that they might have mutually derived from each other's pursuits. It is true that in many branches of science, as in chemistry, geology, and botany, this barrier has to a great extent been broken through; the practical man has found the benefit of scientific generalisations, and the theorist has been compelled to seek the facts upon which his theories are to be based in the mines and manufactories; thus compelling the two classes to work together and learn to understand each other. Still there remains too much of the ancient contempt for "theory," and of an overweening and conceited value for "facts" and "practice."

In no department of science is this carried to a greater extent than between the mathematical and practical mechanics; and yet the mental process by which the parts of a complex machine are contrived and arranged in the brain of the inventor requires the geometrical faculty, as it is called, to a very high extent—that is to say, the power of conceiving mentally the relations of the parts of complex figures in space. So that, in truth, a man gifted by nature as a mechanist is also qualified as a geometrician; and the untaught inventor, struggling to give form and reality to his conceptions of a new machine, is, in reality, practising imperfectly and unknowingly the very geometrical science he despises, and which, if he had acquired its elements, would at once have shown him how to systematise and arrange his ideas.

For the system of mathematics, as it now exists, is the accumulated result of many centuries' work of men thus naturally gifted with the geometrical faculty; and the man who now, directing this mental power to the perfection of machines, professes to exercise it "self-taught," is acting on the presumption that he alone can begin from the beginning, and dispense with the labours of those men of mighty intellect who worked so long to prepare a system for those who were to come after them. To ignore such labours is a piece of mighty presumption and a pure waste of intellect, which usually brings its own punishment in the loss of time and imperfection of the result. "Self-teaching," in this sense of determined rejection of the previous labours of others, so far from being a source of pride and gratification, is a piece of folly, to use the mildest term, if it might have been avoided; and a lamentable misfortune, if the sufferer has had no opportunity of knowing what had been already previously effected and prepared by others in the same line.

Of a piece with this is the case of persons who pride themselves upon executing very difficult works with implements not intended for the purpose, such as elaborate carving, which, we are told, was all done "with a common penknife." The experience of carvers of all ages having shown that there are certain forms of chisels and gouges that are proper for this work, a sensible man would certainly not waste his time by using the worst form of a cutting instrument that he could choose for this particular service. So far from admiring, we should pity the vanity and folly of such a display; and the more, if the merit of the work should show a natural aptitude in the workman: for it is certain, that if he has made good work with a bad tool, he would make better with a good one.

To perfect and reduce to practice the idea of a new machine is no light effort of the intellect, and in proportion to the education of the inventor, so will his steps be rendered surer, more direct, and more rapid. As far as the relative motions of the parts of his machine are concerned his natural faculties may carry him, and probably suggest a variety of constructive methods and cunning devices by which these may be effected; but, in the next place, it becomes necessary to select from these the most appropriate to sustain the forces and resistances,—to estimate the strength to be given to the different parts, their proper qualities of weight, of lightness, and stiffness, the amount of friction, and a variety of other complex conditions which can only be determined by statical or dynamical knowledge, but which are necessary to insure the durability, easy and economical working, and practical value of the contrivance.

In the absence of the proper technical knowledge of theoretical mechanics, the proposed machine, if it possess any value, will only arrive at its perfect and permanent form through a series of abortive attempts, which, by a succession of failures and repairs, may perhaps lead to the removal of the weak points of the contrivance. Those parts which by chance were made unnecessarily strong and heavy, will probably retain their original errors.

The representations of machines and engines in the collections published in the sixteenth and seventeenth centuries, furnish abundant illustration of these remarks. In all that belongs to the mere motion of these contrivances, the greatest possible ingenuity and fertility of invention is displayed. But in all that concerns construction, framing and adaptation of form and dimensions to resistances, strains, and the nature of the work, a total absence of principle and experience is manifested; so that it is apparent that these machines would act very well in the form of models, but that, if actually set to work, the most of them would knock themselves to pieces in a very short time.

A profound knowledge of theoretical mechanics is not necessary for all persons concerned about machines, any more than an elaborate acquaintance with the entire subject of astronomy is needed by every sailor. Yet sailors have no horror of mathematics, and know very well how to make use of the parts that are prepared for them. And all men who are engaged in the contrivance of machinery, whether in reducing to practice their own inventions, or those of others, should be competently instructed in the elements of the subject, as well as in the history of machinery; and the artizans themselves would find their labours greatly facilitated by a knowledge of geometry and mechanics to a limited extent, proportioned to their requirements.

We may hope that one of the permanent results of the Exhibition may be, that men's minds being more forcibly led to the consideration of the subject, a system of professional education for practical men may be organised, so as to enable every one to obtain just so much as may be necessary for him in his own position.

The preparation of such a system of education is difficult, and requires great care to avoid the error of teaching much that is unnecessary, and that, in fact, cannot be comprehended, unless by a student who intends to devote much more time, and to enter much more profoundly into those branches of study than is contemplated for the purposes we are now considering. But we know that difficulties of this kind have been already encountered, and, as it appears, successfully overcome in France, after failures had taught experience.

I have already said, at the outset of these remarks, that not only do practical men require theoretical knowledge, but that, also, theoretical men require practical knowledge, a better acquaintance with the difficulties that practice requires them to lend a hand in developing, explaining, and overcoming. To form a system of education, strictly limited to the requirements of practical men, we must know what these requirements are, and must in imagination place ourselves in the position of these men, to understand the difficulties arising from their occupations, which theory may dispel. We must, in short, select the examples and illustrations of our applied mathematics from the familiar cases of actual machine-work, and endeavour to solve them with the least possible amount of geometry. It may be worth while to consider a little how this may be attempted.

Every machine is constructed to perform a certain specific operation, and accordingly contains parts especially applied to the work in question; which working parts are connected by the mechanism in such a manner that each shall move according to the law required by the nature of the work. One, perhaps, constantly revolving slowly; another rapidly; and a third, back-and-forwards, and so on. But the connecting mechanism by which these different motions are tied together may be varied in many ways, and each is common to all machines that happen to require similar co-existent motions in their working parts.

The nature and principles of trains of mechanism, by which dissimilar motions may be thus produced, the one from the other, can be taught without any reference to the work or purpose of machinery, and is, indeed, best so taught. But to illustrate and fix the teacher's meaning, it is well to show examples of the application of each motion to some real machine.

Now it must always be recollected, that the merit of a piece of mechanism may be exceedingly great, if considered as an example of *pure mechanism*—that is, of the ingenuity or profound knowledge displayed in the conversion of one motion into another, although the purpose of the machine to which it happens to be applied may be very trivial. But this is not the way in which the world would judge of machinery; and yet combinations of pure mechanism that form the essential parts of the most useful and valuable machines in the manufacturing series, were originally invented for purposes of the most trivial and useless character.

The *differential-box* of the bobbin-and-fly-frame was first contrived for an equation clock—that is, to enable the hand of a clock to move round the dial in such a way as to point to the true time as shown on a sun-dial. The *slide-rest*, as we shall presently see, was contrived towards the end of the last century, to enable the amateur turners of the court of France to ornament their snuff-boxes with more precise patterns of guilloche-work. The motions of a mouse-trap may be found in a steam-engine.

Now, in showing the practical application of any given combination of pure mechanism, one machine will do as well as another; but it is better to select one whose purpose and functions are likely to be readily appreciated by the student, that his attention may not be too much distracted from the *mechanism*. Thus, if I were teaching a mathematical student the differential motion, I should select the equation clock as the example, because its purpose depends upon an astronomical principle which forms part of his proper studies. But if I were teaching a mechanist, I should rather take the bobbin-and-fly-frame for my example.

In forming a system of instruction for practical men, therefore, we may, by a more practical selection of examples, be enabled to teach the principles of mechanics, without greatly altering our present methods. It is true that our theoretical writers are rapidly introducing examples of the actual machinery of our own time into their systems, still these books are necessarily rather intended to teach machinery to mathematicians than to teach mathematics to mechanists.

It may be remarked that, at least in one branch of mechanics, the "strength of materials," the value of theoretical and experimental science has been fully recognised by practical engineers, and the Britannia-bridge may be quoted as a triumphant example of the advantages that arise when theory and practice go hand-in-hand.

The object of machines for working in metal, wood, and other materials, is to work rough material into shape, which may be done in three different ways: (1.) By abrading or cutting off the superfluous portions in the form of chips or large pieces; (2.) If it possess ductility, we knead it, or press it into form in various ways, as by hammering, rolling, drawing, &c.; (3.) If it be fusible, we melt it, and pour it into a mould. I forbear to include the producing a given form by joining together pieces, because each piece must be shaped in one or other of the above ways. The most interesting series of machines is that which belongs to the first group; and to this I must, for the present, confine my attention. It may be interesting to sketch the history of their introduction. Machines of this kind are either general, like the lathe or the planing-machines, which are used for a great variety of purposes, or are especially adapted to the production of a single object of manufacture; in which case they are often contrived in a series, as the block-machinery, the machines for making cedar pencils, and the like, and the introduction of such especial machines is of great importance, and has certainly not yet reached its limits. As the machines of this latter kind are commonly modifications of one or other of the first, the history of the two must be considered together.

The origin of the turning-lathe is lost in the shades of antiquity, and the saw-mill, with a complete self-action, turned by a water-wheel, is represented in a manuscript of the 13th century at Paris, and is probably of much earlier contrivance. The lathe was, in process of time, adapted to the production of oval figures, twisted and swash-work, as it is called; and lastly, of rose-engine work. The swash, or raking mouldings, were employed in the balusters of staircases and other ornaments at the period of the Renaissance in architecture, about the end of the sixteenth century, and therefore the swash-lathe assumes somewhat of the character of a manufacturing machine. But the simple lathe was much employed in screen and stall work during the middle ages. The first real treatise on turning is Moxon's (1680), which gives us a valuable picture of the state of the art at that period; and he has preserved to us the name of the engine-manufacturer of that day, Mr. Thomas Oldfield, at the sign of the Flower-de-Luce, near the Savoy, in the Strand, as an excellent maker of oval-engines, swash-engines, and all other engines, which shows that such machines were in demand. A few drawings of such machines occur in earlier works, beginning with Besson, in 1569. From the treatise of Plumier, published at Lyons in 1701, we learn that turning had long been a favourite pursuit in France with amateurs of all ranks, who spared no expense in the perfection and contrivance of elaborate machinery for the production of complex figures. This taste continued, at least, up to the French revolution, and contributed in a very high degree to the advancement of the class of machinery that forms the subject of our present lecture. In our own country the literature of the subject is so defective that it is very difficult to discover what progress we were making during the seventeenth and eighteenth centuries. A few scattered hints only can be collected, whereas in France the great 'Encyclopédie' and other works, abundantly illustrated, give the most precise and accurate knowledge of the state of this and other mechanical arts.

Smeaton has recorded that, in 1741, Hindley the clockmaker of York showed him a screw-cutting lathe, with change-wheels, by which he could, from the one screw of the lathe, cut screws of every necessary degree of fineness, and either right or left handed. It seems to be implied that this was a novelty, and that Hindley had invented it; and it was soon imitated by Ramsden, and is now universal. At all events, such a machine is not alluded to in the French works already mentioned, and serves to show the advance we were then making in the practical improvement of the lathe.

But the clockmakers, to which body Hindley belonged, were the first who employed *special machines* for their manufactures. Their *wheel-cutting engine* has been ascribed to Dr. Hooke, about 1655, and its use rapidly spread over the continent. The gradual improvement of this machine, and the successive forms which it assumed as the art of construction was matured, forms a very instructive lesson. But herein our own countrymen have largely contributed to its perfection. Henry Sully, an English clockmaker, who removed to Paris about 1718, carried with him, amongst other excellent tools, a cutting-engine, which excited great admiration there. The form of the present French engine is, however, derived from Hulot's machine (about 1763). But our English engines, in which the dividing-plate is superseded by a train of change-wheels, so contrived as to require an entire turn of a latch-handle for each shift, and thus secure against error, is derived from Hindley's engine, which he showed to Smeaton in 1741, and which finally passed into the hands of Mr. Reid of Edinburgh.

The *fusee-engine*, which is another special clockmaker's machine, must have greatly contributed to the perfection of machines for working in metal.

But the next great step towards the perfection of machine tools was the *slide-rest*. The slow and gradual way in which this invaluable device acquired the distinct and individual form in which it now exists, is a very curious example of the history of machinery, the development of which at length would occupy too much space on the present occasion, even if it could be made intelligible without drawings. Suffice to say, that although as early as 1648 Maignan published at Rome* drawings of two curious lathes for turning the surfaces of metallic mirrors for optical purposes, in which the tool is clamped to frames, so disposed that when put in motion it is compelled to move so as to form true hyperbolical, spherical, or plane surfaces, according to the adjustment, and that although the fusee-engines, screw-cutting lathes, and other contrivances already alluded to, employed tools guided by mechanism, yet the real slide-rest does not make its appearance until 1772, when in the plates of the French 'Encyclopédie'* we find complete drawings and details of an excellent slide-rest, as nearly as possible identical with that usually supplied by Messrs. Holtzapffel and other makers of lathes for amateurs. It must have been contrived a little while before this publication; but the meagre descriptions that accompany the plates leave us completely in the dark with respect to its history. Bramah's slide-rest of 1794† is so different and so inferior in convenience that the two could not have had a common origin; and we must suppose that the French slide-rest was unknown to that ingenious mechanist, although it is scarcely possible that copies of the 'Encyclopédie' should not have found their way into our libraries.

But the improvements of the steam-engine, its application to giving motion to the wheels of mills and other machines, the increasing employment of iron, and other advances in the construction of mechanism which were now developing themselves, gave men courage to devise and carry out large and extensive schemes for the application of machinery to manufactures. In our especial department we may record, as an early example, Bramah, who in 1784 obtained the patent for his admirable lock, and immediately set about the construction of a series of original machine tools, for shaping with the required precision the barrels, keys, and other parts of the contrivance, which, indeed, would have utterly failed unless they had beeu formed with the accuracy that machinery alone can give. In Bramah's workshop was educated the celebrated Henry Maudslay, who, as I am informed, worked with him from the year 1789 to 1796, and was employed in constructing the principal tools for the locks.

Foremost among the ingenious persons who carried on this great movement must be recorded Brigadier-General Sir Samuel Bentham.‡ From his own account it appears, that in 1791 steam-engines in this country were extensively employed for pumping mines, and for giving motion to machinery for working cotton, and to rolling-mills, and some other works in metal; but that in regard to working in wood steam-engines had not been applied, for no machinery other than turning-lathes had been introduced, excepting that some circular and reciprocating saws and working tools had been applied to the purpose of block-making by the contractors who then supplied the blocks to the navy; even saw-mills for slitting timber, though in extensive use abroad, were not to be found in this country.

General Bentham had at this time made great progress in contriving machinery for shaping wood, as is sufficiently shown by his remarkable specifications of 1791 and 1793; and he informs us that, rejecting the common classification of works according to the *trades* or *handicrafts* for which they are used, he *classed the several operations that have place in the working of materials of every description according to the nature of the operations themselves*, and, in regard to wood particularly, contrived macbines for performing most of those operations whereby the need of skill and dexterity in the workman was dispensed with, and the machines were also capable of being worked by a steam-engine or other power. Besides the general operations of planing, rebating, morticing, sawing in curved, winding, and transverse directions, he completed, by way of example, machines for preparing all the parts of a sash-window and of a carriage-wheel, and actually showed these and other machines in a working state in 1794 in London.

This led to his appointment as Inspector-General of Naval Works, for the purpose of introducing these and various other machines into the royal dockyards, which he immediately set about effecting. From this time (1797) the introduction of machinery for the preparation of blocks and other works in wood at Portsmouth, Plymouth, and other government establishments, takes its origin. In 1802 the General received a most powerful and efficient auxiliary in the person of Mr. Brunel, who in that year presented his plans for the block-making machinery. His services being immediately secured, and Mr. Henry Maudslay engaged for the construction of the mechanism, the admirable series of machine tools were finished and set

* 'Perspectiva Horaria,' p. 689.

* Tom. x. pls. 37, 38, 84, 85, 86.

† Weale's edition of 'Buchanan's Mill-work.'

‡ Bentham's patents. 'Repertory of Arts,' vol. v., p. 293., and vol. x., pp. 221, 293, 367; also Memoir, by Mrs. Bentham, in Weale's 'Quarterly Papers on Engineering,' vol. vi.

to work in 1807, by which every part of the block and its sheaves are prepared.

The completeness and ingenuity of this system, the beauty of its action, and the novelty of the forms and construction of the whole of the mechanism, excited so much admiration that the whole of the machinery in Portsmouth dockyard has usually been popularly ascribed to Mr. Brunel alone. It must not be forgotten, however, that much machinery for the performance of isolated operations had been previously employed, as well by Mr. Taylor of Southampton, the contractor for the blocks for the navy previously to 1807, as by General Bentham himself in the dockyards.

At this distance of time it would be impossible to discover the exact shares of merit and invention that belong to Brunel, Bentham, and Maudslay, in this great work. To the first we may, however, assign the merit of completing and organising a system of machine tools, so connected in series that each in turn should take up the work from a previous one and carry it on another step towards completion, so that the attendant should merely carry away the work delivered from one machine and place it in the next, finally receiving it complete from the last.

Some of the individual machines in the series had, it is true, been previously contrived and employed. Thus, the self-acting morticing-machine is distinctly described in Bentham's specification of 1793, so completely as to entitle him to the full credit of the invention of morticing-machines, whether by the process of boring a hole first and then elongating it by a chisel travelling up and down vertically, or by the process of causing the hole to be elongated by the rotation of the boring-bit during the travelling of the work. The same specification describes boring-machines, some of which are similar in their arrangements to those of the block series; also the tubular gouge which is employed in the shaping-machine, and the formation of recesses, by a revolving and travelling tool, for the inlaying of the *coaks*.

One of the most useful machine tools that made its appearance at the end of the eighteenth century was the *circular saw*. This had been applied to cutting metal on a small scale, as in the cutting-engine, ever since the time of Dr. Hooke; if, indeed, these early examples were not more like circular-files than saws. Where or by whom the wood-cutter's saw was put into the form of a revolving disc has not been recorded. It found its way into this country about 1790, some say from Holland, and was employed at Southampton and elsewhere in wood-mills. Bentham greatly contributed to the practical arrangements necessary to give it a convenient form. He decribes and claims the bench now universally used, with the slit, parallel guide, and sliding bevil-guide, and other contrivances.* Brunel introduced a variety of ingenious and novel arrangements, as well as the mode of making large circular-saws of many pieces.† Mr. Smart also contrived series of sawing-machines for making canteens, cutting tenons, &c.

After the completion of the block machinery it becomes very difficult to trace the subsequent improvements. The art of machine-making for working in metal was gradually advancing, but is not recorded in patents, and very little described in books. The slide-rest principle was extended, large self-acting lathes constructed, and boring-machines of great precision and improving structure were called into existence by the necessity for extreme accuracy in the cylinders of steam-engines. The best engravings of the machines of this period are in 'Rees' Cyclopædia,' and in the volumes of the 'Transactions' of the Society of Arts.

No greater proof of the obscurity which hangs over the history of machine tool-making, in the first half of this century, can be given than the unknown origin of the planing-machine for metal. The machine which Nicolas Focq contrived in 1751, which has been called a planing-machine, has no title to the name, or any resemblance to the modern engine. It is nothing but a heavy scraping tool, which is dragged along the bar upon which it is to operate, and rests upon it, pressed into hard contact with it by strong springs. It will, therefore, smooth the surface, and remove small irregularities, as a carpenter's plane does with a board, but it will not produce a correct plane surface, or even make successive cuts. It is a mere *plane*, and not a *plane-creating engine*. Neither could the machines patented by Bentham in 1791, and Bramah in 1802, for planing wood, although real planing-engines, have suggested the engine in question, for their properties and arrangements are wholly different. The engineers' planing-machine made its way into the engineering world silently and unnoticed; and some years afterwards, when its utility became recognised and men began to inquire into its history, various claimants to the honour of its invention were put forward. We can only learn that, somewhere about 1820, or 1821, a machine of this kind was made by several engineers. Messrs. Fox of Derby, and Roberts of Manchester, appear amongst the number, and the forms which they gave to the engine have remained permanent. Mr. Clement has also been mentioned, as well as others. It is clear that the inventors were not at all aware of the immense importance of their work, but experience has proved the utility of this machine to be so great that it may be pronounced the greatest boon to constructive mechanism since the invention of the lathe. Nevertheless, no drawing or description of the planing-engine is to be fonnd in any English book until 1833, when the Society of Arts published beautiful engravings of Mr. Clement's machine; the complexity of this, and the unfortunate arrangement of the bed, which he mounted on wheels, has prevented it from being adopted. The French and other continental mechanical journals, much earlier began to give engravings and descriptions of the English planing-machine. In 1829 the "Industriel" has one of the simplest, and the Bulletin of the "Société d'Encouragement," the collections of Le Blanc, Armengaud, and others, contain engravings not only of the planing-machines, but of the other machine tools of all our best English makers, generally accompanied by admirable descriptions and minute details that may well serve as models to our own writers on such subjects, and at the same time show how much good service is rendered by the superior mathematical and theoretical education of French engineers. Be it remembered, too, that, not content with describing and analysing our machine tools, which they do in a most liberal and admiring spirit, they also employ their generalising powers in the endeavour to construct improved forms, and with such great promise of success, that unless we also begin to apply science to this subject we run considerable risk of falling behind our ingenious neighbours.

The mortising-engine of the block machinery was applied by Mr. Roberts, of Manchester, to the formation of the key-ways of cast-iron wheels, and also to the paring, or planing by short strokes, of the sides of small curvilinear pieces of metal, such as cams, short levers, and other pieces that do not admit of being finished in the lathe. Thus, under the name of *slotting and paring machine*, a new and generally useful machine tool sprang up; and subsequently another, derived from it, has been produced, and apparently with equal success, under the title of a *shaping-machine*. It is, in fact, a planing-machine, in which the tool is attached to the end of a horizontal bar, which is moved to and fro, so as to plane, with short transverse strokes, a piece of work fixed on a complex adjusting-bed, or on a revolving mandrel, so as to receive the action of the tool.

The existence of such principles lead us to the hope that machines much more comprehensive, and yet simpler in form, will be devised for the same purposes, by means of which the construction of machinery in general will attain to greater perfection, and machine-tools be introduced into workshops of a smaller character than at present, in the same manner as the lathe.

In America, a variety of contrivances are employed in workshops to facilitate and give precision to ordinary operations: as, for example, the foot-mortising machine for wood. The earliest contrivance of this useful tool (the offspring of Bentham's mortising-engine), appears to be in a Pennsylvanian patent by John M'Clintic, in 1827,* since which the machine has got into general use in America, and has consequently been the subject of numerous patents for minor arrangements. One of these, by Page, was engraved in the 'Mechanics' Magazine' (1836, vol. xxvi., p. 385), and thus introduced to English workmen; and in the last year Mr. Furness, of Liverpool, has patented some improvements in England, and endeavoured to introduce the machine. It formed a very interesting object in the Exhibition, together with other American contrivances for boring, tenoning, and such like operations, which the peculiar conditions of that country have called into existence, by creating a market for them.

In reviewing the comparatively slow progress of machine tool making, it will appear that in this, as in other branches, steps in invention that, when once made, appear exceedingly simple

* 1793. 'Repertory,' vol. x., p. 293. † Patent, 1802.

* 'Journal of Franklin Institute,' vol. vi., pp. 18 and 163.

and obvious, are often the most difficult to take. The chance that such steps will be made is increased by bringing to bear upon them the greatest number of heads; for the peculiar faculties or acquirements of one man, or set of men, may serve to carry on an invention to a certain point at which it is prepared for, and requires those of another set of men who may carry it further. In the old time, the exceeding secrecy and jealous care with which every new contrivance was guarded and watched, retarded the advance of machinery to an extent that we can hardly believe. Each man was working in ignorance of his neighbours' improvements, and every art was indeed a mystery. And not only did these difficulties obstruct the progress of machinery, but led to the enormous expense of constructing new machines. We know that the art of construction has undergone a complete revolution since the block machinery was made, but we can scarcely estimate the prodigious amount of labour and thought that was required to give existence to that machinery, which, indeed, could never have been effected without the resources of the nation in the then imperfect state of the art. To these retarding causes must be added the jealousies of workmen and their dislike of new methods.

I have already alluded to the advantage of promoting a more universal knowledge of each other's methods amongst the mechanists of different branches and countries. A very interesting part of the Great Exhibition was the collection of strange-looking tools from France, Germany, and elsewhere, differing in their forms and handles and mode of operation from those employed for the same purposes by our own workmen. Without doubt some of them might afford useful hints; for example, the universal employment of the narrow frame-saw on the continent for work that we perform with broad-bladed saws, stiffened with brass or iron backs, might lead our workmen to consider whether, after all, our practice is not carried too far in this respect.

But the facilities for working in metal, and its general introduction into all kinds of frame-work where wood was exclusively employed, as well as the substitution of cast-iron for brass, has made it imperative upon persons of all trades which are affected by these changes, to learn the management of these new materials, if they desire to profit by the advantages consequent upon their employment. Thus, the philosophical instrument-makers formerly employed brass for their metal-work, and constructed their machines, even the largest astronomical instruments, in a great number of pieces screwed together. We have now learnt that stability is best insured by employing fewer pieces, and that cast-iron is on all grounds a better material than brass. But the tools and methods of working in cast-iron are wholly different, and therefore the philosophical instrument-makers must turn engineers, and employ planing-machines and the like. The making of large clocks, and various other articles of common use, must undergo the same change. It is useless to say that these men can go to an engineer's shop to get jobs done for them as required. Such a method can only lead to a partial and imperfect employment of the new resources and advantages which are to be developed. For instead of a full and complete adoption of these novelties, the use of them will be necessarily evaded in every case where they can be dispensed with, unless the master-workman can employ them freely as his own.

In machinery we have to deal with every kind of material, and to avail ourselves of the peculiar properties of all in their appropriate places; and thus a skilful engineer should be familiar with every kind of mechanical manipulation and material, from a sheet of card-paper to an iron-bar, and ought to know as well how to hem a pocket-handkerchief as to rivet a boiler. It is of no use for him to employ workmen of any trade in carrying out new combinations, unless he himself know how to instruct them. A musician who is about to compose a symphony need not be able to play on the violin like Paganini, or on the piano like Thalberg; but he must be well acquainted with the powers and manipulation of these and every other instrument before he can write passages that will bring out their effects and be adapted to performance. And, in the same way, a man who intends to devise and carry out a new machine must be conversant with the peculiar properties and mode of manipulating every kind of material, that thus he may select and avail himself of them to the best advantage.

ORVIETO CATHEDRAL.

(*With an Engraving, Plate* XIII.)

Of the many hundred travellers who pass annually on the two high roads between Florence and Rome, very few take the trouble to turn even a few miles out of the main route to visit the many interesting cities which lie a little off the roads. Such are Volterra, San Gemignano, Toscanella, Citta della Pieve, Chiusi, Gubbio, Todi, and Orvieto. The cathedral of the latter town shares with that of Siena the reputation of being, after Milan, the finest Gothic edifice in Italy. Built by the same architect, Lorenzo Maitani, these two structures present a great similarity of style. Both are remarkable for the richness of their façade, for the use of *semicircular* arches in the interior, and for the employment of striped bands of black and white marble. The façade of the cathedral of Orvieto is perhaps, at first sight, the most gorgeous thing in Italy. Its yellow, white, and red marbles, its glowing mosaic pictures, its bronze doors and ornaments, as I first saw them in the rays of an August sun, present a perfect blaze of vivid colours most harmoniously combined, which in a northern atmosphere would only look gaudy. But if the eye is delighted at first sight with the colour, it soon becomes disgusted with the forms. The cathedral presents in section the usual nave, aisles, clerestory, and low-pitched roof; this is masked in front by three sham high-pitched gables, filled with mosaics, and ornamented with crockets, finials, and ugly square turrets between. These are avowedly shams, and are worked fair at the backs. These sham gables are the curse of Italian Gothic. They were evidently brought from the north, and the Italians not requiring a high-pitched roof, had recourse to the bungling expedient of a false gable: these are common throughout. All the churches in Assisi (which are avowedly of German origin), have them; as also Siena and the churches at Lucca, including Mr. Ruskin's favourite front, which is entirely a sham gable—rather a curious illustration of the Lamp of Truth.

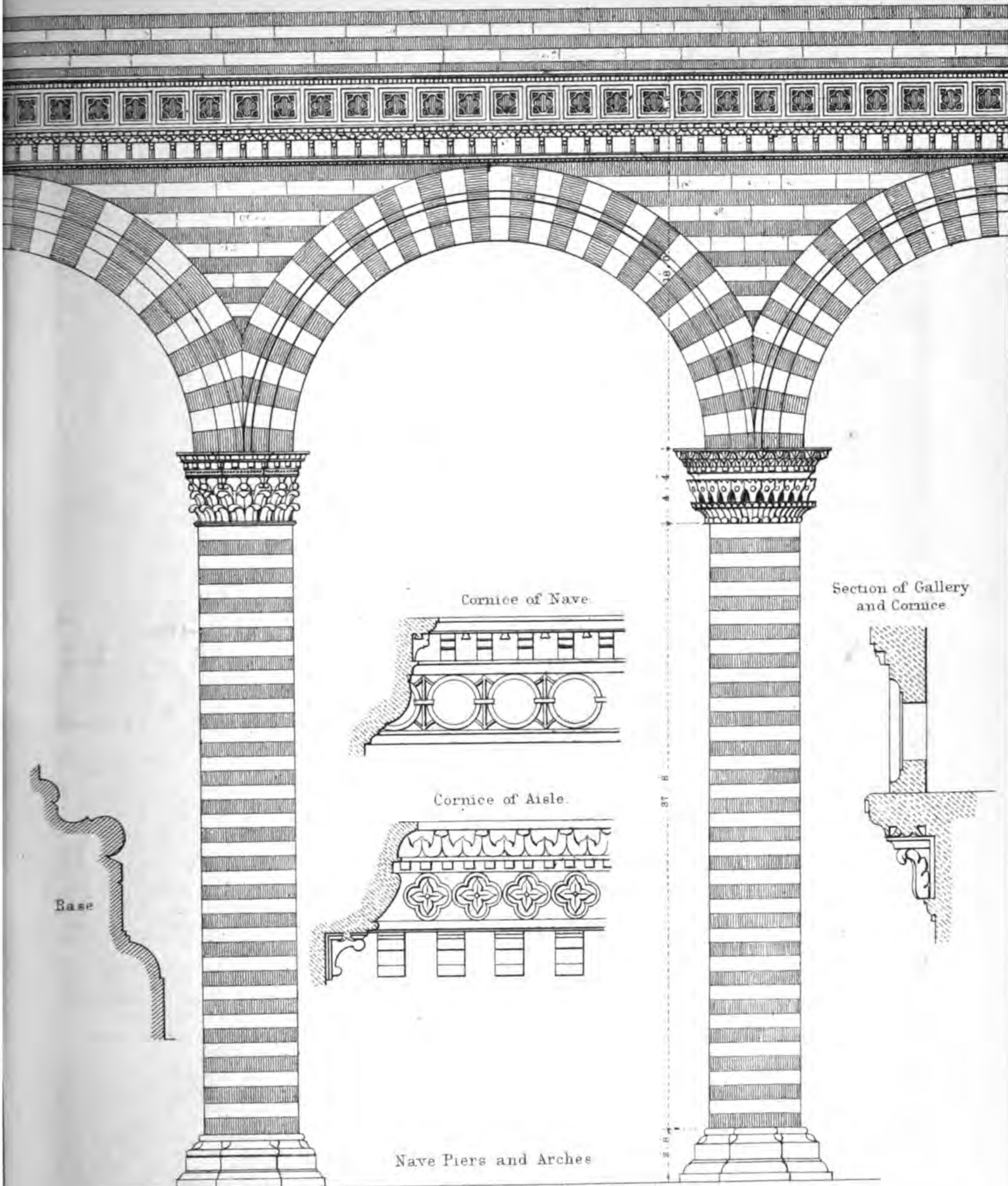
Immediately below the centre gable is a rich wheel-window, inclosed in a square, in a very picture-frame manner; and below, three large doorways, much disfigured with the deeply-cut spirals of the columns—another curse of Italian Gothic. All the details of this front are very rich, and generally extremely elegant. The most remarkable things in this front are the really wonderful bas-reliefs of the scholars of Nicholas of Pisa, with which the pilasters separating the doorways are covered. These represent the genealogy of Our Lord, the Last Judgment, together with a Paradiso and Inferno.

The flanks are extremely beautiful, the chapels are formed into a series of small apsides, with a single traceried window between each—a most elegant arrangement; the clerestory consists of single lancets. The beautiful cornices, figs. 1, and 2, which we have engraved, run round the aisles and clerestory. The interior is extremely grand. We have engraved the piers and arches of the interior, with the small gallery round. Fig. 3 represents a section of this gallery, and fig. 4 the base. The general effect is perhaps too gloomy—that is to say, it is all dark, with no blaze of light at the east end, as in our cathedrals. The mode of glazing is worthy of observation. The windows are partly filled with stained glass, and partly with semi-transparent alabaster, producing a beautifully subdued golden light.

It is not our province to treat of painting and sculpture, we can therefore only allude to the frescoes of Luca Signorelli, and Fra Angelico, and the statues of the Apostles placed against each pillar, by the scholars of Michael Angelo.

ALFRED BAILEY.

Liverpool Water Supply.—The first contract for putting in the main-pipes for conveying water from Rivington is now being proceeded with, on the line of road from the vicinity of Liverpool towards Stanley. The contract has been entered into by a Mr. Crump, from Derbyshire, the distance taken being a mile and a-half. The necessary cutting has been made, and the ponderous tubes, which average 2 tons each, are raised and lowered to their beds by means of a powerful crane, running upon a railway placed longitudinally above the cutting. They are afterwards soldered at the joinings, and rendered completely water-tight. The pipes are 4 yards in length, and 3 feet in diameter inside.



ORVIETO CATHEDRAL.

J. R. Jobbins

IMPORTANCE OF SPECIAL SCIENTIFIC KNOWLEDGE TO THE PRACTICAL METALLURGIST.

By John Percy, M.D., F.R.S.

Introductory Lecture to the Course of Metallurgy, delivered at the Government School of Mines and of Science applied to the Arts.

Metallurgy, as at present understood, is the art of extracting metals from their ores, and adapting them to various purposes of manufacture. This definition, however, is not rigidly exact, nor can I frame one in few words that is so. The etymology of the word "metallurgy" would seem to imply a more extended meaning, and include all the arts in which metals are wrought into objects of utility or ornament; but this is not the meaning now attached to the word. The metallurgist receives the ore from the miner freed as perfectly as possible by mechanical processes from foreign matter.

The knowledge of the principles of metallurgy is the science of metallurgy. But as the phenomena observed in metallurgical processes relate to physics and chemistry, and as mechanical appliances of various kinds are employed in these processes, it follows that chemistry, physics, and mechanics must be the foundation of the science of metallurgy.

The history of metallurgy dates from remote antiquity; and, as the French author Le Play correctly observes, "most of the fundamental phenomena of metallurgy were discovered and regularly applied to the wants of man before physical sciences properly so called existed." Metallurgy may, indeed, be said to have given birth to chemistry.

As the word "science," in relation to a manufacturing art, is often used by persons who seem to have no precise idea of it, I shall first adduce a simple illustration of its meaning. There is an ore of copper, composed of copper, iron, sulphur, and silica. When such an ore is subjected to a series of processes consisting of heating it with the access of air, melting, &c., copper is separated in the metallic state. The sum of these processes is termed the smelting of copper. Now, in this operation of smelting, various chemical changes take place; the sulphur combines with the oxygen of the air, and is evolved in a gaseous state; the iron also combines with the oxygen of the air to produce oxide of iron, which combines with the silica to form a slag, while the copper is separated in a metallic state. We have thus several facts, which are proved by chemical evidence. These facts may, when properly arranged, be said to constitute the scientific knowledge of copper smelting; and that knowledge implies necessarily a knowledge of the chemical relations of copper, iron, sulphur, oxygen, and silica to each other. There are also many other facts connected with copper-smelting; but those which I have selected are sufficient for the present purpose of illustration. Now, the man who conducts the process of copper-smelting in ignorance of these facts has simply an empirical knowledge, in contradistinction to a scientific knowledge, of the process.

That a scientific knowledge of the process may be important to the man who directs copper-smelting works would hardly seem to require an argument. It may, however, be objected, that the process is often satisfactorily conducted by men whose knowledge is purely empirical. Now the objection would have some weight if it were admitted either that the process is incapable of further improvement, or that the ores upon which such men are accustomed to operate were not liable to vary in composition. But such an admission would be a purely gratuitous assumption; and the ores do occasionally contain unexpected ingredients, which, in the event of precisely the same process of smelting being pursued, would tend in a very sensible degree to deteriorate the quality of the copper produced. Hence, ignorance of the presence of such ingredients on the part of the smelter may occasion pecuniary loss; and, in ignorance both of the causes which thus may injure the copper and of the scientific knowledge of the process of smelting, he is certainly not in the most favourable condition for devising an appropriate remedy. It is true that by a series of blind trials a suitable modification of the process might be stumbled upon; but it is equally true that with the aid of special scientific knowledge there is much more probability of arriving at a solution of the difficulty with far greater economy of time and money.

In support of the general proposition, that special scientific knowledge is important to those who direct metallurgical processes, I shall now present to your notice several cases, most of which I can myself substantiate.

A party purchased a large quantity of a particular ore, at the cost of many thousand pounds. Another party purchased at the same time a much larger quantity of the same ore, at the same price. To treat this ore profitably, special scientific knowledge was essential. The former party possessed that knowledge, and gained thousands by his purchase; but the latter had it not, and lost money.

A manufacturer purchased some metallurgical works, and for certain miscellaneous articles on the premises, including a heap of waste product, gave only a very inconsiderable sum. Out of that heap, which in ignorance had been thrown aside as worthless, he realised sufficient to pay for the works, the price of which amounted to several thousand pounds.

An eminent copper-smelter informed me that his ancestor, in purchasing some old copper-works, obtained in value more copper from the furnace bottoms than the purchase-money. In this instance, perhaps, negligence might be ascribed to the seller, but in that last mentioned the error was the result of sheer ignorance.

In May 1841 a patent was granted to William Turner Green and James Gregory, of West Bromwich, Staffordshire, for "certain improvements in the manufacture of iron and steel." The invention mainly consisted in soaking the pigs of iron in cold water previously to their introduction into the puddling furnace.

Again, a short time ago a patent was obtained for plating certain metals and alloys with a particular metal, and a manufactory was erected at a considerable outlay to carry out the invention. It was alleged that the importance of the application consisted not only in the whiteness of the metal employed, but in the economy of the process. Now the metal in question was at that time at least thirty times dearer than tin, and was produced only in small quantity. But the inventor was sanguine, and considered that an ore containing forty per cent. of it existed in abundance, whereas the fact is, that only a few ounces of such an ore have ever been discovered, of which specimens are rare even in mineralogical cabinets; and the ores which contain it and occur abundantly in nature do not yield more than two or three per cent. of it. This case, it is true, may be regarded rather as indicative of ignorance of mineralogy than of metallurgy; still it may be appropriately introduced under the present head, as an argument for the necessity of the diffusion of accurate scientific knowledge amongst metallurgists. The inventor speculated on the probability of a demand creating an adequate supply of the metal at a comparatively small cost; but special scientific knowledge would at least have prevented the precipitate investment of capital on such a speculation.

These facts should be a warning to the numerous class of inventors in this country, whose naturally sanguine temperament is liable to disturb the exercise of their judgment. The published records of patented inventions, indeed, furnish a striking commentary on the proposition before us. The diffusion of the scientific knowledge relating to metallurgy would often prevent the reckless expenditure of money on worthless patents.

Very striking instances in support of the same proposition may be derived from the important branch of metallurgy termed "assaying," or the art of determining the quantity of metal contained in its ores, alloys, or certain other compounds. Without a correct assay, it is obvious there can be no certain knowledge of the value of an ore; and without that knowledge, the purchase of an ore by the smelter is merely a speculation. Now by great practice upon some particular class of ores, the merely practical assayer may arrive at accurate results, and yet be entirely ignorant of the science of his art, or, in other words, of the chemical properties and relations of the elements upon which he operates. But if, as I have already mentioned in the case of the copper-smelter, he should meet with an ore containing foreign and unexpected ingredients, which interfere with the accuracy of the method he had been accustomed to practise, he would not, from his want of scientific knowledge, be able to surmount the difficulty, and would, consequently, from his necessarily erroneous result, seriously mislead the smelter respecting the value of an ore. Or he might equally mislead the seller who relies upon his judgment, either by underestimating the quantity of the particular constituent which he seeks to determine by his assay, or, by overlooking another constituent, it may be of great value.

An ore of cobalt from North America was assayed, and alleged to contain twenty per cent. of oxide of cobalt, which at the time was worth about 30*s.* a-pound. The assayer, however, had made an important mistake; for what he had estimated as oxide of cobalt consisted of oxide of cobalt and oxide of manganese, in the proportion of two parts of the former to three of the latter, the oxide of manganese being in this instance not only utterly valueless, but positively injurious.

An experienced copper-assayer, on assaying a particular ore, obtained what he believed to be nickel-speiss—that is, a compound of nickel and arsenic. Now nickel is a valuable metal, being worth at the present time 8*s.* a-pound. But the supposed speiss contained not a trace of nickel, and was proved to be only a compound of iron and arsenic, a comparatively worthless product. On the ground of this assay, I believe a quantity of ore had been dressed for the market.

The following is a curious and remarkable instance of the importance of accurate chemical knowledge to the metallurgist. The Upper Hungarian Mining Company smelted, during several years, a species of copper-ore termed fahlerz, in ignorance of the fact that it contained mercury, which was ultimately discovered by the accidental observation of a workman. Means were then adopted to collect the mercury, of which the present annual produce amounts to 30,000*l.* in value.

Not long ago I visited a tin-plate manufactory. In the first part of the process of tinning there is constantly formed a black powder, which from time to time is removed from the surface of the melted tin. On interrogating the manager, who conducted us over the establishment, it appeared that he was ignorant of the nature of that powder, which, on subsequent examination, was found to contain sixty-two per cent. of tin in a finely divided state. He suspected that it contained silver; but his knowledge was limited to the fact that, whereas it was formerly thrown into the adjoining river, it was afterwards sold for a few pounds a-ton, but now realised ten times as much.

Occasionally a large sum of money may depend upon an assayer possessing a profound knowledge of certain departments of analytical chemistry. Thus, not long ago there was a dispute between the Bank of England and the Mint respecting the re-coinage of a million of sovereigns. On melting the gold at the Mint several pounds weight of a metal were obtained which had not previously been detected by the assayer. That metal was chiefly iridium, which had been simply mechanically diffused through the gold, and which, in the state in which it was separated, was comparatively valueless. The question then arose whether the Bank or the Mint should be responsible for the loss; and it was some time before a satisfactory conclusion was arrived at.*

It would be impossible to insist too strongly upon the importance of assayers generally receiving sound instruction in the specific department of analytical chemistry which relates to assaying.

Scientific, apart from practical knowledge may in metallurgical establishments lead to most erroneous and occasionally ruinous results. Metallurgy is an art, and, like every other art, can only be acquired by experience. In many processes success depends upon the discrimination of appearances so slight that the eye, in order to detect them, requires to be educated by close and constantly repeated observation. No description, however accurate and minute, would enable a man, though a shrewd observer, to recognise at first such appearances, and consequently to conduct processes in which success essentially depends upon their detection.

The descriptive expressions occasionally used by the practical man may appear to be vague, and he may not be able to define them in language very intelligible to us; yet we may generally be sure that they express correctly the result of his observation, and have a meaning well understood by himself. For instance, on inspecting a blast-furnace in Staffordshire, I perceived that "tap-cinder" (slag from the puddling-furnace, rich in iron) was introduced into the furnace with a mixture of iron ores, not then a very unusual and now a common practice. I accosted the foreman of the works, and asked him his opinion concerning the effect which he supposed the use of "tap-cinder" would produce upon the iron. His reply was, that "cinder has no nature in it." Now the term "nature" expressed his experience of the quality of the iron when "cinder" and ore were smelted together; and, as I knew what that quality was, I knew exactly what was meant by the term in question.

* The presence of minute particles of the alloy of osmium and iridium in gold is sometimes very annoying to jewellers and watch-case makers.

The knowledge of the science of a metallurgical process would of itself be a very insufficient qualification for the man who directs the manufactory. Let a chemist, for example, who may perfectly understand the theory of copper-smelting, but who is entirely ignorant of the practice of the art, attempt to take the management of copper-smelting works, and he would find himself embarrassed at the outset: he would not be able to form a correct judgment in a single step of the process. Without experience he could not decide whether the requisite degree of heat was produced in any of the furnaces, or whether any of the various operations of smelting had been properly effected. Again, let the chemist who has received his education exclusively in the laboratory, and who, consequently, has only been accustomed to deal with small quantities, be simply required to dissolve a ton of copper in sulphuric acid, and at first he would not be a little perplexed: he would find how different the manipulation of the laboratory is from that of the manufactory; he would have to consider of what material he should construct the vessels in which to effect the solution,—of what form and size they should be,—and in what manner heat could be best applied; only the chemist who is himself practically acquainted with the manufactory will well understand the force of these remarks. I have frequently conversed with chemists who have supposed that their chemical education alone rendered them at once fully qualified to conduct operations on the large scale; and who have expressed themselves desparagingly of the practical man. Let such men attempt to conduct the manufactory, and, in all probability, it would soon be seen that the price of their obtaining the requisite practical skill would be heavy loss to the proprietors.

We are thus led to the conclusion, that while scientific knowledge alone will not qualify a man to take the management of metallurgical works, so neither is empirical knowledge the only qualification desirable in such cases; it is clearly the combination of scientific with practical knowledge that will render the managers of such works in the highest degree competent for their responsible positions. And, accordingly, we find that our manufacturers have begun to appreciate the importance of this combination of knowledge in their managers. I could mention several establishments in which the aid of science has been sought with no inconsiderable advantage. I know that men who have received a metallurgical education on the continent are now employed in metallurgical establishments in this country; and I know many instances of English students seeking that instruction in mining and metallurgy abroad which had not been provided for them at home. It is from the combination of scientific with practical knowledge, especially in metallurgical establishments, that we may reasonably expect improvements in metallurgy. The scientific man, without practical knowledge, is likely to project schemes which, however plausible they may appear in theory, could not be profitably carried out in practice. Without experience of the working of processes on the large scale it would be impossible to form even an approximate notion of the cost of production; and the ignorance of financial considerations which the scientific man has not unfrequently displayed has, I doubt not, in many cases caused the practical man to undervalue, or even deny the advantage of the applications of science to manufacturing art. On the other hand, the practical man has often elicited the contempt of the scientific man, by propounding unphilosophical and sometimes absurd explanations of the processes which he conducts; and it must not be forgotten that the practical man, in spite of his purely practical pretensions, will generally, and, according to my experience, always be found ready with an explanation of any phenomena he may observe: indeed, the practical man, paradoxical as it may seem, abounds in theories, often in the highest degree wild and visionary. From these considerations, the importance of the combination of scientific with practical knowledge will more clearly appear.

Although the arguments which I have already advanced may be regarded in some measure as a reply to the objection which, in a former part of this discourse, I anticipated might be urged against the utility of providing public instruction in metallurgy in this country, yet, from its *primâ facie* plausibility, it requires a more specific examination. The objection, it will be remembered, is, that as in Great Britain the practice of metallurgy has attained an unparalleled degree of development, and as this development has been effected in the absence of public instruction in metallurgy, such instruction must now be unnecessary.

By development I mean magnitude of production; but magnitude of production is no certain proof of correspondingly great skill. Let us consider first the special natural conditions under which the development in question has occurred. The largest and most important item of the metallurgical produce of Great Britain is iron; and it is precisely that item which, on comparing the amount of the metallurgical produce of Great Britain with that of other countries, makes the balance so great in favour of the former. Now, the ores of iron exist in extraordinary abundance throughout various districts of this country; and, what is very important in the consideration, the fuel necessary to the smelting of iron exists also in equal abundance, and, for the most part, in close proximity to the ores of iron. We have thus two conditions specially favourable to the production of cheap iron—abundant ore and fuel occurring together; and to these may be added the third condition of denseness of population, and, as a consequence, cheap labour. In no other country, except perhaps Belgium, do we find an equally favourable combination of circumstances for the production of cheap iron, not even in North America, where rich coal-fields extend over a vast area, and the ores of iron exist in great profusion; for, generally, as the two do not occur together, the expense of carriage must necessarily be considerable. Moreover, as the country is as yet but comparatively thinly inhabited, the expense of labour is greater than in Great Britain. In respect, then, to the capability of the production of cheap iron, our own country is at present unrivalled.

But the mere smelting of iron, as compared with some other metallurgical operations, is a simple process. After the introduction of the proper admixture of ores, limestone, and fuel into the blast-furnace, the only satisfactory indication of the working condition of the furnace is presented by the character of the slag as it flows out at the bottom. The quality of the metal produced from the same furnace, comparatively under the same conditions, varies from time to time, even in two successive tappings; and even in the same tapping there may be several distinct varieties of metal. Hence, as in the process of iron-smelting there is but comparatively little opportunity for observation and interference on the part of the manager, and as under apparent identity of condition the product may vary sensibly in quality, the operation itself cannot, in respect to the opportunity for the exercise of skill, compare with many other metallurgical processes.

But it must not be assumed that because this branch of industry has been generally carried on in this country by men who have not a scientific knowledge of the process, it would not with the aid of such knowledge have advanced to a much higher degree of perfection, whether as relates to economy of production or excellence of quality. Nor must it be assumed that because the production of iron (and in speaking of iron at the present time I mean pig-iron) appears to be a simple process, and because the men who conduct that process have frequently no scientific knowledge of it, science has done nothing towards the development of the smelting of iron in this country. Although we may not be able accurately to trace the history of improvement in many instances, yet we may be assured that the improvements which have from time to time been effected in the smelting of iron have not been altogether the result of accident or blind trial. The observation which I have just made respecting the production of pig-iron will also apply to the manufacture of bar or wrought iron, with the exception that in the latter case there is apparently much greater scope for the exercise of skill on the part of the workman and manager.

There are many problems of the highest interest in relation to the manufacture of iron and other metals, at the solution of which we shall, most probably, only arrive by the aid of science. I have already alluded to the production of a slag termed "tap-cinder" in the conversion of pig or cast into bar or wrought iron. Of this slag thousands of tons have, until quite recently, been thrown away every year, notwithstanding it contains a larger quantity of iron than exists in the common argillaceous or most abundant ores of iron; and when it is introduced into the blast-furnace with the ores of iron it tends in a special manner to deteriorate the quality of the iron produced. By the aid of analytical chemistry we are, I believe, enabled to determine why the use of this slag injures the quality of the iron; and thus, having a correct knowledge of the cause, we are in a better condition for devising means to counteract the defect than we should be if that cause were unknown to us.

We import annually a large quantity of foreign iron, especially for the manufacture of steel. In 1850 the importation amounted to 34,066 tons, the value of which may at least be estimated at 500,000*l*. Yet, I presume, if a method should be discovered by which British iron could be satisfactorily substituted for that amount of foreign iron, such a discovery would be regarded as advantageous to this country. Many attempts have been made to effect this substitution, but hitherto with only partial, though, I may add, increasing success. Particular varieties of iron are required for the production of particular qualities of steel; and we are still, in great measure, ignorant of the precise chemical differences between these varieties of iron. But without a knowledge of these differences, the determination of which will require the highest analytical skill of the chemist, we can only make blind attempts to solve the problem in question.

In the smelting of copper there are many points of considerable practical importance which are still very obscure, and which will certainly never be elucidated without the aid of science. Notwithstanding that copper-smelting has been conducted in this country, during a long period, on a scale of unexampled magnitude, there is one point in the last part of the process—the operation of "poleing"—which is even not yet clearly understood: I allude to the effect of "over-poleing." Researches have, it is true, been made on this subject, but still, as it appears to me, without a decisive result. Again, the quality of the copper produced, not only in different smelting establishments, but in the same establishment, at different times, has been found very sensibly to vary in certain respects, especially of late, in spite of the efforts of the smelter to produce a metal of uniform quality. I know, indeed, that in some instances even smelters of great experience have taken special precautions to attain this end, but still not with constant success. Now it is clear, I think, that in such cases chemistry alone will enable us to determine the causes of this variation in quality, and without a knowledge of these causes the smelter can merely grope in the dark after means to obviate the defect. Already, I know that in some instances chemistry has rendered essential service of this kind. The variations in quality to which I have alluded are frequently not in the slightest degree indicated by the appearances of the metal, and only become manifest in the different processes of manufacture to which copper is subjected; as, for example, in rolling, hammering, and stamping, in dipping, and in the peculiar and sometimes very striking defects which it occasions in alloys. In illustration of the variations in the quality of copper, I may mention the fact of the very different degree of corrosion by sea-water, observed especially during the last few years in the copper sheathing of the vessels of the navy.

The smelting of lead would also appear to present a promising field for the exercise of special scientific knowledge. In this country two methods of smelting are practised, and in both the loss of lead from volatilisation is very considerable, amounting to ten per cent. or more. Accordingly, flues of great length, sometimes exceeding a mile, are constructed in order to effect as completely as possible the condensation of the lead smoke or fume. Other contrivances with the same view have been adopted; the smoke has been caused to pass through water by means of powerful exhausting-pumps, or water has been projected in a finely divided state, like rain, into chambers through which the smoke has been made to circulate; and other methods have also been tried with greater or less success, but all attended with no inconsiderable outlay. Attention should rather be directed to the improvement of the smelting process itself, by effecting, if practicable, the separation of the lead at a temperature sufficiently low to prevent volatilisation. But such an improvement, admitting its practicability, is far more likely to be made by the smelter, who, with a practical knowledge of the process, combines the special scientific knowledge relating to lead-smelting, than by the man who possesses only the former.

In tin-smelting, also, we meet with some interesting and important problems, which would seem to require the aid of chemistry for their solution. For example, in the manufacture of the best tin-plates, the tin required is of the best quality, and has, therefore, the highest price. Tin of inferior quality, and of less value by some pounds per ton, is unfit for that purpose. Chemistry will alone explain why one kind of tin is suitable and another not; and when the causes of the difference between one quality of tin and another are known, it is not improbable that a method may be devised for converting tin of inferior into tin of superior quality, the difference of price between these qualities allowing a considerable margin, as manufacturers term it, for the expense of a process by which that conversion might be effected.

I might also, with equal propriety, allude to the manufacture of zinc, which, it is to be hoped, is not incapable of further improvement. There is at present a greater difference between the value of the ores of zinc and the zinc itself than in the case of any other metal.

Another very promising field for the exercise of science in relation to metallurgy is presented by the various metals which have not yet received any extensive practical application. Tungsten, for example, is in this category; it exists in nature in considerable abundance, and is frequently found associated with tin ore, from which it is separated as completely as practicable, and thrown aside as worthless. It is true that attempts have recently been made to employ certain compounds of the metal in dyeing, as had previously been done thirty years ago; but these attempts have not, I believe, as yet been attended with any great success, or a demand for tungsten would have been created in consequence, which is not the case. Failures, however, should only have the effect of stimulating to further efforts in respect to the application of this metal, which, I confidently predict, will not much longer continue a comparatively worthless substance. Very substantial pecuniary emolument will, certainly, be the reward of the man who shall discover the mode of rendering tungsten extensively subservient to the arts. It is only a few years ago that, in respect to commercial value, nickel occupied much the same position as tungsten at the present time; but now it is worth 8*s.* a-pound, or about ten times more than copper. It is the whitening constituent of the alloy known as German silver. The silver-platers who practise the old method of plating by soldering, as well as those who deposit the silver by the agency of voltaic electricity, employ this alloy extensively, the advantage being that when the silver is worn from any part of an article, the alloy beneath sufficiently approximates to silver in whiteness as to deceive the eye respecting the wear. Some years ago, a compound of nickel, termed pottery nickel, was obtained in the manufacture of compounds of cobalt for the use of the potters, which was sold as low as three-halfpence a-pound, whereas now it would fetch 3*s.* 6*d.*

Titanium is another metal which, like tungsten, evidently exists in large quantity in nature, but which has hitherto only been applied to a very trifling extent in the arts, especially as a colouring ingredient in the manufacture of artificial teeth. I confess I am no believer in useless metals, and, therefore, with equal confidence repeat the prediction which I uttered in respect to the application of tungsten. Then, again, I may mention molybdenum, the only practical application of which is in analytical chemistry; and cerium and vanadium, which, if required, there is reason to believe might be obtained in some quantity. We must not disregard a metal on account of its rarity; for some of the rarest metals have of late been applied with great advantage. I may mention, for instance, the native alloy of osmium and iridium, which only a very short time ago was confined to the laboratory of the scientific chemist. The alloy occurs in small grains, so intensely hard that the hardest file will not make an impression upon them. The tips of the so-called gold pens are made of these grains; but for this purpose only the larger grains can be employed. The demand for these grains in the pen-manufacture is now considerable, and the price ranges between six and eight pounds an ounce. Iridium has also been applied as a black pigment in painting on porcelain. In intensity of blackness it is said to exceed all other black porcelain colours, which by the side of the iridium-black appear more or less grey. It is only within the last few years that uranium has been employed to produce the delicate canary yellow colour in glass with which we are all familiar; but the demand for that metal is at present so considerable that there is a difficulty in supplying it. Another similar instance of successful recent application is afforded by cadmium, which occurs in small proportion in certain ores of zinc. This metal in combination with sulphur constitutes the finest and most durable opaque yellow colour with which the artist is acquainted. The metal itself has also been used in conjunction with mercury and tin for filling teeth; but certain disadvantages arising from its use have caused it to be abandoned for that purpose. I have expressly been somewhat minute in detailing the preceding instances of the successful application of metals not long since regarded as valueless to the arts, in order to excite and stimulate efforts to promote the application of the other metals which I have mentioned as still without useful application; and moreover, to encourage the hope of success by showing how extensive a field for application is presented in the various arts.

It will doubtless be remarked, that I have considered the subject of instruction in metallurgy almost exclusively in relation to practise, or in other words, to speak plainly, in a pounds-shillings-and-pence point of view. I have done so for special reasons. This Institution professes to be a School of Mines, the chief object of which should be to render science subservient to manufacturing art; or, what is equivalent, disguise it by words as we may, to make science remunerative. Our practical metallurgists may be men of large hearts and philanthropic views respecting the application of science to the benefit of man; but if we wish to urge upon them the importance of combining scientific with practical knowledge, we must demonstrate that that combination will be of pecuniary advantage to themselves. What care they, if deficient of a taste for science, about any novel and ingenious application, if it cannot be made productive of pecuniary emolument to themselves? What inducement can they have for investing capital to carry into practice an invention, however beautiful and attractive in a scientific point of view, apart from the consideration of gain? If we address men of business on the applications of science, we must take the business view of the matter; and, as from the very nature of my subject, I must be supposed to be speaking to men who either are or may become interested in metallurgical establishments, I have felt it incumbent upon me to speak as I have done.

But let it not be imagined that the study of metallurgy has no attractions for the man of science: so far from that being true, it is a study abounding in problems of great scientific interest, and affording ample scope for the exercise of the highest powers of research; and while the lover of abstract science will discover in it much to reward his attention, to the man who delights in the application of science to the useful purposes of life it presents peculiar charms. To the antiquarian also it will often be found to render good service; for, as the working of metals dates from the earliest period of man's history, the remains of ancient furnaces and the products of ancient metallurgical skill not unfrequently become the subjects of archæological inquiry. It is interesting, moreover, to trace the history of metallurgic art, and to note how the rude and laborious processes of former times have gradually acquired the marvellous development which we observe in Europe at the present day. In order to form a vivid conception of this progress, we have only to witness the Hindoos toiling laboriously at their bellows made of skin, to extract a few pounds of iron from their little furnace, scarcely larger than a chimney-pot, and then to direct our attention to the gigantic blast-furnace of modern times, urged by a blast-engine, requiring for its movement the equivalent in steam-power of a hundred horses, and yielding upwards of two hundred tons of iron a-week.

I should wish to guard myself from the imputation of undervaluing knowledge, whether literary or scientific, which appears to have no direct practical bearing. It would be furthest from my intention to utter a word in disparagement either of polite literature or abstract science. In this utilitarian age there is a danger of forgetting that the human mind is destined for a higher purpose than that of being wholly absorbed in the material realities of life. There is no incompatibilty between the pursuits which elevate, refine, and delight our taste, and those which we are called upon to follow, as well for our personal advantage as for the benefit of our race. In contemplating the marvellous triumphs of human ingenuity at the present epoch of unexampled progress, we should be careful not to depreciate unjustly the character of the education which we received in youth; and we should bear in mind that, although that education may not have made us acquainted with natural objects and phenomena to the extent we might desire, it has yet been the means of subjecting the various faculties of our minds to a most salutary and invigorating discipline.

Stephenson.—The managers of the subscription for the Stephenson statue have determined on London for a site; but his admirers in Newcastle claiming a closer share in his glory, wish to have in their own town some special commemoration of their countryman, and are now raising subscriptions for that purpose.

ON THE PRESENT STATE OF METEOROLOGICAL SCIENCE IN ENGLAND.

By John Drew, Ph. D., F.R.A.S., Member of the Council of the British Meteorological Society.

Several causes have of late years combined to direct attention, in this country, to the difference of climate, the amount of rain, and other atmospheric phenomena on which information can be supplied only by the unassuming labours of practical meteorologists. The presence of cholera in England during the year 1849, led many scientific men, especially the members of the medical profession, to inquire whether, during that unhealthy season, any deleterious changes were traceable in the conditions of the atmosphere. The removal of protective laws from the produce of native agriculture has compelled the farmer to call in the aid of science to increase the quantity and improve the quality of his crops, the confined limits of our small island opposing his extending his operations; hence he has anxiously sought information as to the mean temperature of his locality, in order that he might commit to the soil those productions only to which the climate may be considered favourable. It has followed that the science of meteorology, before confined to the students of natural philosophy, has been favourably viewed by the agricultural class of the community, and the pages of their journals are open to communications on that subject.

It has not been shown, as far as I am aware, that any connection existed between the development of disease during the prevalence of cholera, and the state of the atmosphere as regards temperature, humidity, or pressure. At the close of 1849, I reduced my meteorological observations for the three months of its duration in the town of Southampton, and projected in curves the mean daily height of the barometer, the mean daily temperature, the degree of humidity of the atmosphere, and the daily attacks of and deaths from cholera. I was under the impression that a resemblance between these curves might be found, indicative of a connection between some of these atmospheric phenomena and the ravages of the disease. No resemblance, however, could be traced; the small number of deaths, amounting only to 289, might not have been sufficient to enable us to deduce either a direct or an adverse conclusion.

Though we may have failed hitherto in tracing a connection between any peculiarity in the air and the visitation of the cholera, the investigation of the local causes, which increased the number of its victims, has led to the most important results. The sanitary measures adopted by the local authorities, most beneficially, in the large towns of England—the inquiries which have been instituted into the condition of the poorer classes of the community, and the necessity of improving it, by an abundant and unintermittent supply of pure water, have led to an investigation of the sources of such supply; and this, again, to the determination of the amount of rain received by a given area: hence the labours of those who have been engaged in this research have, at length, become more generally appreciated.

At the commencement of the year 1850, a small number of practical meteorologists, whose attention to the science was not of sudden growth, were induced to take into consideration the possibility of enlarging their sphere of operation—of collecting facts and observations in such number as to form the groundwork for generalisation.

The noble mansion of Hartwell is not devoid of interest from its historical associations. Here, in seclusion, lived the exiled Louis XVIII.; here visited, occasionally, the Count d'Artois, afterwards Charles X.: the "Jardin à la Hartwell" at Versailles, bears testimony to the agreeable recollections of this temporary retreat which accompanied the recluse when the sequence of events had placed a crown on his head. In the spacious and elegant library, Louis XVIII. attached his signature to the document which restored him to the throne of his ancestors. With objects far other than political, a few lovers of science had assembled in this room at the invitation of the present proprietor, Dr. Lee, on the 4th of April, 1850, for the purpose of taking into consideration the present state of meteorological science, and of adopting such measures as might conduce to its advancement. Their deliberations resulted in the formation of a society, to be called "The British Meteorological Society," of which Dr. Lee was appointed treasurer, and James Glaisher, Esq., F.R.S., F.R.A.S. (of the Royal Observatory, Greenwich), secretary; and a council was appointed which, on the 7th of May, elected S. C. Whitbread, Esq., F.R.A.S., president of the society, and the following gentlemen vice-presidents:—Lord Robert Grosvenor, M.P., Hastings Russell, Esq., M.P., Gen. Sir Thomas Brisbane, K.C.B., F.R.S., and Luke Howard, Esq., F.R.S. At this present time the society numbers 150 members, all of them men of a certain scientific standing.

I feel confident that this movement has given an impulse to the study of atmospheric phenomena; and, as a member of the council, and one of those summoned to the original conference, it has since been my endeavour to draw public attention to that science which calls upon all who imbibe the vital air — the "lumen spirabile cœli"—to co-operate in ascertaining the laws which regulate its powers, as the medium of conveying the deadly pestilence, or the health-inspiring antidote.

For the purpose of making known the efforts of this society in furtherance of its design, and of affording a record of the state of meteorological science in England at the commencement of the year 1852, which may hereafter be of some historical value, I have entered upon my present undertaking. In it I shall include a description of the mode of instrumental self-registration now in operation at the Royal Observatory, Greenwich, under the auspices of the Astronomer Royal; and of certain valuable observations and experiments in progress at the Kew Observatory, under the superintendence of Mr. Ronald, at the expense of the British Association for the Promotion of Science.

For some years past the Registrar-General has subjoined to the published weekly returns of births and deaths the results, for the week, of meteorological observations taken at Greenwich. These include the mean daily readings of the barometer, thermometer, and hygrometer; the difference in temperature of each day from the mean of the preceding ten years, the force and direction of the wind, the amount of rain, notices of the electric state of the atmosphere, remarks on the amount of cloud, on sudden changes in temperature, on the strength of the wind, or any other phenomena deserving of notice; the indications of a thermometer exposed to the full rays of the sun; the reading of another sunk 2 feet below the surface of the river Thames. As these papers have an immediate and extensive circulation, and as they classify the causes of death by referring each to its peculiar class of disease, they supply the means of comparing the prevalence of any one in particular with any peculiarity in the state of the air. At the end of the year a digest of the whole is regularly published on a single sheet, for facility of reference.

The weekly returns from the observatory at Greenwich are incorporated, every three months, with a digest of all the returns of births, marriages, and deaths, which have been received during that time. The meteorological portion of this Quarterly Report embraces, beside, returns from about fifty places scattered all over the country; and such has been Mr. Glaisher's care in the comparison of instruments and systematic training of all the observers, that the utmost confidence may be placed in the results. As this is the most valuable combination of observers in the science of which this country can boast, it may be proper to explain the grounds of that confidence which they may fairly claim.

The individuals who have undertaken the observations are, with few exceptions, either graduates of one of the universities, or are fellows of some learned society; it may therefore be presumed not only that they are competent to record phenomena, but that their character would impress the returns with a stamp of trustworthiness and authority. Their instruments have been constructed by the best makers, and have been compared with standards, either directly or intermediately. The scales of the barometers used by them are of brass, leading from the cistern throughout the whole length of the tube. The indices read to ·002 of an inch by means of the vernier, and by estimation to ·001. The barometer recommended by Mr. Glaisher has an adjustment by which the surface of the mercury in the cistern is brought, before reading-off, to touch an ivory index pointing downward, the extremity of which is the zero of the scale; after comparison with the Greenwich standard, it is found necessary to apply a small correction, including index error and capillary action, leaving only the correction for temperature, which element is ascertained from the reading of a thermometer whose bulb dips in the cistern of mercury. Before the results are forwarded to Mr. Glaisher, the barometric readings are all reduced to one standard temperature — viz. 32° of Fahrenheit, the freezing point of water. The wet-bulb and dry-bulb thermometers have also been compared with standards, and, from simultaneous observations with them, are deduced the dew point, the tension of aqueous vapour, the degree of humidity, the weight of vapour in a cubic foot of air, the weight of vapour requisite to complete the saturation of a cubic foot of air, and the weight of a cubic foot of air of the mean temperature and density of the month. The requisite tables for this purpose have been published by Mr. Glaisher, who has derived the greater portion of them from actual experiments and observations, and not from theoretical calculations.*

The thermometers indicating the greatest and least temperature occurring in the preceding twenty-four hours, are registered at 9 a.m. They are for the most part of Rutherford's construction. They are placed horizontally; the tube of the minimum thermometer contains spirit which, on contraction, draws back an index, which, being left behind when the increasing heat again expands the liquid, shows the least degree of heat. The maximum thermometer is of mercury, which urges before it a steel index till the greatest heat is reached, at which point it is left, on the contraction of the metal, by a decrease of temperature.

The rain is measured at 9 a.m., and the quantity recorded is the produce of the preceding twenty-four hours. The force of the wind is estimated, by some observers, from the indications of Dr. Lind's anemometer, described by me in this *Journal*, (*ante* p. 226, Vol. XIII., 1850). All concur in recording, as nearly as possible, the approximate value to be given to the amount, by reckoning a gale as 6, a calm as 0. The nomenclature of the clouds is that first proposed by Luke Howard, Esq., in the year 1803, and lately re-published by him in a small volume, which is presumed to be in the hands of every observer. A clouded sky is represented by 10, and a clear sky by 0; the interpolations are arrived at by estimation.

Though some parts of England are still without a representative, the positions of observers are tolerably well distributed. Thus then we may conclude, I apprehend, fairly, that the utmost reliance may be placed in the monthly reports of those gentlemen whose names are appended to them on every ground, whether we regard their position in society, the valuable instruments in which they have invested no small outlay, or the unison of action which characterises their proceedings.

The results of three months' observation are forwarded to Mr. Glaisher, with every particular requisite to reduce them to what they might be supposed to have been, had they been taken at the level of the sea. They are then arranged in groups by him, according to the latitude, and from them are deduced certain results regarding the climate of the various parts of England, coincidences or irregularities of atmospheric phenomena, and of natural occurrences, such as the arrival and departure of migratory birds, the time of flowering of plants, the progress and prospects of agriculture, falls of snow, thunder storms, appearance of meteors and auroræ, on all which subjects the observers are expected to report for their own localities.

The British Meteorological Society have published blank forms for observations for each month. A full explanation of the instruments, registration, mode of observation, and the principles on which the deductions are made, will be found in my papers on the subject in this *Journal* for July, October, and November, 1850, Vol. XIII.

Mr. Glaisher's Quarterly Reports, diffused throughout the community by means of the newspapers and the scientific periodicals, have been the means not only of spreading information valuable to the man of science, the physician, the agriculturalist, and the engineer, but of exciting and keeping alive an interest in the study of atmospheric phenomena. The labour of comparison and reduction is very great, and that gentleman has received, as he has well deserved, the thanks of all those who desire the advance of science for his indefatigable labours in the cause.

About fourteen months since Mr. Glaisher originated a movement to which the government, the proprietors of a daily journal (the *Daily News*), and the principal railway companies became co-operating parties. His object was to obtain, by means of the electric telegraph, the direction and force of the wind and the state of the weather, at 9 a.m. every day in the year, with the exception of Sundays; these weather-tables are published the next morning in the *Daily News*, and have done much to forward our knowledge of the laws of atmospheric currents. Mr. Glaisher inserts daily the returns on a map of the British Isles, and thus he has before him, graphically, the direction of the wind at a given instant in every part of the country. Should this example be followed by the continental nations, and Belgium has already united in these daily reports, more will, by this means, be effected in arriving at the law of storms than by anything which has yet been undertaken. As this is entirely a novel arrangement, and an important step in advance, I have introduced a wind-map, derived from the daily reports for November 20th, 1850. Mr. Glaisher's comments thereupon will serve clearly to illustrate the value of what has been accomplished, and the benefit which we may expect to derive from a more extensive application of the principle.

"On November 19th, the direction of the wind over Ireland, England, and Belgium, was south-west; it was deflected to the south and south-east among the mountains north of England. A strong wind was blowing at most places south of 53°, more particularly in Belgium, on the south-east coast of England, at Holyhead, Conway, and over Ireland; there was a very high tide in the Shannon; on the southern and western coast of Ireland, a gale had been blowing all the previous night (see the *Express* of November 25th for accounts of wrecks, &c); the change in the reading of the barometer was great, there being one-thirtieth part less air over the northern parts of the country than there was the day before; and it was unequally distributed at places situated north of latitude 53°; the barometer reading there was 28·88, and south of that parallel was 29·23, the difference of temperature was 6°; that at Durham was 48°; and at Jersey was 54°. On November 20th there was a heavy gale blowing over Ireland, and the counties of Cornwall and Devonshire, from the north-west; at Guernsey and Jersey it was from west-south-west; over the south and south-eastern counties of England, and over Belgium, it was from the south-west.

"It is remarkable that at Lancaster, Whitby, Darlington, Shap, Sunderland, and Carlisle, a *gentle breeze* was only recorded with different directions; whilst north of these places *strong breeze* and *hard wind* was noted from the north-east: this day is worthy of special notice, as it is very evident that the air was moving in a circle, the direction in Ireland being north-west; north of France, west; south-east coast of England and Belgium, south-west; and the south of Scotland, north-east; whilst places within this circle were distinguished by weather of a moderate character. The pressure of the atmosphere was different in different places, being the least about Wakefield; its average value south of 51°, was 29·36; and north of this parallel, was 28·83. The temperature of the air at Durham was 45°, and at Truro was 53°. On November the 21st the direction of the wind over Ireland was variable, but was passing from the land towards the sea; on all sides over England and Belgium its direction was uniform, and from the north-west; the air was mostly in gentle motion; the air was almost evenly distributed over the country, and the reduced reading of the barometer was 29·69: the temperature of the air at Durham was 49½°, and at Jersey and Guernsey was 50½°."

Through the kindness of Mr. Glaisher I have been supplied with all the returns which he received, indicating the direction and force of the wind for the 20th of November; those giving the direction of the wind I have inserted in a wind-map, and they afford a graphic illustration of the movement of the air for that day at 9 a.m. It would be easy to multiply the number of such illustrations, but the results of one day are sufficient to indicate how the direction of the movement of the air, at any instant, may be ascertained, and, by transference to the map, may be presented to the eye at a glance; they tend to show how much we may probably learn of the laws which regulate the movements of the air, when observations of this kind are taken extensively over the earth's surface. I trust that, as soon as this thorough practical method is understood, the example thus set will be followed, and the records transmitted to the British Meteorological Society for discussion and comparison.

Having thus described the part taken by private observers in extra-observatorial work, and the progress we have lately made in systematic, united, and continuous effort, it devolves on me to point out the nature of the observations taken at Greenwich; and, by explanations in full, to indicate the extreme value they derive from the beauty of the instruments, and the minute accuracy with which they are recorded by the observers.

(*To be continued.*)

* Hygrometrical Tables to be used with the Wet and Dry Bulb Thermometers," by James Glaisher, Esq., F.R.S.

PRESENT CONDITION OF THE ROYAL TOMBS IN WESTMINSTER ABBEY.

By Prof. T. L. Donaldson.

[*Paper read at the Royal Institute of British Architects, Feb. 23rd.*]

It is now about thirty-five years ago that I first went to Paris. Among the public buildings which I then visited, none interested me more than the Abbey church of St. Denis, the crypts of which contain the ashes of most of the kings of France, from Clovis downwards. Nothing could be more touching than the contemplation of the rifled tombs of such a line of powerful monarchs, arranged in decent order, but without any affected attempt at restoration, or incongruous endeavour to form an arbitrary system of perfect and uninterrupted classification.

In August last I again went to St. Denis with some friends, and then I saw that, without reference to periods, chronological arrangement, styles, or any of the proprieties of art, a vain and pedantic effort had been at work to complete the series of the dynasties of the Valois and the Bourbons, by the introduction of modern recumbent figures, stone coffins, and other sepulchral receptacles, devoid of taste and feeling. I felt how ill the *religio loci* had been attended to, and I left with the melancholy conviction, that all the charm of truthfulness which had once given veneration to these vaults, had irrevocably passed away.

It was under impressions such as these that I shortly after accompanied a foreign friend to Westminster Abbey, anxious to show him the memorials of our olden times and of our greatness in past periods, and that we possessed treasures which would form a favourable contrast to those of St. Denis.

Westminster Abbey is emphatically the public building in England which most attracts the regard of the foreigner, filling him with respect, and producing the most lasting impression upon his imagination. I must own that I felt ashamed, as I drew the attention of my friend to monument after monument of our sovereigns, princes, and nobles, and more particularly to the Shrine of the Confessor. I endeavoured to palliate the state of ruin in which the precious memorials of the history of our country, its arts, and its greatness, were allowed to remain. From want of timely care they are gradually falling into decay, and threatening, in some cases, absolute destruction. "What," said my companion, "can it be true that your government so neglects these speaking monuments of past achievements, that it will not rescue them from utter ruin? What! is the father, is the son of the Black Prince so disregarded by you that you will not preserve, even as works of art, and ere it be too late, the marble that incases their remains, and the bronzes which hand down their lineaments? Have your Edwards and Henrys bled for this? Have they for this perpetuated England's glory in the 13th, 14th, and 15th centuries, and you allow them to be forgotten? Have these queens been in vain distinguished for their public and domestic virtues—in vain renowned for their piety, that you permit their sacred deposits to be despoiled, degraded, trampled upon?

I could not disregard these too just reproaches. The full consciousness at once came home to me, that this interesting series of monuments had been shamefully neglected; that we were too ignorant of their value. Impressed, gentlemen, by a sentiment, which I feel assured that you all partake, I mean by an earnest attachment to the monarchial, yet free institutions of our country, and an attachment to the throne, rendered still more ardent by the political convulsions which we have witnessed, I determined to bring the subject under the notice of this Institute, trusting, that however feeble would be the voice which should be heard pleading the cause of England's past worth, and of the dust of her honoured line of kings, a response would be found in the sympathy of those who would hear me. This spreading far and wide might eventually, perhaps, reach those who have the power, if they only have the will, to rescue from entire annihilation these speaking mementoes of monarchs who once ruled the destinies of this mighty people.

I venture to claim your attention as I take a rapid survey of the Sanctuary or Chapel of Edward the Confessor, and briefly notice the noble tombs by which the Shrine is surrounded.

In pursuing the description of the Chapel of Edward the Confessor, it will be well to follow the chronological order of the dates of the tombs. I must, therefore, remind you that Edward the Confessor, the last but one of the Saxon kings, after an eventful life, and a reign of twenty-four years, died in 1055-6. He had previously rebuilt the dilapidated old church of St. Peter, but being seized with sickness, he was prevented attending the consecration, and deceased a few days after it. Various miracles had been attributed to him during his lifetime, so that he was venerated as a saint long before he was canonised. A first application to the Pope to have him placed on the Roman calendar had been unsuccessful, but a second appeal to the papal throne was more fortunate; and Alexander III. enjoined "that the body of the glorious king should be honoured here on earth as he himself was glorified in heaven." On the return of the messengers the remains of the sainted monarch were, in 1163, solemnly translated by Archbishop Becket into a new and precious feretory, which had been prepared by Henry II., about ninety-nine years after the death of the sainted Edward. When the choir and eastern division of the Abbey church, which was then re-building, had been completed by Henry III., so as to admit of the celebration of divine service, "that sovereign resolved," says Wykes, "that so great a luminary should not lie buried, but be placed on high, as on a candlestick, to enlighten the church." In 1269 the body of the Confessor was removed, about 200 years after his decease, into the new Shrine, the form and decorations of which we shall consider after we have described the other royal tombs.

The king and monks of Westminster were anxious to give peculiar and elaborate magnificence to this Shrine, and consequently it was executed with glass mosaic decorations, and the floor was also laid in a geometric marble-mosaic pattern; the tomb of the royal restorer, Henry III., shines with the like brilliant work. Another fine specimen of a different style, in marble tesselated work, is the magnificent pavement in front of the Abbey altar, to which I shall hereafter revert. Here, then, we have illustrations of a style of art of rare occurrence out of Italy; in Paris none such exists. The monument of Henry III., if met with in Italy, the Holy Land, or Constantinople, would be quoted for its design and enrichments. From the pavement of the north aisle of the choir rises an elevated basement, on which rests the lower division of the royal tomb. Its face has three square compartments; the centre one was once filled-in with a circular porphyry panel, circumscribed with interlacing bands of glass mosaic, and the spandrils occupied with smaller circles of the like work. The outer panels are square, placed lozenge-wise, and of serpentine, inclosed by mosaic bands with circular smaller panels in the spandrils. At the ends are pilasters with a twisted column at each angle. The upper compartments of the tomb, on which lies the bronze effigy of the king, have two spiral columns at the angles, the flutings filled-up with glass mosaics. The centre forms one large panel with a noble slab of porphyry, surrounded by a border of glass mosaics, and held in its place by four bronze pins, the ornamental heads of which project beyond the face of the porphyry. The elevation towards the shrine is different in design, but presents, with some variation of details, the like general divisions. Most of the slabs of precious marble have been abstracted or split, the mosaics picked out, and the columns are deficient. The recumbent statue of the king, now covered with dirt and rust, is of brass, the first, according to Walpole, that was cast in this kingdom; it was once gilt, and probably parts of it were enamelled, and the very plate on which it lies is covered (semé) with the English device of the lion. But the canopy above the royal head is *gone*—the couchant animals are *gone*—the side pillars or buttresses are *gone*—the kingly staff and sceptre are *gone*—and the wooden canopy above, to keep off the dust is a bare fragment.

In the intercolumnar space to the west of Henry III. lies his son Edward I., the English Justinian, who was, to use the words of the accurate Brayley, at the same time a gallant warrior, an able statesman, a wise legislator, in domestic life a faithful and affectionate husband to his excellent queen Eleanor of Castile, and a good father to his children. His tomb is a large plain one, composed of five slabs of grey marble, without any pretensions to decoration, and as unostentatious as the beautiful memorials which he erected to his excellent queen are rich in all the embellishments of Gothic art. The tomb of his beloved Eleanor lies in the intercolumnar space east of her father-in-law, Henry III. She it was who accompanied her warrior husband, Edward I., in all his journeys and expeditions, having in Palestine, as it is recorded, sucked the poison from the wound inflicted in his arm by the dagger of an assassin. She was his partner for six-and-thirty years, and died in 1290, seventeen years before her husband, who was then in his fifty-first year. So tenderly was he attached to the memory of her conjugal virtues and affection for him, that he ordered the erection of the celebrated crosses between Lincoln and London, some of which still remain at Edmonton, Waltham, Northampton, and Geddington, the refinement and variety of whose design and execution are admirable. The last resting-place of this best of England's queens is no way inferior to the other memorials of her virtues; but the same melancholy story must be told of the tomb of the lovely Eleanor of Castile as of that of Henry III. The exquisite beauty of her features realise the Greek type of loveliness; and, in fact, so sweet is the expression, so harmonious are the features, so perfect the profile, that it is said later sculptors adopted her likeness for their figures of the Virgin. And it is curious to remark, that although she must have died at an advanced age—above fifty, for she had been married six-and-thirty years, and had been the mother of fifteen children—yet she is represented young and beautiful as when Edward first wedded her. But all her beauty and grace and virtues have not secured the marble of her tomb from decay, nor the bronzes from abstraction; the very wand or sceptre has been stolen from between her graceful fingers, and the jewels from the crown which incircles her head. The statue and its accompaniments are of brass, once partially enamelled and profusely covered with the devices of Castile and England, but now obscured by the crust of dirt which covers them. May the present century, thou beauteous, noble-hearted daughter of Castile, render thee the justice and respect which were shown thee by thy well-beloved husband! It appears from the contract, which still exists, that Richard de Coverdale undertook the marble-work of this tomb, and William Torrell, the goldsmith, the statue, which was completed in 1292. It would be important for the history of English art to ascertain, if possible, whether Torrell, if not himself an Italian (as supposed by some, who, by an easy modification of the name, make it Torrelli, not merely Torrell), may not have employed, as is done now-a-days, some distinguished English or foreign artist, most probably an Italian, to model and execute the bronze-work; for we need not necessarily conclude, that because the contract was taken by a goldsmith, he was himself competent to design the figure, although he may have had all the conveniences for the mere mechanical operation of casting it. Edward I. endowed the Abbey with lands, then valued at 200*l.* per annum, for maintaining the worship and religious rites connected with the tomb; but these possessions were confiscated at the time of the Reformation, 250 years after.

It is unnecessary for me to make more than passing allusion to the alabaster* tomb of Queen Philippa. The appeals that have been made to the public to raise funds for its restoration, and the exquisite specimen of the work, which was one of the attractions of the Great Exhibition, will have made you familiar with the value of this monument as a work of art.

We next come to the monument of the heroic Edward III., which is on the south side, immediately opposite to that of Henry III. This is a magnificent memorial, consisting of a lower pedestal, 4 feet high, next the aisle, divided into four quartre-foiled panels with highly-elaborated tracery, having central metal shields exquisitely enamelled and emblazoned with the arms of England and France. This pedestal is surmounted by the altar or pedestal tomb, which has on each side six canopied niches; to these are still attached the bronze figures, 18 inches high, richly enamelled on the surface. The tomb is of Petworth marble, and though the architectural enrichments are generally decayed, enough remains to supply authorities for every portion. The venerable figure is of brass, of noble features, with a flowing beard; the ensigns of royalty, which the hands once held, have been destroyed. It is surrounded by a recumbent bronze tabernacle of elaborate tracery, with numerous figures beautifully cast and wrought; and although many portions are deficient, yet they exist in other parts, and might with little expense be replaced. There is above the tomb a richly-worked oak canopy, almost entire, and wanting little to restore it to its original splendour. Yet, scanty as the sum would be to render this tomb as perfect as when it was first put up, the spirit is wanting to render this tribute to the Conqueror of Cressy, the father of the Black Prince, to him who won the field of Poictiers, who founded the Order of the Garter, and erected Windsor Castle. On the margin of the table the aged monarch is described as "the glory of England, the flower of past kings, the type for future ones—a clement king, the peace giver to his people."

The interspace between the next pillars is occupied by the tomb of the unfortunate Richard II. and of his queen, Anne of Bohemia. It is of like design with that of Edward III., of the same materials, and was possibly executed by the same artist. The surface of the marble is frightfully perished, all the elaborate tracery, tabernacle-work, buttresses, and finials, present a time-worn surface, in many parts wholly defaced, and all the sixteen metal statuettes are gone! The recumbent brass statues of Richard and his queen lie side by side, once gilt and covered with worked devices. The arms and hands of both, with the sceptres, ball and cross, which they held, are wanting, as also the lions, the leopard and the eagle, which once lay couchant at their feet. The masses of the recumbent tabernacles alone exist, despoiled of their enrichments, side pillars or buttresses, and angels. The bare arch of the oak canopy, without the carved work which embellished the summit, the cornice, and the upper range of battlements remain. The colours with which they once glowed, which gave expression and relief, are now tarnished or defaced, but still the soffit of the canopy displays unmistakeable evidences or traces of pictures with religious or historical subjects of considerable size.

The tomb of the gallant Henry V., the hero of Agincourt, occupies the east end of the sanctuary, under a stone canopy, which forms the chantry. As we know that oak chantries were not unusual (witness that at St. Albans), and as it was customary to have one in sanctuaries which contained the tombs or shrines of saints, I am led to think, that possibly there might have been an old oak chantry in this part, and that Henry V., finding all the spaces between the piers occupied by the tombs of royal personages, and desiring to be placed in the regal circle around the shrine, may have assumed this place to himself, and replaced the wood chantry with a stone one; yet, so arranged as to form at the same time a superb canopy to his own tomb. The architecture of this monument is not so much damaged as that of many others. This, I think, arises from its being inclosed by the substructions of the chantry and the ceiling, which protect it from the damp. But the sculptured groups, whether of stone or metal, which once filled the deep recesses of the sides, have been stolen. The wood block of the figure and frame, on which it rests, were once covered with a more precious metal, tradition says silver; the carving shows the parts and drapery very completely, but the head, which it is said was of pure silver, is gone. The open iron railing and gates, inclosing the west end of the mausoleum, are most curious specimens of elaborately-wrought metal-work. They were once removed, but they have since been most judiciously replaced by the Dean and Chapter.

Two modest marble caskets, once enriched with bronzes, contained the infant remains of daughters of Edward IV., and of Henry VII.,—"Quam longa una dies, ætas tam longa rosarum,"—with simple moulded plinth, die and cornice. But one is almost fallen to pieces; and the slabs, which a few shillings might secure, are dilapidated and falling to ruin.

The sword and shield which were borne before the heroic Edward III. in France on those battle-fields whose names are "familiar in our mouths as household words," are here exhibited. The helmet, the shield, and the saddle of Henry V. are still attached to the pillars above his tomb. Dusty, dirty, torn and distorted, these memorials of Cressy and Agincourt seem only worthy (apart from their mighty traditions) of an old metal shop.

The throne on which our present august sovereign was crowned, as were also most of her predecessors, shares the same neglect, and has alike been despoiled of its finials, its crockets, and carvings. A thin coating of plaster shows where the painter's art once shone in all its glory. The other throne is of doubtful origin, and patched up in a bastard taste with panels of Italian design. *Proh pudor!*

Having thus briefly noticed the tombs around the shrine, we will now proceed to consider the present state, and the possible restoration of the tomb of the Confessor himself; not that I would seek to revive a worship which every Protestant must hold to be superstitious, but I know not why we should deny to

* It is curious to remark that the alabaster monuments in Westminster Abbey have better resisted the corroding effects of the damp atmosphere than those of Petworth marble, and that the deterioration of the former arises entirely from wanton mischief.

the tomb of a holy and pious man that respect which has never been withheld from bygone worth. And surely, apart from religious considerations, and on historical grounds, we may desire the restoration of so ancient a monument of art, and the preservation of a memorial of a much tried and devout monarch.

The Shrine of Edward the Confessor.

This tomb of the most eminently pious of our kings is as melancholy a fragment of royalty as can be well imagined. Placed in the centre of this sanctuary, it rises the most prominent object of the whole of the royal and sacred shrines, and is at the same time the most humbling witness to our shame. A more august, yet pitiable memento of the transitory nature of all earthly greatness, cannot be conceived. A cumbrous, shapeless mass, stripped of its sparkling mosaics, despoiled of its elaborately enriched columns, its summit superseded by a subsequent incongruous architectural termination, itself in ruins, now contains the relics of the holiest of our line of monarchs, round which kings and nobles, the various states of the realm and the city of London in its palmiest days, were wont to come to pray and tender their choicest offerings. I must quote this as a solitary instance remaining in this kingdom, and one of only a few still extant in Christian Europe, which retains somewhat of the form and substance even of a saintly shrine. Where is now that glory of England, the shrine of her protomartyr, St. Alban? of St. Cuthbert at Durham? of the imperious A'Becket at Canterbury? and of many others that I might quote, once the religious pride of our country?

This tomb is oblong in plan, with a twisted column at each angle, and the spiral flutings were filled with mosaics. The capitals were of early lancet character, painted and gilt. On each side are three recessed trefoil-headed niches, and one at the east end, in which were probably exposed the other sacred relics presented to the Shrine. The whole surface was covered with elaborate geometric figures, sunk in the stone, and filled-in with exquisite mosaic of the Byzantine character, glistening with gold, red, green, and blue, many sparkling fragments of which have still been spared. One capital alone remains *in situ*. Fragmental portions of two large shafts still exist, and support a large slab, 5 ft. 4½ in. long by 3 ft. 4½ in. high, filled with mosaics, interlaced in geometric forms, and probably placed where it now is upon the suppression of shrine-worship at the Reformation. The panels consist of porphyry and green marble. Up to the cornice we may consider that the feretory presents the main mass of the original design of the time of Henry III. (1269). But it appears, that at the period of James II., an upper division in wainscot was added, consisting of two stories of arches, with pilasters and entablatures of Italian or Palladian architecture, parts of which were inlaid with marqueterie-work, in imitation of the mosaics of the lower division. And at this period, probably, it was endeavoured to repair the dilapidated state of the antique work, by filling-up the parts whence the mosaics had been abstracted with plaster, and painting the surface in imitation of mosaic-work. On examining the floor at the west end of the Shrine, there are evidences of the space occupied by the altar, where daily masses were said. And I am led to presume, that the large tablet now upraised on the truncated columns formed the front of the altar.

In order to enable us to appreciate the original design of the Shrine, I would venture to offer a suggestion as to the appearance of this remarkable monument in its pristine form and arrangement. I would call to your mind the numberless reliquaries of silver gilt which remains to us of the mediæval times, like that, for instance, of St. Albin at Cologne, or the gorgeous one at Aix la Chapelle; their sides divided into spaces by columns and arches, surmounted by gable-ended roofs, formed into panels with sculptures, and brilliant with jewels. These reliquaries are but imitations of the larger shrines of the saints of the Roman Catholic calendar. I conceive, therefore, that this of the Confessor, with its spiral columns restored at each angle, mosaics complete, niches filled with precious relics, gable-ends flanked with pinnacles, and sloping roof enriched with panels, its altar in front, and mosaic floor, must have presented an imposing spectacle sufficient to awaken and exalt the fervour of the pious pilgrim. The floor of the chapel consists of a tesselated mosaic of interlacing circles, of meagre general effect from the insignificance of the parts, which are not arranged in grand divisions; the individual patterns, however, are graceful and full of fancy.

But my subject irresistibly leads me not to conclude these descriptions without calling your attention to the magnificent mosaic on the west side of the altar-screen, of the class that Mr. Digby Wyatt calls opus Alexandrinum. It is as fine as any example existing in Italy. It was originally 25 feet square, but a modern arrangement of the steps in front of the communion table, has reduced the margin on the east side. It is traced, on a very minute scale, in Neale's plan to Brayley's work. The arrangement of the tesseræ is precisely like that of the example from the choir of San Marco at Rome, and something in the style of the mosaic in San Lorenzo fuóri le Mura. From the recorded inscription, part of which still remains in brass letters, it appears to have been laid down in 1268, in the time of Henry III. The tesseræ consist of red and green porphyry, lapis lazuli, jasper, alabaster, and white marble. The inscription, consisting of ten lines, occupied the bands round the circles and inclosing the great square. If this pavement were but slightly restored and polished, it would be one of the finest specimens of the class in Europe.

A serious question, from the consideration of which we must not shrink, next arises. Can these masterly relics of ancient art be restored without compromising their authenticity, and without permitting the fancy to supersede sober judgment; and can we thus preserve them as unquestionable and unimpeachable memorials of our art history in England, and of the epochs they now illustrate? Let me ask what is necessary to accomplish this beyond a doubt, beyond a surmise of corruption? A thorough knowledge of the different phases which mediæval art assumed not only in this, but in other countries during five centuries; a scrupulous and submissive respect for the taste, the skill, and genius of the men of that period, and for the art which they enriched by their talents; an absence of self-love. If such be the qualification, I boldly declare my conviction, that in no period of this country, not even in the ages just quoted, existed there men more competent, more faithful, more zealous to accomplish this great work. In the middle ages the artists disregarded the tastes of the preceding periods, and engrafted on an incomplete work the style of their own epoch. But now the very essence of our school is synchronism, and an almost slavish adherence, as it were, to precedent—a laborious search for examples and authority;—not a monument unvisited—not a book unread—not a MS. unexamined,—that contain aught to illustrate and explain the arts of those times.

We have architects, too, whose own works may side by side contest the palm with the buildings of the olden style. And this work might be entered upon with the more confidence under the sound judgment and discretion of the actual professional adviser of the Dean and Chapter, for his taste and skill are proved in the numberless churches which he has erected; his knowledge in Gothic art cannot be excelled; his feeling for it is most intense; in the face of Europe he carried off the palm for the new Gothic church at Hamburg: and he possesses the unreserved confidence of the profession. The name of Scott is a sufficient guarantee, that if the work of restoration be done to these royal tombs, it will be carried out learnedly, truthfully, and artistically.

I seek to avert a vast, a lamentable, a dishonouring destruction, ere it be irrevocable—a calamity, the possibility of which I feel none here present can contemplate unmoved. I ask for no rash nor extravagant re-construction, but merely a replacing of what is evidently known as having once been there—a repetition of what in other parts of the same monument may already have survived the wantonness of wilful dilapidation, or the waste arising from neglect. And never were coincidences more favourable—never was the work more called for, which it has been, perhaps, reserved for the honour of the present times to realise. What would more excite the loyal feelings of the numerous visitors to the Abbey than to see the tombs of England's glorious monarchs treated with respect by those in power, and restored to comparative completeness? And what a moral and historical lesson to teach them how much we owe of the reputation of the English name in mediæval times to their heroism, and much of our present liberties and greatness to their wisdom! The visitors also would see the progressive history of mediæval art during three centuries, and learn to appreciate the beauties of each successive development. Is it wise of our government to let the people see the tombs of our most glorious kings dishonoured, and infer that a feeling of loyalty and affection to past dynasties is of no consequence? Is there not something august and venerable in the kingly state, and shall we allow the record of a dead monarch to be despised and neglected? Is it wise at such moments as these, when all that can possibly be done should be accomplished, to gather round the throne and its antecedents the sympathies and affections of the people, to allow the dust of the dead kings to be as no value? Let us hope, then, that the government will awaken to its duties. It is the common custom of the land, that a family is answerable for the maintenance of the tomb of a deceased relative. Is there no tie of affection and reverence between the crown of to-day and of past times? The Abbey authorities have of late years done much; but they have not the means to effect all that is required: and there is, besides, no pretence to call upon them to restore the tombs deposited within these sacred walls. Their funds are little adequate to uphold the fabric. And the endowments, granted by royal munificence, have been since confiscated. Let us hope, then, that the high-minded advisers of the Sovereign will appreciate this duty, and show their loyalty to the throne and prestige of the crown of England, by causing the restoration of these dilapidated memorials of ancient sovereignty.

In the discussion which took place on this subject, on March 8th, Mr. Donaldson expressed his obligation to the Chairman for enabling him to put the members in possession of some additional information which he had received since the last meeting, in a letter from Mr. C. H. Smith, explaining that the green stones in the mosaic pavement before the altar were not, as he had supposed, serpentine, but, in fact, pure green porphyry. He had, in the next place, been favoured by Mr. Britton with a report on the National Monuments and Works of Art in Westminster Abbey and other Public Edifices, printed in 1841 by order of the House of Commons. He also begged to submit for inspection the following interesting objects:—Some beautiful sketches of the monuments referred to (with other antiquities at home and abroad), by Mr. Burgess; a specimen of the marble floor of Conrad's Choir in Canterbury Cathedral, with a coloured rubbing of about a quarter of the pavement of Becket's Shrine, both contributed by Mr. Austin of Canterbury; and a fragment of the thick coating of paint, &c., with which the Purbeck marble statues in the Temple Church were formerly encrusted, exhibited by Mr. Edward Richardson, sculptor. Mr. Donaldson next referred to a rubbing of a monumental brass in the floor of Edward the Confessor's Chapel, and stated that, at the coronation of her present majesty, a portion of the lower part of the brass was entirely removed by one of the workmen employed, solely because it interfered with the erection of a gallery, raised to enable some of the distinguished visitors to witness the ceremony. By examining the marble slab in which this brass was inserted, he had been able to trace the whole of the original design, and of this he exhibited a drawing, which, by its contrast with the rubbing showing its present state, would enable the meeting to judge of the desecration and abstractions to which the monuments in Westminster Abbey were liable. Mr. Donaldson next referred to a drawing of a suggested restoration of the Shrine of Edward the Confessor, differing in the character and arrangement of the upper part from that which he submitted at the last meeting. He, however, utterly disclaimed the slightest wish, in these suggestions, to encroach in any way upon the province of Mr. G. G. Scott, who was so well qualified to conduct the restoration of the monument. His only object was to remove the impression of the incongruous addition to the Shrine made in the time of James II., and to show the different modes of restoration which might be adopted. Probably the drawing now produced was more in accordance with a manuscript in the possession of the Dean and Chapter than the former.

Mr. G. G. Scott, the architect to the Dean and Chapter, said, with regard to the monuments themselves, he would mention first, that extraordinary group of which the Shrine of the Confessor was the principal, executed as they were by Italian artists in the time of Henry III. These comprised the two mosaic pavements, the Shrine of the Confessor, the tomb of Henry III. himself, those of his children and grandchildren in the ambulatory round the choir, and a little monument, not generally known, to the son of William de Valence. The latter monument exhibited a small piece of glass mosaic-work and brass, and was laid in the floor immediately under the step of the monument of Henry V. He had found that Abbot Ware, or De Ware, was appointed in 1263, immediately after which he went to Rome, and probably there saw mosaic monuments, which led him to wish to introduce that style into England. He was at Rome in 1267, and on his return, brought with him the various stones, porphyry, and glass mosaic, and men capable of executing works in both materials. The names of two of the principal of these had been preserved; the mosaic pavier was Odoricus, and the man who executed the glass mosaics was called Peter, a Roman citizen, his surname not being known. The date of the [altar] pavement was 1268, and of the Shrine, 1269. Mr. Scott next quoted the following passage from Professor Willis's 'History of Canterbury Cathedral':—

"The Shrine of Edward the Confessor, which still remains, although in a sadly mutilated and neglected state, in Westminster Abbey, will serve to illustrate the arrangement of Becket's shrine, and probably those of the other principal saints. It stands, like Becket's in a chapel, and separated from the choir and high altar by a reredos, but yet not a detached building, as the lady chapels so commonly were. Architecturally speaking, the chapels of Becket and Edward are within the choir at its east end; the pavement in both cases is raised above the level of the choir, and each shrine is a parallelogram on the plan, and stands east and west. The altar is at its west end, and in contact with it, so that the saint is placed behind the altar, *retro altare*; and reiprocally, the altar is at 'the head of the saint,' since the head of a corpse was always laid to the west. These phrases have already occurred in our quotations from the monkish chroniclers; for example, in the Saxon cathedral, the matutinal altar was placed at the head of Dunstan; and Anselm, Odo, Wilfrid, and others, were deposited behind altars. On the other hand, in chantry chapels, the tomb of the uncanonised founder is commonly at the west of the altar, so that the priest stands at the foot of the tomb. The description of the shrine of St. Cuthbert at Durham, will also serve to illustrate the two already mentioned. This, too, was placed behind the great reredos of the high altar upon a raised platform inclosed, and forming what was called a 'feretory,' or chapel for the reception of the feretrum. This platform may still be seen extending partly into the great eastern transept, or 'Nine Altars,' as it is called. In the midst of it 'his sacred Shrine was exalted with most curious workmanship of fine and costly green marble, all lined and gilt with gold, having four seats or places convenient underneath the shrine for the pilgrims or lame men setting on their knees to lean and rest on, in the time of their devout offerings and fervent prayers to God, and holy St. Cuthbert, for his miraculous relief and succour.'" (Under the shrine of Edward the Confessor there are arches, three on each side, which probably served for a similar purpose.) "'At the west end of the shrine of St. Cuthbert was a little altar adjoyned to it, for mass to be said only on the great and holy feast of St. Cuthbert's day in Lent..... And at this feast, and certain other festival days, in time of Divine service, they were accustomed to draw up the cover of St. Cuthbert's shrine, being of wainscot, ... and a strong rope was fastened thereto, and did run up and down in a pulley under the vault for the drawing up of the cover; fine sounding silver bells were fastened to the said rope, which at the drawing up of the cover made such a goodly sound, that it stirred all the people's hearts within the church,' &c. This cover was painted and varnished within and without; and within the feretory, on both north and south sides, there were ambries of fine wainscot for relics."—*Rites of Durham.*

The peculiarity thus mentioned in the shrine of St. Cuthbert at Durham, applied exactly to this at Westminster. All the historians he had met with said that the seven niches in St. Edward's Shrine were made for the patients to kneel in, to receive miraculous cures; and it would be found they were exactly of the proper height to receive persons kneeling. Probably, too, in the Westminster Shrine, there was a cover, to be drawn up as at Canterbury. Seeking also for proofs of its existence, Mr. Scott had found three holes immediately over in the vaulting of the roof, through which he had no doubt the cords passed by which the cover of the shrine was raised. In Keepe's History (1680), the upper part of the feretory of St. Edward was described as having been covered with plates of the purest gold, set about with precious stones. Dart described it as of gold and precious stones, adding that the workmanship exceeded the materials. In the library of Westminster Abbey there was an old Service Book, of the time of Richard II., and an initial letter of the service for St. Edward's day contained a rude representation of the monument, as a stone erection, with a very rich golden or gilt shrine above, set with precious stones. The form of this Shrine was represented in the drawing as something like the roof of a cathedral without the lower walls. It had the aisle roof, the clerestory, and the principal roof; and on the inclined surface corresponding with the aisle roof, was a representation of the king in his robes, probably in enamel. There was one great dissimilarity between the existing remains and this drawing: the latter showed the whole of the seven niches in a row on one side; but that mode of representing them would probably quite accord with the artist's notions of accuracy; and although the representation could not be trusted for a minute detail, this error could not be taken as a proof that the upper part was entirely dissimilar to the original; especially as the illuminators of those days would think more of the gold part than of the stone. No one could doubt that there was an altar at the head of this monument; and he could not help thinking it was standing till the time of the Great Rebellion. He found that it had certainly not been standing since, and there was proof that a certain amount of ruin took place in the Abbey at that time. At the end where the altar stood, a hole appeared to have been made by some accident, and this had been patched up with a common panel taken from some monument of the seventeenth century. This looked, therefore, as if the injury had taken place at that time. The altar was certainly not standing in the time of Dart, whose words were—"An altar stood there, which, even since the Reformation, has been casually erected at our coronations; particularly at that of Charles II." Sandford, in his account of the coronation of James II., spoke several times of "the altar of St. Edward," upon which, he said, the regalia were placed. Looking, however, to the drawing given in the same work, this altar appeared to be only a very little table; and that it was not permanent was also proved by the author referring to "one Turkey carpet, to be placed under the altar of St. Edward." Whether the old practice of placing the regalia on "the altar of St. Edward" had been continued till the last coronation, Mr. Scott was unable to say. He thought Mr. Donaldson's idea that there were several pillars upon the Shrine, to carry lights, was probably correct. Many documents proved that lights were used around the Shrine. On the north and south of the Shrine were the tombs of Edith, wife of the Confessor, and Maude, wife of Henry I.; and a manuscript referred to by Dart stated, that on certain days a lamp was burnt at the sides of the altar, near those tombs; a large lamp before the altar, and three others before that. There was a great practical difficulty in deciding what was the original design of the altar end. At present a large slab stone, inlaid with mosaic, was supported very rudely by two spiral columns, similar in form, but larger than those formerly at the east end, being 7½ inches in diameter, whilst the latter were only 4 inches. These western columns had neither capitals nor bases; but by excavating under one of them, he had found that it ran into the ground to just the length of the column whose capital only remained in its place at the south-east angle of the monument. As to the slab thus supported, he did not quite concur with Mr. Donaldson that it had been the front of the altar; partly on account of its height, which in that position must have been 3 ft. 10 in.:—an unusually great height.* At all events, this large slab was not very far out of its original place. It projected 7 or 8 inches beyond the width of the Shrine, and on that projection, as elsewhere, the mosaic pattern appeared, and that pattern corresponded with those on the narrow slips above the niches; the different patterns of the two sides being each conected with a corresponding portion of the large end slab. Judging from the remains of the ancient inscription round the monument, it must have extended round the west end; therefore, the large slab could not then have been placed quite so high as at present. His theory was, that it formed the upper part of the reredos of the altar; and that, being thus wider than the lower part, the latter was equally widened, by narrow slips, down to the floor. The extreme edges of the long slab being destitute of ornament (except some modern imitation of mosaic), he imagined those surfaces were hidden by the columns at the two western angles, thus increasing the width of the altar front still more. To suit this position of the columns, the entablature at those points must have projected over them in a manner not unusual in works of that period and style. The whole of the cornice was modern, and the original entablature must have been injured when the metallic shrine was removed after the Reformation. Remaining thus dilapidated for a time, it was probably repaired in the time of Queen Mary, to which era might perhaps be ascribed the pseudo-shrine now surmounting the monument. Judging only from the style of that addition, he should have considered it a work of the reign of James II.; but Dart spoke of it as being so old that he thought it was coeval with the lower part; an opinion he would scarcely have held if it had been made when he was a boy. Afterwards, at the time of the Great Rebellion, Mr. Scott supposed that the altar was thrown down, and that the large slab above-mentioned, with the architrave above it, fell down, ruining the whole of the west end; and when it was repaired, the fragment of the seventeenth century was used, as before referred to—the present disposition of this part dating from the time of Charles II. With respect to the monument of Henry III., Mr. Scott stated that the canopy existed about 150 years ago. He might leave the members to their own comments on the other tombs. The great question was that of restoration. What Mr. Donaldson had said of the present dreadful state of these monuments was perfectly true; but the question was—what they were to do with them. There were two views to be taken of the case: on the one hand, if these monuments were renewed, would they be *the* monuments that were erected to these illustrious individuals? Supposing they were to introduce some of the beautiful glass mosaic of Mr. Stephens into the Shrine of the Confessor, it would cease to be the work which Peter, the Roman citizen, carried into execution. If they renewed the marble of Queen Eleanor's tomb, it would not be the monument which Edward erected to his Queen. Moreover, it might be fairly said that the very identity of these things was proved to the public mind by their dilapidation. If they had come down to the present time without a speck upon them, the public would not believe they were what they professed to be. The very wounds they had received were the proofs of their identity; and though it was grievous to witness their decay, he could not help feeling that possibly, if those wounds were repaired, we might cease to love the place as we did now. The case on the other side appeared to be equally strong. In one word, were the monuments of the victors of Cressy and Agincourt, and of the sainted Edward, to depend for their duration on miserable English marble, and perishable Reigate stone? He would not in any way appear to attempt a decision between these two views of the question; neither of which he had stated as indicative of his individual opinion, but on the contrary, he should be glad to hear the opinions of others on so interesting a subject. As one step towards restoration, however, instantly, by the aid of government if it could be procured, or by other means, perfect drawings should be made of every mediæval monument in the Abbey, as now existing; with every detail shown with such perfect minuteness, that, in the event of their perishing, it might be easy to re-construct them. In addition to their present state, another set of drawings might give a complete restoration of them, according to the judgment of those who undertook it—probably a committee of architects and antiquaries—with models of such things as could not be well shown by drawings. Such a series would serve as the authority for restoration now or hereafter; and even if not so used, they would be of the utmost value.

Mr. E. Richardson said objections to restoring the monuments had been raised by many learned and respected antiquaries, from a jealous fear that all originality might thereby be lost; but, on the other hand, many valuable relics had been destroyed from a honest belief in their utter worthlessness, and a consequent neglect of timely repair. He could wish to see the existence more frequently of the feeling displayed by Lady Dudley, who, in her will, dated in 1673, adverted in strong language to the fact, that the tombs of her noble ancestors, in the Beauchamp Chapel, Warwick, had become much blemished by consuming time, and were in danger of utter ruin; and she accordingly bequeathed a certain sum for their perpetual repair. With regard to the Westminster tombs, his motto would be, to cleanse but to destroy not; to add as little as possible, and not even that little without the best authority. Accurate and careful drawings, casts, &c. should be taken during the progress of restoration. An immense number of valuable historical monuments had entirely disappeared within the last twenty or thirty years. Indeed, a recent letter from the present historian of Leicester to Mr. Richardson stated that he had recently discovered, in a field near Nottingham, a fine effigy of a crusader, standing as a rubbing-post for cattle.

It was suggested, at the close of the proceedings, by Mr. Donaldson, that a party should be formed to visit the monuments at Westminster; and accordingly, on the 15th, the members, to the number of one hundred and fifty, assembled and, accompanied by Messrs. Donaldson and Scott, minutely examined not only the royal tombs, but every object of interest connected with the Abbey.

The discussion was renewed at the Institute on the 22nd, at the conclusion of which a proposition was moved by Mr. T. L. Donaldson, and seconded by Mr. Papworth, "That the Council of the Institute be requested to draw up a humble address to be presented to the Queen, praying that her Majesty will be pleased to appoint a Commission for the purpose of taking into consideration the dilapidated condition of the Royal Tombs in Westminster Abbey, with a view to the adoption of such measures as may be proper for the preservation and perpetuation of these important national monuments; and that the seal of the Institute be affixed thereto." The proposition was put from the chair, and carried unanimously.

* In reply to Mr. Scott, Mr. Scoles observed that the canonical height of the altar, according to the Roman ritual, was 3 ft. 4½ in.; Mr. Digby Wyatt said that the early altars were higher; and Mr. Donaldson observed that there were some in Italy 4 feet high.

THE ABSORBENT POWER OF CHALK, AND ITS WATER CONTENTS.

By Prof. David Thomas Ansted, F.R.S.

[*Paper read at the Institution of Civil Engineers.*]

The wide extent and uniform character of the chalk formation of England, and the vast population more or less directly concerned with its presence at or near the surface, impart great interest and importance to every fact connected with its physical condition. The author having been lately engaged in some investigations with reference to the absorbent power and capacity for water of different parts of the chalk, and having obtained some results which are not, it is believed, generally known, an account of the investigation is now laid before the Institution of Civil Engineers, as having distinct and immediate reference to the practice of engineering. The account of the experiments is prefaced with a short statement of the geological character of the rock referred to.

The upper cretaceous formations of the British Islands include the chalk, commonly so-called, reposing first, and only partially, on impure and variable deposits of mixed calcareous, siliceous, and argillaceous rock, called sometimes the upper greensand; and then on a bed of tough clay, generally known as the gault, very impermeable to water, and very persistent wherever the base of the chalk series has been reached. The upper greensand receives its name from the frequent presence of minute particles of silicate of iron, and often passes insensibly into impure and dirty chalk. The gault, the thickness of which is moderate, generally preserves its essential character and appearance, and is very important in keeping up the water contained in the chalk, and preventing it from passing down into the underlying sandy beds of the lower cretaceous series.

The range of the upper cretaceous deposits of England is limited absolutely by the south and east coast line, extending from near Bridport, in Dorsetshire, round by Beachy Head and Dover, along the Essex, Suffolk, and Norfolk coasts, to Hunstanton, near Lynn; while a straight line drawn on the map from Bridport to Hunstanton passes not far from the line of outcrop of the lower cretaceous deposits, or lower greensand. There is also a considerable outlier of chalk further to the north, in Lincolnshire and Yorkshire. Within these lines is contained a total area of about 20,000 square miles of country, from about 2000 square miles of which the chalk has been removed, by denudation, in the weald of Kent, and Sussex, leaving about 18,000 square miles, of which perhaps about 8000 square miles are so completely covered by thick tertiary deposits of clay and other impervious matter as to conceal the chalk, and to remove it entirely from observation. There still remain, however, about 10,000 square miles of country occupied by the chalk, or covered with less considerable though often very important beds of gravel. This district generally presents a range of smooth hills, or downs, for the most part much above the sea level, and often scooped out into hollow combes.

The chalk lies generally in nearly horizontal beds, or with a very small dip, although in certain parts it is much tilted and broken. With the exception of the North and South Downs, which dip, the former to the north, and the latter to the south, the general and very moderate inclination of the whole mass is towards the south-east, so that there is formed an irregular, triangular trough, or basin, between the North Downs and the range of chalk hills in the counties of Buckingham and Hertford. The chalk which forms this basin is covered by the older tertiary formations of the London and plastic clay series.

The subdivisions of the chalk are not very strongly marked, but are sufficiently distinct to be worthy of some notice. They are most conveniently designated as the upper, middle, and lower portions respectively, since by the use of these terms their relative position is merely indicated. The lower portion is, however, very generally known as the chalk marl, or clunch, terms not always applicable. The beds of the upper chalk alternate with layers of flint, not uniform over extensive areas, but on the whole sufficiently regular, and marking with much precision, though not invariably, the stratification of the rock. Occasionally there are transverse crevices, also occupied by flints, but they are nowhere so nearly adjacent as to offer any effectual barrier to internal drainage, and the passage of water through the whole mass. There is no marked limit to the upper beds beyond the mere absence of flint bands; and the position of the lowest band of flints is a local accident. The bottom beds of the chalk are usually of somewhat lower specific gravity than the upper, the cubic foot of the latter rock weighing on an average nearly 159 lb., whilst the same quantity of the former weighs barely 154 lb. The colour of this portion is generally of a darker and dirtier tint, approaching to grey, and is often affected by the presence of green particles of silicate of iron. The texture is apparently rather closer and harder, so that the clunch has been used in the ornamental internal works of some ecclesiastical buildings. This part of the chalk contains no flint bands, but a considerable quantity of siliceous, and some argillaceous matter is disseminated through the mass. In the place of flint there may often be recognised distinct partings of soft and almost rotten chalk. The whole character of these lower beds somewhat approaches that of the harder and more compact limestones, quarried for building purposes in various parts of the country; but it appears from experiment, that the whole rock is highly absorbent of water. The beds of doubtful character, intermediate between the white chalk with flints and the grey chalk with siliceous grains, may be conveniently designated as the middle portion of the whole series. The chalk here is tolerably compact, of a whitish-grey colour, and of a specific gravity intermediate between the two other kinds. Detached flints sometimes occur in it, but never in bands.

The thickness of the chalk varies much in different parts of the country, but may certainly be considered to reach 1000 feet where it has not suffered denudation. The thickness of the different divisions is indeterminate.

The general aspect of chalk, from all parts of the formation, varies with its condition, moisture, and the degree of exposure it has undergone. The effect of long exposure near the surface seems to be to harden it, whiten it, and render it both more dense and more absorbent. This, at least, is the result of the experiments recently made. The chemical condition of all chalk is very similar. It consists of a very large per centage of carbonate of lime, with small admixtures of the salts of magnesia and soda, besides other substances found in the seawater.

Having now briefly sketched the chief physical peculiarities of the chalk, the condition of this rock with respect to water must be described. The observations are based on experiments recently made on slabs of chalk, carefully selected, and the whole of the results were obtained in the King's College laboratory, under the immediate superintendence of Dr. Miller, the professor of chemistry in that college. The object of the experiments was to ascertain the positive and relative absorbent powers of different kinds of chalk, when exposed in various ways to water. The details of the experiments are appended in a tabular form, but their meaning may be rendered more clear by a little illustration.

Of the upper chalk two specimens were experimented on; one from Boxmoor, taken from near the surface in a dry state, and preserved for six months in a dry atmosphere before the experiments were tried. The other was from Erith, taken wet, and sent at once to the laboratory. These, as well as the other specimens, were cut square, and as nearly of the same size as possible, each weighing from 3 to 4 oz., which was as large as could be conveniently experimented on with accuracy. The specimen from Boxmoor (No. 1, in Table) was hard, rather brittle, and 2·55 specific gravity. It contained, when first weighed (after six months' exposure to a dry atmosphere), about 27 parts in 10,000, by weight, of water. On exposure to a perfectly dry atmosphere for twenty-four hours, it lost about three-fourths of this quantity, but did not part with the remainder of its water until it was dried *in vacuo*; but no heat was used in the experiments. It may be concluded from this, that the upper chalk, when it is to all appearance perfectly dry, contains one-third of a pint of water in each cubic foot, and that this quantity is never parted with under any heat, or in any dryness of the atmosphere. On exposure to a saturated atmosphere, this specimen was found to absorb, in forty-eight hours, 42 parts, by weight, out of 10,000, or above 15 parts in 10,000 beyond the quantity contained in the ordinary dry state; and although it is possible that a larger quantity might have been absorbed in a longer time, it is clear, that for all practical purposes, the result obtained is sufficient. The absorption from a moist atmosphere in the case of an exposed surface of the rock, must be very small and unimportant.

Although, however, the quantity of water taken up by chalk from moist air is small, the case is very different when the water

Table of Experiments.

Geological Position and Locality of the Specimen.	Specific Gravity.	Weight of the Chalk per Cube Foot.	Absolute Weight of the Specimen in its ordinary state when air-dried.	Weight at intervals of twenty-four hours, while exposed in a perfectly dry atmosphere, and afterwards *in vacuo*.	Weight when absolutely Dry *in vacuo*.	Weight at intervals of twenty-four hours, while exposed in a saturated atmosphere.	Weight when fully Saturated.	Weight of Water in each Cube Foot of Saturated Chalk.	Bulk of Water in Saturated Chalk, (1 cube foot = 1.)
		lb. oz.	Grains.	Grains.	Grains.	Grains.	Grains.	lbs. avoir.	
1. Upper chalk. Leyhill, near Boxmoor . .	2·55	158 14	1320·0	1317·4 1317·4 1318·0 1316·7	1316·4	1321·9 1322·0	1562	24·987	·40
2. Upper chalk. Erith	..	..	..	1158·0	..	..	1481	..	·54
3. Middle chalk. Cow-roast Well, 30 feet from the surface	2·55	158 14	1212·6	1211·5 1211·3 1212·0 1210·5	1210·2	1214·0 1213·6	1415	22·731	·35
4. Middle chalk. Cow-roast Well, 64 feet from the surface	2·40	149 9	1659·0	1656·2 1656·2 1656·5 1655·4	1655·2	1659·8 1659·8	1920	20·628	·33
5. Lower chalk. Tring cutting, near the chalk marl bed, hard and dry near the surface	2·47	153 15	1473·0	1464·5 1462·2 1462·4 1458·8	1458·2	1477·4 1481·0	1693	21·349	·34
6. Upper greensand, or lower chalk marl. Marsworth, at the junction of the Grand Junction with the Wendover branch Canal	..	..	1657·6	1639·0 1631·0 1629·6 1622·4	1620·4	1660·8 1674·0	crumbled to pieces.	..	..

is presented in a liquid form. The specimen from Boxmoor, when saturated, was found to have taken up more than 18½ per cent. of its weight (equivalent to two-fifths of its bulk) of water; but as it seemed possible that the condition of the rock might have been affected by long exposure to dryness and subsequent saturation *in vacuo*, the experiment was again tried with a specimen (No. 2) of chalk from the wet upper beds at Erith, taken from below the usual level of the water in the wells in the neighbourhood. The result in this case was yet more startling, as it showed an absorption of nearly 28 per cent. of water by weight, or more than one-half the bulk of the mass of chalk experimented on.

It seems clear from these experiments, in which the ordinary condition of the bed is very fairly represented, that the upper chalk is capable of receiving into its mass a quantity of water amounting to more than two gallons for every cubic foot of rock beyond the quantity usually contained in dry chalk under ordinary exposure.

It would be desirable, if possible, to ascertain the rate of percolation of the water when the upper surface of dry chalk receives rain, and becomes fully saturated to a certain depth. The experiments hitherto performed are only sufficient to show that the rock is porous, in the common sense of the word, and transmits water downwards very rapidly.* No one, indeed, can have lived in, or even visited a chalk district, without being aware of the extremely short time required for the surface to become dry after the heaviest showers, and the total absence of floods wherever the chalk is exposed without a thick capping of impermeable gravel. When it is considered, also, that 1 inch of rain falling (which supposes a very heavy and long-continued shower) is equivalent only to about half a gallon of water on each square foot of surface, and would not therefore fully saturate the rock to the depth of 3 inches, and when, moreover, the effect of the innumerable small cracks, always seen near the surface, is taken into account, it must be admitted as highly probable, if not certain, that a much larger proportion of the rain falling on exposed chalk is absorbed than has hitherto been assumed. It will be understood that these remarks apply to the upper chalk; but as a large part of the exposed chalk throughout the country belongs to this part of the series, it has important reference to the condition of the rock with regard to water.

The upper chalk may be regarded as most usually the conducting, and the lower chalk as the containing part of the formation, so far as water is concerned. The condition of the middle and lower chalk is, as has been shown, better adapted to retain than to conduct water; and this is especially the case with regard to the lower beds. This part of the series acts as a reservoir, giving off its water supplies with great steadiness, but with some degree of slowness. Two specimens of this part of the series, both obtained from the solid rock in the sinking of a well near the Tring-station of the London and North-Western Railway, were submitted to experiment. One specimen (No. 3) was obtained near the junction of a remarkable chalk district with the true chalk, at a depth of about 30 feet from the surface, but probably very near the top of the denuded chalk deposit, and affected by the presence of a thin argillaceous band at no great distance. The other specimen (No. 4) was taken from the same sinking, 34 feet vertically below (No. 3); and it is believed to be a fair average sample of the middle part of the chalk series. It presents a specific gravity of 2·40, the cubic foot weighing 149½ lb. This rock was found to contain, when thoroughly air-dried by an exposure of six months' duration, about 23 parts of water in 10,000. About three-fourths of this quantity was readily given off by subsequent exposure to a perfectly dry atmosphere, and very little more than the original quantity (in all 28 parts) was re-absorbed on exposure to a saturated atmosphere; showing that the absorbent power in this respect was small, and even less than in the case of upper chalk. On full saturation, the specimen absorbed about 16 per cent. of water by weight, or exactly one-third of its bulk, the quantity of water contained in the cubic foot of saturated chalk being, therefore, something more than two gallons.

A specimen was then obtained from the lower chalk, from the beds intersected by the Tring cutting, selecting a portion from near the 79½ mile-stone from Birmingham. This specimen (No. 5) being air-dried, like the others, and for the same time, showed a specific gravity of 2·47, weighing therefore about 154 lb. the cubic foot. It then contained more than 10 parts in 1000 of water, about three-fourths of which were rapidly parted with on exposure to a perfectly dry atmosphere; but the rest, amounting to more than the quantity of water contained in the upper chalk in its ordinary state, was not parted with by any

* Between the period of reading this paper and the time of publication, the author has obtained results of some importance bearing on this subject, which he hopes shortly to lay before the members of the Institution. The rate of transmission of water into and from chalk, appears to establish beyond doubt the fact, that chalk acts on water by capillary attraction only.

exposure short of a vacuum. On subsequent exposure to a saturated atmosphere, more than 15¼ parts of water in 1000 were absorbed; and when the specimen was saturated, it was found to contain something more than 16 per cent. of water, which will be found to exceed one-third of the bulk of the chalk, showing the water contents to exceed 2⅛ gallons per cubic foot.

The differences between the quantity of water contained in the various specimens in their natural state, when dry, and in their saturated state, will be thus seen to be not only actually greater, but greater in proportion in those in the upper parts of the chalk series, amounting in the Boxmoor specimen to 183 parts in 1000, and in the last specimen to 148 parts; and it may be concluded, generally, that wet chalk contains upwards of 12½ per cent. more water than the same rock when dry, the measurement still being by weight.

Below the beds of grey chalk, and quite at the foot of the chalk escarpment near the Tring-station, there exists a bed of greenish colour, which it was thought might either be the lowest chalk marl, or the representative of the upper greensand. A specimen, which on examination was found to contain 22½ per cent. of earthy matter, was selected, and was subjected, as far as possible, to the same experiments as the others already decribed. In its ordinary state, after six months' exposure, this specimen (No. 6) was found to hold nearly 23 parts of water in 1000, about half of which was parted with after twenty-four hours' exposure in a perfectly dry atmosphere; but the rest evaporated very slowly. On being afterwards exposed in a saturated atmosphere, about 33¼ parts of water were absorbed in 1000, equivalent to more than a gallon of water in the cubic foot; but on being placed in water, the absorption was so rapid and considerable that the specimen fell to pieces, and the experiment could not be proceeded with. There can be little doubt that a wet rock of this kind, when exposed in a cutting, must in time be removed by the draining of water through it on its upper side, and if not protected will cause a slip of the whole overlying mass.

The conclusions to be drawn from the experiments referred to are of very considerable interest, for the uniformity of the chalk as a rock formation is one of its most remarkable characteristics; and in deciding a point concerning any of its physical properties, similar properties may be attributed to the whole mass. It is clear that the chalk must be regarded as a rock which everywhere admits of the percolation of water, receiving into itself and conveying to its lower bed the water that falls on or is brought to its surface; and this readily explains the uniformly dry appearance it presents, and the absence of any streams arising from mere surface drainage where exterior exposure of the rock itself occurs. The streams arising in chalk districts are either the produce of springs oozing out of the chalk, or are obtained from those places where the rock is covered with an impermeable mass of clay; but springs can only rise out of chalk where the mass is permanently wet, and thus there must be a surface of permanent wetness, and below this a surface of full saturation, since the quantity of water received from rain cannot fail to sink down until it reaches some part where the rock is already fully charged with water. The uniform experience of all persons employed in well-sinking, and in other excavations in chalk, proves also that water is generally to be obtained at moderate depths in the rock, but that in order to obtain a large and steady supply, it is often necessary to descend to a great depth.

It is also clear that particular bands of rock contain much more water than others, some indeed being apparently though not really dry when below the surface of permanent wetness, while others give off water readily, and to a great extent. When, however, the actual quantity of water present in a given space of solid chalk is calculated, the result is very striking. Thus, from the data already given, it is easy to find, that each square mile of dry upper chalk, one yard in thickness, always contains nearly 3,500,000 gallons of water; but that the same quantity of rock is capable of absorbing, and would contain, if saturated, upwards of 200,000,000 gallons. The water contents of the same mass of lower chalk, when dry, would be nearly 12,000,000 gallons; and when saturated, about 180,000,000 gallons.

Although, perhaps, the extent of surface of exposed chalk, into which the rain would immediately descend without interruption from gravel or vegetable covering, is small in proportion to the whole range of the rock, yet it may be worth while to consider the probable effect of the rain-fall under such circumstances. The mean annual rain-fall in the east of England may be estimated at 26 inches, of which at least 18 inches cannot fail to be received into the mass of the rock: now, the descent of this to the surface of permanent wetness, at a rate which, though comparatively rapid, must be really extremely slow, will end in limiting that surface to a position having a general and rude parallelism with the surface of the ground. Where, however, the ground is covered with impermeable clays, the wetness would not rise to the same level as where it is uncovered; so that an additional cause of variation is thus produced, and in those parts where the rock is permanently covered with thick and widely-spread impermeable material, as over the London basin, the lateral percolation being the only kind available, the position of this surface would be still more seriously affected.

On the other hand, the surface of full saturation being dependent chiefly on the quantity of water introduced into and percolated through the rock, in times long anterior to the present, would probably be more uniform and permanent. That a portion of the chalk exists in this state of full saturation is almost certain, judging from the nature and constitution of the mass itself; and that it depends to some extent on the present levels and general position of the chalk surface, rather than on the geological position of these beds, and the place of their outcrop is equally probable.

It may also be considered, that wherever the gault extends, underlying the chalk and keeping up the water, there must be at and below a certain depth from the surface, a supply of water to the extent of 180,000,000 gallons for each square mile of one yard in thickness; and that the surface of permanent wetness, dependent chiefly on the present rain-fall, is so far above this lower surface of saturation as to insure a supply, at least equal to one-half of the rain falling on the whole of the immediately surrounding district.

In conclusion, Professor Ansted said his experiments had been conducted with great care and accuracy, the quantities given were absolute, and the experiments, as far as they went, must be considered valuable, because they represented positive facts. Indeed, his object in laying the communication before the Institution was to bring forward facts, and not to offer opinions. In those experiments it was found that chalk was capable of containing on an average at least two gallons of water to the cubic foot, a result that could not be anticipated by any one looking at the condition of other rocks. The similarity between sandstone and chalk was so slight as hardly to require notice. New red sandstone, which was a soft variety of the rock, was not capable of containing one-fourth part of the water held in the chalk, and could not therefore be compared with it. Whatever was the case with one part of the chalk might safely be applied to the whole mass of rock; and he had therefore alluded to what he called "the surface of permanent moisture" as the probable actual condition of the chalk in the lower part of its mass. Sandstone, more than any other rock, was divided into distinct portions, with scarcely any communication between the different parts. He quite agreed that it was more important to consider the rate of percolation than the absorbent power; but the latter was easily ascertained by experiment, whereas the first required large operations, and it was even then difficult to arrive at satisfactory conclusions. The question with regard to the actual quantity of water in the chalk, and the use of the chalk as a bed to supply water, was surrounded by many peculiar difficulties, and any information which could be depended on with regard to the condition of the chalk itself, was of value. The facts he was aware of, with regard to the depth at which water could be obtained in the London basin, led him to form a conclusion as to "the surface of permanent wetness" beneath that deposit. Water was generally found in the chalk up to its contact with the London clay; but the surface of contact of the two rocks was very irregular. He believed "the surface of permanent wetness" to be generally below the beds which were called plastic clay, and which, for the most part, contained a considerable thickness of sand and gravel. What had been determined with regard to percolation was sufficient to show, that no one well would supply the immense quantity of water required for the consumption of a large city, although sufficient might thus be obtained for the supply of a large brewery, or other establishment. In his opinion, the supply of water for even a large town, much less that for such a city as London, should never be dependent on wells sunk into the chalk. He did not wish, however, to enter upon that subject, his object being rather to bring forward facts relative to the question of the absorbent power of rocks.

In the discussion which followed the reading of the paper, Mr. F. Braithwaite described some experiments made by him, which were so similar to those of Professor Ansted, that he begged to hand in a tabular statement of the results; they were made on chalk taken from a well at a depth of 204 feet from the surface of the ground.

Locality of the specimens of Chalk.	Before Drying.		After Drying 48 hours at 212°		After Drying 72 hours at 212°		Loss.	
	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.
Taken immediately above a fissure, yielding water at 29 feet in the chalk.	9	15¾	9	0	9	0	0	15¾
Taken immediately below the fissure	10	10	9	9½	9	9	1	1
Taken above a fissure, at 55 feet in the chalk .	3	9	2	15	2	14	0	11
Taken below the fissure .	4	15	3	14½	3	14½	1	0½
Taken above a fissure, at 68 feet in the chalk .	12	3	10	1	10	0	2	3
Taken below the fissure .	10	9	8	12	8	10	1	15

REGISTER OF NEW PATENTS

COMPOSITION FOR PRESERVING FROM DECAY.

A. V. Newton, of Chancery-lane, for *an improved composition, applicable to the coating of wood, metals, plaster, and other substances which are required to be preserved from decay; which composition may be also employed as a pigment or paint.* (A communication.)—Patent dated November 19, 1850. [Reported in *Newton's London Journal.*]

Claims.—1, the manufacture of the composition described, under any and all its modifications, and its application as a pigment, or as a coating to preserve wood, metals, plaster, and other substances from decay; 2, the use, in such composition, of silica, or silicic acid, or of silica in some one or more of its combinations,—the presence of which substance is an essential element in the improved composition; 3, the use of protosulphuret of antimony, in the manner and for the purpose hereafter explained.

For the above purposes a mixture, containing the following materials, may be prepared either by the employment of natural products, or or of suitable metallurgical refuse:—

Metallic zinc	14	parts by weight.
Metallic iron	1	"
Oxide of zinc	369	"
Oxide of iron	278	"
Silicic acid	70	"
Argil	8	"
Charcoal	47	"
Carbonate of zinc	223	"
	1000	

These substances are first reduced to a very fine powder, and are afterwards ground up with raw fixed oil (poppy and linseed oil, by preference, in the proportions of two parts of linseed-oil to one of poppy-oil). The composition, thus prepared, is used in the same manner as ordinary oil-paint,—it being, however, first diluted with a mixture of two parts of raw fixed oil, and one part of essence of turpentine, or more if required. It is said that two coats of this composition (over which any other paint may be afterwards laid) will be sufficient to protect the surface of damp walls from the effects of the weather; and it will not be liable to crack or scale off. The composition is equally applicable to stone, plaster, wood, metals, &c.; and may, therefore, be advantageously employed for buildings of all kinds, ships, stockades, piers, jetties, sleepers for railways, turnpike and other gates, bridges, and other large works of public utility.

When stone walls, plaster, or cement, are to be operated upon, they must first be well scraped, and freed from all previous paint, and well soaked with a mixture of one part of sulphuric acid, at 66°, to five parts of water. This liquor must be applied until effervescence ceases. The surface is then left to dry, and three coats of the composition are to be laid on, care being taken to let each coat dry before applying the next coat. In cases where the surface is very damp, or impregnated with saltpetre, it will be found advantageous to add to the composition, above-mentioned, from eight to ten per cent. of protosulphuret of antimony.

The patentee gives five formulæ (which are modifications of the improved composition) as the best results of numerous experiments.

In certain cases, it may be advisable to employ the following coating or mastic, in order to fill up joints, holes, or flaws, &c.; or it may be used to coat the entire surface to a thickness of from $\frac{1}{10}$th to $\frac{1}{3}$ of an inch in depth:—

Carbonate of lime	450	parts.
Silica	87	"
Charcoal	83	"
Metallic iron	47	"
Alumina	20	"
Metallic zinc	1	"
Oxide of zinc	37	"
Peroxide of iron	25	"
Peroxide of manganese	250	"
	1000	

These substances are to be reduced to a fine powder, well mixed, and ground to a suitable consistence in a mixture of three parts of linseed-oil and one part of hempseed-oil.

PRESERVING AND CURING SOLUTION.

P. A. Lecomte de Fontainemoreau, of South-street, Finsbury, and 39, Rue de l'Echiquier, Paris, patent agent, for *certain improvements in preserving animal substances from decay, by means of a composition applicable to the cure of certain diseases.* (A communication.)—Patent dated September 4, 1851.

Claims.—1, the application of metallic salts, but principally of sulphate of zinc, at the degrees of heat laid down or thereabouts, for the preservation of corpses or anatomic parts, and animal substances in general, from decay; 2, the application of the said solution, combined with emollient substances, for the cure of wounds or other similar external diseases of the human body.

The salts of zinc as they are found in commerce may be used, but the metal itself is preferred on account of its superior state of purity. A portion of zinc, previously granulated, is dissolved in a solution of sulphuric acid and water, of the strength of 30° or 40° of Beaume's aërometer. The solution is filtered and left at rest several days to allow it to deposit all the heterogeneous particles it holds in suspension; when the deposit is formed, the liquid part is decanted with care, and is employed for injections, it being introduced through one of the arteries of the corpse. If the subject is to be exposed to the open air during the operation, an addition is made to the solution of one-third of its weight of oil of turpentine. Any desired odour is given by an essence. To preserve anatomical parts by immersion, the solution is employed in a pure state, and concentrated only to 20° or 25°. For the cure of gangreous wounds and other similar external diseases, the inventor employs the liquid in the highest concentrated condition, and weakens it in a decoction of linseed, marshmallow, or other emollient plants, and reduces it to the strength of 4° to 10°; it is made use of by imbibing lint or compress, with which it is applied on the wound, care being taken to change it each time. To disinfect places, the liquid is dissolved in water, and reduced to the strength of 10°. For washing the hands or other parts, the solution is reduced to 2° or 3°.

APPARATUS FOR DELINEATING OBJECTS.

(*With Engravings, Plate* XIV.)

James Palmer, of 4, Porteus-road, Paddington, for *improvements in delineating objects, and in apparatus and materials for that purpose.*—Patent dated August 23, 1851.

The purpose of this invention is to furnish the means of producing drawings of all descriptions of objects in a much simpler and more perfect manner than is effected by the camera lucida, camera obscura, graphic telescope, and other instruments hitherto proposed for that purpose.

Claims.—1, the modes of constructing apparatus for delineating; 2, the mode of delineating objects in the apparatus, and with the pencils described; 3, the mode of delineating objects upon gelatine with the etching-needle, and printing the delineations so made; 4, the mode of enlarging the delineations made as described; 5, the apparatus for enlarging the delineations; 6, the mode or modes of manufacturing insoluble gelatine.

A plate of glass, about two feet square, is mounted in a framework (which is also a perfect easel), of which a front view is shown by fig. 2, a side view by fig. 3; I, being a support for the canvas, for the purpose of using the delineator as an easel. It is furnished with adjustments A, for supporting the glass in a vertical position at any convenient height. On one side of the plate of glass, and at a distance of several inches from it, is fixed the frame B, representing a pair of spectacles, also capable of adjustment in position. One of the apertures of the spectacle-frame is closed by a plate or shutter C. The operator applies his nose to the spectacle-frame, and looks with one eye through the glass at the object which he wishes to delineate, and he then traces over the outline of the object on the glass with a pencil, formed of a mixture of wax, soap, shellac, and lamp-black, which is capable of marking very distinctly on the smooth surface of the glass. In this way an exact drawing of the object, in true perspective, is obtained with great facility. The spectacle-frame preserves the position of the eye, without interfering with freedom of vision. The instrument is very convenient, and its use is readily acquired, which can scarcely be affirmed of any of the instruments hitherto proposed for the purpose, as is shown by the very slight use which is made of such instruments. The drawing on the glass is transferred to paper by tracing it, or by pressing a moistened sheet of paper upon it. Fig. 4 is a front view, and fig. 6 a side view of a delineator capable of being attached to the table.

The same apparatus is used in a similar manner for drawing with an etching-needle on a sheet of gelatine supported by the glass, or on a sheet of glass coated with gelatine. The drawings thus made may be printed from the gelatine as from a copper-plate. To enable the gelatine to be used for printing on moistened paper without adhering to it, the patentee renders it insoluble by immersion in chemical solutions. Gelatine so prepared does not adhere to the paper, and may be immersed in cold or warm water without injury. The prints from the gelatine may be transferred to stone or zinc, and printed in the ordinary manner of lithographic printing, the engraving which illustrates this invention being a specimen.

The invention is applicable to making drawings and engravings of buildings, machinery, landscapes, flowers, or any other stationary objects. For taking portraits a rest is provided, to keep the head of the person in a stationary position, as in fig. 1.

These drawings or delineations are necessarily smaller than the real objects, but their size may be varied by varying the relative distances of the glass and the object from the eye of the operator. When it is required to increase the size of the drawings, a drawing on glass or gelatine H, is placed in an instrument somewhat similar to a oxyhydrogen microscope, by which a magnified image is thrown on a disc of glass, ground on both sides, which is supported by the delineator. The interior of the instrument is shown by fig. 5, and the exterior by fig. 7; D, is a door through which a solar lamp is introduced and placed on a pedestal C; the light from the lamp passes through the condensors F, which has the effect of causing the image H, to be reflected, the proportions of which are regulated by condensors at E, an adjusting screw G, regulating the necessary focus. K, represents a door for the purpose of allowing heat to escape, to prevent injury being done to the gelatine upon which the image to be reflected is drawn. A sheet of gelatine is fixed on the back of the glass disc, and the magnified image traced upon with the etching-needle, or with the pencils above mentioned.

WATERPROOF BRICKS AND TILES.

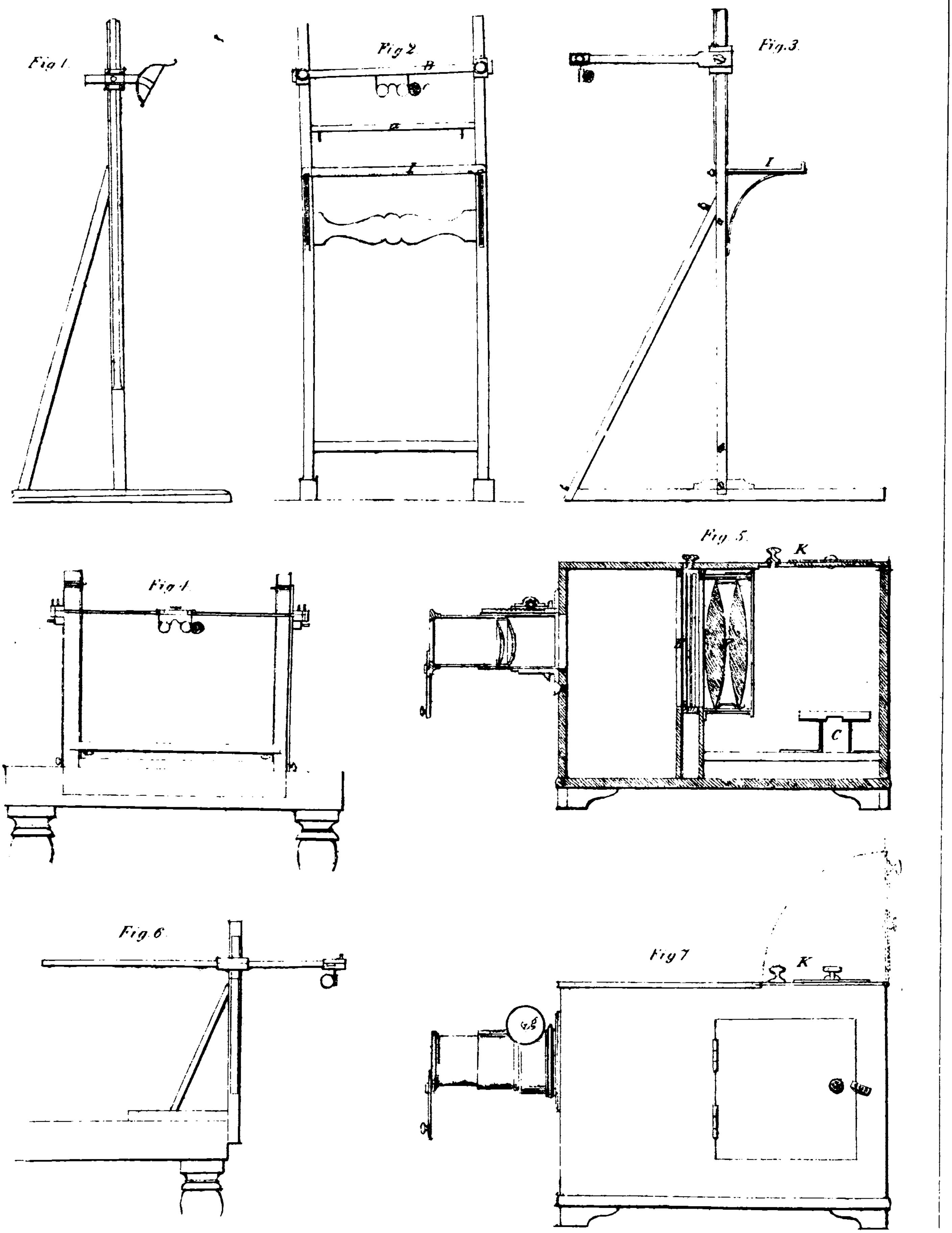
(*With Engravings, Plate* XV.)

John Workman, of Stamford-hill, Middlesex, furnace builder and fumist, for *improvements in the manufacture of bricks, tiles, and other articles of like materials.*—Patent dated July 31, 1851.

This invention consists in making bricks, tiles, and other porous articles of like materials, non-absorbent or waterproof. The bricks, &c., are first conducted into the hot-air chamber A, which is heated by heated atmosphere in a furnace and apparatus to a very high temperature, as 500° Fah. and upwards; then through the solution B, into the second chamber C, where the solution is baked or burnt in; after which they are passed from the endless chain on to the inclined plane, ready for stacking. The chain works over a canted driving-wheel D; on the same shaft is a worm-wheel E, driven by the endless screw F, on the shaft G, which shaft is worked by the bevil-wheel and pinion H, I. The pinion I, is fixed on the fly-wheel shaft of a portable steam-engine, which gives motion to the whole of the apparatus. The shaft G, is prolonged to the laying-on end in front of the chamber A, to drive the canted wheel or drum J, by the screw and spur-wheel, as before, to draw up the return chain ready to reload and pass into chamber A. There is also fixed on the same shaft a light spur-wheel K, driving the pinion L. On the spindle M, is keyed the rigger N, driving the pulley O, by a leathern strap, which works the fan P, the air from which passes up the pipe Q, into the horse-shoe pipes, forwards and backwards through the furnace to pipe R, returning over the horse-shoe pipes into the bottom of air-chamber A, at S. The flame and heat, after enveloping the bent pipe R, passes against the water-heater T; then under, behind, and through the flue U, against and over the front and through the centre flue V, to the chimney. The water-heater and brickwork at back keep the intense heat from evaporising the solution in the chamber W. The chains work on rollers turning on bearings fixed to plates of chambers, which are lined with fire-brick throughout. The top and bottom is formed of fire-tile, covered with a layer of sand from end to end, to retain the heat. The chamber C, has a lining of sheet iron underneath at X, also covered with sand to prevent radiation of heat. The chains return under the chambers on rollers turning in carriages fixed to the columns, which also are stay-bars to keep them to their proper distance, and they pass under the stoking-floor Y, to the front; the columns are fixed to the plates with two bolts each. The chambers are carried off by a pipe *a*. *b*, is the damper. The cistern *c*, contains the solution, the supply of which is regulated by a valve and the float *d*. *e*, passage for solution to chamber W. The bricks, &c. are kept on the chains by pins fixed in the cross-pieces of the links, which are kept firm by stay-bars *f*, *f*, and work on the thimbles *g*, secured by the nuts *h*. *i*, is the thermometer to ascertain the temperature in the chamber A. *j*, the ash-pan, to prevent ashes falling on the chains. *k*, a bar with a slot and screw-bolt, to regulate the angle of the inclined plane to give a self-acting motion to the bricks, &c. towards the stack. The spindle M, works in brackets fixed on plates of chamber A, the same as long shaft G. The whole of the machine is made portable, for convenience of transit from place to place. The engine and boiler are easily disconnected, and, when the machine is not in use, can be employed for pumping or other purposes deemed necessary.

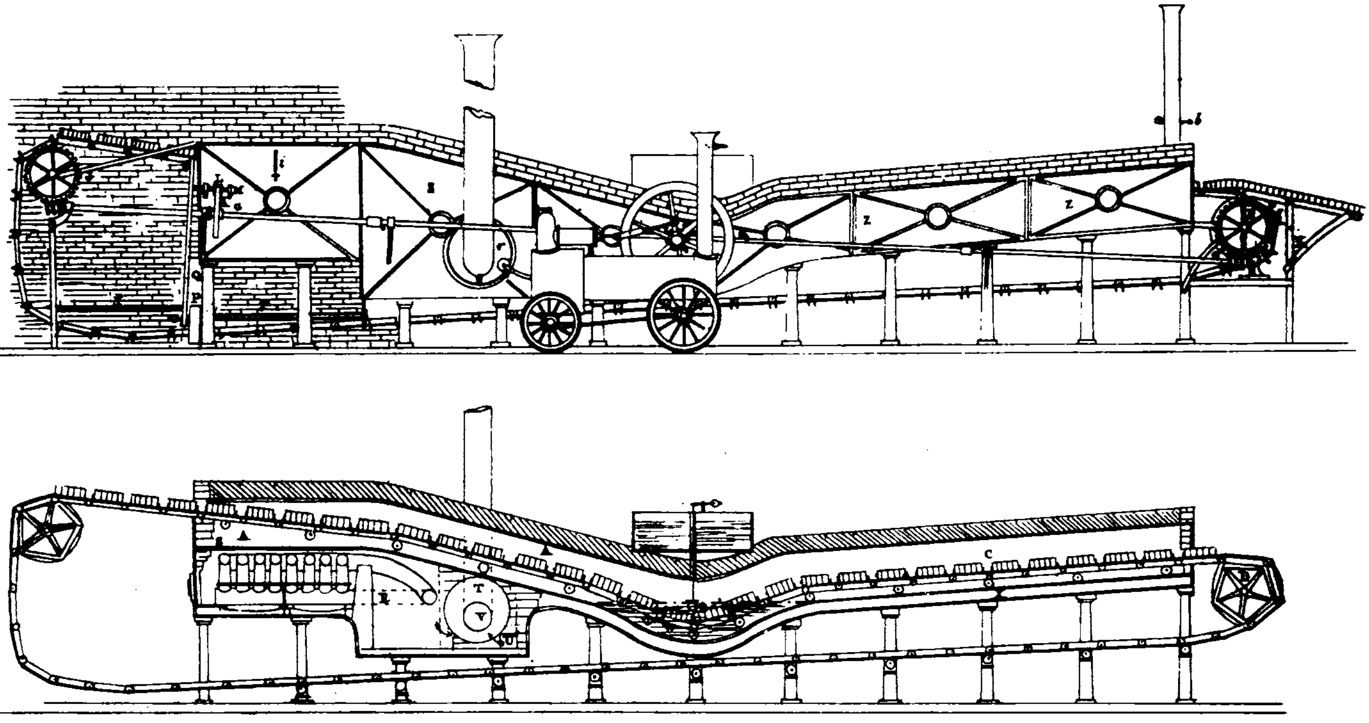
Those bricks, &c., that are intended for building dock walls, stores, cellars, warehouses, tunnels, baths, tanks, and basement stories of buildings, to keep them dry and waterproof, are placed on the chain from the outside of the machine, and moved at a given speed through the chamber A, into a solution consisting of whale or seal oil and sugar of lead, in the proportion of 1 oz. to 1 gallon of oil; the sugar of lead is to be well pounded and mixed previous to being put into the tank, and the passing of the chains through the solution will keep it continually moving. The speed given will regulate the necessary time for the materials passing through the solution, after which they rise up an inclined plane and drain themselves; they then enter the second hot-air chamber, where they undergo the process of baking and hardening; from thence they are propelled on to an inclined plane outside, and are then stacked, hollow, so as to allow the atmosphere to take effect on them as much as possible. It is necessary for them to remain in this position at least fourteen days before being used for building, but the longer time they are in the atmosphere the more they will oxide with it. Bricks that are intended for facing and building houses, &c. that are exposed to the damp, undergo the same process, but linseed-oil is used instead of whale or seal oil; and for tiles the same.

Bricks, tiles, and other like materials, waterproofed by this process, will be found to keep their colour and have a clean appearance after they have been washed by rain, and will keep the house dry and consequently much warmer and healthier. From 25,000 to 30,000 bricks per day can be made non-absorbent by this process.



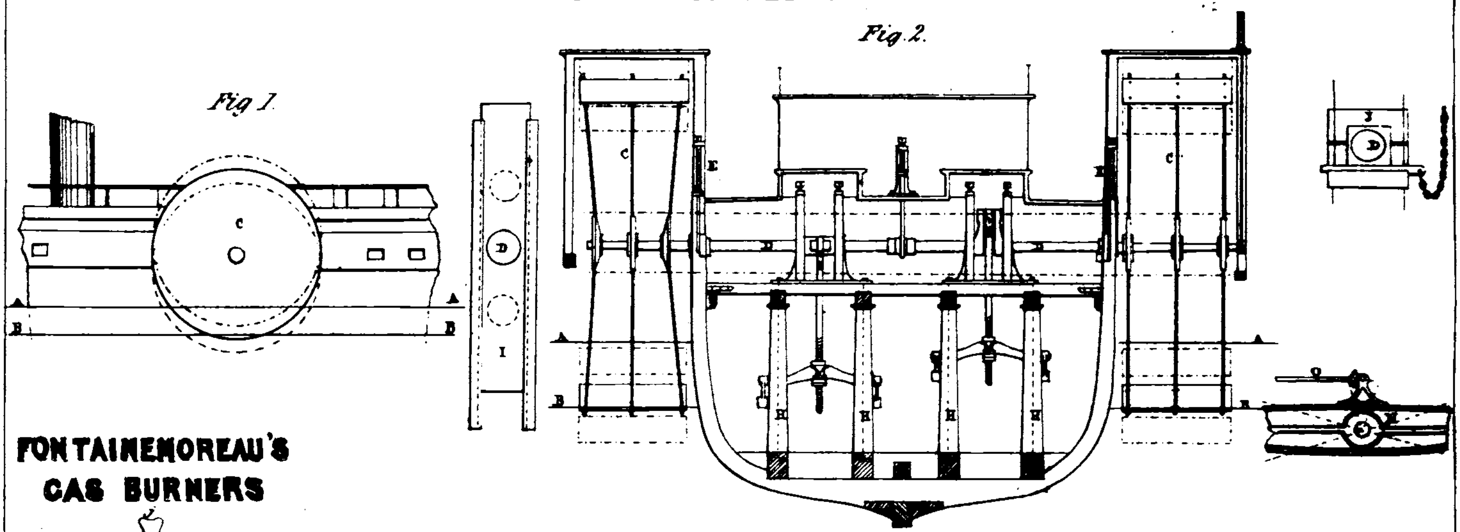
PALMER'S PATENTED APPARATUS FOR DELINEATING AND ENLARGING OBJECTS.

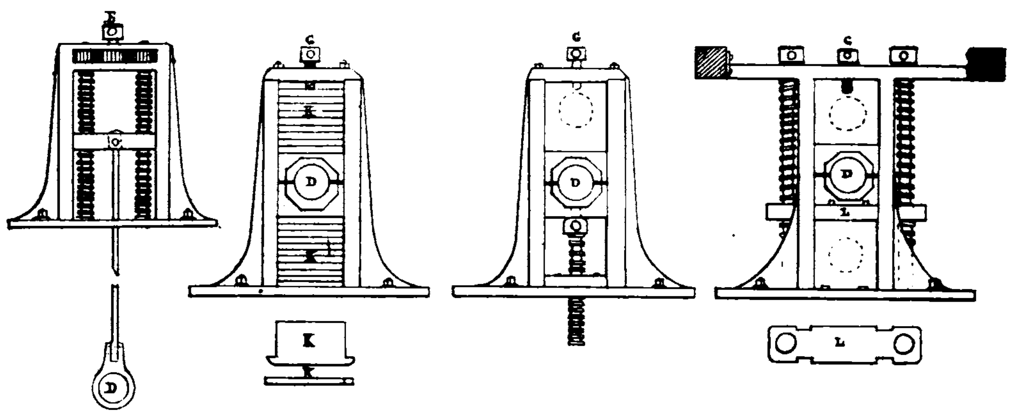
WORKMAN'S. WATERPROOFING BRICKS, TILES, &c.



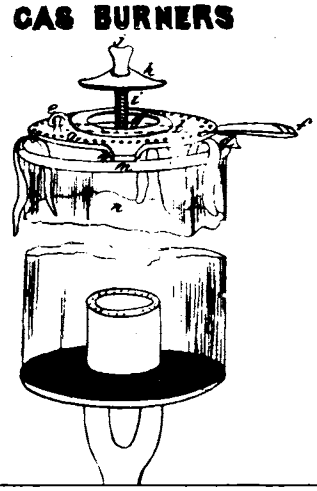
DRAKE'S PADDLE WHEEL.

Fig. 1. *Fig. 2.*





FONTAINEMOREAU'S GAS BURNERS



GAS BURNERS.

(*With Engravings, Plate* XV.)

P. A. Lecomte de Fontainemoreau, of South-street, Finsbury-square, Middlesex, for *certain improvements in apparatus for gas-lighting.* (A communication.)—Patent dated August 28, 1851.

Claim.—The combination of an apparatus for regulating the supply and action of air on the flame of gas-burners, whereby the illuminating power of the gas is increased—*i. e.* with a given volume of flame a considerable economy in the consumption of gas is effected, a stronger, more steady and calm light is produced; likewise, a more complete decomposition of the gases and carbon is effected.

The apparatus is composed of two parts: first, a perforated wire-cloth, or metal diaphragm, which is placed at the bottom of the chimney, around the burner; this prevents the air entering the glass chimney before it has travelled through it. By this means the air necessary for the combustion of the gas is made to reach the centre of the flame, and act on its interior surface in a diffused state, of great and minute divisions, and its molecules correspond to the molecules of gas. The resistance that the air meets at its egress, by the disc next described, highly favours the action of the flame, which, instead of being blue and unsteady, acquires a fixity and density which gives it a great analogy to that produced by the carcel-lamp. The engraving represents the second part of the apparatus: *n*, is the upper portion of the glass chimney of an argand burner, which is fitted at the top to an earthenware ring *m*; this is fixed to a circular metal disc *a*, placed one-sixth of an inch above it, in order to cause a current of air between the glass and the apparatus. The disc has an opening in the centre; *d*, is the cover to the opening in the centre of the disc, with a hinge *e*, which connects it to it, and serves for the purpose of passing a light through it to ignite the gas; *f*, is a handle for raising it. The cover has an opening *g*, in its centre, provided with a valve, perforated with holes *h*; this, when it is necessary to increase the area for the egress of air, can be raised by means of a screw *i*, which is fixed in the said valve *h*, between the head of the screw *j*, and the nut *k*, and is supported on a cross-piece, with a screw-hole in the centre, shown by the dotted line *l*, fixed at its two extremities to the periphery of the cover *d*; the height of the screw, from its extremity to the nut *k*, should be about two-thirds of an inch.

PADDLE WHEELS.

(*With Engravings, Plate* XV.)

J. P. Drake, of St. Austell, Cornwall, for *improvements in constructing ships and other vessels, and in propelling ships and other vessels.*—Patent dated September 4, 1851.

The patentee considers that there are certain fixed relations between the engine, number of strokes, diameter of wheel, and dip of paddle, which will bring out the whole power of the engine and maximum effect. Having once obtained these relations, by calculation or experiment, the object of the invention is to retain their propulsion; and the accompanying engraving and explanations will show how this is proposed to be effected.

Fig. 1 represents a longitudinal view of an ocean steamer, with wheels on the raising and lowering principle. A, load immersion line; B, light immersion line; C, paddle-wheel in its fixed position, according to present practice, the dotted lines showing to what extent the wheels may be elevated or depressed to regulate the dip of the paddles, as required to bring out the full power of the engine under every variation of the immersion line from A to B.

Fig. 2 shows a midship section of an ocean steamer on this principle, for regulating the wheels, as explained by fig. 1. A, B, light and load water-lines. C, paddle-wheels, one with outer bearings, the other without, the latter greatly diminishing the overhanging weight. D, shaft or axle in the usual fixed position, the horizontal dotted lines showing the extent to which it may be raised and lowered, as explained also by fig. 1. E, screws for raising and lowering the wheels, these screws being of sufficient power to raise three times the weight of the wheels and axle. F, screw for adjusting the axle at the outer bearings, if the old plan wheel be retained. G, iron framing, with plummer-blocks for the axle to revolve in; these blocks to raise and lower with the shaft, and to rest on shifting iron plates. In this framing screws may be introduced, as shown at G, for the purpose of adjusting the shaft, instead of those marked E, if desired. H, supporters of engine-framing G, to be made of wood, and tied to the sleepers by an iron tie-bolt passing through the axles of the pillars H, with screw points to screw into plates fixed in the sleepers, as indicated by the dotted lines. This frame to be constructed by the builder, and will be found more compact, stronger, and lighter on the whole, than the usual iron frame, and may be more readily removed in case of repair, &c.; at the same time, an iron engine-frame throughout may be introduced, if wished, or the old engine-framing altered to the purpose required. I, a self-acting iron slide at the side to keep the water from entering the vessel, the axle passing through it at D. J, plummer-block at the side-bearings, and shaft, with a key to keep it from turning during the process of raising or lowering the wheels. K, resting plates for the plummer-blocks, to be in thickness equal to one day's displacement between A and B, so as to admit of the wheels being adjusted daily if necessary. L, plan of screw-bed as above. M, crossheads for crank-rods, which are fixed when adjusted by nuts above and below, as explained. N, centre part of beam, with a plan for working the valves instead of eccentrics attached to the shaft. O, rod connecting with the valve-levers. This will simplify the process, and leave the crank-rods only to be adjusted as shown at M, and which, if the engine be on the direct-acting principle, may be regulated at the crank end of the rod with equal facility.

When the vessel at starting is brought down to the immersion line A, the wheels are to be raised so as to give the paddles the best determined dip, and as she lightens they are to be lowered to retain that dip; this can be done at such intervals as may be deemed expedient. The men are to be stationed ready to act as directed, the engine stopped at command, and the shaft locked or keyed at the side-bearings J, and the beams also locked. The crank-rods are then to be released at the crossheads M, by raising the upper nut to the distance required; the small screws above the plummer-blocks also turned up; the weight of the shaft may then be relieved from the resting plates K, by one turn of the screws E, or F, and one or more of these plates withdrawn and placed above the plummer-block. The shaft is then to be lowered into its place by means of the screws E, F; the lower nut at the cross-head M, is turned up to secure the connecting-rod, and the small screws turned down to make all rigid. The shaft and beams being then unlocked, the engine may resume its working, and the vessel proceed on her way after a detention of not more than five minutes.

The inventor considers, first, that the increased oblique action which has been the great obstacle to the common wheel is entirely obviated; secondly, the immersion of the vessel not being restricted by the wheel, she could carry more cargo than would be at present consistent with speed, safety, or economy; thirdly, the centre of gravity is kept lower in light immersions, by which stability and safety are increased; fourthly, the appropriate dip of the wheel is unaltered under all circumstances, thus maintaining the perfect proportion between power and speed.

SUSPENDING AND LOWERING SHIPS' BOATS.

W. S. Lacon, of Great Yarmouth, for *improvements in the means of suspending ships' boats, and of lowering the same into the water.*—Patent dated February 23, 1852.

The object of the invention is to suspend ships' boats in such a manner that, in the case of any sudden emergency, they may be lowered and put to sea, without the risk of the tackles which connect the boats to the ship retarding the operations of lowering and floating them clear of the ship; likewise, preventing the possibility of the ship, in its onward progress through a rough sea, dragging forward a lowered boat, and capsizing or swamping it.

Claims.—1, the suspending of ships' boats by chains or ropes, which are capable of disengaging themselves, by their own weight, from the ship when once the lowering of the boat is accomplished; 2, the employment of a friction-pulley and friction-strap, or other analogous contrivance, for regulating the descent of ships' boats into the water; 3, the means described for running-out the suspending chains, cords, or bands of boats uniformly, whereby the danger consequent on lowering one end of a boat quicker than the other is avoided.

The boat is raised by the use of the ordinary tackle, and when elevated, it is permanently retained in the desired position (see

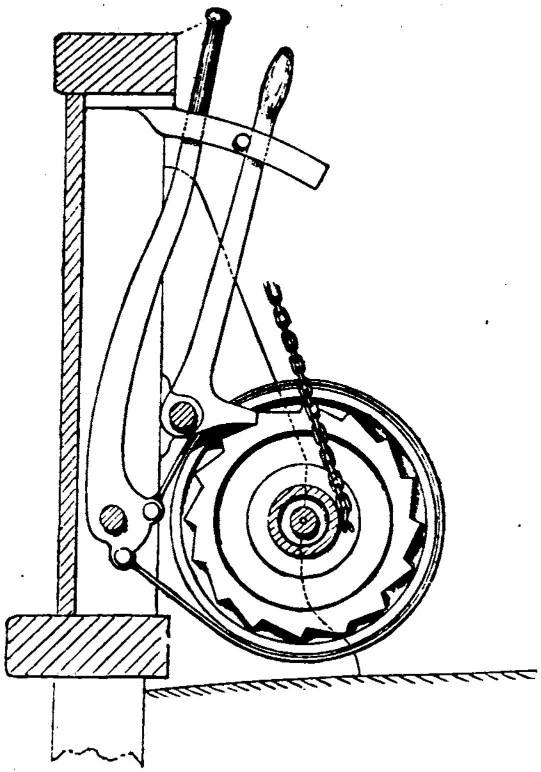


Fig. 1.

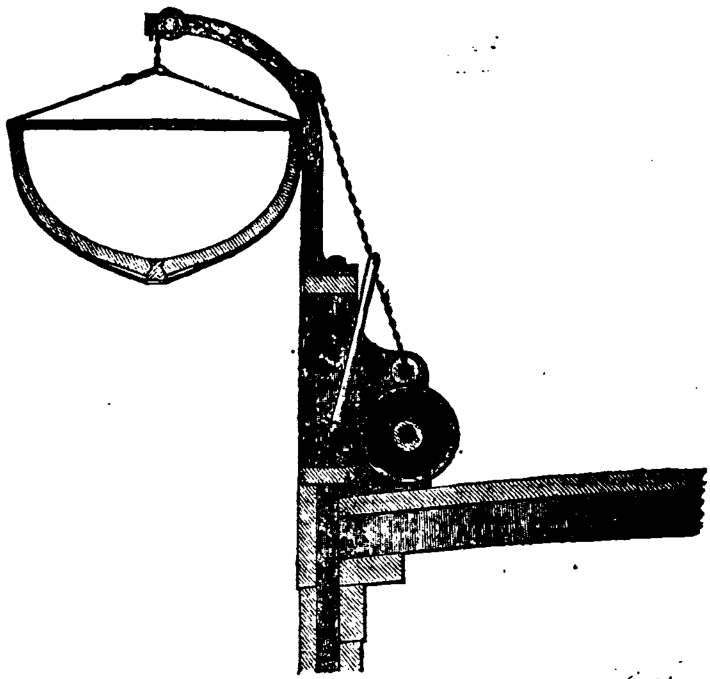


Fig. 2.

fig. 2), by passing around it, near the head and the stern of the boat, two broad belts or straps, composed of metal or platted rope, and having a ring attached at either end, the inner ring being for the purpose of forming a permanent attachment with the suspending-chains, and the outer ring for allowing of a temporary connection, by means of a splicing-rope, to a ring of the suspending-chains.

The engraving, fig. 3, represents an inside view of a boat suspended according to the patented improvements; the chains or ropes for supporting the boat pass over friction-pulleys or sheaves fixed to the davits or iron brackets which are secured to the bulwarks of the ship. The ropes or chains pass down from the davits to convave barrels, and are connected thereto by the last link in each chain catching into a curved pin projecting from the periphery of its barrel. These barrels are mounted on a shaft, turning in bearings in the bracket-pieces. When the ends of the slings have been connected by the splicing-ropes, the barrels are caused to revolve, by means hereafter described, for the purpose of tightening the suspending-chains, and causing them to sustain the weight of the boat. The raising tackles are then removed. About the middle the shaft carries a large friction-pulley, to which a ratchet-wheel is affixed; around this pulley a friction-strap is placed, and the ends of the strap are jointed to a lever (see fig. 1), which works on a fulcrum-pin. Into the teeth of the ratchet-wheels a catch takes, projecting from a lever which works on a pin, for the purpose of preventing the running-down of the chains by the rotation of the barrels. Each lever is to be brought forward and set fast by means of a pin, which is readily withdrawn when the apparatus is to be brought into operation. It will be seen that in all these cases the levers of the friction-strap and pall are retained in their places by means of a bolt. If this bolt were locked, by means of a master-key fitted to all the boats alike, and if one of these master-keys were at all times worn, suspended by a ribbon or lanyard, by the captain, officers, and petty officers of the ship, no boat could be lowered without authority, and the danger of a rush to the boats by the crew and passengers would thus be avoided.

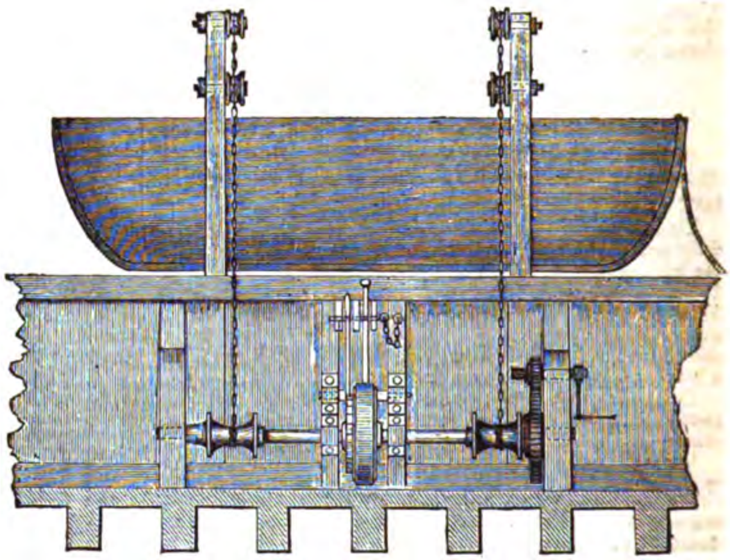


Fig. 3.

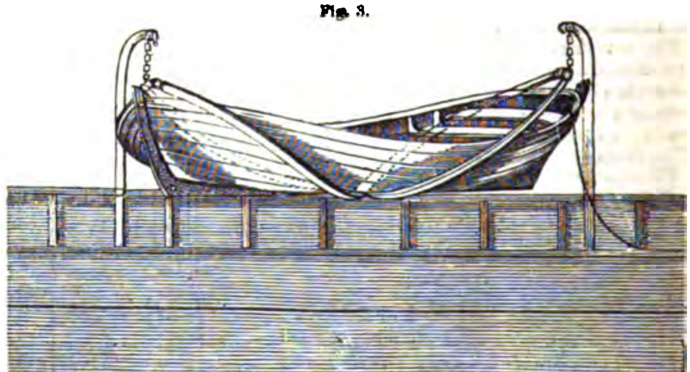


Fig. 4.

When it is required to lower the boat, a man inboard withdraws the pin pressing forward the lever of the friction-strap, which causes the strap to retain its hold of the friction-pulley, and thus prevents the premature revolution of the shaft. He then thrusts back the second lever into a retaining or self-acting catch, and lifts the pall from the teeth of the ratchet-wheel. On loosening the gripe of the friction-strap, the boat will descend gradually by its own gravity, and quickly, irrespective of any weight that may be in her; by the men in the boat letting slip the lashing of the straps, the boat will be clear, and the straps and chains may be hove back into the ship by means of the winch, shown in fig. 3, which also may be used to raise the boat instead of ordinary tackle. But in cases of emergency, when, either from the rapidity with which the ship may be going through the water, from a heavy sea, through want of time, or from people rushing into the boats, it may be dangerous to cast off the lashings of the slings, or if in attempting to let go the lashings of the straps, either of them should foul, then, if the friction strap be slackened when the boat reaches the water, the weight of the chains and the resistance of the boat will pull round the barrels, and the ends of the chains not being fast, will slip from off the projecting pins of their respective barrels, and will be lowered into the water, being prevented from going down by the run by means of two small lines, the loop or eye at the end of each slipping from off the pin when the turns of the lines have run off the barrels, and the boat, as before, will be free of its connection with the ship, and will ride along in safety by means of the painter, and the slings and chains may be hauled into the boat, or if the lashings of the straps be let go the straps and chains will sink into the water clear of the boat.

When it is necessary that the boats should be swung inboard, the inventor proposes to carry the straps from the chain which passes over one swinging davit to the chain which passes over the other, making them cross under the bottom of the boat, as shown in fig. 4; by this means, when the davits are turned to bring the boat over the deck of the ship, the arrangement of the cradle will not be disturbed, as it would be if formed as above described.

METEOROLOGICAL QUARTERLY REPORT.

On the Meteorology of England during the Quarter ending December 31, 1851. By James Glaisher, Esq., F.R.S., Secretary to the British Meteorological Society.

Till October 28, with the exception of a very few days, the mean daily temperatures of the air were above their average values, at times to the amount of 8° to 10°; the average daily excess for the period was 3°·7. On October 29, a period of exceeding cold weather set in, and for 37 days the daily temperature was below its average value, frequently amounting to 8°, 9°, and 10°, less frequently to 11° and 12°, and in one case, exceeded 13°; the average defect for the period was 6°·2. So cold a November has not been since the year 1786.

The period from December 5, to December 24, was mostly warm, though at times it was cold; the average daily temperature was 2°·5 in excess; and to the end of the year, from the 25th, it was 2°·5 in defect.

The reading of the barometer was in excess in each month, and greatly so in December.

The fall of rain only amounted to two-fifths of its average fall for the quarter; and this deficiency of rain has been general over England, Scotland, and Ireland, excepting only the county of Norfolk. There has been much less water mixed with the air, and the degree of humidity of the air has been unusually low, particularly in December.

The mean temperature of the air at Greenwich, for the quarter ending November, constituting the three autumn months, was 49°·1, being 0°·2 below the average of 80 years. For the month of October was 52°·6, exceeding the average of 80 years by 3°·3; for the month of November, was 37°·9, being below the average by 4°·5; and that for December was 40°·5, being above the average by 1°·7.

The mean temperature of the dew point was 46°·4 in October; 32°·2 in November; and 29°·9 in December; these quantities are, 1°·0 in excess, 9°·2 and 7°·1 in defect, of their average values.

The mean degree of humidity for the quarter was 0·773, its average is 0·887: this implies great dryness.

The mean reading of the barometer in October was 29·726; in November, was 29·781; and in December, was 30·135. The high reading in December was remarkable.

The fall of rain in October was 1·8 inch; in November was 0·6 inch; and in December was 0·6 inch. The averages for these months are 3·2 inches, 2·7 inches, and 1·5 inch respectively.

Snow fell on the 29th of October at Stonyhurst, and sleet at Durham; 3rd of November at Stone, Derby, Hawarden, Liverpool, and Manchester; 4th at Uckfield, Stone, Hartwell Rectory, Aylesbury, Linslade, Cardington, Bedford, and Nottingham; 14th at Norwich; 15th at Norwich, Nottingham, Manchester, and Stonyhurst; 16th at Thame, Holkham, Durham, and North Shields; 17th at Falmouth, Thame; Linslade, Holkham, and North Shields; 18th at Uckfield, Cardington, Gainsborough, Durham, and North Shields; 19th at Linslade, Nottingham, Liverpool, Manchester, Wakefield (Whitehaven a little), Durham, and Dunino; 20th at Oxford, Thame, Stone, Hartwell House, Hartwell Rectory, Aylesbury, and Bedford; 21st at Aylesbury; 22nd at Hartwell House; 24th at Stonyhurst; 26th at Gainsborough; 27th at Stone, Hartwell House, Hartwell Rectory; 29th at Hartwell House.

Hail fell on October 2nd at Helston and Maidenstone-hill; 3rd at Jersey; 4th at Jersey and Guernsey; 5th at Uckfield and Stonyhurst; 6th at Nottingham; 15th at Liverpool and Whitehaven; 16th at Thame; 18th at Guernsey; 24th and 25th at Jersey; 29th at Guernsey, Falmouth, Torquay, and North Shields; 30th at Guernsey and North Shields.—1st November, at Falmouth, Liverpool, and Whitehaven; 2nd at Falmouth, Torquay, Maidenstone-hill, Thame, Hartwell House, Hartwell Rectory, Nottingham, Hawarden, and Liverpool; 3rd at Guernsey, Helston, Torquay, and Hawarden; 4th at Guernsey and Hawarden; 10th at Guernsey, Helston, and Falmouth; 11th at North Shields; 16th at Helston; 17th at Falmouth and Torquay; 20th at North Shields; 24th at Guernsey, Falmouth, Hawarden, and Liverpool; 25th at Guernsey, Helston, Falmouth, Torquay, and North Shields; 26th at North Shields; 28th at Guernsey.

Auroræ were seen, on October the 2nd at Maidenstone-hill, Oxford, Radcliffe Observatory, Cardington, Norwich, Nottingham, Stonyhurst, Whitehaven, Durham, North Shields, and Dunino; 3rd at Cardington and Nottingham; 4th at Nottingham and Durham; 14th and 15th at Stonyhurst; 18th at Durham; 28th at Wakefield, Stonyhurst, Durham, Whitehaven, and North Shields; 29th at Hartwell Rectory, Nottingham, Wakefield, and Dunino.—4th of November at Aylesbury and Nottingham; 5th at Stonyhurst; 13th at Stonyhurst; 20th and 21st at Aylesbury; 24th at Dunino; 26th at Stonyhurst.—6th of December at Hawarden, Liverpool, Wakefield, Durham, and North Shields; 8th at Hawarden; 22nd at Nottingham, Hawarden, Stonyhurst, Whitehaven, Durham, North Shields, and Dunino; 23rd at Whitehaven and Dunino; 28th at Grantham and Dunino; 29th at Grantham, Stonyhurst, North Shields, and Dunino.

At Acton Clinton, six miles east of Stone, on Oct. 29, an aurora was seen. The same aurora was seen at Edinburgh and at Cambridge.

At Durham, on Nov. 29, at 7h. 3m. p.m., many meteors were seen near Aldebaran: as many as fifteen were counted in a quarter of an hour.

Aurora Borealis, as seen at Nottingham by E. J. Lowe, Esq.

Oct. 29, 5h. a.m., splendid aurora.

Nov. 4, 6h. 30m., low arch; 6h. 48m., a streamer vertically upwards between ζ Ursæ Majoris and β Bootis.

Dec. 22, 6h. auroral glare.—10h. 50m. bright streamers.—11h. streamers half way to zenith, great intensity in north; brightest streamer through α Cephei, which streamer oscillated laterally about 20′ backwards and forwards in 30s. periods. The aurora extended in the west to β Pegasi, and in east to θ Ursæ Majoris.—11h. 6m. nearly gone.—11h 8m. three streamers in north; the most easterly passed under η Ursæ Majoris, and another under θ.—11h. 11m. fine streamers, which if continued would pass 1° east of β Ursæ Minoris, diameter 30′.—11h. 12m. the streamer moving west; if continued would pass through γ Ursæ Minoris.—11h. 13m. it is now midway between γ and η Ursæ Minoris; in altitude it extends to elevation of θ Draconis.—11h. 14m., between β and γ Draconis.—11h. 16m., west of γ Draconis.—11h. 16m. 30s., 1° west of γ.—11h. 17m. 30s., 2° west of γ.—Soon clouded over.

Meteors, as seen at Nottingham by E. J. Lowe, Esq.

Oct. 1, 8h. 20m., meteor equal to a star of 2nd mag., moved downwards at an angle of 45° towards the north from 1° above Cor. Caroli, and which passed 15′ north of that star.

Oct. 7, 7h. 35m., spark-meteor, equal to star of 2nd mag., blue in colour, fell from under Cassiopeiæ horizontally to 2° east of β Ursæ Majoris, duration 3 sec.—8h., a blue meteor, equal to a star of 1st mag., passed downwards from south at an angle of 40°, passing 2° under the moon.

Oct. 19, 12h. 9m., large meteor from between α Pegasi and α Andromeda, fell downwards, leaving a train of light.

Oct. 30, 8h. 25m., a fine meteor, equal in size to Saturn, but much brighter, of a decided orange colour, having a long tail of sparks, fell from δ Draconis to about 76 Ursæ Majoris; duration 2 sec.; position when first seen, right ascension 12h. 53m., N.P.D. 31°; position when last seen, right ascension 9h. 32m., N.P.D. 26° 20′.—8h. 50m., another, in size equal to a star of 2nd mag., fell rapidly from ζ Andromeda to δ Piscium; of yellow colour; continuous streak of light left; its brightness only equal to a star of 3rd mag.; duration 1 sec.—9h. 4m., another, equal to a star of 3rd mag., but not so bright, and being not one body but composed of many separate sparks, moved slowly from about 72 to o Piscium; its duration 2 sec.

Nov. 3, 5h. 32m., a large meteor, pale orange colour, which increased from a point to four times that of Saturn before it started from a position 13° south of Alphaca; it moved slowly, passing 30° south of Arcturus to near horizon; after moving 15° it increased rather suddenly to six times that of Saturn, and turned bluish; vanished suddenly; duration 12 sec.; kite shaped.

Nov. 12, 10h. 10m., a meteor, orange-red colour, with sparks, in size equal 2nd mag. star, but brighter, moved from β Persei through the Pleiades; duration 1 sec.

Nov. 14, 10h. 45m., a meteor, equal to a star of 2nd mag., fell from Polaris perpendicularly downwards; train of light; moved rapidly; descended to the Dragon's head.

Nov. 15, 6h. 18m., a small meteor fell perpendicularly downwards from η Ursæ Majoris; colour yellow; slight tail; duration almost instantaneous.—6h. 20m., a small meteor fell perpendicularly downwards from β Bootis.

Nov. 16, 6h. 58m., a meteor equal in size to Jupiter, with tail, fell from 1° above Saturn, and moved 40° horizontally towards south; duration 2 sec.—7h. 4m., a small meteor fell rapidly from above α Andromeda towards Altair; colourless; duration ½ sec.—7h. 5m., a small meteor, no tail, fell rapidly from α Arietis to 2° east of Saturn.—7h. 36m., a small meteor, perpendicularly downwards midway between α and β Aurigæ.—7h. 45m., a meteor equal in size to Saturn, red, with large sparks, and left a continuous train, passed upwards through θ, η, and 3 Draconis; duration 3 sec.

Nov. 17, 10h. 50m. a meteor, in colour, size, and brilliancy equal to Rigel, fell perpendicularly downwards from γ Pegasi.

Nov. 18, 10h. 8m., a meteor, red, no tail, fell from 4° north of α Cygni perpendicularly downwards to south of Vega.

Nov. 20, 11h. 10m., a meteor equal a star of 3rd mag., orange colour, fell perpendicularly downwards from midway between η Ursæ Majoris and λ Bootis, duration 1 sec.—11h. 13m., another, of the same size and colour, fell perpendicularly downwards from γ Ursæ Majoris; duration 1 sec.

Dec. 1, 8h. 23m. 45s., a meteor increasing from a point to twice the size of Saturn, of an orange-red colour, fell from α Ceti, faded near ζ Eridani; duration 4 sec.—10h., a meteor in north.

Dec. 24, 11h. 4m., small meteor, equal to a star of 3rd mag., of an orange colour, with tail, fell from 5° south and 5° lower than Mars, downwards at an angle of 45°.

Meteorological Table for the Quarter ending December 31, 1851.

Names of the Places.	Mean Pressure of Dry Air reduced to the Level of the Sea.	Highest Reading of the Thermometer.	Lowest Reading of the Thermometer.	Mean Estimated Strength of the Wind.	Number of Days Rain fell.	Amount of Rain Collected.	Height of Cistern of the Barometer above Sea Level.
	in.	°	°			in.	ft.
Jersey	29·815	70·0	27·0	1·8	46	9·20	75
Guernsey	29·778	65 5	33 0	1·3	50	9·90	123
Helston	29·785	66·0	31·0	1·3	54	10·30	106
Falmouth	..	71·0	30 0	1·2	51	9·72	120
Truro	29·803	67·0	24·0	0·4	47	10·44	55
Torquay	..	67·0	32·0	2 4	32	5·84	160
Exeter	29·834	68 0	23·0	1·5	38	6·13	140
Clifton House, Isle of Wight	29·820	69·0	24·6	0·1	34	5·95	110
Chichester	..	65 0	25·0	..	..	4·70	23
Southampton	29·763	67·0	25·9	0·2	40	5·24	60
Uckfield	29·787	69·0	19·0	0·6	28	5·42	180
Lewisham	29 790	68·9	22·0	0 5	34	3·39	82
Royal Observatory	29·806	70 1	24·3	..	28	3·00	159
Maidenstone Hill	29·815	67·8	24 2	..	27	2·80	107
Chiswell-street Brewery	29·828	69·5	31·0	..	29	2·93	96
St. John's Wood	29·770	68·0	22·0	1·0	34	3·15	150
Rose Hill (near Oxford)	29·789	67·0	21·2	1·7	29	4·41	270
Thame (Oxon)	29·784	69 0	21·0	0·6	41	4·10	230
Radcliffe Observatory	29·791	69·8	20·5	1·8	32	4·17	210
Stone Observatory	29·757	68·0	23·0	0·5	42	4·35	320
Hartwell House	29·771	70·0	21·0	0·6	38	..	250
Hartwell Rectory	29·757	67·6	21·5	0 6	46	4·02	290
Aylesbury	29·788	68·0	22·0	0·4	30	4·40	284
Linslade	29·787	70·0	19·0	..	37	4·32	313
Cardington (near Bedford)	29·766	67·8	21·0	0·7	37	4·82	100
Bedford	29·760	68·5	23·5	0·7	27	3·92	100
Norwich	29·723	65·0	28·0	0·9	47	9·75	89
Derby	29·787	66·0	21·0	..	41	4·93	100
Holkham	29·743	67·3	25·0	1·0	46	7·70	39
Highfield House	29·727	70·0	19·2	0·3	47	5·16	103
Hawarden	29·761	66·0	24 0	1·6	35	5 40	280
Gainsborough	29·755	66·0	26·0	0·8	39	3·40	30
Liverpool Observatory	29·747	63·4	29 7	0·8	43	6·86	87
Manchester	29·787	68·0	21·0	..	38	7·16	137
Wakefield Prison	29·754	69 5	24·0	1·9	46	2·78	115
Stonyhurst	29·761	63·3	20·7	1·4	47	3·76	381
York	29·777	65·0	23·0	..	32	2·82	50
Whitehaven	29·681	63·0	23·5	2·0	52	6·52	90
Durham	29·704	61·8	26·0	1 2	30	1·28	340
Newcastle Lit. and Phil. Soc.	29·761	64·0	23·5	..	26	3·24	127
North Shields	29·785	65·0	28·0	2·2	40	2·14	124
Glasgow	29 690	63 2	25·9	..	43	5·32	121
Dunino	29·653	64·0	22·0	..	23	1·84	250

The mean of the numbers in the first column is 29·767 inches, and it represents that portion of the reading of the barometer due to the pressure of air: the remaining portion, or that due to the pressure of water, is 0·262 inch; the sum of these two numbers is 30·029 inches, and it represents the mean reading of the barometer for the quarter at the level of the sea.

The highest readings of the thermometer in air were 71° at Falmouth, 70°·1 at the Royal Observatory, 70° at Jersey, Hartwell House, Linslade, and Highfield House; and the lowest readings were 19° at Uckfield and Linslade, 19°·2 at Highfield House, 20°·5 at Radcliffe Observatory, 20°·7 at Stonyhurst, and 21° at Thame, Hartwell House, Cardington, Derby, and Manchester.

Rain fell on the least number of days at Dunino, Newcastle, Bedford, Maidenstone-hill, and the Royal Observatory; and on the greatest number of days at Helston, Falmouth, and Whitehaven. The places where the least falls took place were Durham, North Shields, and Dunino, and the mean amount at those places was 1·74 inch; the largest falls occurred at Guernsey, Helston, Truro, Falmouth, and Norwich, and their mean value was 10·02 inches.

At Derby the fall of rain in the year 1851 was 23·9 inches; the average fall from the preceding seven years is 28·9 inches.

At Cardington the fall of rain in the year 1851 was 18 inches, being 6 inches below the average of the last five years.

At Rose-hill, near Oxford, the great drought of the past season, as everywhere else, was very remarkable. At this spot the springs have never failed; but the river has been lower than ever remembered, some of the smaller branches having become completely dry, and almost stagnant.

At Glasgow the fall of rain in November was 1·1 inch only, being 4·9 inches less than the average of the preceding five years.

At Dunino the springs and lakes were nearly dried up.

PROCEEDINGS OF SCIENTIFIC SOCIETIES.

INSTITUTION OF CIVIL ENGINEERS.

March 2.—James M. Rendel, Esq., President, in the Chair.

The first paper read was *"On the Electric Telegraph, and the principal Improvements in its Construction."* By F. R. Window, Assoc. Inst. C.E.

After a brief notice of some of the early systems of telegraphs employed by the ancients, such as beacon fires, and the escape of water from perforated vessels, as described by Polybius, and also a few of those of modern construction, such as Amonton and Chappe's semaphores, and the Universal Telegraph invented by Sir Charles Pasley; a description was given of some experiments made in the last and present centuries on the possibility of transmitting electricity to considerable distances, with the view of adapting this power to telegraphic purposes. Among these were mentioned the experiments of Du Fay, who in France, in the year 1733, discharged a Leyden jar through upwards of four miles of wire; of Winckler, who at Leipsic, in 1746, discharged a Leyden jar through a long wire, a portion of the river Pleiss being included in the circuit; and of Dr. Watson, who in 1747 suspended a length of two miles of wire on posts at Shooter's-hill, and sent electrical currents through it, the circuit being completed by the earth. This was particularly noted, because in all the earlier inventions of the present century a separate wire was reserved for this purpose.

The general existing system of electric telegraphs was then examined, and divided by the author into three distinct departments:—1st, the Battery, or the motive-power; 2nd, the Wires and their insulation, or the means of conveying the power to the place of its action; and 3rd, the Instruments, or the means of using the power. Of the two former there was little to be related, inasmuch as they had received scarcely any attention from inventors, which the author regretted, as he thought these departments offered the widest field for substantial improvement.

The ordinary voltaic batteries were then described, together with the method of obtaining electricity from the permanent magnet, as employed by Cooke and by Henley, and the manner in which it was adapted to the use of the telegraph. The means of insulation were mentioned as specially needing reform, the above-ground system being uncertain and imperfect in its action, and the underground systems too expensive in their construction. It was explained that the object of Mr. Clarke's metallic capped insulators was to prevent dew from being deposited upon the porcelain cups, as was always the case from the good radiating qualities of all non-conductors. The invention consisted in surrounding the insulators with a metallic substance, by which, from the bad absorbing properties of metals, the radiation from the porcelain was greatly checked, and it was thus prevented from cooling down below the dew point. A short description was then given of the principal existing instruments; amongst which were Cooke's five-needle, Cooke and Wheatstone's double and single needle, Wheatstone's indicating, Bain's chemical decomposition, Henley's magnetic, Brett's printing, and Bakewell's copying telegraphs.

The paper concluded by asserting that the present systems of electric telegraph must by no means be considered as perfect; and inventors were recommended to turn their attention to the improvement of the batteries, and the means of insulating the wires, rather than to the production of new instruments, in which division it was stated that perfection could be carried little further, until some important changes were effected in the other two departments.

The second paper read was "*The History, Theory, and Practice of the Electric Telegraph.*" By C. C. Adley.

The first portion of the paper contained a description of the various modes of transmitting signals proposed and adopted prior to the electric telegraph. The plans of Cardinal Bembo, the Marquis of Worcester, Robert Hooke, Amonton, Marcel, Linguet, and Chappe were noticed.

The various forms of telegraphs, in which electricity was the exciting cause, were then described. These were divided into two eras, the Electrostatic and Electrodynamic. The Electrostatic era comprised all telegraphs in which statical or frictional electricity was the acting principle, such as the plans of Odier, Lesage, Lomond, Betancourt, Reiser, Cavallo, Salva, and Ronalds. The Electrodynamic era included all telegraphs in which voltaic or dynamic electricity was the prime mover, as were the telegraphs of Sœmmerring, Schweiger, Wedgewood, Coxe, Ampere, Dyar, Schilling, Gauss, Alexander, Wheatstone, &c. This brought the chronology of the electric telegraph to the year 1837, and the history was then concluded to the year 1851, by a classified list of the various patents.

The second part of the paper was devoted to the theory and practice of the electric telegraph; and the subject was enlarged upon under the following heads:—1st, the principles adapted; 2nd, the materials employed; 3rd, practical difficulties, and remarkable deranging causes, with investigations as to their origin; 4th, the laws which govern the action of the telegraph; 5th, theories of the mode of transmission of the electric fluid, and of the earth-circuit; and 6th, practical applications and concluding remarks. These heads were again subdivided, and the various portions of the telegraph were treated of separately. The modes of connecting the instruments at the stations were given in detail, together with several practical rules for detecting faults, and the general manipulation of a line. Various defects which occurred in practice were pointed out, and the consideration of remedies was invited. The action of the aurora borealis, the demagnetisation of the needles by lightning, and their frequent derangement by other disturbances, were noticed. A lengthened and elaborate investigation was entered into, with a view of arriving at the origin of the periodic disaffections of the magnetic needles, which the author attributed chiefly to the electric variations of the atmosphere, magnetic storms, earth currents, thermo-electric currents and caloric. An original law which governed the deflections of the magnetic needles was introduced by the author. The laws of Professors Wheatstone and Ohm were also given, as well as the theories of Dr. Faraday, Magrini, Gauss, and other philosophers.

The various applications of the electric telegraph were then described, such as for printing, for working a series of clocks isochronously together, for the comparison of the pendulums, for registering meteorological observations, for producing explosions for blasting, for comparative astronomical observations, chronoscopes for measuring the flight of cannon balls, &c. After citing proofs of the commercial value and public service of the electric telegraph, the paper concluded with a few observations as to the ultimate destiny and world-wide utility of so wonderful an invention.

March 9.—In the discussion on the above Papers, the various instruments introduced by Cooke and Wheatstone, Henley, Brett, Bain, Bakewell, and Siemens, were exhibited and described, their several peculiar merits being fully explained.

The system of underground wires, coated with gutta-percha and lead, as introduced in Prussia by Mr. Siemens in 1848, was stated to be perfectly successful, no difficulty existing in discovering leaks or injuries to the wires; when any occurred, which was very seldom, they were easily repaired. The system now extended over nearly four thousand miles, in Prussia and Russia.

It was objected that the nomenclature was incorrect, and that, instead of the "Electric," it should be called the "Galvanic," or the "Voltaic" Telegraph, as the connection between electricity and galvanism was not as yet clearly established.

The use of a series of wires was suggested for tracing the causes of magnetic disturbances, and series of observations at stations along lines were proposed, as likely to induce beneficial results; and they would be easily performed since the introduction of the photographic self-registering instrument.

The important results likely to be rendered by the connection of the telegraphic wires with the Royal Observatory at Greenwich, were stated to be, among others, simultaneous astronomical observations; the determination of difference of longitude; isochronous action of clocks, so as to exhibit Greenwich, or any other time agreed on, simultaneously at any number of clocks in the metropolis, or any other towns throughout the kingdom.

The practical difficulty of the perfect insulation of the wires, in the over-ground system, and the provisions necessary against wanton depredation, and the atmospheric influences, were fully discussed; and it was generally acknowledged that, with all the known imperfections, the over-ground system had hitherto proved the best and most economical in England; at the same time, the great merit of gutta-percha as a means of insulation, was fully admitted.

It was shown, that galvanic action was being extensively used in Berlin, for communicating between the various government offices and the fire and police stations; and at Boston, for a complete net-work of fire alarms to the different stations of the engines.

The origin of the idea of the submarine telegraph was given, and the construction of the wire laid down between England and France was described. It appeared, that on that station the common needle instrument had hitherto been generally used, but that occasionally messages were recorded by means of Brett's Printing Telegraph, which might eventually be made very useful.

March 16.—The discussion turned chiefly on the comparative advantages of the under-ground system of connecting wires, as practised in Prussia, and the suspended system, in use in this country. On the first introduction of the electric telegraph, it was not known to what extent it would be employed; and on that account the suspension system was preferred, as enabling additional wires to be fixed with but little extra expense. At present, a single line of telegraph wire in Prussia, insulated by gutta-percha covered with lead, laid at a depth of two feet underground, cost 30*l.* per mile, inclusive of the instruments. The suspended system was shown to be not nearly so expensive, and when accidents occurred, they were more rapidly and easily repaired. The recent great improvements in Bain's printing telegraph were described; and it was shown, that by it three hundred words per minute had been sent through this instrument; that fifty-six thousand messages per month had been transmitted on the Eastern Counties Railway, for railway purposes alone; and that such was its extended use for mercantile purposes, that the content of a closely-printed 8vo. volume was sent out in messages, per day, from the Central Telegraph Office alone. Such was the facility afforded by the instruments now in use, that they were chiefly worked by boys taken from the Orphan Asylum, who fully understood how to work them after a fortnight's practice.

Several very ingenious applications of the instruments were described, and specimens of the submarine telegraph wire, intended to be laid down between Dover and Ostend, were exhibited. The general advantages of the introduction of the electric telegraph were pointed out, and it was stated that attention should be directed chiefly to improvements in the mode of insulation of the wires, in both the underground and the suspension systems, as the instruments were now comparatively perfect.

March 23.—The first paper read was "*On the Results of the use of Tubular Boilers, or of Flue Boilers of Inadequate Surface, or Imperfect Absorption of Heat.*" By Admiral Earl Dundonald.

This paper advocated the general introduction of what were termed, "economical heat-trap boilers," or boilers having vertical water-tubes, instead of oblique fire-tubes, contained within a chamber, into the upper of which the hot products of combustion were introduced, and allowed to circulate until, by the abstraction of heat, they descended to the bottom, and passed into the chimney at a temperature little exceeding that of boiling water. From some trials which had been made at Woolwich and Chatham in 1844, as well as from the experience which had been gained by their actual application to some of the North American transatlantic steam-packets, and some in the service of the Emperor of Russia, it was contended that these boilers possessed greater evaporative powers, and were more economical than those ordinarily in use; and, moreover, that their safety was much greater, owing to the products of combustion passing into the chimney at a very low temperature, instead of the usual high temperature, from which it was apprehended much danger had been, and might still be, incurred.

The second paper read was, "*On certain points in the Construction of Marine Boilers.*" By J. Scott Russell, M. Inst. C.E.

The author having arrived at certain theoretical results relative to the construction of marine boilers, put them into practice about ten years back, in designing the boilers for the Royal Mail steam-packets *Clyde, Tay, Tweed*, and *Teviot*; and as they had been in constant work ever since, running from 42,000 miles to 48,000 miles per annum, without material repairs, he believed their durability, combined with effective combustion and economy of fuel, had been fully established. The principles upon which these boilers were constructed differed from those generally recognised. In the first place it was considered that a judicious distribution of the most intensely heated surfaces would be conducive to durability; and for this purpose, instead of returning the flues over the furnaces, the top of the furnaces and the hottest flues were brought to the surface of the water, and the cooler, or return flues were taken to the bottom of the water. The water was admited at the bottom and was gradually warmed as it rose, the greatest heat being imparted at the last moment, by which means the bubbles of steam were prevented from accumulating in contact with intensely-heated metal. In the next place, the capacity of the furnaces, or fire-boxes, was unusually large, and their height above the incandescent fuel much greater than usual. The evaporating surface in these boilers was also much more than customary, there being no less than three feet of evaporating surface for every foot of furnace bars. The process of blowing-off was provided for by arranging under the flues and furnaces large water spaces, as reservoirs for the collection and blowing off of brine and other deposit.

The last paper was "*A description of a Diaphragm Steam Generator.*" By M. Boutigny (d'Evreux).

The principle upon which this steam-generator was based, was that "bodies evaporate only from their surfaces." This being received as an axiom, it must necessarily follow that in the construction of steam-boilers, either the evaporating surface of metal should be extended to its utmost limit, or the water should be so divided, and its evaporating surfaces be so multipled, as to arrive at the same end, of obtaining the greatest amount of steam by the expenditure of the least amount of fuel. The steam-generator was described to consist of a vertical cylinder of wrought-iron, 25 inches high by 12½ inches diameter; the base terminating in a hemispherical end, and the upper part closed by a curved lid, upon which was attached the usual steam and safety-valves, feed, steam, and other pipes, &c. The interior contained a series of diaphragms of wrought-iron, pierced with a number of fine holes, and having alternately convex and concave surfaces. They were suspended by three iron rods, at given distances apart, in such a manner as not to be in contact with the heated exterior, or shell of the boiler. When any water was admitted through the feed-pipe it fell upon the upper (convex) disc, which had a tendency to spread it to the periphery, the largest quantity falling through the perforations in the shape of globules; the second diaphragm being concave, tended to direct the fluid from the circumference to the centre, and so on, until if any fluid reached the bottom of the cylinder, it mingled with a thin film of water, in a high state of ebullition, that being the hottest part of the boiler. It appeared, however, that in its transit through these diaphragms, the water was so divided, that exposing a very large surface to the caloric, it was transformed into steam with great rapidity, and with great economy of fuel. The boiler described had been worked for a long time at Paris with great success, giving motion to a steam-engine of 2-horse power. The consumption of coal was stated to be very small, 789 lb. of water having been converted into steam by 182 lb. of coal in nine hours, under a pressure of ten atmospheres. The chemical part of the question was carefully examined, and it was shown, that at that temperature the iron was exactly in the best condition to bear strain. The practical application on a large scale was submitted to the engineers, the author having only proposed the system for small boilers, and under circumstances of wanting to obtain a motive power in situations of restricted space, and where first cost was a great object.

ROYAL SCOTTISH SOCIETY OF ARTS.

Feb. 23.—Dr. Lees, LL.D., President, in the Chair.

"*Description of an improved Instrument for Drawing Ellipses.*" By G. H. Slight, Engineer.

The instrument is somewhat similar to a pair of compasses, with the legs formed of round steel rods, on either of which a pencil fixed to a tube is fitted to slide and revolve freely. When the rod which carries the pencil is inclined to the paper or other surface to be drawn upon, and the pencil made to revolve, touching the paper throughout its course, it describes on it an oblique section of a cylinder, and therefore a correct ellipse; the obliquity of the section, or the length of the ellipse varying with the inclination of the rod. The improvements consist in a method of moving the pencil nearer to or farther from the rod for different sizes of ellipses, so as to preserve its parallelism to the rod; and in making both legs round and of different lengths, with the means of lengthening or shortening the longer leg, to facilitate its adaptation to longer or shorter ellipses.

March 8.—"*An account—in continuation of those formerly read before the Society—of the progress made in the Drainage of Haarlem Meer during the last year.*" By T. Grainger, C.E.

This short paper, in continuation of Mr. Grainger's description of the drainage of Haarlem Meer, in North Holland, was read by the Secretary. After describing the difficulties to be encountered in the prosecution of this great undertaking, from the size of the lake, and principally from the circumstance that its level, even at the surface, was considerably below that of the sea, so that the whole of the water had to be raised to such a height as would enable it to reach the sea by its own gravity, Mr. Grainger alluded, in general terms, to the various works undertaken to effect the object in view, such as the canal, 33 miles long, 124 to 147 feet in width, and 10 feet in depth, with which the lake had been surrounded to convey the pumped-up water to the sea—to receive the drainage of the district—and to maintain the internal water communication previously afforded by the lake itself—and also to the three gigantic steam-engines, 360-horse power each, erected at different points of the lake, giving motion to 27 pumps, which raise 186 tons of water at each stroke. The canal and all the other preliminary works having been completed, the pumping was commenced in May, 1848, from which date to 30th April, 1851, the lake had been lowered 7 ft. 3 in., which was the state of matters when the subject was last brought before the Society. During the months of May, June, July, August, September, and October, very satisfactory progress was made, notwithstanding that a considerable quantity of rain fell in August and September, the level reached at the end of October being 9 ft. 7·74 in. below the original surface, or at an average rate of 4·79 inches per month. In November a great quantity of rain and snow fell, raising the level about 4 inches; and in December the weather was still unfavourable, so that at the end of that month the level stood at 9 ft. 5·58 in. below the original surface, or a total gain since April 30th of 2 ft. 2·58 in., or 3·32 in. per month. This progress may appear to be inconsiderable; but, when it is recollected that the lowering of the lake one inch involves the raising of upwards of four millions of tons of water, and allowing for the rain and snow falling during these eight months, that there could not have been less than 186 million tons of water pumped up during that period, the performance will appear great indeed. To give a better idea of this, it was stated that 186 millions of tons is equal to a mass of solid rock one mile square and 100 feet high, allowing 15 cubic feet to a ton. The average progress has been less last year than what it was in the preceding one; but this is readily accounted for by the *increased lift* of the pumps, and by the difficulty of forming the channels which lead the water to them. At the commencement of these operations, the average depth of the lake was 13 ft. 1·44 in.; and as 9 ft. 5·58 in. have been pumped out, there only remained at the end of December last an average depth of 3 ft. 7·786 in. It is therefore trusted that the drainage will be completed, if not in the autumn of this year, at least in the summer of 1853. A paragraph has been going the round of the newspapers about disastrous accidents to the boilers, which will delay the completion of the works for two or three years. It was stated that there were no grounds for such rumours, as the official report for January, which Mr. Grainger had received, mentioned that the boilers of only one of the engines (the Lynden) were out of repair, and that it was expected that these would be repaired by February; so that, by this time, it is hoped that the whole of the engines are again at work.

"*Description of a Safe Lock.*" By J. Whyte, Easdale.

This may be considered as a modification of the ancient Egyptian lock. The main bolt has six or eight notches on each side, and there are as many spring bolts playing with these. Along the tops of these spring bolts a slide works (which, in fact, is the key), which is cut on one of its edges in the form of waves, and when it is fully pushed home, these wave lines are so formed as to press down the whole of the spring bolts to the level line, so as to free the main bolt, which then has liberty to open or shut. On the other hand, while the slide or key is withdrawn, the spring bolts instantly enter the notches in the main bolt, and prevent it from moving. The advantages are stated to be the difficulty of picking this lock, or of making a slide or key to fit it; for even the thickness of writing paper introduced betwixt the slide and the spring bolts, will press some of them down into the notches of the main bolt, and prevent it from opening. Besides, the key-hole is very small in proportion to the size of the lock.

NOTES OF THE MONTH.

Architects' Benevolent Society.—The second annual general meeting of this society was held at the Freemasons' Tavern on the 9th ult., David Mocatta, Esq., in the chair. Mr. John Turner, the secretary, read the report, from which it appeared that the amount in the hands of the treasurer, at the commencement of the present year, was 493*l.* 9*s.* 1*d.*, out of which 400*l.* had been invested in the funds of the society, and 58*l.* 10*s.* applied in furtherance of its objects; leaving a balance of 34*l.* 19*s.* 1*d.* in the treasurer's hands. It congratulated the society on the position it held in the estimation of the profession, and regretted that its operation was limited by the smallness of its funds. It also called the attention of the meeting to the kindness of the committee of the Institute of British Architects, in permitting the use of their committee-room for the meetings of the council, the benefit of which was, besides the pecuniary one, that of its existence being recognised by the parent body. The chairman observed, that at present they had the support of only 400 members of the profession, but confident hopes were entertained of an increase. Votes of thanks were passed to the council and officers of the society for their services during the past year, and they were re-elected for the one ensuing, with the exception of Messrs. W. Grellier, and G. Gutch, deceased; and with the addition of Messrs. H. Baker, and G. Bailey, as members of the council. Mr. Kendall proposed a vote of thanks to the chairman, which was carried unanimously, and briefly acknowledged by him, after which the meeting separated.

Artists' Conversazioni.—The third of these interesting meetings was held at the Freemasons' Tavern on the 27th ultimo. Portfolios of drawings were exhibited by Messrs. Goodall, Woodman, Wood, W. C. Smith, Miller, Whymper, and others. The concluding meeting of the series will take place on the 24th inst., when the members are expected to furnish a selection of works, which may include the choicest of those previously exhibited.

Belgian Patents.—The new law project relative to Belgian patents is under examination of a parliamentary committee, and there is every probability that this project will be shortly adopted by a large majority of the Chambre des Representants, on the following simple basis. All patents, both home and foreign, are to pay the same tax, viz., 10 francs the first year, 20 francs the second year, 30 francs the third year, and so on, augmenting 10 francs each year, during twenty years, at which period patents will expire. These payments must be made before the end of each year, or the brevet becomes public property. Great care will be required in translating and revising specifications and drawings, in order to obtain grants for patents of importation.

Protection of Inventions.—Lord Colchester's Bill to Extend the Provisional Registration of Inventions under the Protection of Inventions Act of last year has just been printed by order of the House of Lords. The time is to be extended until the 1st of February, 1853.

Coal Traffic at a Halfpenny per Ton per Mile.—We understand the Great Western are making arrangements with parties in South Wales to bring large quantities of Welsh coal to London at ½d. per ton per mile. The great Western, as well as the Great Northern—and we might say the Berwick and other railway companies—know full well the advantage of carrying coals long distances and in large quantities.—*Herapath.*

Submarine Operations on the Rocks at the Gate, near New York.—The long-continued and severe cold weather compelled M. Maillefert to suspend operations on the rocks at the Gate from the 12th of December until Monday, the 2nd of February, when he re-commenced firing on Pot Rock, and since that time has continued his submarine operations every day that the weather was favourable for blasting. The severity of the cold may best be illustrated by the brief statement of the fact that Long Island Sound was frozen over, the icy bridge extending from the island to the mainland, and reaching to within less than a mile of Pot Rock. Of 1488 hours, comprising the entire months of December and January, there were 1155 hours during which the temperature was below the freezing point, and of the remaining 333 hours, the greater portion of the time storms or high wind prevailed to such an extent as to wholly suspend submarine operations. The firing on Pot Rock can only be effected during the continuance of slack-water, which in the commencement of operations lasted only from eight to sixteen minutes. Between the 7th of November and the 12th of December most of the charges fired on Pot Rock were in water of greater depth than 20 feet, with a view to the removal of the rock to the depth of 24 feet. At present the charges are being fired on isolated points of the rock, between 19 and 20 feet; the sounding for which, during the short period allowed by slack-water, necessarily makes the operations slow. The difficulties with which the operations at the Gate are surrounded are far from abating the energy and good courage of M. Maillefert. He recommenced operations on the first favourable day, and confidently trusts that ere long he will be able to complete this great useful work, which has become an object of general interest, and in the execution of which, so far, he has been eminently and most wonderfully successful. When M. Maillefert commenced operations at the Gate in August last (late in the season), but few persons had confidence in his success. The plan of blasting under water, by placing the charge on the surface of the rock (without drilling), using the water as a fulcrum or resisting medium, was by most persons considered unphilosophical; but complete success has attended this great experiment, which he has been enabled to make, and the efficiency of this new method of submarine blasting has been so thoroughly demonstrated as to convince the most sceptical. During the period we have been making efforts to remove the rocks at the Gate five lives have been sacrificed on Pot Rock, four persons by the upsetting of a boat in passing over it, and one man by a blow on the breast from the tiller of a vessel, in consequence of the rudder striking the top of the rock while the vessel was passing over it. The discovery of this new mode of blasting rocks under water without drilling, the value of which has been demonstrated by the removal of one of the most dangerous rocks in the world from the very borders of a whirlpool, is worth millions to the commerce of the world. Pot Rock is no longer a terror to navigators—no longer an obstruction to the navigation of the Gate by any vessel that has used that thoroughfare for the last twenty years. The whirlpool has ceased its roar, for it no longer exists, and the great chasm in which it has had its home for centuries of time has been filled up by the *debris* of the submarine explosions on the rock which created it.—*New York Journal of Commerce.*

The Panama Railway.—This line is rapidly progressing, and strong reinforcements of labourers have been sent to Navy Bay from Carthagena and from the United States. It is expected that the line will be opened to Gorgona in June or July next, by which time a cast-iron bridge to cross the Chagres, which is in course of construction at New York, will be completed and fixed. It is the intention of the railway company to push on the works between Gorgona and Panama with all possible dispatch.

Tafalgar Hall.—We lately visited this highly popular place of amusement. It comprises a spacious and elegant *salon* and gallery, decorated in the most tasteful manner; and is moreover embellished by a number of chandeliers, of the most chaste description, and of magnificent looking glasses on an extensive scale. These attractions, together with the novelties of an invisible orchestra, and a telegraph that silently announces the respective dances, present an *ensemble* that will well repay a visit. The proprietor seems doing his best to deserve success, and we have no doubt but that he will obtain it.

COMPETITIONS.

Sir—The authorities of county towns almost universally assume architects and engineers to be the most amiable class of individuals under the sun. They want something done—a bridge, for instance. They advertise for competition drawings, and promise a premium for the best design, which just about pays for paper, &c., and expect them to travel to the spot, make levels, surveys, and be at all manner of expense for the chance of getting the said premium. Witness the following magnificent offer for Upton-upon-Severn Bridge:—

"Re Upton Bridge.—*Particulars for Architects.*

"The proposed bridge must have not less than three arches;—the piers to be either of stone or iron;—the arches of iron;—one arch, on the Upton or western side of the bridge, must be made to open, and of not less than 45 feet span. The bridge must be erected on the line recommended by Mr. Walker, C.E., when he made a survey of the old bridge in 1849, being about 35 feet below the old bridge. The width of the river at high or flood water, at that line, is about 280 feet; but it is considered that 200 feet water way in the clear will be sufficient. The bridge must not be less than 18 feet wide in the clear. The roadway must not be raised above its present level; and the estimate must include the cost of making good the approaches at each end. The materials of the old bridge will be given to the contractor. Some portions of the stone are supposed to be very sound and good. There is no good stone in the neighbourhood, but it may be had from the Forest of Dean, and from Shropshire, by railway or water conveyance.

"Inasmuch as it is expected that the Commissioners of the Severn Improvement will be willing to contribute such portion of the cost of the new bridge which will be incurred (extra) in consequence of the opening arch, or in the piers, or other works attendant thereon, and solely rendered necessary on that account; the estimates and specifications must specifically state what proportion of the cost of the bridge will be due on that account; and also what the bridge will cost without an opening arch and works attendant thereon.

"A premium of 25*l*. will be given to the architect whose plan may be selected to be carried out.

"The drawing of Mr. Walker, before alluded to, showing the site of the old bridge and the line for the new one, lies at my office, College-yard, Worcester, for inspection.

"*All further particulars required by architects proposing to furnish plans, &c., must be obtained by them upon the spot.*"

"No further particulars than the above can be given.

"C. A. Helm, Deputy C. P.

"*College Yard, Worcester, March 16th, 1852.*"

"*No further particulars than the above can be given.*" Now, as these particulars amount to nothing, it follows that all must be collected on the spot, which would cost in money out of pocket at least 10*l*. There will be a number of designs sent in, there is no doubt of it, and the competitors will be the amiable persons the Deputy C.P. considers them. I think, Sir, it would have been as well just to have given with the particulars a cross-section of the river and approaches, if competition designs were really wanted, which I beg leave to doubt; and if engineers and architects generally were of my way of thinking, they would not compete without proper information being furnished.

One who is not a Competitor.

LIST OF NEW PATENTS

GRANTED IN ENGLAND FROM FEBRUARY 14, TO MARCH 25, 1852.

Six Months allowed for Enrolment unless otherwise expressed.

William Edward Newton, of 66, Chancery-lane, Middlesex, civil engineer, for improvements in the manufacture of coke, and in the application of the gaseous products arising therefrom to useful purposes. (A communication.)—February 23.

Jean Theodore Coupier and Marie Amedee Charles Mellier, of Maidstone, Kent, gentlemen, for certain improvements in the manufacture of paper.—February 23.

Charles Cowper of Southampton-buildings, Chancery-lane, Middlesex, for improvements in machinery for combing and preparing wool and other fibrous substances. (A communication.)—February 23.

Samuel Banes, of Bethnal-green, Middlesex, master mariner, for certain improvements in apparatus to be applied to, or connected with, the cables of ships or other vessels when riding at anchor.—February 23.

William Stirling Lacon, of Great Yarmouth, Norfolk, gentleman, for improvements in the means of suspending ships' boats, and of lowering the same into the water.—February 23.

James Pilling, of Rochdale, Lancaster, spinner and manufacturer, for certain improvements in looms for weaving.—February 23.

William Walker, of Plymouth, Devon, commander in the Royal Navy, for a method or means of ascertaining and indicating the deviations or errors of the mariners' compass.—February 23.

Richard Archibald Brooman, of Fleet-street, City of London, for improvements in windmills. (A communication.)—February 23.

Thomas Young Hall, of Newcastle-upon-Tyne, coal owner and colliery-viewer, for improvements in screens for screening coal, and other substances requiring to be screened.—February 23.

Samuel Boulton, of Manchester, agent, for improvements in the treatment of metallic ores, and certain salts and residuary matters, and in obtaining products therefrom.—February 23.

Thomas Walker, of Birmingham, for improvements in steam-engines.—February 23.

Alfred Charles Hobbs, of New York, United States of America, engineer, for certain improvements in the construction of locks and other fastenings.—February 23.

Peter Armand Lecomte de Fontainemoreau, of South-street, Finsbury, London, for certain improvements in gas-burners. (A communication.)—February 23.

Henry Bessemer, of Baxter-house, Old St. Pancras-road, Middlesex, for improvements in expressing saccharine fluids, and in the manufacture, refining, and treating sugar.—February 24.

Russell Sturges, of 8, Bishopsgate-street, City, London, merchant, for improvements in weaving-looms.—February 25.

Charles Reeves, jun., of Birmingham, Warwick, manufacturer, for certain improvements in the manufacture of bayonets, swords, and other cutting instruments.—February 27.

Charles John Mare, of Blackwall, Middlesex, for improvements in constructing iron ships or vessels, and steam-boilers.—February 27.

James Pilbrow, of Tottenham, Middlesex, civil engineer, for certain improvements in apparatus for supplying the inhabitants of towns and other places with water.—March 3.

George Leopold Ludwig Kufahl, of Christopher-street, Finsbury, London, engineer, for improvements in fire-arms.—March 3.

George Wilkinson, of Streatham-terrace, Shadwell, engineer, for improvements in ships and other vessels.—March 4.

Alfred Trueman, of Swansea, manager of copper-smelting works, and John Cameron, of Loughor, chemist, for improvements in obtaining copper from ores.—March 4.

Alexander Parkes, of Birmingham, for improvements in separating silver from other metals.—March 8.

Edward Moseley Perkins, of Mark-lane, London, for improvements in the manufacture of cast-metal pipes, retorts, or other hollow castings.—March 8.

James Graham, of Camden-grove, Peckham, Surrey, for improvements in treating ores containing zinc, and the products obtained therefrom.—March 8.

James Wambrough, of Albert-road, Mile-end, manufacturer, and William Allen Turner, of Fish-street-hill, London, merchant, for improvements in the manufacture of flocked fabrics.—March 8.

Frederick George Underhay, of Wells-street, Gray's-Inn-road, engineer, for improvements in apparatus for regulating the supply of water to waterclosets and other vessels, and in taps or cocks for drawing-off liquids.—March 8.

Enrico Angelo Ludovico Negretti, and Joseph Warren Zambra, both of Hatton-garden, London, meteorological instrument makers, for improvements in thermometers, barometers, gauges, and other instruments for ascertaining and registering the temperature, pressure, density, and specific gravity of aëriform fluids and liquids, or solid bodies.—March 8.

Alfred Vincent Newton, of Chancery-lane, Middlesex, mechanical draughtsman, for improvements in machinery for combing wool and other fibrous substances. (A communication.)—March 8.

George Wright, of Sheffield, and also of Rotherham, York, artist, for improvements in stoves, grates, or fire-places.—March 8.

William Edward Newton, of Chancery-lane, Middlesex, civil engineer, for improvements in propelling vessels. (A communication.)—March 8.

Joshua Crockford, of Southampton-place, Middlesex, gentleman, for improvements in brewing, and in brewing apparatus.—March 8.

Augustus Turk Forder, of Leamington Priors, Warwick, solicitor, for an improved fender.—March 8.

Richard Archibald Brooman, of Fleet-street, London, for improvements in presses and in pressing. (A communication.)—March 8.

Charles Augustus Preller, of Abchurch-lane, London, merchant, for improvements in the preparation and preservation of skins, and animal and vegetable substances. (A communication.)—March 8.

Uriah Scott, of Grove-street, Camden-town, Middlesex, engineer, for improvements in wheels and in springs, and in spring-bearings for carriages.—March 8.

John Henry Johnson, of Lincoln's-inn-fields, Middlesex, and of Glasgow, for improvements in weaving carpets and other fabrics, and in the machinery or apparatus employed therein. (A communication.)—March 8.

Walter Young, of Springfield Ironworks, Salford, Lancaster, millwright and engineer, for an improvement or improvements in steam-engines.—March 8.

Alexander Cuningham, of Glasgow, Lanark, ironmaster, for improvements in the treatment and application of slag, or the refuse matter of blast furnaces.—March 8.

William Pidding, of the Strand, Middlesex, gentleman, for certain improvements in mining operations, and in the machinery or apparatus connected therewith.—March 8.

Peter Van Kempen, of West Ham, Essex, accountant, for an improved refrigerator to be used in brewing, distilling, and other similar useful purposes. (A communication.)—March 8.

William Willcocks Sleigh, physician and surgeon, of London, for a counteracting reaction motive-power engine.—March 8.

Alexandre Hediard, of Rue Taitbout, Paris, gentleman, for certain improvements in rotary steam-engines.—March 8.

Paul Rapsey Hodge, of Adam-street, Adelphi, Middlesex, civil and mechanical engineer, for certain improvements in the construction of railways and railway carriages, parts of which are applicable to carriages on common roads. (A communication.—March 8.

Thomas Ellison, of Queen's-road, Pentonville, Middlesex, painter, plumber, and glazier, for certain improvements in the manufacture of imitation marbles, granites, and all sorts of stones.—March 8.

Pierre Henri Bareau, of Paris, manufacturer, for certain improvements in the manufacture of carpets, velvets, and other fabrics.—March 8.

William Smith, of Park-street, Grosvenor-square, Middlesex, civil engineer, and Archibald Smith, of Princes-street, Leicester-square, Middlesex, engineer and machinist, for certain improvements in electric and electro-magnetic telegraph apparatus, and in the machinery for and method of making and laying down submarine, submerged, and other such lines.—March 8.

Colin Mather, of Salford, Lancaster, machine maker, and Ernest Rolffs, of Cologne, Prussia, gentleman, for certain improvements in printing, damping, stiffening, opening, and spreading woven fabrics.—March 11.

Benjamin Goodfellow, of Hyde, Chester, engineer, for improvements in boilers for generating steam.—March 11.

Joseph Denton, of Rochdale, Lancaster, gentleman, for improvements in machinery or apparatus for manufacturing looped, terry, or other similar fabrics.—March 12.—This patent being opposed at the Great Seal, was not sealed till the 12th March, but bears date the 23rd February last, the day it would have been sealed had no opposition been entered.

John Mercer, of Okenshaw, Clayton-le-Moors, chemist, and John Greenwood, of Irwell Springs, Bacup, Turkey-red dyer, for certain improvements in preparing cotton and other fabrics for dyeing and printing.—March 18.

Francis Wheatley, of Greenwich, Kent, gentleman, for an improved safety cab-omnibus.—March 18.

William Froggatt, of Manchester, house and decorative painter, for a certain improvement or improvements in the process of decorative painting, which improvement or improvements are applicable to rooms, halls, carriages, furniture, and other purposes to which decorative painting has or may be applied.—March 20.

John M'Dowall, of Walkinshaw Foundry, Johnstone, Renfrew, North Britain, engineer, for improvements in cutting wood and other substances, and in the machinery or apparatus employed therein, and in the application of power to the same, parts of which improvements are applicable for the transmission of power generally.—March 20.

William Westley Richards, of Birmingham, gun manufacturer, for certain improvements in fire-arms, and in the means used for discharging the same; also improvements in projectiles.—March 20.

William Symington, of Trafalgar-place, West Hackney-road, Middlesex, gentleman, Charles Finlayson, of Manchester, engineer, and John Reid, of the same place, gentleman, for improvements in flues, and in heating air, and in evaporating certain fluids by heated air.—March 22.

John Drumgoole Brady, of Cambridge-terrace, Middlesex, Esq., for improvements in helmets, cartridge-boxes, and other military accoutrements.—March 22.

Edward Morewood and George Rogers, both of Enfield, Middlesex, gentlemen, for improvements in shaping, coating, and applying sheet-metal to building purposes.—March 24.

John Macintosh, of Berner's-street, Middlesex, civil engineer, for improvements in ordnance and fire-arms, and in balls and shells.—March 24.

Antoine Maurice Tardy de Montravel, of Paris, France, gentleman, for certain improvements in obtaining motive power, and the machinery employed therein.—March 24.

Isaac Brookes, of Birmingham, manufacturer, and William Lutwyche Jones, of Birmingham, manufacturer, for certain improvements in stoves, and other apparatus for heating.—March 24.

William Whitaker Collins, of Buckingham-street, Adelphi, civil engineer, for certain improvements in the manufacture of steel.—March 24.

William Cole, of Birkenhead, Chester, architect, and Alfred Holt, of Liverpool, Lancaster, civil engineer, for an improved method of preventing and removing the deposit of sand, mud, or silt, in tidal rivers in certain cases, and also in harbours, docks, basins, guts, or other channels communicating with the sea through tidal rivers or otherwise, the same being applicable in certain cases to other rivers or moving waters.—March 24.

John White and Robert White, of Cowes, Isle of Wight, ship builders, for improvements in ship building.—March 24.

William Henry Hulsberg, of Mile-end, Middlesex, for certain improvements in the treatment of wool, hair, feathers, fur, and other fibrous substances, and in machinery or apparatus for the same.—March 24.

William Archer, of Hampton-Court, Middlesex, gentleman, for an improved mode or modes of preventing accidents on railways.—March 24.

Thomas Bell, of Don Alkali Works, South Shields, for improvements in the manufacture of sulphuric acid.—March 24.

Richard Parris, of Long Acre, Middlesex, modeller, for improvements in machinery or apparatus for cutting and shaping cork.—March 24.

William Pidding, of the Strand, gentleman, for improvements in the construction of vehicles used on railways, or on ordinary roads.—March 24.

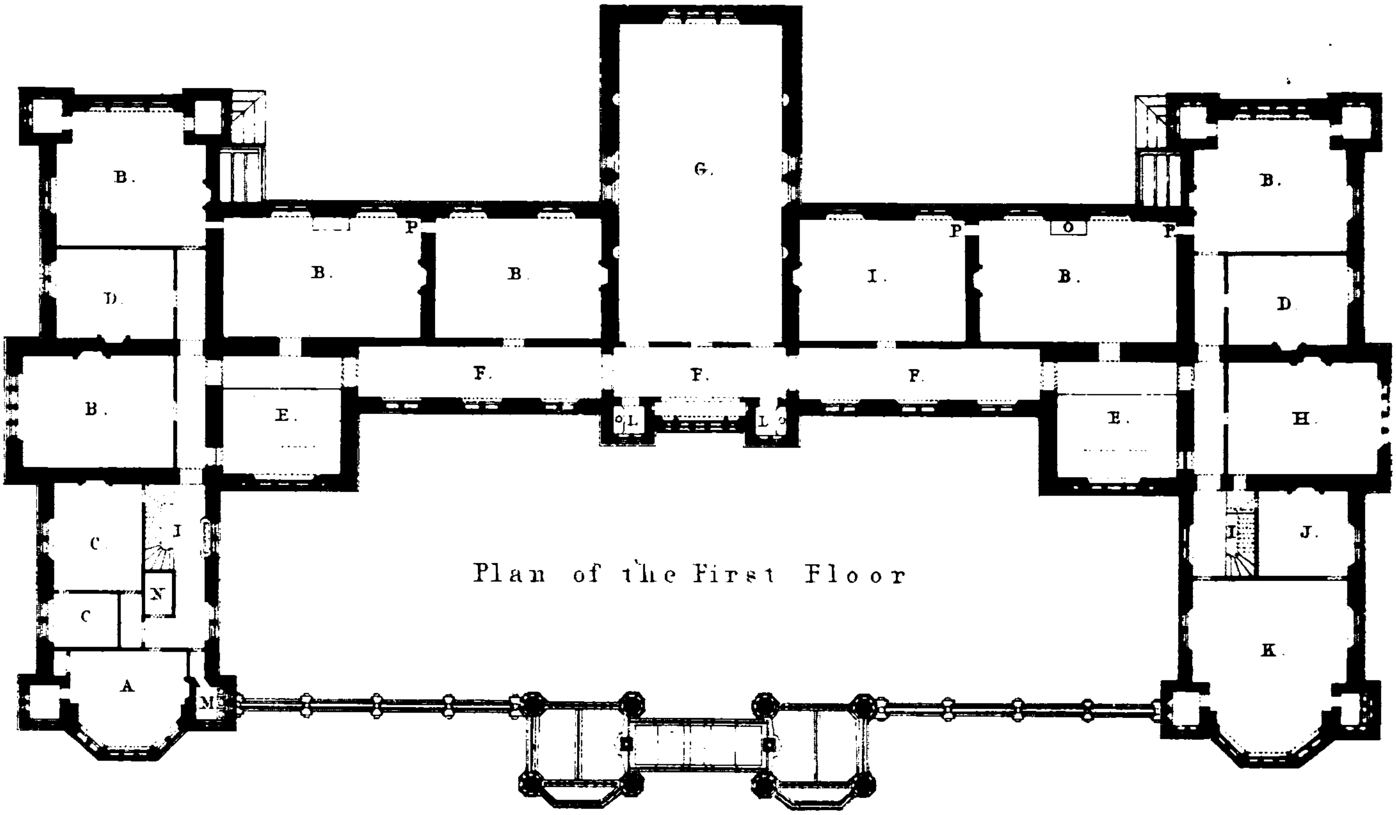
Edward Hammond Bentall, of Heybridge, Essex, iron founder, for improvements in the construction of ploughs.—March 25.

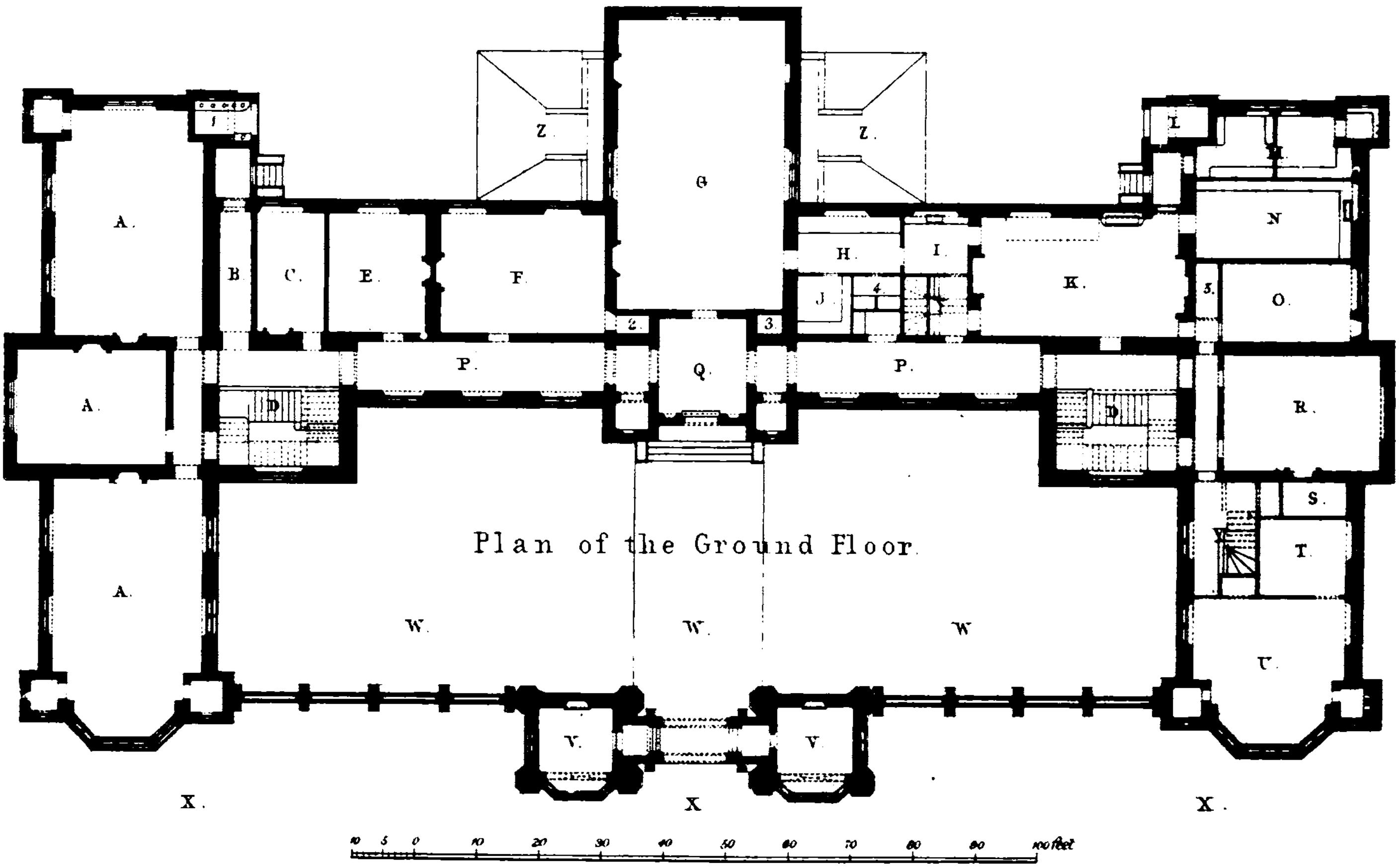
John Smith, of Bilston, Stafford, brass-founder, for certain improvements in locomotive and other steam-engines.—March 25.

Errata.—In the Discussion on "Polychromatic Embellishments in Greek Architecture," *ante* p. 46, col. 2, line 29, *for* "there was evidence," *read* "there was no evidence;" p. 47, col. 1, line 17 from bottom, *for* "interior" *read* "exterior;" p. 47, col. 2, line 2, *for* "the colouring would only resemble the decoration of a theatre," *read* "the houses so coloured would only resemble the scene of a theatre;" line 17, *for* "Beauty and the Graces." *read* "Beauty and Grace."

STEWART'S HOSPITAL EDINBURGH.

DAVID RHIND ARCHITECT. EDINBURGH.

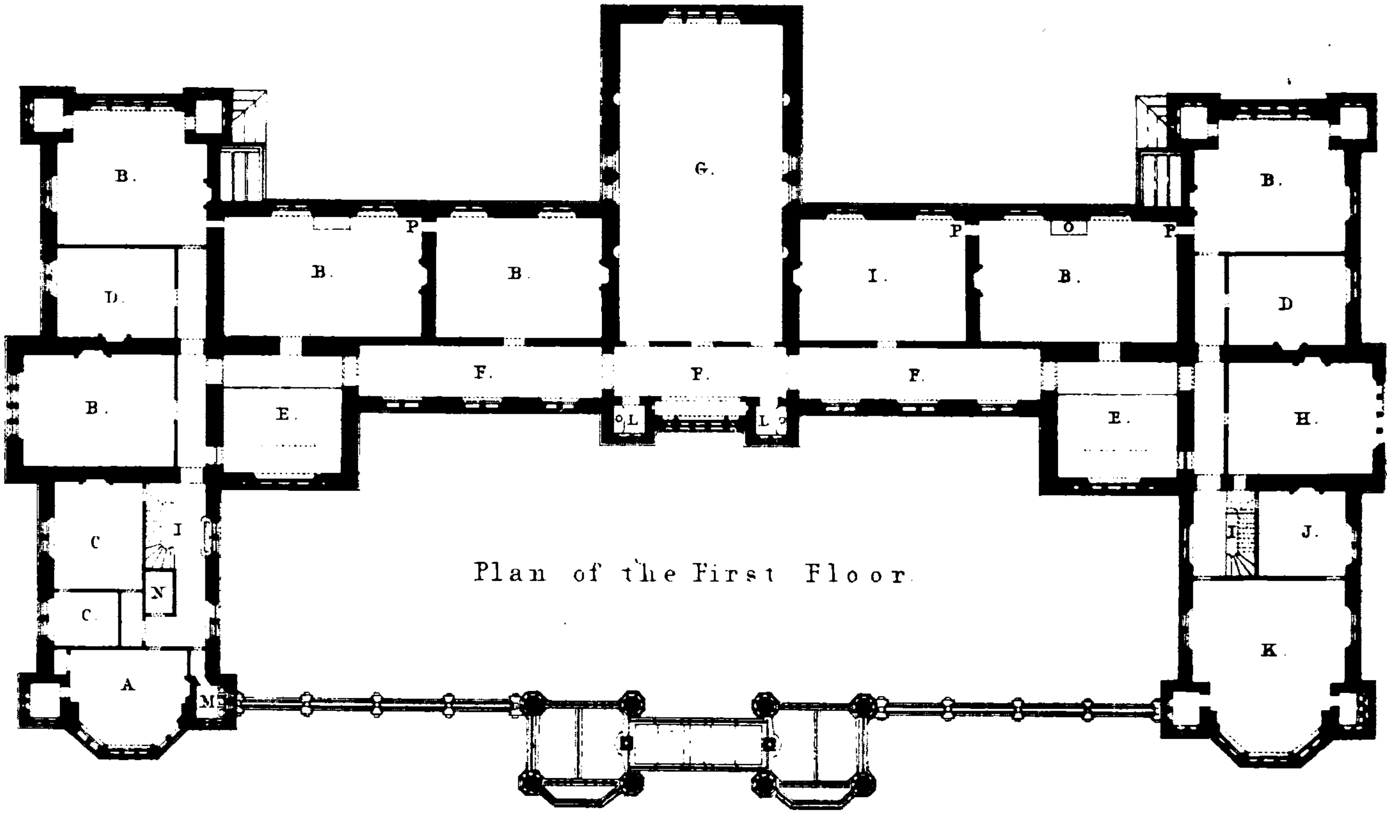




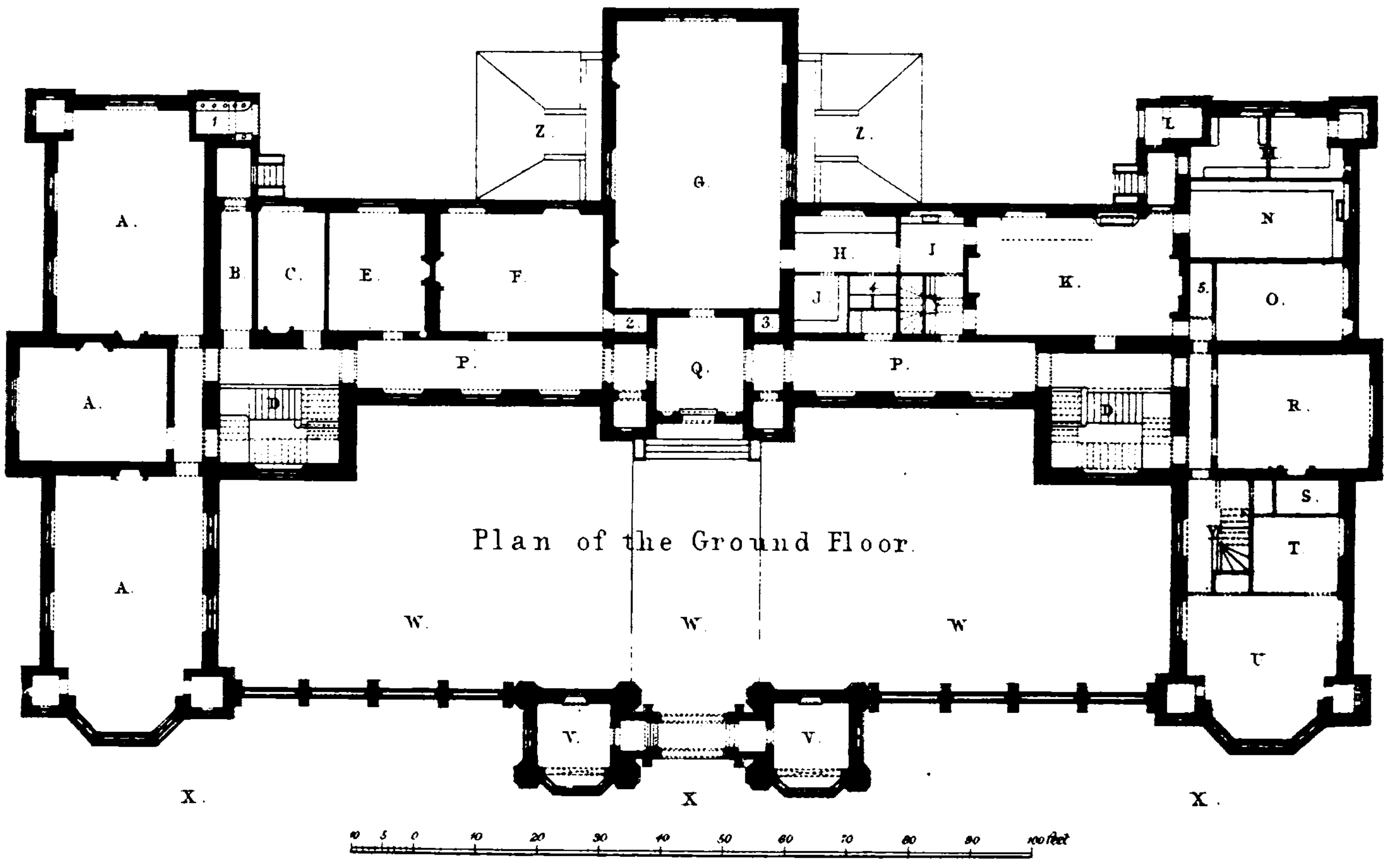
J.R. Jobbins

STEWART'S HOSPITAL EDINBURGH.

DAVID RHIND ARCHITECT. EDINBURGH.



Plan of the First Floor.



Plan of the Ground Floor.

J.R. Jobbins

PL 17

J.R. Jobbins 3 Warwick Ct.

JRGH .
ınd Architect

STEWART'S HOSPITAL, EDINBURGH.

David Rhind, Esq., Architect.

(*With Two Engravings, Plates* XVI. *and* XVII.)

This building, which is now far advanced towards completion, and the dimensions of which are shown in the plans published in our present number, stands on the rising ground south from the Queensferry-road, and immediately adjoining Watson's and the Orphans' Hospital. The architecture of the edifice is Elizabethan, with the corbelled turrets and other features which were incorporated with that style on its adoption in Scotland, as in Heriot's Hospital and other buildings of that period. It occupies three sides of an oblong square, and the projecting wings are connected in front by an open screen, having a central gate and lodges of a highly ornate character. The main body is surmounted by two square towers with ogivel terminals. These are grouped with lesser turrets at the corners, some rising from the ground and others from richly moulded corbels, investing the entire mass with a picturesque effect. The fenestration is also peculiarly well proportioned, the play of light and shadow being at once broad and varied; and when the extensive terraces in front are completed, which will add much to the breadth and elevation of the structure, it will take its place among the attractive specimens of architectural skill for which Edinburgh is remarkable, and some of which are also the productions of Mr. Rhind.

The entrance-hall is light and elegant, the staircases and passages are wide and lofty, and the first feeling on entering the building is a consciousness of the presence of light and cleanliness, and a total absence of cloistered darkness and seclusion.

The two plans engraved will explain the interior arrangements. On the ground-floor are the class-rooms, boys' dining-hall, apartments for matron and masters, visitors'-room, trustees'-room, together with servants'-hall, butler's-room, store-rooms, kitchen, &c.; over the west end of this floor there is a mezzanine containing baths, wardrobes, napery closets, house servants' bed-rooms, &c.; and between the dining-hall and the kitchen there is also a mezzanine with bed-room accommodation for the kitchen servants.

The first-floor consists entirely of bed-rooms, excepting the chapel, which has been placed there for convenience, being only intended to be used for morning and evening prayers, as the boys, like those in similar institutions, will attend public service in one of the Edinburgh churches. The rooms at the west end of this floor are reserved for the sick, and there is a chamber in the floor above for those afflicted with contagious disease.

There is a sunk floor at the west end of the building containing laundry, washing-house, drying-rooms, heating-chambers, &c., and also a covered play-ground for the boys in wet weather; while, in an upper floor extending over a part of the bed-room floor, there are also washing-rooms, play-rooms, &c. The chapel has an open timber roof of pine, stained and varnished; the screen, the pews, and all the timber fittings are being made of the same material. The windows will be filled with stained glass of elaborate design, containing medallions illustrating the leading incidents in the life of Christ, with appropriate inscriptions, emblems, &c. The blazon of the founder and his wife, together with that of the city of Edinburgh and the Merchant Company, the permanent trustees of the charity, are also introduced. Two handsome mural monuments of Caen stone and marble are to be placed here, in memory of the donor and of the late Mr. Longmore, of the Exchequer, whose invaluable services the trustees have determined in this way to commemorate. The floor is to be laid with encaustic tiles, and altogether the chapel promises to be complete and consistent in its character and decorations.

The building of the hospital was begun in 1849, and is expected to be ready for occupation next spring. It is intended for the maintenance and education of poor boys in the neighbourhood of Edinburgh, giving preference to those having the name of the founder, "Stewart," and his wife, "McFarlane;" and there is ample accommodation for nearly one hundred children.

The funds for building and endowing the hospital were left by Mr. Daniel Stewart, of the Exchequer, who died in 1814, and in consequence of the judicious manner in which these funds have been invested by the trustees to whom they were confided, the bequest has been attended with a result which could not have been anticipated by the donor.

References to Plan of Ground Floor.

A, A, A, Class Room
B, Passage to Playground for Boys
C, Strangers' Reception Room
D, D, Great Staircases
E, Masters' Dining Parlour
F, Trustees' Room
G, Dining Hall
H, Butler's Pantry
I, Pantry
J, Crockery
K, Kitchen
L, for Ash Cart
M, Larder
N, Scullery
O, Store
P, P, Corridors
Q, Entrance Hall
R, Servants' Hall
S, Housekeeper's Store
T, Housekeeper's Bed Room
U, Housekeeper's Parlour
V, V, Gate Houses
W, W, W, Open Court
X, X, X, Terrace
Y, Y, Stairs up to Mezzanine Floor, and down to Sunk Floor
Z, Z, Sloping Banks to Play Room, under Dining Hall, &c.
1, Washing Place for Boys while at Play
2, Safe
3, Flue for Heating Upper Corridor and Chapel
4, Wine and Beer Cellar
5, Coal Depot

References to Plan of First Floor.

A, Trustees' Committee Room
B, Bed Rooms for Boys
C, Head Master's Parlour and Bed Room
D, Masters' Bed Rooms
E, Great Staircases
F, Corridor
G, Chapel
H, Convalescent Bed Room
I, Staircases to Attics
J, Nurses' Room
K, Sick Room
L, Boys' Watercloset to be used during the Night
M, Masters' Watercloset
N, Housemaids' Watercloset
O, Warders' Beds
P, Inspection Openings

RETROSPECTIVE CRITICISM.

Sir—Criticism appears to be deprecated for buildings, on the one side, and carefully or else indolently eschewed on the other. Now, I cannot help thinking that it would be infinitely better, if, instead of being eschewed, it were fairly *chewed*, swallowed, and digested. No doubt the chewing and swallowing it would sometimes prove not a little disagreeable; still, highly salutary also. I admit that there are very few who are capable of fairly criticising either buildings or designs for them; what I call fair criticism being based upon deliberate examination and also consideration of both merits and defects.

That there is considerable merit in the design for the Mechanics' Institute at Burnley, which forms the subject of one of the plates in the last number of your *Journal*, I do not deny; still, it would have been better had a little revision been bestowed upon it by its author. Careful revision is, in fact, essentially requisite for all productions of architecture, because being once *erected*, a building cannot be *corrected*—at least, not without very great trouble and expense, and under very peculiar circumstances.

Whether the architect himself can plausibly justify it by any speciousness of argument, I know not; but the inclination which he has given to the area-balustrade before the entrance front is, in my eyes, no better than a violation of architectural grammar, and an arrant distortion of the most unpleasing kind. Whatever slope or other inequality there may be in the level of the ground itself, surely perfect horizontality ought to be observed for the lowermost *architectural* line in a building, as well as all the rest; or, if the lines nearest to the ground are to be made parallel to the ground, why then all the other lines ought surely to deviate equally from horizontality, in order to preserve parallelism to those below,—an absurdity never yet perpetrated, perhaps merely because it happens to be an impracticable one. Had the ground inclined in both directions from the centre of the front, the case would have been totally different, because then there would have been two sloping lines opposed to and balancing each other, just as the raking cornices of a pediment, or those of two lateral ascents leading up to a portico.

Not understanding the necessity for it, I am ill-disposed to excuse the inequality of the fenestration,—not so much because it is inequality, as because it is misplaced or reversed, there being *more* apertures on the ground floor than on the upper one; whereas, had there, on the contrary, been *fewer* below than above, the very desirable expression of solidity would, instead of being as now forfeited, have been attained in a striking degree. Further, according to the engraving, the side elevation has not only, as well as the principal one, more windows below than on its upper floor, but a central *solid* or pier below instead of an aperture! In other respects, I greatly prefer the design of the ground-floor there, to that of the corresponding portion of the front. The front itself, too, in my opinion, would have been very much better had the columns of the portico been placed on the level of the top of the area-balustrade; for they are at present raised so much above it, as to appear insignificant in comparison with the lofty blocks on which they are hoisted.

C.

THE ECCLESIOLOGY OF THE LAKE DISTRICT.

By Rev. Owen W. Davys, B.A. St. John's College.

[*Paper read before the Cambridge Architectural Society, Feb. 26th.*]

Of the various points of interest which yearly attract the travelling portion of our countrymen to the Lake district, that which forms the subject of these remarks is perhaps the very last. What lover of church architecture would or could prefer the lowly edifices of the north, hardly discernible in their picturesque retreats, to the noble towers and spires which alone give dignity to the otherwise dismal fens through which the Great Northern express hurries its passengers from London to York? Yet I should not introduce the subject to your notice were there not a cause. There is, as I last summer found, a peculiar interest attached to the churches of Cumberland and of that district whose religious wants were for a long time supplied by the care and by the messengers of the lordly Abbot of Furness.

Local difficulties lay in the path of those who would construct

"Such plain roofs as piety could raise"

in the Lake district. The primary strata whose uplifted rocks gave to the country all its natural grandeur, could not be modelled by any human chisel; the red sandstone had to be fetched from a distance, and, when all the difficulties of its carriage had been overcome, it was found too fragile to bear for long the images of the beautiful details of Gothic architecture,—the wintry blast, the driving sleet of the late autumn, the rainy deluges of summer, soon obliterated what the patient hand of the artificer had designed. Again, however pious the wishes of church founders, however liberal the sums they consecrated to church building, they soon found that no magnificence of art could vie with the neighbouring beauties of nature. What tower could symbolise the stability of the faithful with half the silent eloquence of Skiddaw or Helvellyn?—what spire could point to heaven with half the sublimity of the pike of Scawfell?

What, then, did the Lake architects do? They acted like wise men; they employed all their care to construct edifices which should answer all the practical ends of houses of God, that in these comparatively humble buildings men might learn to serve that Providence whose wonderful works they could without behold. I speak here of the parish churches; but no sooner did the granite rocks give place to more level country, as the mountains sloped towards the sea, than the stately Abbey of Furness, the Priory of Calder, the collegiate Church of St. Bees, and the Cathedral of Carlisle, raised their heads to show that it was the absence of the way, not the want of the will, which prevented the architects of the north from building fine churches among the mountains. The same cause which made the inhabitants mountain shepherds made their places of worship little more than ecclesiastical huts.

It is my purpose now, and I will carry it out ceasing further introduction, to bring briefly before your attention one or two of the mountain churches which I visited, with the simple remark that if you have seen one you have seen a hundred; they only vary in size and in the use of details, which are rare indeed, being generally confined to a single window or door in each edifice, as at Patterdale and Ennerdale; except in a church which in its position must be considered large and fine—Crossthwaite, the parish church of the town of Keswick. I shall then pass on to a glance at each of the finer buildings which I just mentioned, and which, though not among the mountains, may fairly be included among the architectural specimens of the Lake district.

The church at Patterdale is familiar to all tourists who have visited the finer end of what is justly considered the most lovely English lake. This humble edifice is, in fact, a long barn of granite, with a rough tower at its west end; the only attempt at style being found in a rude window on the south side, bearing the distinguishing features of a square-headed Perpendicular window, carved in red sandstone.

The chapel at Ennerdale had, I believe, its duties originally supplied by the chapter at Calder Priory, who, when building their own very beautiful church, in all likelihood constructed this humble edifice. The eastern triplet may thus be accounted for, with its solitary cusping in the central light, a peculiar and interesting phenomenon in architectural detail. This humble building is not often seen, the neighbouring most romantic lake lying out of the ordinary line of tourists; but both in their respective ways may form an attraction to the pedestrian who is fortunate enough to find himself on a clear day prepared to walk over the mountains from Scale Hill to Calder Abbey. This church is whitewashed inside and out, the latter being the common course pursued by the mountaineers for giving to their houses as well as their churches an appearance of cleanliness.

I pass on to a large church on the same plan as Patterdale, but much more deserving of examination, the mother church of an extensive district—Crossthwaite. This church has been erected at different periods, and has of late been most beautifully and judiciously restored and reseated by the piety and care of a neighbouring layman. The wall of the north aisle is the oldest part of this edifice; it is Norman, and has a door of the period remaining, blocked up and quite plain; the windows are insertions, of Decorated and Perpendicular character, all square-headed. The east window is alone Pointed; it is artfully contrived so as to preserve the few cusps which the design—Decorated—includes; the material, as usual, being the soft red sandstone. On the south side there is a square-trefoiled priest's-door, a new porch, and at the west end a low massive tower. This church is deserving of study as containing a general type of the peculiarities of Lake architecture. The font is very beautiful and most richly ornamented—in fact, the only portion of the edifice which is so, the piers and arches being as plain as possible. My object being here to speak of antiquarian curiosities, I pass over without particular notice the much-famed monument of Southey in the south aisle of the chancel, and the beautiful windows of modern stained glass, which add so materially to the effect of the newly-arranged interior.

The abbey remains of the Lakes are a host in themselves, and Furness is a noble representative of them. The impression which a hasty view of the remnant of this great Cistercian establishment left on my mind was, that out of Ely I had never seen so splendid a collection of architectural studies. The shell of the church is a rare example of Transition-Norman. The chapter-house, who can contemplate its exquisite Early English details without wonder?—what Geometrical work can vie with the educational buildings which lie more to the south? If we seek for later work, the western tower shows that Perpendicular architects knew how to imitate the massiveness of the neighbouring walls, while their skilful carvers inserted on the south side of the presbytery a series of sedilia calculated to prove, by comparison with the older work around, the advance which three centuries had made in art.

Furness is beyond praise as well as description: Calder, however, is more within compass and less known. This priory, which is situated some few miles from the coast, between Furness and St. Bees, was dependent upon the former, and in its church several of the peculiarities of the larger edifice may be found. The dates of the remains at Calder, which consist of a large part of the church and some of the conventual buildings, are various; the earliest portion seems to be the west end, which has a Transition-Norman door remaining. The piers of nave, which are perfect on the north side, have a singular section, which is seen again in those of the transept. The transept and central tower are Early English, the triforium of the former very good, the piers of the latter various and peculiar. The choir is very short, but has a most richly ornamented series of sedilia. The east wall is gone, as is the greater part of the central tower. To the south of the transept is a building which appears to have been the chapter-house; it is a rich and rare specimen of Geometrical design, but nearly all gone. The east window has been most simple and elegant, and well arranged for the soft material in which it is worked. The remains at Calder are well deserving of the careful examination of those tourists who have an opportunity of visiting the picturesque glen in which they are situated.

We must pass St. Bees over with the hasty remark that it is a cross church, with a massive tower at the intersection. It has some fine Early English work about it, and is used—that is, part of it—as a chapel for the college which exists there.

Carlisle, though little thought of as a cathedral on account of its grievously decayed state, is nevertheless a most interesting edifice for antiquarian research. This cathedral was originally of the usual plan; its nave, however, with the exception of two compartments, was destroyed by the parliamentary forces at the Rebellion. The vestige of what must have been once a very fine structure is used as a parochial church; the material of which this is built is blue limestone, which matches but indifferently with the red colour of the other parts of the church, not to mention that it has itself been patched in divers places with sandstone and brick. The south transept is of the same date and stone with the fragment of the nave, and, like it, wears a most doleful appearance. The north transept is of Geometrical date, and has a dilapidated window, which once must have been a fine specimen of the style. The central tower is the work of almost every conceivable period: its original piers are Norman; these have been elongated in after times by piers rising from the old abaci, and carrying Pointed arches; an architect, when the Perpendicular style was prevalent, seems to have had the glory of finishing the composition.

It is really a solace to enter the choir of the cathedral after a view of the incongruous jumble of architecture of which the remainder of the edifice is composed. This is truly worth seeing, and is in something like repair, much having been done to it of late years, though much remains to be done. It is made up of Early English and Decorated work, and contains many peculiarities. The earlier architects do not seem to have done more than the pier-arch stage with the aisles, and this they did not finish, the caps of the piers having been wrought afterwards from the blocks the original architects left. The Early English arcades, and in fact the whole of the work in the aisles, are most truly beautiful. The Decorated architects carried up the choir to its present imposing height, and finished it towards the east with that most glorious front which contains, amidst other beauties, the window which is justly considered the finest specimen of the finest period of Tracery in England. This window is so beautifully delineated in Mr. Sharpe's series of Decorated windows, that I need only refer you to that valuable work for a correct likeness of it. The stall work, the rood, and some other screens in a side chapel, for which this choir is famous, are perhaps as fine studies of mediæval carving in wood as can anywhere be found. I never remember to have seen anything more elaborate than the screen in the chapel I have just alluded to.

Carlisle, then, though poor as a cathedral, nevertheless presents—as my hasty glance at it has, I think, shown—a very valuable series of architectural studies; and though we could have wished that the Commissioners of Henry VIII. had spared us Furness as the cathedral of the Lake district, it is clear that Carlisle, if its restoration, as lately prophesied in a county paper, can be brought about, would be no unworthy mother church of the several interesting buildings there, some representatives of which we have endeavoured hastily to describe.

And that description has not, I trust, been wholly without interest, for it cannot have been so if it has in any way borne witness to the fact, that whatever difficulties had to be overcome, there were not wanting among our forefathers men of energy and piety sufficient to raise in the wildest part of England edifices meet for the high solemnities of Divine worship.

CHURCH OF ST. SEPULCHRE, NORTHAMPTON,

WITH ESPECIAL REFERENCE TO THE RESTORATION OF THE ROUND.

By Rev. G. A. Poole, M.A.

[*Paper read before the Architectural Society of the Archdeaconry of Northampton, April 14th.*]

Previous to the reading of the paper, Mr. Scott gave the following summary of his report on this church, which he had prepared for the information of the Restoration committee:—St. Sepulchre's is one of four Round churches in England, all of which were built either by the Templars or the Crusaders. That at Cambridge and this at St. Sepulchre are a little anterior to the institution of the order of the Templars. Round and octagonal churches were originally intended to overshadow some particular and sacred object. There are two such at Jerusalem, the Mosque of Omar, built by the Mahommedans, overshadowing a very curious rock in which is a cave into which it is supposed the blood from the sacrifices was drained. A very similar building was constructed by the Christians over the tomb of our Lord, so that in the same city there were two such buildings, both overshadowing a rock with a cave. Two of the Round churches in England were built at the time of the present Church of the Holy Sepulchre at Jerusalem, so that they may be said to be contemporaries of the church of which in some respect they are copies. The English churches, however, are vastly inferior in scale to their original prototype. Like the Church of the Holy Sepulchre, the Cambridge Church had a triforium and clerestory. The Temple Church, too, had groined aisles, a triforium, and clerestory. In the Northampton Church the circle of pillars is surmounted by pointed arches; and at a first inspection there seemed to have been neither groined aisles nor triforium. On a closer examination it was manifest that there had been a triforium and groining to the aisles, for he found marks of the original groining all round the walls. Britton had treated the pointed arches as contemporary with the pillars from which they spring. Mr. Poole believed them to be absolutely modern, and it was clear they never could be contemporary with the pillars. Before the arches were built the pillars must have been lengthened by taking off the capitals and interposing an addition to the shafts. The destruction of the triforium probably took place some time in the 14th century, when the walls were thrust outwards so as to lead to the removal of the groining: the wall was saved only by building the huge buttresses, and the tower was probably added at the same time. The original chancel probably terminated with an apse. With respect to the restoration, Mr. Scott saw no difficulty as to the external walls of the Round, and it might be possible to restore the groining shafts. But when they came to the triforium all must be purely conjectural. Upon the subject of the proposed restoration he felt bound as an architect to regret that such a step was necessary, but as a churchman he also felt that it was a regret which he ought not to entertain. If it were merely a question of taste he should neither enlarge nor add to; but one being necessary, he preferred addition. The present tower, round, and chancel were, in fact, three distinct buildings, producing a picturesque effect; how the additions which he proposed to suggest would look he confessed he could not speak about with anything like confidence. However, his plan was to add a chancel in such a way as to make it as obviously an addition as possible. The style to be Early Decorated.

The Rev. G. A. Poole then read the following paper:—

I have a good hope that, if I trespass on your time and attention with rather a longer and drier paper than usual on St. Sepulchre's Church, it will not be without your good-will and indulgence. In a former paper I treated it rather as connected with the *history* and *description* of the fabric; I shall now discuss questions relating to its *proposed restoration*, and to the intricacies which it presents to the architectural student. I shall, however, preface what I have to say with a few notes of its probable history, which is, indeed, an important part of the case which I hope to make out for its restoration.

The Church of St. Sepulchre, like the church of the same dedication in Cambridge, is popularly, but untruly, attributed to the Templars. If antiquity be an element of interest (and we of this Society shall not deny that it is), it has a still higher interest than it would have if it were founded by that much-enduring, much-performing, much-maligned, and much-injured order, for St. Sepulchre's Church was erected before the Templars had any existence. At the same time, the kind of interest which it would have, if built by them, it does not lose, inasmuch as it is clearly associated with the Crusades, or at least with the pilgrimages to the Holy Land, out of which the Crusades took their rise. The most tangible memorials of our pilgrim or crusading fathers are the Round churches, one of which, the second in antiquity, is the subject of the present paper. I will not repeat how the Christians who had reached Jerusalem, and worshipped there at the churches of the Resurrection and of the Martyrdom, desired to erect on their return, some church dedicated to the same service, which might remind them, at least in form, of those venerated places. There they had found the *Sepulchre* surrounded by a circular church, and joined to it the *Martyrdom*, or the place of our Blessed Lord's crucifixion, forming what might very well be represented by a chancel eastward of the Round. Such in general form are all the Round churches still existing. There is a Round answering to the church of the Resurrection, or of the Sepulchre (for in our glorious faith the tomb and the place of the Resurrection are one), and there is the chancel answering to the Martyrdom, which was built over the spot on which our Lord's cross had been raised. Among the pilgrim warriors was one with whom we have especial concern. This was Simon de S. Liz, a Norman, a friend of the Conqueror's, a man of great possessions and high titles, a devout man, and a man of energy and activity; for he was twice a visitor to the Holy Sepulchre, though the second time he did not return farther than a convent dedicated by himself to our Lady of Pity on the banks of the Loire, where he stopped on his homeward road to die. Unfortunately for the ecclesiologist of the nineteenth century, the church builders of the twelfth and two following centuries seldom left on their works any record of the hand which erected them. It is only, therefore, by inference that we assign to Simon de S. Liz the erection of the Church of St. Sepulchre; but this inference is so strong that it may be considered as a point determined as fairly as such points usually are.

We often hear at our meetings of the interest which attaches to the study of a church with reference to its history and its original character. I will now illustrate this interest from the church before us, confining myself, however, to the Round, the only portion which is attributed to Simon de S. Liz. In the interior we have a circle of eight cylindrical columns, supporting pointed arches. The columns are decidedly Norman, and the arches, though pointed, are so exceedingly simple, being only of one order, with a flat soffit, that if it were possible to conceive that any Norman arches could be pointed, we might certainly suppose that these were of the same date with the columns. Yet it was *à priori* very unlikely that if this church was really of the date assigned it, it would have had pointed arches. In consequence it has given rise to various opinions. Mr. Parker, of Oxford, declares it an example of pointed arches of a pure Norman period, accounted for by the foreign influence which might under these circumstances be fairly expected. Mr. Sharpe has included this among examples of the Transition period, which commences, according to his dates, about 1145. I had myself, in a work published some four years ago, attributed these arches to Simon de S. Liz, who died in 1127, but in my last paper on this church, I ventured, after a more careful survey, with express reference to the restoration, to state that the arches, which had been so variously interpreted, were in fact so recent as to be separated in their history from the columns, it might be 400 years or more. Since that Mr. Scott has discovered, *beyond all possible doubt*, that not the arches only, but also part of the columns themselves were recent, the capitals having been taken off and the shafts lengthened about 2 feet. Thus one very interesting question is set at rest, and the arches neither cast any doubt upon the original date of the church as they would on Mr. Sharpe's statement, nor need, as Mr. Parker suggests, foreign interference to account for them. The lengthening of the pillars, by insertion in the shaft, without altering the bases or capitals, is a commoner course than is usually imagined, and, in its results, one of the most puzzling of all changes in the fabric. It is done at St. George's, Stamford, in a very unceremonious way, the inserted portion being octagonal, while those above and below remained cylindrical; this, however, makes it less puzzling than usual. At Spalding, several feet have been thus inserted, and the whole design of the church seemed hopelessly obscured until this was discovered, and then all fell easily enough into its right place. Here I will show you how many difficulties were occasioned by this single fact. At the north-west of the outer round, in the interior, is an original groining shaft. Nothing would seem more clear than its use, and yet nothing so difficult as to conceive how it could serve its purpose with the present piers, which are not now of the same height as this shaft. Again, there are two tiers of Norman windows in the outer round. The upper tier ought to belong to a triforium, but with the present tiers there was no room for it. Now these points also are cleared. There is room for a triforium, and the groining shaft is ready to perform its office. The groining also gives rise to several questions of by no means easy solution; but these are rather constructive than ecclesiological. They are most admirably treated in Mr. Scott's report, which is now before the Society. On these I will only observe that the difficulties are increased just threefold, by the after addition of aisles to the chancel. It is most probable that the original church had a simple chancel without aisles; and, moreover, that even after there were aisles, the entrance to the chancel only was at first open from the Round, the aisles being approached from the chancel.

The first question before us is purely mechanical. Are the walls of the Round in a state in which they can be left with safety; and, if not, can they be restored to such a state without rebuilding? If the architect says YES to either of these questions, they will, of course, remain. If he says NO to both of them, another question occurs. Shall they be rebuilt, or suffered to tumble down and remain in ruins?—a question which would hardly occur to one of *common sense*, and which is therefore most worthily argued in the terms of one of *uncommon genius*. "Do not," says Mr. Ruskin, "let us talk of restoration. The thing is *a lie* from beginning to end. You may make a model of a building, as you may of a corpse, and your model may have the shell of the old walls within it, as your cast might have the skeleton, and with what advantage I neither see nor care: but the old building is destroyed, and that more totally and mercilessly than if it had sunk into a heap of dust, or melted into a mass of clay: more has been gleaned out of desolated Nineveh than ever will be out of rebuilt Milan. But it is said that there may come a nececessity for restoration! Granted. Look the necessity full in the face and understand it on its own terms. It is a necessity for destruction. Accept it as such, pull the building down, throw its stones into neglected corners, or make ballast of them, or mortar, if you will; but do it honestly, and do not set up *a Lie* in their place. And look that necessity in the face before it comes, and you may prevent it............ Take proper care of your monuments, and you will not need to restore them. A few sheets of lead put in time upon the roof, a few dead leaves and sticks swept in time out of a water-course will save both roof and walls from ruin. Watch an old building with an anxious care, guard it as best you may, and at any cost, from every influence of dilapidation. Count its stones as you would jewels of a crown; set watches about it as if at the gates of a besieged city; bind it together with iron where it loosens; stay it with timber where it declines; do not care about the unsightliness of the aid; a crutch is better than a lost limb; and do this tenderly, and reverently, and continually, and many a generation will still be born and pass away beneath its shadow. Its evil day must come at last; but let it come declaredly and openly, and let no dishonouring and false substitute deprive it of the funeral offices of memory." For my own part, it seems to me that Mr. Ruskin's exposition of his own views precludes the necessity of an answer. It is in short a *reductio ad absurdum* of his own principles—that is if they *are* his principles, for I suspect that, like most impassioned declaimers, he has really gone beyond what he himself at all believes and feels. His words have run away with him; or perhaps his characteristic αυθαδεια has impelled him to lay about him so vigourously that he has broken his own knuckles against our hard heads.

Let it be granted, then, that the outer walls are not to become a ruin, but are either to be kept up, or, if that be impossible, to be rebuilt stone by stone. And now what do they consist of? They comprise the exterior of an aisle, and of a triforium. If, therefore, they remain, you have a triforium where none really exists. To perpetuate this mendacious deformity would surely be more like a lie, and an ugly one too, than a careful restoration in the interior of that triforium of which the interior still exists.

But it is assumed that the mutilation too, has its history, and so should be respected. So, also, have half-a-dozen other destructive changes in the fabric their history, and some of them an older history, in all probability, than the destruction of the triforium; as, for instance, the insertion of a semi-Norman door at the north of the Round. But I deny that, in any proper sense, these have their history. They are old, and that is all. They tell of nothing, and nothing tells of them. Besides, history, in the sense in which we are using the term, has its degrees of comparison. If we are dealing with a building without any associations but those of age, everything which approaches it in antiquity approaches it also in historic interest and value; and even the last feature or the last patch it has received, or the last amputation it has suffered, forms part of a vaguely-defined stream of antiquarian interest, and is equally worthy of respect. But when the main fabric is of very singular interest—when it has a history of histories, and all the rest have but a history of blank pages—can we compare the changes with the fabric in interest, and plead that they shall be respected on any large conservative principles? If they are in themselves beautiful, or even good, as is the case with the tower and spire of St. Sepulchre, and as was the case, as we judge from two exquisite brackets, with the Early English and Geometrical additions, it is another matter; then, for their own sakes, we retain them, and also for the sake of their own history, and of the history which they serve to enrich; for what is a beautiful addition to a building, full of high associations, but a note of the admiration in which it was held, and the reverence with which it was treated by some whose own work is worthy to be held in honour? Such additions are like the glosses of gifted men on the half-inspired epic of one yet more gifted. The changes in the Round of St. Sepulchre are no better than the blurred notes and the dog's-ears in a schoolboy's Homer. Nay, they are not so good, for they do not even tell of clumsy pains, and of a wish, however vain, and of a labour, however soulless, to reach the spirit of the text.

This is hard measure; but come with me into the interior, and you will find yet more proofs that it is just. From the time of the completion of the Round to the present day, there is not one change which is not bad in itself, and not one which does not show that the church was treated as if it had no history at all, and no beauty. Indeed, the only touch of tenderness or reverence is on the exterior, where two good massive buttresses, soberly and honestly without affecting anything more, support the tottering walls. These are Decorated in date; and I mention them especially, because I think their very different character affords strong presumptive evidence that the changes within were very much more recent, as they certainly are very much less judicious; in other words, these buttresses supported, in all probability, not the church as it is at present, but the triforium and the original clerestory. And now what are the changes which, after this date, were substituted for more buttresses, which would have been the right course, and for conservative repairs? They were these. The removal of the groining of the aisles, and the destruction of the triforium, while its exterior was left, telling of what does not exist, a sort of *ex post facto* lie, a criminal not morally, but by the tyranny of after circumstances. Besides this, there was the stilting of the piers, the substitution of Pointed for Norman arches, and of a most meagre octagonal clerestory for a round triforium, and all that formerly intervened between it and the roof. Of the roof itself I say nothing, for I believe all are agreed that it ought to be replaced by a better. And yet, even of the roof, I will say that it *is not*, simply because it *cannot be*, worse than the rest of the alterations, and for aught that appears, it is of the same date with the most important of them, so that I know no claim which the rest have on our respect which the roof has not also. But I cannot thus dismiss the clerestory. It is not even circular. That one condition of its existence where it was, that outer form and vesture of the soul which was within, was denied to the clerestory at its rebuilding. Certainly, the architect who conducted these changes knew that he had nothing to fear from conservative critics, or from any who had too tender a recollection of pilgrims or crusaders.

I will now venture to enumerate three kinds of church restoration, which are so far from *a lie* that they are absolutely and distinctly truthful; so far from reckless that they are essentially "tender and reverential."

First, there is that never-ending, still beginning restoration, for which there is room in a large fabric almost from its completion, and which may be so careful and extensive as to admit of no signs of far-spread decay, a course which is now being pursued at Lincoln, where no single stone is allowed to be replaced except by its facsimile. This course cannot be otherwise than satisfactory, if it has been carried on from the beginning, and where it is not so it is the penalty of past neglect; and, as for its being untruthful, since it is the condition of all sublunary things to need repair of some kind, this course is really to enter into the truth of things; to accept it, and to follow it out to its just conclusions. It is simply absurd to talk of expressing either our admiration or our reverence for anything of use and beauty, and our thankfulness to our forefathers for their bequest to us, by letting it tumble to pieces, and become of lower, less graceful, or inferior use. This course of restoration, however, must be followed *to the very letter*. At York, where constant attention is given to the works, but, perhaps, with less strict surveillance of authority, one of the capitals in the Early English arcade in the north transept is replaced with a bust of the Duke of Wellington! This warning, however, is unhappily not needed here, for for this kind of restoration there is no place at present in St. Sepulchre. I hope it may be left, ere long, worthy of such jealous custody as to require it but seldom, and that *when* and *as* it does require restoration, such as this may be given to it.

Secondly, when a church has fallen into general decay by long neglect, but has not suffered material changes in the fabric, it may surely be restored by the insertion of masonry where it is absolutely needed, at the same time leaving every fragment which will still perform its proper office untouched. Here the course pursued reveals itself; and the effect, if in any degree bad (as it is not as compared with a more sweeping reparation), is only so much so as to be a fair penalty for the neglect which has caused such a restoration to be needed. This kind and degree of restoration may be followed in the outer Round of St. Sepulchre.

Thirdly, and finally, there is the restoration of an integral portion of the fabric which has perished by neglect or violence, or accident, or which has been replaced with something worse than ruin—an incongruous substitute without any virtue of its own. And this is *desirable* in proportion to the interest or other merit of the building; *safe* in proportion to the assurance we have of the character of what is destroyed; *necessary* in proportion to the use, and *graceful* in proportion to the uselessness in a hard dry sense, of that which has perished. Under this head would come the greater part of the restoration, such as I have advocated, of the Round of St. Sepulchre. Interesting unquestionably it is in its history and associations far beyond ordinary churches. It is certain that the several features I have mentioned did exist: it is equally certain that they had a well-defined character, of the very details of which we may discover traces, of the broad lineaments of which we cannot doubt. Its use is not, perhaps, greatly lessened by its present incongruities, but all the more graceful the attempt to remove them; nor do I believe that I have to contend with those who would really argue the matter as a *cui bono* question, in the Harriett Martineau sense.

Parallel cases are not wanting. St. Peter's Church, in this city, suggests a very close parallel. It appeared, during the course of the restoration, that one bay of the chancel had been destroyed. The curtailed east end had been built up in the fourteenth century, and had been bungled afterwards, perhaps in the seventeenth. The plan and the style of the original chancel were certain: the details many of them came to light, and—with a skill and patience which I trust to see often exercised in like cases—the present east end was designed by Mr. Scott. Is it a lie? It would be, if it pretended to be the old east end bodily, or even its facsimile; but pretending only to be a thoughtful, patient, ungrudging attempt to replace what others had recklessly destroyed—(and even in the careful search for vestiges of the ancient fabric, and in the scrupulous recordings of them, confessing that, in the nature of things, it could only be an attempt and an approximation)—I hope we shall never have cause to blush for it as a delinquency, or to regret it as a mistake.

Another parallel still closer I find, in perhaps the very highest restoration, all things considered, which has yet been effected in England; and this also by the professional help and care of Mr. Scott. At the east side of the south wing of the western transept of Ely Cathedral, was a chapel dedicated to St. Catharine, to which it is on record that the brethren of the monastery retired for their services while the central tower was expected daily to fall; and in which they had just finished vespers on the eve of the festival of St. Ermenilda, 1322, when the tower did actually fall with a noise like an earthquake. The addition of an octagon to the western tower, soon after this event, caused lamentable breaches in the whole of the west transept; the north wing actually fell, and the south wing was wrenched and shaken throughout, and so remains to the present day. There was a time at which its *beauty* and its *interest* pleaded alike in vain for the Chapel of St. Catharine; and it was *of no use*, so it was pulled down, and the materials were used in a questionable attempt at propping the adjacent walls. The design, the execution, the expediency were not lower or worse than they were in the changes made in St. Sepulchre; but a day came when use meant a different thing, and history had a voice to the heart as well as to the ear, and everything did not seem barbarous which was old; and cost, and energy, and courage of purpose (for such repairs required courage) were not spared, and the foundations were discovered, and the details were sought and found, to such an extent as to secure a restoration generally correct. And there again is the Chapel of St. Catharine. Not so *useful*, indeed, as the space which had to be cleared out to restore it, for that was used as a lumber room; and those who gravely ask the question of use, are not likely to suggest or to accept any better use for the restored oratory. But in what sense the restoration can be called a lie, in what sense it is not a high tribute to the fabric *as it was*, I cannot conceive.

Mr. Blore proposed, and Mr. Scott seconded, a vote of thanks to Mr. Poole for his able advocacy of the thorough restoration view of the question, Mr. Scott guarding himself, however, against being supposed to go quite with him in some of his opinions.

ON MEDIÆVAL ART AND ARTISTS.

By M. Digby Wyatt.

[*Paper read at the Royal Institute of British Architects, March 22.*]

At a meeting of the Institute on March 22nd, the discussion on the Restoration of the Royal Tombs in Westminster Abbey was renewed. Mr. Wyatt considered the subject might be examined under four aspects especially: first, in reference to the actual monuments themselves, and their particular forms at different epochs in their history; secondly, the peculiar processes which some of them exhibited—processes which distinguished them from all other monuments in this country, and the majority of which, he might observe, were not English; thirdly, as landmarks in the history of national art, for (exhibiting foreign influences in many of their details) they affected the question of the sources whence the elements of more essentially English art had been derived; and lastly, which was the most important point of all, these monuments were to be considered in reference to the question, whether their restitution could be successfully carried out or not.

In regard to the peculiar form of the Confessor's Shrine. It would be remembered that, in the earliest ages of the church, the bodies of the saints who suffered martydom were deposited in the catacombs; and the different religious rites of the church were celebrated upon the stone which covered the altar in the chapels in which the remains were interred. After the persecutions of the early Christians ceased, the bodies of these saints were removed from their tombs in the catacombs, and placed under the altars of the churches, so that the same ceremonies might be performed over them as before. Hence the bodies of saints were put into stone coffins, or receptacles of that kind, and deposited beneath the various altars. After a time, the curiosity of the faithful became excited, and in some instances doubts were expressed whether the relics which they reverenced were actually in these receptacles; and it therefore became desirable that the faithful should actually see them at different times. Shrines were accordingly made, which admitted of being opened, so that on certain feasts the congregation might be permitted to inspect the sacred relics; and on those occasions, pilgrims came from all parts of the country in order to confess, and to obtain the usual indulgences. That was known to have been the case in many of the churches of Italy, more particularly at St. Peter's, where the body of the apostle was preserved. Up to the tenth century pilgrims went to Rome from all quarters to view the relics of the saint; and a full account was given by Anastatius of the form of the tomb, and the way in which the pilgrims approached it—putting their heads in a certain fixed place, very much as it appeared they did beneath the Shrine of Edward the Confessor. In order to preserve even the shrines which held these relics from the vulgar gaze, the church introduced *antependia devants d'Autel*, or altar frontals, completely covering the shrines, which were only taken down at certain of the principal *festas*. As the church increased in power, the different popes sent presents of holy relics to various sovereigns of Europe, who in turn formed altars for their reception, similar to those of Italy. He believed, therefore, that on the canonisation of St. Edward, his body was deposited probably beneath the altar, in the feretory described as having been prepared by Henry II.; because, in an account given of the subsequent elevation of the body of the saint into a shrine, Henry III. was described as having desired to raise it up as a candlestick to illuminate the church, so that the faithful might behold it from all parts of the earth. In that way the shrine was gradually lifted up; and so, in Italy particularly, many of the bodies of saints were known to have been taken from underneath the altar—their original position—and placed on high, above it, in large metal shrines. In France, the habit of elevating shrines containing relics grew into very great popularity, particularly in the district of Limoges. According to the observations of the Abbé Texier, there were at the present time many hundred "coffrets" for relics in the small district surrounding Limoges; and although none of the larger ones which were recorded to have existed were preserved, the form of the smaller ones still remaining gave a good idea of them. The French shrines were placed above the altars, and sometimes in a detached position, similar to that of the Confessor at Westminster. The principal relics being regarded as of the utmost importance, their envelopes were frequently enriched with enamels and other decorations. In this manner the shrines of saints became objects of national pride, and great sources of revenue to the churches which contained them; and thus in England the bodies of St. Cuthbert at Durham, St. Hugh at Lincoln, St. Thomas at Canterbury, St. Joseph at Glastonbury, and other saints, were raised in splendid shrines, and became centres of attraction to the people, and the offerings made at them created vast incomes for the ecclesiastics. The different arrangements employed for displaying these relics were very interesting.

Mosaics.—The mosaics of Westminster Abbey were of two kinds, "Opus Grecanicum," and "Opus Alexandrinum," the former being the glass-mosaic employed in the tomb of Henry III., and the latter the marble and porphyry work of the two pavements. The first stage of mosaic, it should be remembered, was when the practice was entirely Greek; the Greek artists, on their expulsion from Byzantium, under the Iconoclastic Emperors, having formed a school at the church of Santa Maria in Cosmedino at Rome. That school existed till about the year 800, when the troubled state of the church prevented the further development of the art, and there ensued a complete lapse for some centuries in Italy. About the year 1150 Desiderius, one of the "Abbati" of the great Benedictine establishment at Monte Casino, sent for workmen from Greece, in order "that the art might not be lost in Italy, and that the young men of that country might learn the mode of manipulation." Shortly afterwards the Greek work began to be imitated in Italy and Sicily, though more particularly at Rome and Florence. Andrea Tafi, Gaddo Gaddi, and Pietro Cavalini, became skilful workmen in Italy during the thirteenth century, when the second series of great mosaics—those of Santa Maria Maggiore, San Giovanni in Laterano, &c.—were carried out. This series differed materially from the former; and it was in this latter style of mosaic that all the examples in Westminster Abbey were executed. These specimens were peculiarly interesting, because, independently of the inscriptions upon them —which proved their date beyond any doubt whatever—the evidence afforded by their style showed that they were works of the manner and period referred to, and displayed the English sympathy of the thirteenth century with Italian art. The pavement of Becket's crown in Canterbury Cathedral, in addition to portions of "Opus Alexandrinum," comprised a very perfect specimen of the old Florentine mosaic, or "lavoro di Commesso," which was quite a different kind of work, the best specimens of it being preserved in the Baptistery at Florence, and the church of San Miniato on the hill above the same city. The latter description of mosaic was formed by drawing the desired pattern on the surface of the marble, and chasing it completely out, and then cutting out of another piece of marble of a different kind the pattern necessary to fill up the cavities of the former. This kind of mosaic was carried still further at Sienna by Beccafumi, who attempted to produce effects of light and shade by the use of different tints of marble; and it ultimately led to the regular Florentine mosaic, in which, in addition to attempts to realise chiaro-scuro, colour was introduced by the employment of different stones, and even jewels. In the earlier specimens of Florentine mosaic, the only colours were red, black, green, and white.

Enamels.—The tombs at Westminster exhibited some very curious specimens of Limoges enamel. At Constantinople there existed originally a peculiar style of filagree enamel on thin sheets of gold, to which gold threads being attached formed little chambers, into which pounded glass of different colours was put; and the whole being placed in a "muffle" furnace, the glass was fused so as to hold the threads permanently in their proper places, and to convert the surface into a beautiful minute glass-mosaic picture. Specimens of this kind of enamel were exported from Constantinople to different countries of Europe; and examples of it might be seen in England, in the famous Alfred Jewel, a brooch in the Hamilton collection of gems in the British Museum, &c. This style of enamel getting into France, was imitated by the workmen there, who however retained the old Gaulish practice, which was of a kind similar to that which might be seen on harness, and other ornaments discovered in barrows. The above kind of enamel was formed by the following process:—a copper ground was taken, and lines incised in it; powdered glass was then put into the cavities, and the whole being fused and polished, and the metal afterwards gilded, the different lines and parts cut out glowed with enamel colours, in a manner similar to that which had before existed in Byzantine work. The peculiar connection which existed between Byzantium and Limoges, through the Venetians having employed Byzantine workmen to execute mosaic and filagree enamels, was pointed out. In this last style their most important commission was the well-known Palla d'Oro, or Paliotto of St. Mark's, ordered about the year 900, by the Doge Orseolo, which was supposed to have been executed in imitation of the altar frontal of St. Sophia at Constantinople. At the end of the twelfth century the Venetians had considerable intercourse with France, and established at Limoges a depôt for the merchandise they sent from Venice, such as embroidery, spices, and other rich objects from Greece and the east, which reached Limoges by way of Marseilles. There still existed at Limoges the streets of the Venetian merchants; and it was a remarkable fact that the very Doge Orseolo, who ordered the altar frontal at Venice, came afterwards and lived at Limoges. Thus, the French of Limoges produced, from a combination of the old Gaulish enamel and that of Byzantium, the peculiar material known as Limoges enamel. The principal application of enamel, illustrated by the tombs at Westminster, was that of forming the effigy of the deceased in wood, and overlaying it with plates of metal having incised lines, in which the enamel patterns were inserted. The tomb of William de Valence, earl of Pembroke, was perhaps one of the most interesting examples in this country. The figure of St. Edward, on the side of his feretory, was probably carried out in Limoges enamel, for it was not to be imagined that the tomb of William de Valence was a singular case;—there was a complete effigy of Walter de Merton, bishop of Rochester, executed in enamel by workmen who came over expressly from Limoges and set it up in the cathedral. The beautiful altar frontal in the south ambulatory is completely Florentine in its character and in the details of its fabrication. Other interesting processes might be referred to as illustrated in Westminster Abbey, the monuments in that edifice furnishing a complete history of decoration, as applied to textile fabrics and embroidery in this country.

Nationality of Workmen.—With regard to the nationality of the different workmen employed upon these monuments—remembering what Mr. Cockerell had written on the subject—it might be observed that Henry III. was, to a certain extent, identified as to time with Nicola di Pisa, who was regarded as the great reformer of art in Italy. Before the time of that great artist, however, many important works had been executed by the old Lombard school of art, particularly in the districts of Milan, Pavia, and Lucca. Of this school were the Comaschi, the freemasons of that district, who, as Mr. Hope stated, and as it was generally believed, connected themselves with other bodies in Europe, and dispersed themselves in various directions, carrying out important works wherever they went. If it were not for the passing action of some such body, it would be difficult to account for the singular appearance in France of a strange sort of Early English style; agreeing with that of buildings executed by Nicola di Pisa, by the Cosmati at Rome, by Massuccio at Naples, and other artists anterior and immediately posterior to the year 1300. The examples of this peculiar style were few, and were found in adjacent localities, exactly as if some passing body had visited them, and left its impress and moved on. It might be supposed that they had visited England, and brought with them a certain amount of Early English. Indeed, he could not otherwise account for the peculiar appearance of the ornamental sculpture of that period. Henry III. ascended the throne in 1216; and, during his boyhood, was for some time involved in trouble and warfare. At a later period, however, he appeared to have engaged in the production of works of art. Now, in considering the question by whom these works were carried out, it should be remembered that the king was continually quarrelling with his barons about the number of foreigners (Poetivins and Italians especially) he brought into the country. The popes of that time insisted on their right to institute to all the churches in England; and the monastic orders in this country were placed in the closest relation with Rome, embassies and other communications with that city constantly taking place. In the last three years of the pontificate of Gregory IX., three hundred different Italian priests were nominated to English benefices, these being regular clergy, entirely independent of the monastic orders. Each pope, during Henry III.'s reign, exercised the same right, and must have sent over a large number of Italians. In looking for actual records to support this view, it appeared that in 1253 William of Florence was an artist employed by the king, and in 1260, by an order printed in the Close Rolls, the king directed a sum of money to be paid to him, "for making an altar frontal as we have directed him." Again, in the year after the elevation of the relics of St. Edward (1269), the king appointed William of Florence master of his works at Guildford, and paid him sixpence a-day, which was at that time very good pay; though in Edward I.'s time workmen received considerably more. Among the first artists employed by Edward I. was "Master Torrell," who worked upon the tomb of queen Eleanor; there was also Andrea Giletto, and a "Master Walter." Mr. Hunter had shown that nine English sculptors were engaged upon the Eleanor Crosses, but that was at a somewhat later period, quite the end of the century; whereas the earlier artists appeared to be principally Italians. It was curious, also, that when Edward I. wanted to carry out his principal works at St. Stephen's Chapel, he had to send out and impress men, who no longer hung about the court as in Henry III.'s time. Judging from these circumstances, it would appear that the prestige of the Italian artists had departed from them, and many had probably quitted the country, or given up their artistic pursuits. The new order of men probably learned their art from these Italians. William Barnaby and Hugh of St. Albans were unquestionably English; but from that time the same excellence was no longer found: a different spirit pervaded the latter works, the style of which was rather actual and dramatic; whilst the former were reflective and æsthetic. It would not be forgotten that Odoricus and Pietro, the artists of the mosaics at Westminster, were very great men.

Restoration.—Of the remains at Westminster Abbey, if restorations could be reconciled to the conscience, their necessity must be undoubted. But, setting aside the artistic view of the question, it was to be remembered that every Englishman had an historical duty in the matter. It would be very injudicious to lay down any general rule, or to say dogmatically that these tombs should or should not be restored. Much would depend on the state of the particular monuments, and every case had its peculiar circumstances. It might be possible to restore the form of a monument, so as to give symmetry to the object, or preserve its solidity; and at the same time enable every one to know what part was old and what new. That plan had been actually carried out in the restoration of the Arch of Titus at Rome, where the restorers, instead of attempting to imitate all the fine carving of the old *marble* work, had restored, in Travertine *stone*, the general form, so that at a distance it appeared a perfect and beautiful arch; whilst on a nearer inspection the new work was found to be only sketched, and the old preserved in all its purity. Thus, there was a complete solid restoration of form and effect, yet the work was perfect as an historical monument. With regard to the crumbling ruins of the decaying monuments at Westminster, it should be remembered, that "out of dead bones life cometh," and in their very decadence and mutilation was recorded a history of those Reformers who overthrew what they considered superstitious monuments, and a kind of tradition of the state of feeling in their time. It was right to respect the ancient sovereigns of England, and if their memorials perished, a spirit of loyalty should induce us to erect others to commemorate their virtues, if we respected them; but the testimony of those Reformers should be likewise respected. If these monuments were to be restored, at least a brass inscription should record their precise state immediately prior to the commencement of the work of repair. Where objects were peculiar for their beauty, and where, by any ingenious process, they could be brought back to their original condition—without addition or subtraction—or where they could be improved by washing off dirt, or by otherwise cleaning and varnishing, the employment of any such process (which was only uncovering veiled beauty) was perfectly legitimate: but even that had its limits. Only the other night it was agreed that there was no colourist like Time, and that all the polychromy of art was scarcely harmonious till its tones were blended by age. Why, therefore, should what time had done be undone? If these monuments were to be restored, all must agree that *great care* would be required. He should be very sorry to see any rash hand applied to them; he should be, indeed, as grieved to see them "restored," in the common acceptation of the term, as he should be to notice the rust rubbed off a beautiful green bronze of the Etruscan period.

ON THE PRESENT STATE OF METEOROLOGICAL SCIENCE IN ENGLAND.

By John Drew, Ph. D., F.R.A.S., Member of the Council of the British Meteorological Society.

The Royal Observatory, Greenwich.

(*With Engravings, Plate* XVIII.)

For a period of not less than 160 years, systematic observations of the places of the sun, moon, planets, and fixed stars, have been recorded at the Royal Observatory with an accuracy not surpassed, if indeed equalled, elsewhere. The government of this country have evinced a sound discretion in the appointment of the most eminent mathematicians to the office of "Astronomer Royal"—an office now held by Mr. Airy, whose mind is ever actively engaged, not only in sustaining the character of the Observatory for accuracy of observation by the introduction of instruments superior to any hitherto employed (witness the new 14-feet transit-circle, and the altitude and azimuth circle), but in adding to its efficiency in every collateral branch of science. Under his auspices the magnetical and meteorological observatory was originally established; and, of late, the new system of automatic registration of the magnetical and meteorological instruments by means of photography (invented and brought to perfection by Charles Brooke, Esq., M.B., F.R.S.), has been introduced, and now forms a most striking feature in that department of observation. Successive governments have shown a liberality in promoting the objects for which the Observatory was originally founded—viz., to afford assistance to the navigator in traversing the pathless ocean, by the formation of tables founded on the data there recorded; these are printed yearly in the 'Nautical Almanac,' which exhibits results in a systematic form, and is of inestimable value both to the astronomer and navigator: it is supplied to the public at almost a nominal price. The volumes of magnetical and meteorological observations, as well as the astronomical, are readily and gratuitously bestowed upon individuals who are labouring in those departments of science. Of the great utility of those laborious quartos I can myself speak experimentally, having, at the representation of the Council of the Royal Astronomical Society, received a grant of the entire series: they have supplied me with valuable directions, and have solved many difficulties which would have obstructed my progress.

In the year 1837, it was determined to erect a magnetic observatory, for the purpose of investigating the laws of magnetism, on the full understanding of which the mariner's compass depends for improvement, and the chart by which the navigator is guided for its accuracy; conjointly with these investigations an elaborate system of meteorological observation was commenced, in the expectation of discovering some of those causes which produce the variations in the conditions of the atmosphere—a kind of knowledge auxiliary to navigation, in which so much depends upon that variable element, the wind. Greenwich, moreover, was understood to be well appointed in a trained corps of observers, renowned for the accuracy and care which they had employed in the most exact science; and the published Reports, which originated in 1840 and have extended to 1850, have proved the wisdom of the choice of that locality for the magnetical and meteorological instruments.

The magnetic observatory is a small detached building, its nearest angle being 230 feet from the nearest part of the astronomical observatory, and 170 feet from the nearest out-building; the material is wood, and iron has been carefully excluded from its construction; the form is that of a cross, with four equal arms nearly in the direction of the cardinal magnetic points; its extreme length and breadth are each 40 feet, and the breadth of each arm, which is 10 feet high, is 12 feet. The only iron to be found throughout the whole building is in the fire-grate in the anteroom, the mean-time clock, the sidereal clock, and the check-clock. In the Greenwich volumes, before alluded to, will be found a series of elaborate observations, tending to the determination of the degree of influence on the magnets exerted by this small portion of iron; and the results, as declared in the volume for 1847, show that the influence is insensible, or so minute that it may fairly be neglected in practice.

The declination magnet is 2 feet long, 1½ inch broad, and ¼-inch in thickness; it is supported by a braced wooden tripod-stand, resting on the ground, unconnected with the floor. The centre of the magnet rests within a stirrup of gun-metal, which has been found to diminish the extent of vibration, and bring the magnet to rest with less agitation; fibres of untwisted silk suspend it, and allow it to move freely, horizontally, a small quantity on either side of the magnetic meridian. Upon the magnet slide two brass frames; one of these carries a cross of delicate cobwebs, the other a lens, in one of whose foci is the cross; through this lens the cross can be well observed by the telescope of a theodolite, and the vibrations of the magnet on either side of the magnetic meridian may be read off on the divided horizontal circle of that instrument. Until the introduction of photographic registration, the observations of the three magnets were taken and recorded every two hours of the day and night, and the check-clock was contrived to indicate any irregularity in the observer, who was expected to depress a pin at his appointed time; as the clock-case was locked, the number of pins depressed, and the time when, indicated whether or not an observation had been neglected. At the present time the magnets are read off instrumentally only three times daily, as a check to the photographic registers, and as a means of forming a photographic base-line of measurements, as will be more fully explained hereafter.

The mode of taking the observations instrumentally is the following:—The mean-time clock, with the application of a correction determined astronomically for the day, shows Göttingen mean-time for the day, which is + 39 min. 46 sec. on Greenwich time. It was determined by a conference of philosophers of all nations, that simultaneous magnetic and meteorological observations throughout Europe should be regulated by that longitude.

In the field of view of the theodolite is a fine vertical wire, moved right and left by a micrometer-screw. On looking into the telescope the cross of the magnetometer is seen to pass, during a vibration, alternately right and left. The observation is made by turning the micrometer till its wire bisects the magnet-cross at 45 sec. and at 15 sec. before the pre-arranged time; and again, at 15 sec. and 45 sec. after: the mean of these observations will be the position of the magnet for the proposed time. It was found, experimentally, that the magnet vibrated in 30 sec.; and hence this interval is allowed between the observations. If the magnet be at rest, which occurs only a few times in the course of a year, one reading of the theodolite only will give its position.

The adopted result, in runs of the micrometer-screw, is then converted into degrees, minutes, and seconds, their value having been previously determined. The difference between this and the reading of the circle of the theodolite corresponding to the astronomical meridian, which has been previously determined most accurately, is registered as the magnetic declination. The mean declination of the magnet, or, as it is more popularly termed, the variation of the compass, at Greenwich for the year 1847, was 22° 51′ 18″ west of the astronomical north. The reductions for 1850 are now complete: for that year I find that the mean declination differs but little from 22° 30′ west.

The horizontal-force magnet is the same size as the declination magnet; it, with its suspension-frame, is supported by two halves of a skein of untwisted silk: this is the bi-filar magnetometer invented by Professor Gauss, in 1837, for the purpose of determining the horizontal intensity separately. The two lines of suspension pass over two pulleys, and hang parallel to each other when the needle rests in the magnetic meridian. Then, on turning the whole apparatus horizontally, so as to make the needle deviate from the magnetic meridian, its tendency to return to its former position causes the threads to assume directions oblique to each other; and there is some position of the needle in which its directive force is equal to the force by which the threads resist being made to cross each other's directions. It is easy to adjust the instrument so that when this equilibrium takes place the needle shall lie in a direction at right angles to the plane of the magnetic meridian; the torsion of the threads by which the needle is made to assume that position indicates the horizontal component of the magnetic force, and every change in the intensity of the latter affects in a direct manner the position of the needle. The force of torsion is computed, and, being known, the deviations of the magnet on either side of its mean place will give the value of the horizontal force. The details of the determination of this element may be found in the 'Greenwich Observations.' To the cell which carries the magnet is attached a mirror; this mirror

Photographic registration of the declination and Horizontal force Magnets

FIG. 5.

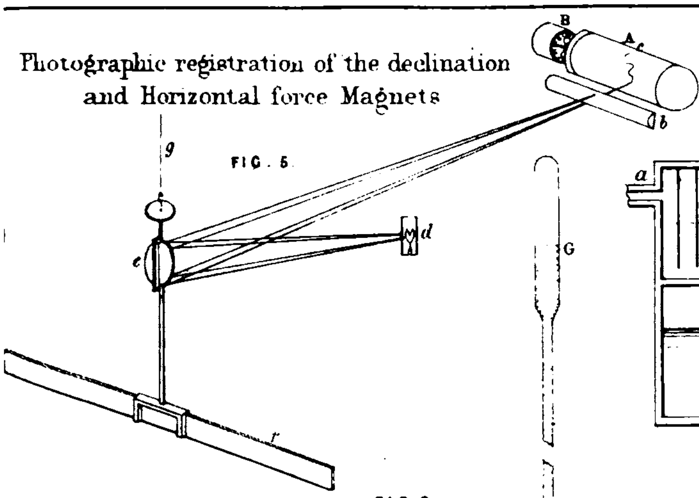


FIG. 1.

Section.

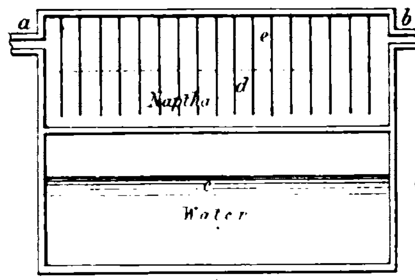


FIG. 2.

Plan.

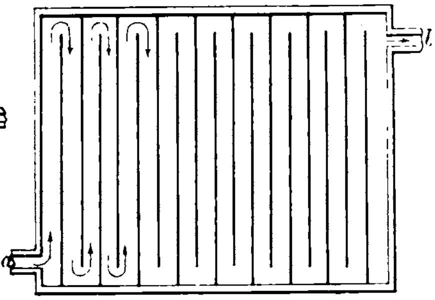


FIG. 3.

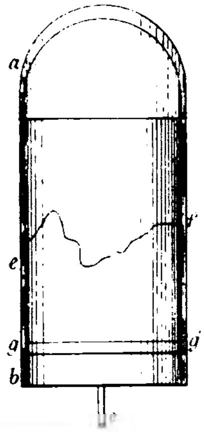


FIG. 6.

The Barometer.

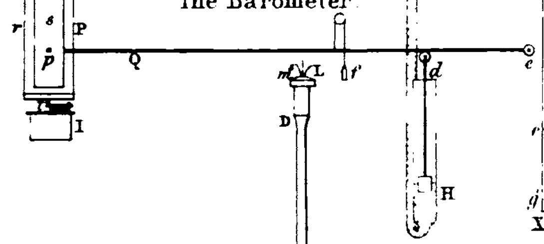
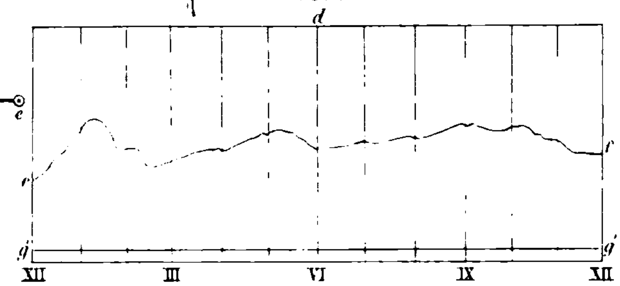


FIG. 4.



INTERIOR OF THE ELECTRICAL OBSERVATORY AT KEW

FIG. 9

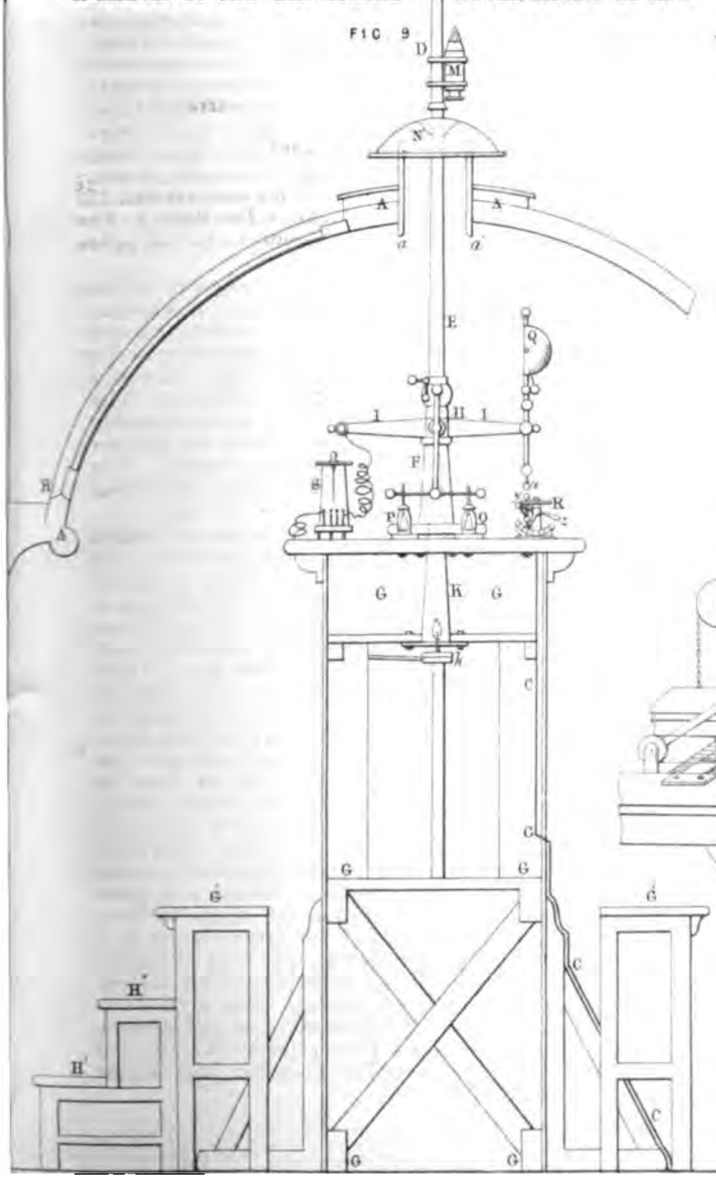


FIG. 7.

OSLER'S ANEMOMETER AND PLUVIOMETER.

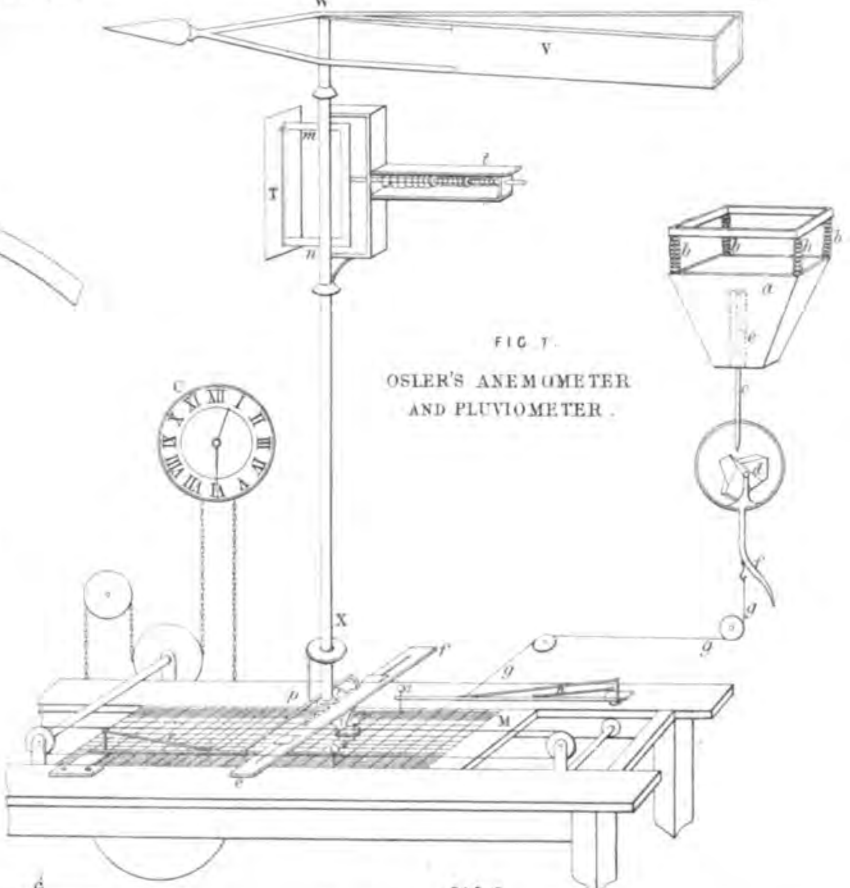
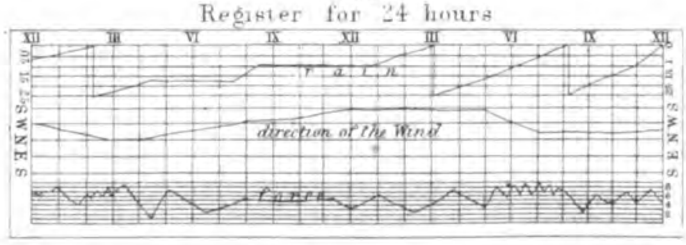


FIG. 8.

Register for 24 hours



reflects the image of a scale fixed to the opposite wall towards a telescope, at which sits the observer noting the number of divisions passed over during a vibration, the mean of which is the deviation of the position of the magnet from its mean place due to the time when the observation is taken.

The vertical-force magnet is of the same dimensions as the other two; it is crossed at the centre by a short axle, which is sharpened to a knife-edge, and rests or vibrates on agate bearings. The bar is made to assume a horizontal position by means of a moveable weight. It is provided with a mirror situated over its centre of motion, with its plane oblique to the magnetic axis of the bar; a scale is affixed to the opposite wall, and the mirror reflects its divisions to the eye of the observer, who, looking through a telescope, reads the division of the scale which appears in coincidence with a horizontal wire in the field.

By an accurate determination of the vertical and horizontal components of the magnetic force, we are enabled to deduce the inclination of the magnetic needle, and the intensity of the magnetic force for any given locality. Greenwich, in combination with foreign observatories, has done its part in supplying data for determining—1, the irregular variations of the earth's magnetic force, which apparently observe no law; 2, the periodical variations, whose amount is a function of the hour-angle of the sun or of his longitude; 3, the secular variations, which are either slowly progressive, or else return to their former values in periods of very great and unknown magnitude.

A dipping-needle in a small detached building is read every two or three days. It is 9 inches in length, and the circle which measures the dip is 11 inches in diameter. The mean dip for the year 1848 was 68° 54′ 45″; for 1850 the reductions have just been completed; for that year the dip differs but little from 68° 40′.

Though the instruments just described do not form a part of the meteorological establishment of the Observatory, strictly speaking, yet, as their movements are registered photographically, and in combination with those devoted to atmospheric changes, and as, moreover, for the last ten years, the whole arrangements have been superintended by the same person (Mr. Glaisher), I considered it necessary to say thus much respecting them. I now proceed to those which record more particularly atmospheric variations.

On Photographic Registration of Meteorological Phenomena.

On this subject I shall endeavour to be sufficiently explicit to convey a clear notion of the ingenious contrivances by which automatic registration is attained; but it is not my intention to describe them so minutely as would be requisite were I about to give directions for their construction. Those who may wish to construct a similar apparatus may consult, advantageously, the 'Philosophical Transactions,' Part I., 1847, and Part I., 1850; and the Greenwich 'Magnetical and Meteorological Observations,' 1847.

On the first introduction of photographic registration by Mr. Brooke, that gentleman adopted the light of a camphine lamp, as producing the most powerful photographic effect. For this has now been substituted a mixture of common coal-gas and naphtha, which is found to be quite equal in brilliancy, and far more manageable. The gas, on admission into the magnetic observatory, is received into a tin-box divided horizontally into two compartments, the lower of which contains water, and half of the other is filled with naphtha. This upper half is partitioned off into eighteen cells by vertical divisions, each attached alternately to different sides of the box.

Fig. 1 is a section, and fig. 2 a plan of this box or receiver; *c*, is the portion partially filled with water, which is heated by the jet of gas *f*; *d*, is the naphtha compartment, half-filled with that substance; as the water heats the naphtha, the upper part of the compartment at *e*, becomes filled with vapour, and the gas, entering at *a*, traverses the compartment in the direction of the arrows, as shown in fig. 2, unites with this vapour, and the two gases in chemical combination issue at *b*, and the combined gases are distributed throughout the building.

The paper on which the photographic trace is received is a strong woven paper, of equal texture throughout; in manufacturing it, all foreign substances which might combine injuriously with the chemical substances used in its future preparations have been carefully excluded.

A sufficient quantity of paper for the consumption of three or four weeks is treated in the following manner:—"To a filtered solution of 4 grains of isinglass in 1 fluid ounce of boiling distilled water are added 12 grains of bromide of potassium, and 8 grains of iodide of potassium. The solution, either when hot or cold, is evenly laid upon the paper with a camel's-hair brush, in such quantity as to thoroughly wet its surface, but not to run off; the paper is then dried quickly before the fire. The paper thus treated is preserved by keeping it in a dry place and in a drawer.

"When a cylinder is to be charged with photographic paper, the room is darkened and illuminated only by a candle, whose flame is surrounded by a cylinder of yellow glass. The paper is laid flat in an earthenware dish, and is washed with an aqueous solution of nitrate of silver, made by dissolving 50 grains of crystallised nitrate of silver in one fluid ounce of distilled water, which is laid on in quantity not sufficient to run. The paper is then in a state fit to be placed upon the cylinder.

"When the paper is to be taken off the cylinder, the room is illuminated in the same way, the cylinder is detached from its mounting, the external cylinder is drawn off, and the paper is unfolded and laid flat in a dish. In this state it exhibits no trace of the action of the light. It is then washed with a solution of gallic acid, to which a few drops of acetic acid are added, till it is moderately wet all over; the impression begins soon to appear, and in a few minutes acquires its full strength. The paper is then repeatedly washed with water till the water runs off quite clear. Solution of hyposulphite of soda (formed by dissolving 1 drachm of the hyposulphite in 5 oz. of distilled water) is then poured upon it, and water is added in considerable quantity; after this has remained about five minutes, the paper is washed repeatedly with water. The trace is then securely fixed, and light may be admitted into the room. The sheets are then usually preserved for gradual drying within the folds of linen towels."

The cylinders alluded to in the above extract are those around which the paper is wrapped to receive the photographic trace. They are, in fact, French glass-shades (such as are used to protect works of art), 11½ inches in length, and 14½ inches in circumference. The shade, after having been blackened in the inside, is cemented into a cap 1 inch deep, having a brass pin projecting from the centre. A second shade, a little larger than the former, is placed over the paper when it has been attached in a moist state to the first; this latter cylinder is kept in its place by a few turns of tape round the collar part, which is moistened with water; damp list is also placed between the hemispherical parts of the shades. This provision is necessary to prevent the paper from becoming dry during the time it is subject to the photogenic action, for dryness would very materially destroy its sensibility. When the axis of the cylinder is required to be horizontal, as in the registration of horizontal movements, the pin which is in the line of the axis and the cylinders themselves rest on friction-rollers; a ben vire on the axis is caught by a fork attached to the hour-hand of a time-piece, which is about the size of a ship's chronometer, and thus the cylinder is carried round once in twelve hours, or any other period which may be determined, with such smoothness and ease as not to alter the rate of the time-piece in the slightest degree. One-twelfth of the circumference of the cylinder will evidently measure one hour, and about $\frac{1}{10}$-inch will be the measure of five minutes of time.

Fig 3. *a*, vertical cylinders charged with photographic paper; *b*, wooden cap; *c*, central pin.

Fig. 4. *d*, the paper unwound and divided into twelve parts, marking the hours; *e*,*f*, the trace of the movement of the mercury in the barometer during that time; *g*, *g′ g′*, photographic base-line.

The time-piece, in moving the vertical cylinder, lies flat underneath it. In the case of a horizontal cylinder it is placed with its face vertical, and facing the cap (see fig. 5, B).

For the sake of convenience each cylinder is made to perform double duty. The barometer and vertical-force magnetometer are registered on the same cylinder, and their traces are allowed to cross each other in opposite directions, which, with a careful adjustment, can easily be effected without interference. The declination and horizontal force magnetometers are registered in the same way, on a cylinder whose axis is horizontal; and the wet and dry bulb thermometers share a cylinder between them.

To describe now the manner in which the photographic trace is left, commencing with the declination magnet. The light by which the trace is made is placed slightly out of the direction of a straight line joining the suspension-skein of the magnet and the centre of the photographic sheet. The chimney which covers the light (a jet of gas united with the vapour of naphtha) is perforated by a slit $\frac{1}{10}$-inch long and $\frac{1}{100}$-inch broad (see fig. 5, A); the light from this slit falls on a metallic concave mirror, which is carried by the suspension apparatus of the magnet, and moves with it; by it the light is made to converge about the centre of the cylinder of photographic paper, at a distance of nearly 12 feet. To reduce the image of the slit to a neat spot of light, a cylindrical lens of glass is interposed. Now, as the magnet, and with it the mirror, turns in azimuth, the image of the slit runs along this lens; and, at whatever part it falls, it is concentrated into a definite and brilliant spot of white light, which leaves a photographic trace on the prepared paper; and as this is constantly carried round by the time-piece, the effect produced will be a continuous line around the cylinder, with deviations to the right or left indicating the horizontal movement of the magnet.

As in practice it is found that the length of the paper is not always the same, it is therefore necessary to have a time-scale for each portion after it has been detached from the cylinder; this is effected by shutting-off the light for an instant, which causes a break or light space in the photographic trace. The time is noted accurately, and the same thing is repeated, we will suppose, one or two hours afterwards; the distance between these breaks supplies data for a time-scale for that especial register.

To measure the ordinates from this time-scale, which may be considered as a line of abscissæ, the actual deviation of the magnet at particular instants, four times daily, is read off by the theodolite (in the manner mentioned above) in degrees, minutes, and seconds of arc; these readings, compared with the length of the ordinates at those times, supply the means of reducing all the others to the same dimensions.

As it can never be expected to obtain glass cylinders with perfectly cylindrical surfaces, or perfect surfaces of revolution, there is a probability that the line of intersection of a plane perpendicular to the axis of the cylinder, with the paper on the surface, will not be a perfectly straight line when the paper is opened out. To obtain a base-line on each sheet the following plan is adopted:—An independent ray of light, impinging perpendicularly to the axis of the cylinder from a light 6 inches distant, is received by the cylindrical lens, and marks a strong line all round the cylinder, which, when the paper is unrolled, becomes the line of abscissæ on which the times are set off; while perpendicular ordinates from it will be proportional to the movement which is the subject of measure (see $g' g'$, in fig. 4).

The arrangements for the horizontal-force magnet are precisely the same as those described for the declination-magnet. Every part of the cylinder apparatus, except that on which the light falls, is covered with a double case of blackened zinc, having a slit on each side on the the same horizontal plane as the axis of the cylinder; and every part of the path of the photographic light is protected, by blackened zinc tubes, from the admixture of extraneous light.

The vertical-force magnet traces its line of movement by reflected light on a cylinder charged with paper, whose axis is vertical; the other portions of the apparatus resemble so nearly that already described that a further account is unnecessary. On the east side, the same cylinder receives the trace of the barometer. At the distance of 30 inches is a large syphon-barometer, the bore of the upper and lower extremities of its arms being about $1\frac{1}{10}$ inch; a glass float in the quicksilver of the lower extremity is partially supported by a counterpoise acting on a light lever (which turns on delicate pivots), so that the quicksilver constantly supports a definite part of the weight of the lever. This lever is lengthened (see fig. 6), to carry a vertical plate of opaque mica with a small aperture, whose distance from the fulcrum is so regulated with regard to the distance of the point of action of the float-wire that its movement is four times the movement of the column of the cistern-barometer. Through this hole the light of a gas-jet, collected by a cylindrical lens, shines upon the photographic paper. Another pencil of light from the same jet shines through a fixed aperture, with a small cylindrical lens, for tracing a photographic base-line upon the cylinder of paper, similar to that for the cylinder of the declination-magnet.

Such parts of the apparatus adapted to photographic registration of the declination-magnet and barometer only are shown in the engraving as are requisite to explain the mode of its action.

In fig. 5, A, is the cylinder covered with photographic paper, the axis of which is horizontal; B, is the time-piece which gives it a rotary motion; *b*, is a cylindrical lens, bringing to a point the light from the jet *d*, which has been reflected by the mirror *e*; *f*, is the magnet suspended by the silk thread *g*; as this turns in azimuth, the mirror *e* turns with it, and the reflected image of the slit in the chimney covering the jet of light runs along the cylindrical lens, by which it is brought to a point on the paper, on which it leaves a trace as shown at *c*. In the course of one rotation of the cylinder this trace will have gone all round it, with deviations to the right or left indicating the movement of the magnet in azimuth during the time occupied by the rotation.

Fig 6 shows the arrangement of the barometric apparatus. Q, *e*, is a lever whose fulcrum is *e*, the counterpoise *f* nearly supporting it; *s*, is an opaque plate of mica, with a small aperture at *p*, through which the light passes, having before been refracted by a cylindrical lens into a long ray, the portion only of which opposite the aperture *p*, impinging on the paper; *d*, is a wire supported by a float on the surface of the mercury; G, H, is the barometer; P, the vertical cylinder charged with photographic paper; *r*, the photographic trace; I, the time-piece, carying round the cylinder by the projecting-arm *t*.

It is evident that the respective distances of the float and the aperture *p*, from the fulcrum may be regulated so that the rise and fall of the float may be multiplied to any extent required. At Greenwich, the extent of the photographic record is four times the actual rise and fall of the mercury in the cistern. These contrivances were shown in the Great Exhibition of 1851, Mr. Brooke having supplied his apparatus.

The wet and dry bulb thermometers are registered by the same means as the instruments already described. They are very large, for thermometers of the usual size would not sufficiently shut-off the light. The fluid employed is quicksilver, and the bore of the tube is $\frac{1}{10}$-inch; the tube is cylindrical, and 8 inches long. The bulb of the wet-bulb thermometer is covered, in the usual way, with muslin, to which moisture is communicated by the capillary passage of water through lamp-wicks: they are capable of elevation by means of a coarse screw, so that the mean temperature for the time of observation may be brought near the centre of the cylinder; but the bulbs are so adjusted as to stand about 4 feet from the ground, the small variation in height being simply for the purpose of having the trace recorded upon a convenient part of the paper. Plates cover the thermometer-frames, with apertures so narrow that the column of mercury shuts out the light. Across these plates a fine wire is placed at every degree, and a coarser wire at every 10°, and also at 32°, 52°, and 72°, so that there may be no chance of mistaking the reading of the degrees of temperature. The light of a jet of gas is condensed, by a cylindrical lens whose axis is vertical, into a well-defined line of light, which shines through the thermometer-stalk upon the cylinder of paper, which is close to it. As the cylinder of paper revolves under this light, it leaves a broad sheet of photographic trace, the breadth of which varies with the varying height of the quicksilver in the thermometer-tube; but, inasmuch as the light is intercepted by the wires placed across the tube at every degree, there are spaces traced by the wires in which there is no photographic action. These appear on the paper in the form of light lines on a dark ground, and serve the purpose of reading-off the thermometers, which is facilitated by the broader lines marking the decades of degrees; nor is any photographic base-line needed, for the wires form the only register required. The cylinder receives the trace of the wet bulb on one side, and of the dry on the other. Its axis is of course vertical, and it is made to revolve once in forty-eight hours; the paper, when removed, will therefore show the variation of both thermometers during the last twenty-four hours, one half of the photographic trace being due to the dry-bulb, the other to the wet-bulb thermometer. The circumference of this cylinder is 19 inches.

Such, then, are the arrangements for the automatic registration of meteorological and magnetical instruments now introduced into the Greenwich Observatory, and their value, as indicating the minutest movements, is very great; while the labour of watching each instrument and recording its variations every two hours is entirely dispensed with. The consequence of the introduction of self-registration has been, that two observers are more efficient than four under the old system. We are not aware, as yet, of the effect of time on the photographic trace; to insure permanency, therefore, the variations of the instruments are inked-in by a definite line along the edge. The papers are kept carefully arranged in the daily order, and ready for immediate reference with the other records of the establishment.

Of the radiation-thermometers, which measure the amount of heat radiated from the earth's surface, of those sunk beneath in the soil, of the thermometer 2 feet below the surface of the river Thames, and of the actinometer, which measures the direct heat of the solar rays, little need be said; I therefore pass on to the

Anemometers.

To have the means of registering the amount and direction of the wind for every hour of the day had long been a desideratum with scientific men, and much ingenuity has been shown in the mechanical contrivances which have been entered upon for that purpose. The instrument which has met with the greatest approbation in England is Osler's anemometer, one of which has been erected lately at the new Royal Exchange, and another has been in use at Greenwich for many years; its indications are constantly recorded, and are considered by competent judges to be very trustworthy, the instrument having undergone various changes and improvements since its first erection. The instrument traces on a sheet of paper the direction and pressure of the wind, and the amount of rain which may have fallen in 24 hours. A copy of this register is shown in fig. 8. The anemometer itself consists of a vane V, fig. 7, turned by the wind, attached to a hollow vertical spindle W, X: the paper is divided longitudinally by lines, the central showing the direction of the wind marked S., W., N., E., S.; the upper part receives the trace which indicates the amount of rain; the lower part shows the amount of pressure of the wind on a square foot of surface exposed to its full force. The register paper is placed on a board M (fig. 7), and accurately fixed every day at 10 a.m. This board is carried along by the clock shown at C, at the rate of about an inch per hour. The engraving shows the original contrivance to effect this object, but in consequence of the continual failure of this chain-apparatus, another construction has been adopted: the movement of the board has now been effected at Greenwich by rack-work connected with the pinion of a clock.

The pencil 1, is the index of direction; this pencil is operated upon by the vane V, turning the hollow spindle; there is a pinion at *r*, which, as the vane turns in the direction of the wind, acts on the rack-work of a transverse bar *e*, *f*, and so causes it to move on the one side or the other. The centre of the board lies due north and south; if, therefore, the wind blows from the north for twenty-four hours, it is evident that the trace will be along the centre of the board throughout its whole length; if the wind at a certain time veers to the east, the transverse board, and with it the tracing-pencil 1, will be turned aside by the action of the pinion in the cogs, and the line now described will be parallel to the direction of the other, at a distance from it equal to one-fourth of the number of cogs which would come into action at an entire revolution of the spindle; the trace in this direction will continue till the wind again shifts, and the number of horary divisions through which it extends will show the time during which the wind was blowing from that quarter.

The first adjustment for azimuth was obtained by observing, from a certain point, the passage of a star behind the vane-shaft, and from that observation computing the azimuth; then, on a calm day, the vane was drawn by a cord to that position, and the rack was so adjusted that the pencil's position on the sheet corresponded to that azimuth.

For the pressure of the wind the shaft of the vane carries a plate 1 foot square (T, in fig. 7), which is supported by horizontal rods *n*, *m*, sliding in grooves; this plate is urged in opposition to the wind by three springs inclosed in the box *t*, so arranged that only one comes into play when the wind is light; and the others necessarily act in conjunction with the first as the plate is urged more and more forcibly by the wind. A cord from this plate passes over a pulley and communicates with a copper wire running down the centre of the spindle, which is finally brought to pull upon the spring-lever *v*, and thus the pencil 2, which is attached to it, is drawn in a direction transverse to the motion of the board, the further from its zero-line in proportion to the force with which the plate is driven back by the wind. A series of lines numbered 2, 4, 6, 8, &c., shows the amount of pressure on the square foot; the intervals of these lines are adjusted by applying weights of 2 lb., 4 lb., 6 lb., &c., to move the pressure-plate in the same manner as if the wind pressed it. The pin 3, registers the amount of rain which is thus recorded. The water which has been collected by the gauge passes into the funnel *a*, which is suspended by spiral springs *b*, *b*, *b*, *b*, which lengthen as the quantity increases; into the bottom of this vessel is fixed a tube *c*, open at both ends, in a vertical position, over the top of which is loosely placed a larger tube *e*, closed at the top; when the water has risen to the level of the inner tube it begins to discharge itself gradually into a tumbling bucket *d*, which is inclosed in a globe under the receiver; when full, the bucket falls over and discharges its contents, which run through the waste-pipe *f*, and cause an imperfect vacuum in the globe, sufficient to produce a draught through the pipe *c*, which thus acts as the longer leg of a syphon, and the water continues to flow from the receiver through the interval of the two pipes *c*, and *e*, till the whole is drawn off, when the spiral springs *b*, *b*, *b*, *b*, immediately elevate the receiver to its original position.

Now, if we suppose the quantity of water necessary to produce the action thus described to be equivalent to $\frac{1}{4}$-inch of rain, the mode of registration will be easily understood. The pin 3, is connected by means of the cord *g*, *g*, with the receiver, which cord is kept tightened by the spring *h*; as the apparatus descends from the weight of water during the fall of rain, this pin advances further and further from the zero of the scale which is shown upon the registering paper, until $\frac{1}{4}$-inch has fallen, when, as this is drawn out and the receiver ascends, the pin is drawn back to its original position, and the same process is repeated.

The register represented in fig. 8* is supposed to record the phenomena of twenty-four hours. It will be seen that rain continued to fall for nearly four hours, when $\frac{1}{4}$-inch having been received, the trace is brought back to the zero-line; five hours afterwards another $\frac{1}{4}$-inch had been collected; in two hours more about $\frac{1}{16}$-inch, when the rain ceased, and none fell for four hours, as is denoted by the line traced parallel to the zero-line; rain then fell for an hour; a cessation of three hours followed; two hours after another $\frac{1}{4}$-inch was collected; and, for the remainder of the time, a gentle fall is indicated by the gradual departure of the trace from the zero-line; the amount of rain collected in the twenty-four hours will therefore in this case be $\cdot 25 + \cdot 25 + \cdot 25 + \cdot 06 = \cdot 81$ inches. On the same paper the traces of the force and direction of the wind may be seen and readily understood. The point of the compass from which the wind blew at any hour is registered along or near the centre of the paper, and the force at the lower part; the zero being the bottom line, and the increase of force being indicated by the departure of the trace from this line towards the inner portion of the paper.

These explanations serve to exhibit the general principles on which this beautiful apparatus is constructed, though the details may occasionally differ. The anemometer and pluviometer have been many years in use at Greenwich, and their registrations are considered very satisfactory. The noble building of the Royal Exchange has been supplied with an anemometer on the same construction, except that the register is vertical; and the anxious merchant, by inspecting the register, can easily satisfy himself whether the wind of the preceding night or day has been favourable to the arrival of some richly-laden vessel of which he may be in daily expectation.

Whewell's Anemometer.—Another anemometer, invented by the Rev. Dr. Whewell, Master of Trinity College, Cambridge, is likewise in constant action at Greenwich; it is also self-registering, and indicates the rate of movement of the air and the directions in which that movement takes place. A horizontal brass plate is connected with a vertical spindle, which passes through the axis of a fixed cylinder, having a vertical bearing upon a plate at the bottom of it, and a collar bearing in a horizontal plate at the top of the cylinder. The vane turns the whole of the apparatus above the cylinder, which consists of a fly, and a system of wheels working into each other; as the fly turns round, with greater or less rapidity according to the motion of the air, these wheels are set in action, and communicate motion to a vertical screw fifteen inches in length; the revolution of this screw causes a pencil, which is connected with a nut, to descend. The cylinder is covered with

* By an oversight the hours in the engraving reckon the wrong way.

paper, on which are marked the points of the compass, and on this the pencil leaves a trace, the length of which is proportioned to the force of the wind. The fly has eight sails, like those of a windmill, inclined at an angle of 45° to the direction of the wind; upon the axis is an endless screw, which works a vertical wheel, of 100 teeth; another endless screw on its axis works a horizontal wheel, of 100 teeth, which is attached to the great vertical screw by which motion is given to the pencil; the descent of this pencil is measured by a vertical scale, and a calculation is made, from accurate measurements of the different parts of the apparatus, of the amount of horizontal movement of the air which is due to an inch of the screw's downward movement. The following are the measures of the principal parts of this anemometer:—

Length of each sail from axis to end	2·30 in.
Length of the flat part of each sail	1·92 in.
Inclination of each sail to the wind	45°
Forty-five revolutions of the vertical screw correspond to...	2 in.
Number of teeth in the vertical wheel............	100
Number of teeth in the horizontal wheel.........	100

Therefore, 10,000 revolutions of the fly cause the pencil to descend through the distance of one thread of the vertical screw, or through a space equal to $\frac{2}{45}$-inch = 0·044 in.

Assuming that the effective radius of the sail is 1·7 in.,

The circumference described is 1·7 in. × 2 π =	10·68 in.
Therefore the motion of the wind in one revolution is	10·68 in.
In 10,000 revolutions	106,800 in.,

corresponding to ·044 in. of the vertical screw, or to one revolution of the screw. From this it follows, that the motion of the wind corresponding to the descent of the pencil through 1 inch is 200,250 feet, or 37·9 miles.

The results of Osler's anemometer give the force and direction of the wind, and of Whewell's give the amount of horizontal movement in the air, for twenty-four hours; these are amongst the weekly published results of the Greenwich observations.

Another self-registering rain-gauge, besides that already described, is employed at the Observatory; it is on Crosley's construction. The collected water falls into a vibrating bucket; as soon as one side is full, the bucket oversets and presents another compartment, which, having received its portion, discharges it in an opposite direction. The bucket is thus, during the fall of rain, kept in a state of vibration. An anchor with pallets is attached to the axis on which it turns, which acts upon a toothed-wheel by a process exactly the reverse of that of a clock-escapement. This wheel communicates motion to a train of wheels, each of which carries a hand upon a dial-plate, and thus inches, tenths, and hundredths are registered.

Kew Observatory.

The Observatory at Kew is a building the property of the government, which has been lent to the "British Association for the Advancement of Science," for some years, for the purpose not so much of carrying on an uninterrupted series of observations on atmospheric phenomena, as for enabling the members to form a sound judgment on various instruments submitted to trial and comparison in that place. It has been for many years under the superintendence of Mr. Ronalds, whose skill and ingenuity have diplayed themselves in various contrivances connected with observation. The new dew-point instrument, by Regnault, is now undergoing a severe trial, and other inventions are frequently submitted to the test of his accurate discrimination. It is not consistent with my design to notice all that this gentleman has done for science, but I cannot forbear alluding to a very neat contrivance by which the variations of the magnet are daguerreotyped on a plate of prepared metal, which is moved by clock-work, and thus forms an accurate register of its oscillations. The whole apparatus is very compact, and the observatory at Toronto has just been supplied with one by the British government. The account may be found in full in the 'Philosophical Transactions,' Part I., 1847.

Mr. Ronalds has invented a self-registering barometer, in which the expansion of the mercury by heat is counteracted by bars of zinc, a metal which expands about one-sixth part of the expansion of mercury at the same temperature; as these expand they put in motion a system of compound levers, to which the barometer-tube is attached, and thus the surface of the mercury is always kept at the same distance from the zero of the scale as it would be were it not to be subject to expansion with an increase of temperature.

The branch of atmospheric investigation in which the merits of Mr. Ronalds are most extensively recognised, is electricity. In the year 1843 the Observatory was completely fitted with every requisite for judging of the electric state of the atmosphere, and the contrivances were found to answer their purpose so well, that those adopted at Greenwich and Toronto were copied from them, and erected under Mr. Ronalds' superintendence. A description, therefore, of those in use at Kew will be all that can be required to give a general view of what is doing in the best observatories in England, in the registry of the electric state of the atmosphere.

Mr. Ronalds has lately completed a contrivance by which the state of the electrometer is registered by the daguerreotype. The prepared plate of metal is suspended vertically, and is drawn up by clock-work, and the gold-leaf electrometer is interposed between it and the light. On the opening of the leaves a mark is left on the surface of the metal plate, exactly at that spot which corresponds to the time when the occurrence took place and the duration of the electric action. This instrument is described in the paper just referred to; but of its action from personal investigation I am not prepared to speak. The electric apparatus now about to be described I have just inspected, and was much gratified by the state of efficiency it is in, as well as by the compactness and simplicity which mark all the arrangements. The dome in which it is located rises high above the rest of the Observatory, and there are no buildings or trees to interfere with the full development of the electricity existing in the air. We may therefore conclude that the records deserve our full credence, both from the nature of the instruments and the character of the observer, and the favourable situation in which the observations are taken. The Reports of the British Association bear witness to their nature and value.

Mr. Ronalds' attention has for some time past been directed to experiments on "frequency" of atmospheric electricity—that is, the rate at which a new charge rises to its maximum after the former charge of an atmospheric insulated conductor has been destroyed. The observations are taken at such periods of the day as sunrise, noon, and sunset.

For the record of the rapidly succeeding and varied electric phenomena during the passage of a storm, he has introduced what he terms a "storm-clock," without which it would be impossible for one observer to register the observations. It consists of a time-piece, which carries an index down a long sheet of paper laid on the desk; this it accomplishes in half-an-hour, and the observer has simply to record the events as rapidly as they occur opposite to the point of the index, which can evidently be done much more rapidly than by reading the chronometer and setting down the time at successive instants. In the hurry of the moment mistakes are often made, and several phenomena are entirely lost; whereas one observer, by means of this contrivance, accomplishes as much work as two could effect in the usual method.

Fig. 9 represents the dome of the Observatory at Kew, with the electrical apparatus *in situ;* through the centre of the dome a circular aperture has been cut, in which is fitted a mahogany varnished cylinder *a, a'*. G, G, G, G, is a strong cylindrical pedestal, which serves as a closet for articles connected with the observations. It is surrounded by a stage G', G", and H', H", are steps by which the observer ascends. C, C, C, C, the safety-conductor, for conveying the electricity away from the building. The principal conductor D, D, is a conical tube of thin copper 16 feet high; E, is a brass tube into which it is firmly secured; F, is a hollow glass pillar, the lower end of which is trumpet-shaped and ground flat. A collar of thick leather is interposed between F, and the table, and such is the firmness of the whole that the conductor has resisted gales which have uprooted trees in the neighbourhood. H, is a spherical ring carrying four arms at right angles to each other, three of which are shown in the engraving; I, I, are two of these. *k*, is a lamp for warming the glass tube F, in order to produce perfect insulation; K, is a chimney of copper, closed above, passing through the table, and entering but not touching F. By this arrangement the lower part of F, is generally warmed too much and the upper too little; but the pillar F, being conical, some zone always exists between the two ends which is in the best possible state for electrical insulation. L, is a set of finely-pointed platinum wires soldered to D. M, is a Volta's small lantern. N, is an inverted copper-dish or parapluie, fitted by a collar and stays on E, and of course insulated by F; its least distance from the mahogany cylinder is 3 inches. It will be seen that, by this arrangement, the active parts of all the electrometers and the conductor itself are insulated by the glass pillar. O, Volta's electrometer No. 1; P, Volta's electrometer No. 2; Q, Henley's electrometer; S, a galvanometer by M. Gougon. No. 1 is the most sensitive, and comes into action first; No. 2 then exhibits symptoms of electric action; when this has arrived at the maximum of its scale, Henley's is found to be affected, and the record of these three will give the force of electricity of the air under all circumstances. R, is a discharger; or, as it is termed in the Greenwich observations, a Ronalds' spark-measurer. The length of the spark is measured by means of a long index, which exhibits the distance of the two balls *x*, and *y*, from each other on a multiplying scale, *y* being attached to a rod *y*, *s*, which is raised and lowered by means of a glass lever. Each division of the scale represents one-twentieth of an inch in the length of a spark; the divisions, of course, are not equal, and they serve to estimate fortieths of an inch, or even less.

The results of Mr. Ronalds' observations have been, from time to time, published in the Reports of the British Association for the Advancement of Science. An epitome of the electro-meteorological and magnetic observations and experiments down to the end of 1848, has been printed by that gentleman for private distribution.

Such, then, are the instrumental means and the organisation with which, in England, we are provided for the purpose of recording atmospheric phenomena; nor are these all, for at Oxford, Cambridge, and some other places few in number, very valuable and efficient observers have recorded and published registrations more extensive than can be expected from private observers, but far inferior to the elaborate system pursued at Greenwich. Private individuals in various localities record phenomena without publishing their results, or joining any society which has the cultivation of meteorological science in view. I apprehend their number is not great, or they would be more generally known.

From the view of what is accomplished by extra-observatorial efforts, we are compelled to arrive at the conclusion that much remains to be done before we shall become acquainted with simultaneous movements in the air, or variations in its thermohygrometric state, even within so narrow a district as our own country. We trust that the British Meteorological Society will be the means of establishing a constant communication with the scientific societies of other nations, and we are anxious to enlist on our side the officers of the royal navy and of the mercantile marine. The ships of Great Britain traverse the ocean in every direction, and at all periods of the year. They are commanded by men accustomed to watch natural phenomena, and the regularity of life at sea is favourable to the systematic registration of the barometer and thermometer; but, to render the records valuable, the instruments must be of a superior character to those usually found on ship-board, calculated not only, as they are, to show differential, but absolute values.

Then, again, our observers, whose reports are published every three months at present, from want more of time than inclination, confine their observations within too narrow a range. In addition to the pressure, temperature, and hygrometric state of the air, it would be highly advantageous could we, for all localities, ascertain in addition the rapidity of evaporation, the range and intensity of solar radiation, and the state of electric tension; all which, in their varied combinations, go to make up that general result which we call *climate*, and which, unitedly, produce effects upon the natural world and the human frame, varying according to the preponderance of one or the other element. A knowledge of all these would lead us, most probably, to conclusions approaching the truth as to the adaptation of one particular series of crops to certain parts of the kingdom, and of the fitness of certain places for those who are suffering from peculiar diseases. We do not, moreover, at present, distinguish the rainy hours in a day, but simply record the daily fall; and this leaves us deficient in one important element. Upon the whole, we may conclude that meteorological science is in a state of infancy; that it is, and must long continue to be only a science of observation; that recorded phenomena are at present too few, and those taken over only a small portion of the earth's surface; nay, the two-thirds of that surface occupied by the ocean, though exercising a most important influence on atmospheric changes, may, as regards observation, be considered a blank: too few are they and insignificant to enable us to draw conclusions or deductions which shall hold good over a large extent.

Meteorology is precisely in that position in which geology was found eighty years ago, or microscopic science at a still later period; and yet, since that time, how many facts then obscure have been elucidated in the structure of the earth!—for how many sound principles has geology gained universal reception! How many secrets of nature has the microscope disclosed!—how many wonderful transformations, then undreamt of, has it unveiled!

Happy shall I be, if this record of the present state of meteorological observation in England shall lead to a co-operation with scientific institutions on the continent of Europe. Till a combination of this kind has become universal, meteorology will have but little chance of taking its place with the other sciences, notwithstanding that it has claims on the attention of all mankind, and that its laws, once developed, will assuredly benefit the entire human race.

Winsor House, Southampton. JOHN DREW.

ON CLOCKS AND CHRONOMETERS.

By Professor E. COWPER.

[*Paper read at the Society of Arts, London.*]

Mr. COWPER stated, at the commencement of his lecture, that his object was rather to *illustrate* what was known than to bring forward any decided novelty; to make the subject clear to those who were not familiar with it; and also to impress more deeply on the minds of those who were so the principles which perhaps they admitted, but to which they did not allow due importance. He then observed that *time* was an abstract idea; it could be neither seen, nor heard, nor touched, and the only way of obtaining a *measure* of such an intangible thing was by noticing what might be *done* during any interval: it is while the earth is turning once round that we call the interval a day. And he then showed a little instrument (fig. 1), consisting of a spiral pulley S, and a circular pulley C, on the same axis; to a cord over the spiral pulley was hung a funnel F, containing sand, and to a cord over the circular pulley was hung a weight W.

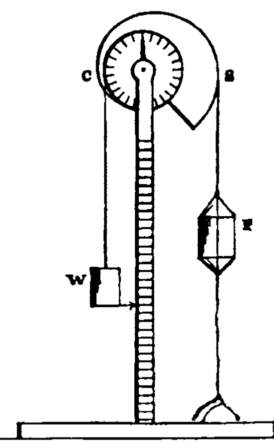


Fig. 1.

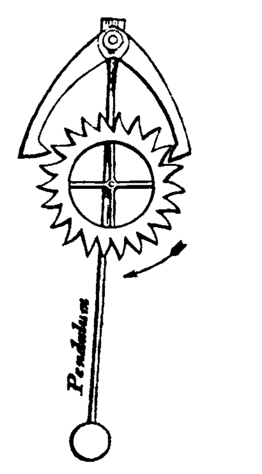


Fig. 2.

The pulleys were supported on a stand, and the stand marked with inches, to which an index on the weight pointed; also an index on the stand pointed to degrees marked on the circular pulley. The operation was as follows:—The funnel being filled with sand, raised the weight to the top of the stand, and *while* the sand ran out was a certain interval of time. As the sand ran out, the weight descended and marked *inches* of time; the circle turned and marked *degrees* of time; the sand being measured, gave *pints* of time; and the sand being weighed, gave *ounces* of time; so that the abstract idea of time was converted into lineal measure, angular measure, capacity, and weight.

The motion of the pendulum and its application to clocks was explained thus:—As the pendulum performs its vibrations in equal time, it is employed to regulate the descent of a weight or the uncoiling of a spring, the weight or spring keeping the pendulum in motion. This is effected by connecting two hooks with the top of the pendulum (fig. 2). The hooks extend over a toothed-wheel, so that, as the pendulum vibrates, the right-hand hook falls into the right-hand side of the wheel, and the left-hand hook falls into the left-hand side of the wheel. The weight has a constant tendency to pull the wheel round, but it cannot turn while the hook is between the teeth. Now, as the pendulum vibrates, the hook (suppose the right hook) which detains the wheel is lifted up, and the tooth *escapes* past the hook, and the wheel moves on—but only a little way, for now the left hook comes between the teeth, and the wheel is again stopped, and cannot move another step until the left hook, in its turn, is lifted up by the swinging of the pendulum, when another tooth escapes. The wheel moves one tooth at each two vibrations of the pendulum; therefore, if the pendulum measures seconds, and there are thirty teeth in the wheel, it moves once round in one minute. The hooks above described are technically called the *escapement*, and the wheel the *escape-wheel;* the ends of the escapement are called the *pallets*, and are shaped as inclined planes, against which the teeth of the wheel press and give impulse to the pendulum, so that in all escapements there are three motions—viz., *locking* the wheel, by the pallet coming against a tooth; *unlocking* the wheel, by the vibration of the pendulum lifting the pallet away from the tooth; *impulse* to the pendulum, by the tooth pressing against the pallet as the tooth is escaping. By merely bearing these three operations in mind, it will be easy to understand any escapement. The vertical, horizontal, lever, duplex, and chronometer escapements were then described, and illustrated by large models two or three feet diameter. It was shown that the old English vertical escapement required so much room that the watch was necessarily thick and clumsy; while the other escapements allowed the watch to be made very thin.

Mr. Cowper then illustrated, by diagrams and models, the principles of the teeth of wheels laid down by Camus, Professor Willis, and others, and particularly urged on manufacturers (many of whom were present) the importance of accuracy and correctness of *form*, and also the importance of making the greater part of the action of the teeth take place after passing the "line of centres" (*i.e.*, a line from centre to centre of the wheels). It was shown that when a toothed-wheel drives a *pin*-wheel, the action is entirely behind the line of centres. Thus, in a common Dutch clock the pinions are made with wires, and the toothed-wheel drives these pinions with so little friction that they scarcely ever wear out. He then begged the manufacturer to consider the fact that the Dutch or Germans supplied the *kitchen* wooden clock; the Swiss supplied the *ladies'* pretty flat watch; the French supplied the *drawing-room* ormolu clock; and the Americans are beginning to supply the *counting-houses;* and he urged them to endeavour to meet their demands.

Discussion.—Some observations were made by Mr. G. F. Hall and Mr. Varley on the deterioration, in the course of time, in the strength of springs. It is well-known to clockmakers that the "blueing" is essential to the stiffness of a spring; and as, by oxidation or any other cause, the blue wears off, the elasticity of the spring becomes gradually less. Mr. Dent has made some experiments quite corroborative of this.

Mr. Bennett said that American clocks and Geneva watches had been mentioned in the course of the paper. It would be a great benefit in every way if we could rival these very cheap, and, on the whole, very good time-keepers. He had made many efforts to do so. To this end he had relinquished the use of the fusee, had reduced the number of wheels to three or four, and had struck or punched the dial-plates in the manner of the American dials. Still he had been unable to produce his clocks at as low a price as theirs. The Americans sell a clock and case for less money than an English cabinet-maker can make the case alone. This and the expense of the mainspring were the difficulties which caused his failure. The Swiss watches are not the best, but still they are very good time-keepers, and they are made for about two-thirds the cost of ours. The cause of this is employment of labour, subdivided and encouraged to the last degree. They never employ, as we do, about a hundred men on the different parts of a watch; but many of the parts are made by the women and children of the families. They also show themselves superior to us in adopting improvements, from whatever quarter they come, instead of resisting them as the English workmen do. He did not hesitate to say that he was never above appropriating an idea or an improvement, provided it were likely to be of service to his work.

Mr. H. Cole said that this discussion was one of great interest from other points of view than the mechanical. It was striking to have heard the last speaker say that he did not mind appropriating the idea of another inventor; and Mr. Hall, that a valuable invention was kept secret lest it should be stolen. Now, such expressions as these indicated the existence of very great confusion as to what were the rights of an inventor, as well as defects in the laws protecting those rights. The law should be such that an inventor could easily and cheaply secure his right, and then be able to bring his invention into the market without risk of its being pirated from him.

Mr. W. F. Cooke said that one reason for the greater expense of our watches had been overlooked, and that was the natural preference felt by Englishmen for thoroughly well-made articles. But it was wrong to speak as if there had been no reduction in the cost of clocks and watches; there had been a proportionate reduction during late years to that of most other articles of manufacture. He could corroborate from his own knowledge what had been said of the subdivision of labour in Switzerland. He had seen the same men working on the farms in the morning, and in the evening with their wives and children employed in their cottages on watch-work around one central lamp.

Mr. Loseby thought that too much stress had been laid by Professor Cowper on the exact epicycloidal shape of the teeth in watch-work. In such minute work it was all but impossible to obtain a shape theoretically correct; and, indeed, was the advantage so great? Watches in which the epicycloidal shape had not been attempted, kept time well and had lasted long.

Mr. C. Frodsham differed entirely from Mr. Loseby. His experience had shown him that attention to the exact shape of the teeth was of the greatest importance. For example, the deposit which is so often found about the centre-wheel of a chronometer is nothing but minute particles of metal worn off from the teeth, owing to their not being of the correct shape. Moreover, he had found that a mainspring applied to a chronometer in which the teeth were accurately cut, gave a much greater effect than it had in one in which they were carelessly cut; and after twelve months' working the wear and deposit had been much less. He had frequently found the teeth both of watches and clocks worn into an approximation to the true curve; and further, he knew of a clock in which the teeth had been properly cut which had been at work for fifty years without any perceptible wear. Lowden had fallen into the error, into which Mr. Loseby seemed inclined to follow him, of thinking that an isochronal adjustment of the balance-spring would be a cure for all the evils of bad workmanship in a watch. The isochronal adjustment was a highly ingenious thing and an admirable safeguard, but it would be far better not to require it. He was so sure on this point that he had no doubt the main reason why, in two chronometers of equal reputation, one surpassed the other, was that in that one the curves of the teeth had been truly cut.

Mr. G. F. Hall said that whatever the escapement or the form of teeth, a correct judgment might be formed of different clocks by ascertaining the relation which the weight of the pendulum bears to the weight or power required to keep the clock going. Thus, assuming that where these are equal the clock is of medium quality, we may make the rule that, as the weight or power is a higher fraction of the weight of the pendulum, so is the clock a more perfect measurer of time. In the most carefully-finished clocks of the present day, the relation is $\frac{16}{4}$, 16 representing the weight of the pendulum, 4 that of the power. A comparison of this with the proportion in the common clocks, or even in the best commercial French clocks, shows at once the great difference between them. The better sort of German or Dutch clocks to go eight days are generally provided with a weight of 14 lb.; while the pendulum rarely exceeds 4 oz., in which case the fraction will be $\frac{4}{224}$. Nor are French clocks of commerce often of a higher quality. Reducing these fractions, we have for the best astronomical clocks of the present day, 1; and for the common household clocks, ·004465 nearly. If power could be transmitted through the train without variation, this difference between the weight of the pendulum and the weight of the power would be of little consequence; but mathematical accuracy in transmitting uniform power through wheels and pinions cannot be obtained, and therefore it becomes of the highest consequence. The available force to keep up the vibration of the pendulum in the best astronomical clocks is, after deducting friction, about 1 gr. to each vibration. Taking, as before, the weight of the pendulum at 16 lb. we have $16 \times 7000 = 112{,}000$ gr. kept vibrating by 1 gr. $= \frac{1}{112000}$. It is not this small fraction of the weight, however, which is of immediate importance, but the variation of it, arising from the impossibility of making the wheels and pinions mathematically true and concentric, whence each tooth is a lever of a different value from its neighbour. In pinions, owing to their small diameter and to the process of hardening, tempering, and straightening, this difference is considerable. From this and other causes, a train will always vary as much as 4 per cent., in which case the impulse will range from 1·02 gr. to ·98 gr., the extreme difference being $\frac{4}{100}$ths of a grain. It will now be evident how the heavy pendulum and the light weight are better than the reverse, for in the former we have the variation $= \frac{\cdot 04}{112000}$, which is increased in the latter to $\frac{4}{112000}$. The variation is thus magnified two hundredfold, the clock mechanism remaining the same in all other respects. But in common clocks the variation of the train is often more than 30 per cent., enough totally to destroy the synchronism of a light pendulum. Mr. Hall gave the following as a summary of the characteristics of a good clock:—The pendulum compensated and suspended by a spring of not more strength than sufficient to prevent the possibility of fracture; the angle of vibration never exceeding 1° 30′; a dead-beat escapement with the angle of escape between 65′ and 75′; and finally, the proportions named above between the weight of the pendulum and the clock weight.

Mr. Frodsham said that the principle of small power and heavy balance, which Mr. Hall had been advocating, was that of the old clockmakers; but he thought it erroneous, though he had abandoned it reluctantly. The clock which would go with the least power would be thereby shown to be mechanically correct, but that would not prove it to be so horologically; for it was always the case in practice, that if the arc of vibration shortens, the vibration is quickened, and therefore it becomes of importance to have more power than is absolutely necessary at hand to overcome accidental impediments, such as even the mere thickening of the oil by temperature.

Mr. Bennett wished to see our watchmakers in a condition to be able to supply the general trade with improvements that were being made in watches for the most scientific purposes. The question to be solved was, how to produce a better-going watch, and at a lower price than heretofore; and he wished to speak not of chronometers, but of watches for the multitude. Our chronometers cannot be beaten; but it is of little consolation to know that fact, if our common watches are not improved thereby. Now, in lamenting as he had done in his former remarks the lack of intelligence in our workmen, he had certainly spoken from his own experience. We have no systematic education for our workmen; while the Swiss are bound by law to give a certain competent education to their sons. Again, unless we subdivide labour to at least the same extent as they, we shall not compete with them. Their principle is to make each operation so simple and certain that it can be thoroughly well performed by a work of only small power, or even by a boy; whilst his constantly repeating the same thing gives him almost unerring accuracy. Again, many parts of the Swiss watches are made by women, who are yet able to perform all their domestic duties; and in this it would be very well if we could imitate them, for men have to become half women before they can become thoroughly accustomed to a confining and sedentary employment, which is unnatural and constitutionally hurtful to them; and there are many parts of a watch in which a woman's delicate fingers are far fitter than a man's. He could not forget the frightful disclosures which had been made by Mr. Mahew and Mr. Sidney Herbert as to the employment of females in departments of trade quite overstocked with them, nor how essential these disclosures had proved it to be that some other field should be found for their labours. In what he had said, he was not speaking without experience: he sold about three foreign watches to one of English make, a proportion which is increasing: and though this is so, yet the duty on their import is decreasing, proving, what is no secret, that a large number are smuggled over.

Mr. Frodsham said that, from facts which had come within his knowledge, he was quite sure that, *cæteris paribus*, we can compete with the world in watch and clockmaking. The common Swiss watches are but flimsy, and will last but a few years; while they are extremely expensive to repair if damaged. He had been employed some time back to make some watches for the Sikhs; they weighed 2¼ oz. each, and after they were made, he had shown them to a Geneva maker, who confessed that they could not be made in Geneva for nearly the same price as he (Mr. F.) had charged. Nor can they compete with us in Paris (the weight and workmanship being equal) within 100 per cent. It is surely no discredit to say that good watches cost more than those which contain less of the precious metal, or are only gilt to the thinnest possible degree. The jewels in them are often false; and, indeed, scarcely any species of deception is left untried that will reduce the cost price and make them bear a higher rate of profit. It did not appear to him that subdivision of labour was wanted so much as accurate intelligent superintendence. We did not require workmen so much as horological architects. It is a well-known fact, that the best English chronometers and watches were full 100 per cent. cheaper than those of comparative merit produced abroad. And so great is the value of the best English chronometers and watches in the foreign market, that it is utterly impossible to make way against them; and so great is the demand for them that merchants are content to allow their orders to stand for twelve months.

Sir J. P. Boileau observed that there was doubtless an increasing desire on the part of the people to buy cheap watches; and if so, they will be obtained from one market or another. It was therefore important that we should be able to make them. He could not speak with regard to watchmakers, but in other branches of mechanics he knew that intelligence was on the increase. As regarded compulsory education, alluded to by Mr. Bennett, he believed that it did not succeed. In the canton of Vaud the law fines every parent who does not send his child to school, and yet far fewer are sent to school in that canton than in the canton of Geneva, in which there is no compulsory law.

ON A NEW SYSTEM OF ELECTRO-TELEGRAPHY.

By George Little.

[*Paper read at the Society of Arts, London.*]

The chief novelty in this instrument is the way in which the needle is suspended. In place of a needle on a central axis vibrating above and below the point of suspension, a common needle is used, hanging from a "reservoir of magnetism" above it; the vibrations being all below the point of suspension, as in a pendulum. By the use of this improved instrument, the inventor hopes to overcome the main difficulties which, during the fifteen years of its existence, have lain in the way of the perfectly successful and economical working of the electric telegraph, viz.:

1. *Those arising from imperfect insulation of the conducting wires.*—This is eluded or overcome by the amount of power required to work the improved needle; being so small that the escape from a great length of wire is of little consequence, enough being always left for the efficient working of the instrument.

2. *Vibration of the needles during working.*—This occurs in the old needles from their having motion above as well as below the axis; the improved needle, from its being suspended, is not liable to the same evil. One pole of the needle only is thus exposed to the influence of the magnetism of the earth, which is counteracted by gravity.

3. *Deflection of the magnets from local causes.*—It is well known that the magnets are deflected from their vertical position, owing to the passing of currents of electricity from the atmosphere to the earth, as well as probably by upward currents also. In such cases it is usual for the operator to move the stops against which the needles beat, until they are equidistant from the needles on either side; but this is only an imperfect remedy, as the needle in its deflected position must move with greater freedom on one side than on the other. In the improved instrument, should the indicator be from any cause deflected, the whole of the indicating part may be moved onward in the same direction with the disturbing cause, which has the effect of bringing the coil of wire equidistant with the needle, and therefore of causing it to move equally and freely to either side.

4. *Demagnetisation of the needles.*—The annoyance caused by this under the old system is extreme. It takes place chiefly from alterations in the electrical state of the atmosphere (lightning), and from the constant jarring of the needles against the stops in the dial plate; and as the needle has on each occasion to be taken out and remagnetised, the impediment becomes a very serious one. This defect is obviated in the improved instrument by the needle being suspended from a powerful source or reservoir of magnetism, whence the lower or indicating part is kept in a highly magnetic state. The inclosing the needle in a tube of spirit effectually prevents its jarring.

5. *Imperfection in the mode of suspending the needles.*—The needles under the old system are often found to stick fast, from

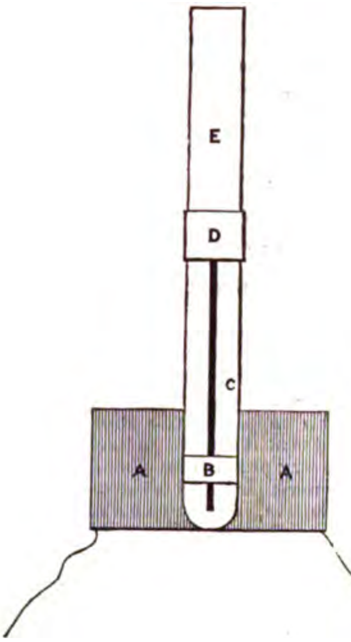


Fig. 1.

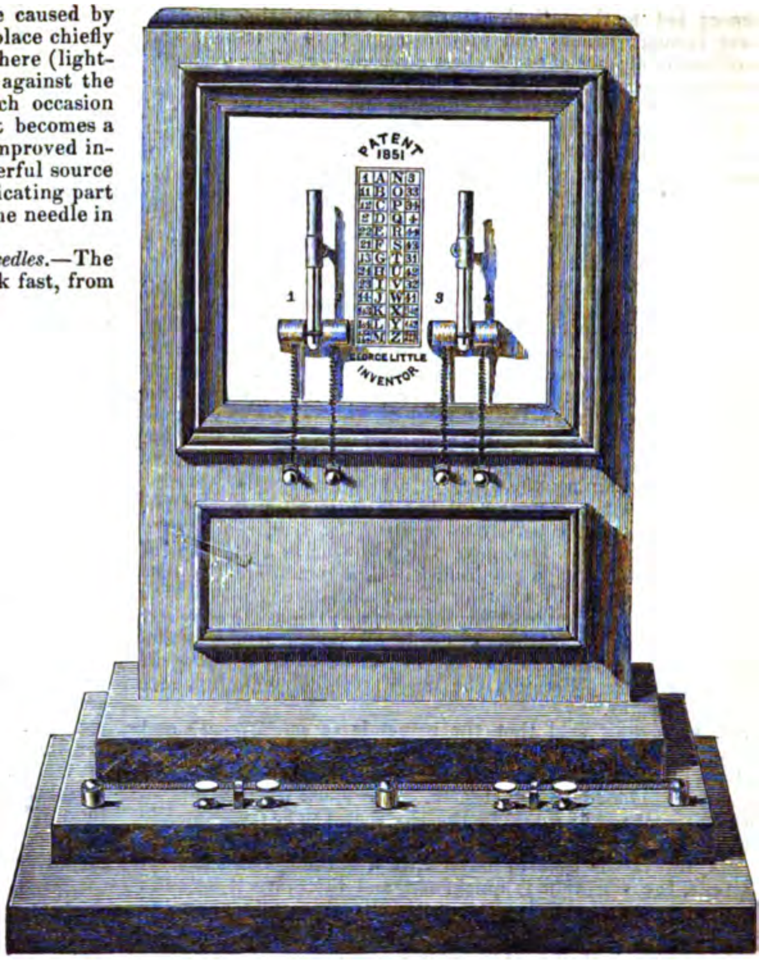


Fig. 2.

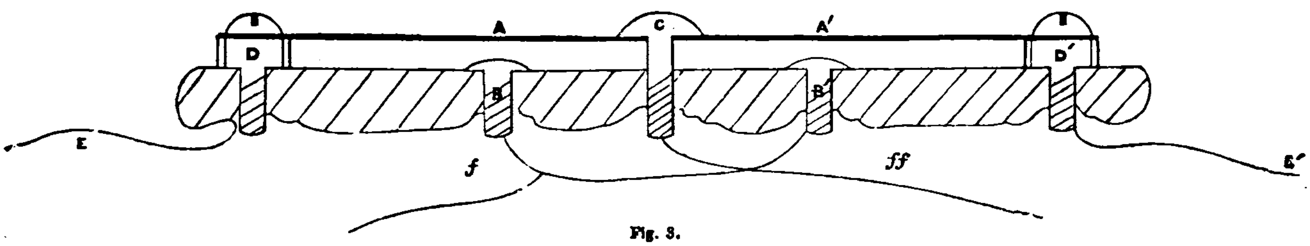


Fig. 3.

the friction caused by rust at the points of the axes; an evil which is done away with by the method of suspension from a fixed magnet.

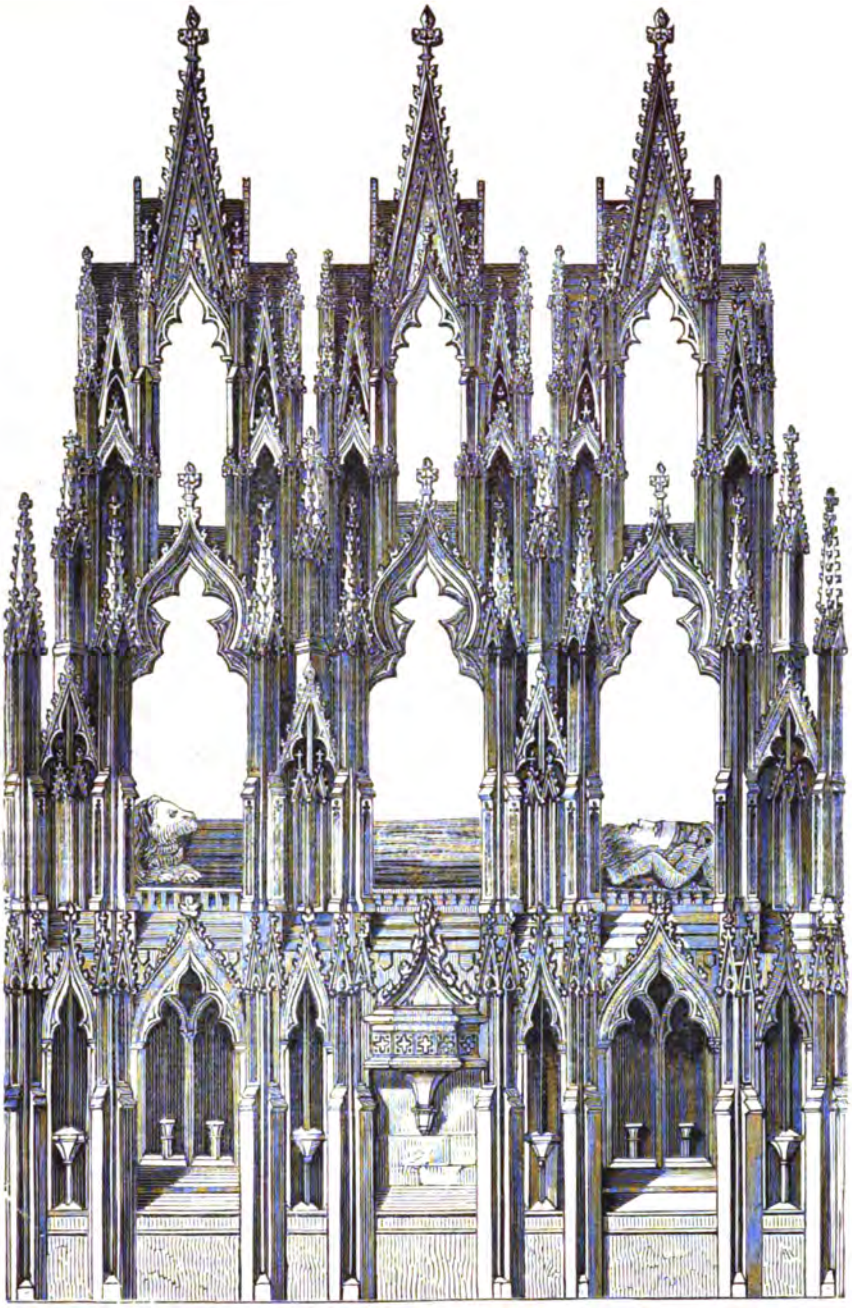
In fig. 1, E is the magnetic reservoir, held in the socket D; C, a glass tube filled with spirits of wine. The needle is seen suspended from the reservoir, having its north pole downwards. A, A, the coil of wire, secured to the tube by the strap B. The spirits, as before stated, are to prevent the jarring of the needle againsts the sides of the tube during manipulation. The socket D, is jointed, so that the whole apparatus can be moved on it to the right or left.

Fig 2 shows the apparatus complete, with the dial which Mr. Little employs. One of the indicators has on either side the figures 1 and 2; the other has the figures 3 and 4. The letters of the alphabet are represented by the alternate pointing of the indicators to these figures, and by the combination of such motions; and the key to these motions is shown on the table between the indicators.

Another method of dispensing with the axial method of suspension is to attach the needle or magnet to a float of cork or glass, which will then be drawn up and down in the tube instead of from side to side; the motion thus obtained being capable of interpretation in a similar manner to that just described.

Fig 3 shows, on an enlarged scale, a method of changing the course of the electric current. A, A', two spring levers, fixed at D, D', which can be pressed down into contact with the studs B, B'. *f*, and *ff*, the connecting wires of the battery; *f*, leading from the positive end to the studs B, B', and thence, when A is depressed, to the pillar D, and by the wire E to the earth. The current then returns by the line wire through the coil of the instrument, and by the wire E' to the pillar D', and thence by A' to the stud C, and by the wire *ff* to the other end of the battery; thus completing the circuit, and causing the indicator to move into the reverse position.

The paper concluded with an estimate of the commercial advantage likely to result from the use of the new method, and stated that "there are at present about 700 telegraphic instruments at work in Great Britain, and it may be assumed that 1000 more will be required for perfect communication, making in all 1700. The average cost of these may be taken at 12*l.* each, or 20,400*l.* in all. Add to this an annual cost of 5*l.* per annum on each instrument for repairs and extra power consequent on imperfect insulation, and the amount for fourteen years will be 139,400*l.* The same number of my double-indicating instruments may be made for 1700*l.*, while their annual cost will not exceed 2*s.* each, being in fourteen years 4080*l.*; by which I calculate that a saving of more than 135,000*l.* would be effected."



TOMB OF EDWARD II., GLOUCESTER CATHEDRAL.

Among the many beautiful monuments in Gloucester Cathedral, that represented in the accompanying engraving without doubt ranks highest for artistic merit. In describing this magnificent specimen of monumental architecture, we cannot do better than quote Brayley and Britton's work on the 'Beauties of England and Wales,' in which they say,—"The Tomb of Edward the Second, erected by his son and successor, near the high altar, is probably the most ancient piece of sculpture in England which exhibits such perfection of art. On the tomb, beneath a modern canopy consisting of three arches of two stories interlaced with minute tabernacle work, is a recumbent figure in alabaster of the deceased monarch, regally robed and crowned. The head is supported by two angels; the right hand bears a sceptre, and the left supports an orb or globe. On the side of the tomb are three arches in recess, and four smaller ones, all of which have had statues; on the spandrils of the former are six shields. On the rails of the north side are the arms of England, with those of Oriel College, Oxford, and an inscription dictated by the Society of that foundation, who repaired this monument in 1737. The capitals of the two pillars between which the tomb is situated were then painted with a number of white stags on a red ground, a circumstance which has given rise to a vulgar report that the body of the murdered king was drawn from Berkeley Castle to Gloucester by those animals. Rysbrach, by whom this monument was visited, with professional admiration supposed it to have been executed by some sculptor who flourished in that age in the north of Italy." Messrs. Brayley and Britton, however, suggest that it may have been executed by Peter Cavalini, an artist who was brought into England by Edward I.

NOTES ON CONSTRUCTION.

By Samuel Clegg, Jun.

[*An Introductory Lecture, read at the School of Construction. First Term: January*, 1852.]

⁎ These Notes, when completed, will be published in a separate form, as a Hand-Book for the use of the Students at the School of Construction.

I propose at present to lay before you an outline of the subjects which will be considered in the lectures of the first term, and to explain to you in a *general* way the value of the study of building as a science. Young architects, who may favour me with their presence, will understand I do not intend in any way to touch upon architecture as a *fine art:* I do not intend to talk about beauty, except only as *correctness* in any design may be considered as one element of it. Proportion and position are gained by calculation, and therefore come under the consideration of architecture as a *science* common to both the architect and engineer. Proper proportion constitutes *beauty;* and bad proportion, though bedecked with ornament, is *ugliness.* It may be likened to a very plain woman, inoffensive when with retiring manners she asks for no homage, but disgusting when by conceit and finery she seeks notice. I therefore start with this axiom: that there is no part of a structure, no matter where its situation or for what its purpose, that is not capable of having correct proportion assigned to it; but, as a matter of course, proportion will depend upon *material.* The nature and properties of materials used in building, and the methods of applying them in works, are essentially the first things to study; and Timber, as the most useful and general agent, may be taken first.

It is not only the different *kinds* of timber whose properties are required to be known, such as the "fir," the "oak," or the "teak," but it is the qualities of the different kinds of the same timber which is of the greatest importance. To specify that "fir," shall be used in any work, without defining the quality of that fir, would be utterly useless as a safeguard, and the contractor would supply the cheapest—the most important to his pocket—without any regard to its importance in the work. It is quite true that he must not supply a quality of timber that will *fail* or break at once, for then, by the law of contract, he would be made to suffer; but he may supply a description that will decay very soon, and thus the reputation of the designer would be perilled.

I shall explain to you, then, the different qualities of the fir timber that is imported from the ports of the Baltic—Memel, Dantzic, Riga, and Norway *baulk*, as the squared logs are called; also of the pine timber that is brought from America, such as the red, yellow, and pitch pines, all having different virtues and values according to the strains they may have to resist, or the situations in which they may be placed, as to exposure to the vicissitudes of climate, weather, or in contact with other material that may act upon them.

Another form of imported timber with which the builder has to become conversant is when the baulk is cut into deals, planks, and battens, at the places of shipment; and as these are used for smaller and more highly-wrought work, other considerations beyond mere strength and durability have to be attended to. For instance, the yellow deals from Christiana are durable and "mellow," which makes them work easily under the plane, and fit for the joiner; but those from Göttenberg, although durable, are totally unfit for the joiner, as they are stringy and incapable of being brought to a smooth surface. Again, the white deals of St. Petersburgh expand and contract with every change of weather, however well they may have been seasoned; so do the Swedish; but the Norway deals may be depended upon. The yellow pine deals must not be employed where strength is required, but the red pine are peculiarly strong. Besides these considerations, which I have merely instanced to show you the value of such knowledge, there are many others; some being capable of being explained in a lecture, but there are others which practice in the use of timber alone can render you conversant with. Oak, again, is not of one quality only. Old oak is fit for some things, young oak for others; and some qualities are fit for nothing. There are also different qualities of teak wood; indeed all kinds of timber require to be specified for with judgment based upon a knowledge of the peculiar properties of each.

These timbers I have noticed can be selected in the market, and are commercial commodities; some very good men can select their timber with certainty when they see it upon a wharf, but they know nothing of its nature beyond its workable and useable nature. It may have grown with its roots upwards for what they know, or it may have been a week or a hundred years in attaining its timber size for what they care. Place these men in situations where they have to select their timber in the forest, and they will be at sea although on dry land, and not know how to choose. The growth and felling of timber is a part of the science of construction, for we cannot always be sure of having to exercise our knowledge in England only. The colonies are powerful magnets, which are drawing many an engineer towards them, and *there* they will have to cut their own trees. They must know the age of the tree approximately, and mark the season in which to fell them.

Seasoning timber is another matter of great importance. I need not tell you that the expansion or contraction arises from the presence of vegetable juices, or absorbed moisture between fibres of the wood, and is the cause of warps, twists, and cracks. Some timbers absorb more readily than others, and are more liable to warp; seasoning prevents this.

The decay and the methods of preserving timber, I need not say, are essential studies; and I shall go into all these questions carefully, for I assure you even the quantity of knowledge gained of them in lectures, will assist you greatly in practice. Lectures put thoughts and ideas into proper train, and save a great amount of wandering.

After timber comes Stone, as a material for our consideration; and geology and mineralogy are sciences which should be studied, for they are of essential service to the engineer, and deserve his peculiar attention: they teach him where to search for stone, and permit him to know the quality of the stone he will find. I however cannot enter into either of these, they are studies of themselves; and I should strongly advise you to read and learn them sufficiently, to avoid making blunders, which even a partial knowledge might prevent. I take stone as I take timber—as a commercial commodity, and treat of it as to its fitness for the purpose required. It is not improbable that I may give you a lecture on quarrying stone; but I am not anxious to do so, for Sir J. Burgoyne's little work, published in Weale's cheap series, renders any further description almost superfluous. This book, and that of Mr. Stevenson on lighthouses, are the only useful books of the series relating to engineering. It is hardly needful that I should say anything to you of the value of the knowledge of the different qualities of the stones used in building. The qualities of the same stone vary like timber. Thus the Irish granite and that from Scotland are as distinct as possible. Cornish granite differs again from both, and some of it is only useful for the manufacture of china. Sandstones and limestones are equally variable. Then, again, we have the oolite and Purbeck stone, and others met with in the more recent formations, which require distinct notices. It is the idea of some that stone is stone all the world over: but some are fitted for sea work, are difficult to dress, or to be brought to a smooth face; others are fitted for the springers of arches, and the ordinary purposes of engineering, where great finish is not essential; and then again, some crumble or flake away on exposure to the atmosphere, and we constantly see a stone advertised as being a good weather stone, which is always a great recommendation; the position in which stone is set in work influences this quality very much. And I shall be able, I think, to explain these matters to you, so that they will be perfectly plain.

Having dismissed these, we shall come to a subject of the greatest moment, both to engineers and architects—I mean Lime, the material upon whose virtue depends the excellence or the reverse of our mortars, cements, and concrete, and through them of the durability of our buildings. Some mortars will not set when exposed merely to the weather; others will become hard beneath water. Some lime requires much sand to make good mortar, other kinds but little. Then again, the mode of slaking is of importance very often; in short, care is required in every stage of the preparation of mortar.

Limestones and the limes they furnish, then, is an inquiry to which I must point your serious attention. It is by no means a difficult or complicated subject, and simply requires the exercise of a little common-sense to master. The limestone chosen with reference to the nature of the work requires to be burnt; and although the art of burning lime is in the neighbourhood of large towns exercised as a separate trade, the engineer has frequently to construct his own kilns, and burn the lime upon the spot. It is, moreover, frequently essential for him to burn his own lime, that he may be certain of its freshness. Lime-burning will form part of a lecture; mixing mortar, and the minor observances connected with this, will also be considered.

The limestones I have just alluded to, and the limes they furnish, are those whose properties are *natural*. But eminently hydraulic lime, or lime that will set under water, may be made artificially, and often with so much success as to be superior in its hydraulic property to that furnished by the natural rock; and in many localities it will also have the advantage of price, a consideration always of importance in building: for engineers and architects must be commercial as well as scientific men, and he knows his business best who can produce the best work at the least cost; indeed, the reputation of an engineer is frequently based upon the fact of his labours having, by moderate expenditure, ensured to the undertaking a good return in money.

The next material which nature supplies us with that I shall mention, is Iron. Iron does not become serviceable to the engineer until it is reduced from the native ore to the state of cast-iron, wrought-iron, or steel; but as the student should not be unacquainted with the geological and geographical position, and the mineral characters, nor with the processes of reducing the ore, I shall give a general outline of them. Of iron, as a material of construction, I shall of course speak fully, and it will form part of the subject of the strength of materials. Cast-iron is employed to resist compression, and wrought-iron to resist extension, and the safe limits of their respective strengths it is of consequence to know.

This will conclude my notices of natural materials, and I shall then proceed to the question of Bricks and Brick-making; upon the latter subject I shall say but little, for the art is essentially practical, and, armed with the few hints I shall think necessary to give you, you will learn more by a visit to a brick-field than from a dozen lectures. On the qualities of bricks it may be necessary to occupy your attention; but it will be on the proper methods of applying bricks in work that it will be essential that I should enlarge. The manner in which bricks are laid together to form a wall, the precautions to take in carrying up work, and the commercial maxims relating to brickwork, you cannot study too carefully. Walls, carried up to all outward appearance soundly and substantially, often "split," by which term is meant the separation of the front from the back; this arises from want of cross-bond, which cannot be detected when the work is completed: it is only in case of failure that the want of it is proved. Cracks in walls arise from the insufficient over-lap of contiguous bricks on the face of the work, and is of less danger, for it can be detected. Against these two mishaps, therefore, the attention must be directed. Besides settlement arising from unequal foundation, which is a distinct consideration, there are those resulting from improper and unequal thicknesses of joints, and from the employment of mortars in the same wall different in the quickness of their set; or from some incompressible material, such as stone, occupying several courses, being used in contiguity with mortar joints. To avoid all these errors, a little care and consideration is all that is required; and the simplicity of the precautions makes it wonderful how so much bad brick-work can have been executed. But we constantly hear of chimney-breasts that have split, party-walls that have slipped or sunk, and houses that have doubled-up just as the roof was being put on; nor need any one be surprised at these occurrences whose attention is given to the proceedings of speculative builders, in the suburbs of London especially. These failures cannot be called *accidents*, for accidents are explained as *chances*, accidental as a quality non-essential; whereas, in truth, with many of the buildings to which I allude, that they stand is the accident—instablity is a quality not separable from their constitution. In many cases the bricks are bad, the work is bad, and the disposition of the supports is bad; what keeps them together until the work sets can scarcely be pointed out, and the fact that falls only occur occasionally (much oftener though than some think, because, unless life be lost, they seldom come before the public), serves to show what may be done with good materials properly placed. Of course there are many exceptions; and those builders who do their work well, and strive to produce houses not merely to *sell*, but to *last*, are the witnesses I could call to prove the extent to which rubbish such as I have pointed out is prepared for the market.

The removal of the brick duties has not yet produced that improvement in the make of bricks which we ought to find; large quantities of the worst description are at this time being sold at prices for which a good material ought to be provided. The Great Exhibition showed, what every one knew, that bricks of the most admirable quality, bricks far exceeding stone in hardness and durability, could be obtained in various parts of the kingdom; but as bad bricks can be bought for less than good bricks, so long as houses built of the former will sell as readily as if the better kind had been used, especially if bedizened with a little compo, the knowledge is of very little use, and builders for the market will continue in their present course. There is nothing that a good brick is not capable of, and people when they term the best of fellows "*a regular brick*," show an appreciation of this fact. There are some bricks that will bear anything, and that too without a wince. Look, for example, at the lower courses of the towers of Hungerford bridge,—look at those of the Glasgow chimney-shaft, 100 feet higher than St. Paul's; while others yield unconditionally to a shower of rain, or decline a trial of strength with even a slight frost, and permit it to peel their faces as a cook would pare a potato. I have seen specimens tried that were being used in two neighbouring buildings,—one resisted uninjured fifty tons, the other was crushed by three.

It is a common practice with "cutting" builders to compound the mortar with the earth dug out of the foundations, in lieu of sand. The surveyor for the ground landlord, should he employ one, may beg that this be discontinued, may swear, may threaten that he will withhold his certificate for a lease,—often wholly in vain, the builder trusting to the good nature of the ground landlord, the desire of the solicitor of the estate to issue leases, or unwillingness on the part of the surveyor, when the house is up (and has not tumbled down), to punish him with what would in many cases be ruin.

The opinion seems to be general amongst the bricklayers employed on the class of houses to which I am alluding, that *headers* are quite unnecessary; that if the walls be built of whole bricks and bats, to look like headers and stretchers, any *tie* between the outer face of the wall and the inner is quite uncalled for. I have several houses in my mind at this moment, where the facing of the walls being a better sort of brick, is, from bottom to top, simply tied to the inner part of the wall by headers 4 inches apart everyway! The men know better, spite of all that has been done to destroy the race of skilled bricklayers; they know perfectly well that the wall is unsound, but, if they are not building for themselves—in which case desire to *save* leads them to the evil—they are forced by the instructions of their employers to act as they do. Add to what I have been pointing out, imperfect foundations, sham arches, pockets in the chimney-breasts filled with rubble, the absence of even *timber* bond (bad in the long run, but useful in the first instance when hoop-iron and cement are not used as they should be),—and my hearers will agree with me, that the *accident* happens when a house so built *stands*.

For much of this house-buyers are to blame. They look at the outside with eyes that see not, found their calculations on the rent which by some means or other has been obtained for the frail tenement for which they are in treaty, and discover too late that they have bought a constant source of expense and annoyance. If, in all cases, an architect or other competent person were called in previously to the purchase, to examine the house, the buyer might be spared this loss, the honest and able builder would be protected, and those who have practised the "cutting" system would find it necessary to mend their ways and build better.*

Nor is it, frequently, much better with engineering works. The brickwork is let by contract at so much per cubic yard, for, as the work is usually in mass, it can be measured better by the cubic yard than by the superficial rod. The face of these masses is built well enough, but the inside is filled-in with bats. Young men, without experience, are frequently entrusted with the seeing that this work is carried out properly, and in accordance with the specification; but what chance has he against a contractor's foreman, "up to every dodge" to blind and deceive his opponent? Even an experienced overseer may be deceived, for the upper course is always covered with mortar and hidden from the view, so that unless the inspector stand over the work there is no chance for him, if the contractor be determined to cheat. Fortunately, this is not always the case, but I am sorry to believe it to be the exception and not the rule.

With Masonry there is less chance of deception, for the work proceeds more slowly, there are fewer joints, and the bond is

* The '*Builder*.'

more bold. The only care necessary (but this care is very needful) is when ashlar facing and rubble or brick backing or hearting is used; *then* the joints in this hearting must be worked very close, that the settlement may be as equal as possible, for settlement is only in the joints; the front-work, therefore, occupying probably many, will settle much less than the back. But walls of ashlar masonry, dimension for dimension, are of less stability than those of brick or coursed rubble, since this quality is not dependent upon the cementing matter between the stones, but upon the gravity of each mass. To give security to work of this nature, cramps and joggles have to be employed to unite the stones and courses, and it is this detail which renders masonry interesting.

With masonry I shall conclude the section relating to the simple application of materials to construction; and I shall commence the next with the Strength of Materials, a subject deserving careful and constant study. Economy and strength are both dependent upon the proper adjustment of the dimensions of the parts composing a structure. Work is paid for by the cubic foot, or some other measure of quantity, according to the nature of it. If a piece of timber, a bar of iron, or a wall, be made larger than the necessity of the case demands, the extra and needless quantity has to be paid for, so that the work costs more than it ought to do. All material not uniformly supported has to bear its own weight, in addition to that to be superimposed or suspended from it. Suppose, for instance, a beam was required to bear 1 ton equally distributed over it, and suppose the beam itself weighed 1 ton, it would have to be twice as strong as if the beam weighed nothing. Now, if the beam weighed ½-ton, and was strong enough, the first beam would have to bear an extra ½-ton of its own weight, and would be weaker than the last. A beam might be made so huge as to break of its own weight; for instance, the extreme limits between bearings of a wrought-iron tubular girder similar to that erected over the Menai Straits, is 1400 feet—no dimension, either of height, breadth, or thickness of metal, would enable it to support itself beyond this span. So you perceive the strength of materials, even in the two cases I have put, is of great moment. Many work by "*rule of thumb*," that is, they take their ideas of dimension from precedent, often without regarding the difference either of work or position of the new structure. Avoid this by all means: be able to give a reason for all you do; never take a dimension at hazard, unless it be some trifling part of a large mass of framing or other complicated assemblage of parts, the extra dimension of which would be of no moment. In large timber work, again, whole baulks are perhaps employed where a less sized timber would serve; but the expense of cutting or "converting" this would probably be more than the value of the timber saved,—it is therefore *practically* more economical to use the whole baulk, although *theoretically* the system is erroneous.

For the calculations necessary to compute dimension, certain data are needed. Pieces of timber or iron, for instance, are broken, crushed, or pulled asunder by weights; these being reducible to units, are added as constants to the formulaic expression which serves for the same material in all cases. I wish particularly to explain to you the method of obtaining these constants; for in new countries, or with new materials, you cannot find what you want in books, and must consequently try your own experiments. The apparatus required, and the *modus operandi* for practical purposes, is extremely simple; and you need never be at a loss, or take the experiments of others for granted, unless you are lazily inclined, and care not about chancing a mistake.

I shall speak of Cranes, and the mechanical powers used in the erection of heavy structures, enabling men to perform what they could not accomplish without such aid. Deprived of mechanical power, a man's force is limited to his muscular strength, of which he has but little in proportion to his bulk and weight when compared with other animals; his disposable mechanical force, when daily exerted for ten hours, being only about one-tenth of his weight, but for short periods he can exert much more, but *only* for short periods: it therefore seems that nature intended him to use his brains more than brute force, and it is astonishing the weight of matter even one man can lift, and the economy (in money) with which he can do it, by most simple and primitive contrivances. When I say that I shall speak of cranes, I do not mean that I shall impose upon you all that can be said of the different sorts used for wharf or warehouse purposes, but confine myself to those used for more temporary purposes in the erection of engineering works, such as traversers, derricks, and others; indeed, they may be considered as parts of scaffolding, and will be included in the same lecture. Scaffoldings and centerings are frames of timber put together for temporary purposes; roofs and timber bridges are those erected for permanent use; and although the principle of constructing both is the same, there are many considerations not common. They differ most in the details of their several parts, in the methods of uniting these parts, and in the amount of work put upon them. When the systems upon which these framings are designed come to be investigated, they are resolved into exceedingly simple and beautiful elements; no extraordinary quantity of mathematical knowledge is required to understand them, but they must be studied properly—"the stick must be taken hold of at the right end"—and then all is smooth and pleasant.

I will give you an instance of the value of the knowledge of the common principle of framing, or, I should rather say, the value such knowledge would have been. A gentleman in Dorsetshire, to whom I was on a visit, was carting hay from a large water meadow, and to get his wagons over a water channel he had placed two beams of timber, on which the wheels might run. The load was heavy and the bridge frail, and after a good deal of deflection and grumbling one of the beams broke. He exclaimed, "There, now I'm done! I have no more sticks; rain will come to night as certain as taxes, and I shan't get my hay in!" I was standing by, and told him I would make his engineering all right for him, for I saw that it was only a few of the bottom fibres of the beam that had yielded, leaving the top as strong as ever. I sent for a saw, and much to his alarm I cut the other beam across, as deep down as the other had yielded; I made the ragged break of the other fair with the saw, making an aperture of about 1 inch perhaps; bent the beams till the saw-cut opened to about 1½ inch, and drove in a piece of elm, as a wedge, to keep the sides of the notch from coming together again. This done, I turned the beams with the broken or wedged side upwards, and they were sufficiently stiff to allow the wagon to pass over. This method of stiffening beams is very old, and still very common; and gentlemen who have estates of their own, or estates to manage for others, should know a little of such plain contrivances.

Of timber bridges there are a vast variety of arrangements; but except for some particular purposes (though I do not at this moment recollect one), and under some circumstances rendering the execution difficult, those formed with bent beams are the simplest, cheapest, and best, and I shall not trouble you with many other forms.

We now come to the last section of the first term of lectures, and we shall have to take for our studies brickwork and masonry in place, and ascertain, by the best known rules, the dimensions proper for different works built of them—as, for instance, retaining walls. Experience has shown that banks of different earths will "stand" at different slopes, and, presuming all to be of the same height, we may say that chalk and gravel will stand at 1 to 1; sand at 1½ to 1; clay, if perfectly clean, at about 1¾ to 1; but if mixed with sand, thus possessing the power of absorbing and holding water, 3, or even 4 to 1 will not be in many cases too much slope to give it. The greater the slope the greater the pressure on the back of the retaining wall, and the greater must be the thickness to withstand it. The *theory* of the stability of walls to support earthwork is, of course, necessary to be understood; but the calculations to gain *dimensions* must not be based upon the data that mathematicians have assumed, for the varying circumstances under which such walls are placed render experimental data comparatively useless. The walls are not of that uniform character and stability which they are taken to be in theory; moreover their safety depends in a great measure upon their proper back drainage; and it is practice, aided by the knowledge of the statical laws relating to such works, that alone will enable us to get at sure dimensions.

The theory of the arch, also, is an extremely pretty piece of analysis, but perfectly useless to give us dimension, or even the best figure. The difficulty in the way of determining the best figure of an arch lies in our comparative ignorance of the manner in which pressure is actually communicated. The materials supposed in mechanical problems are usually perfectly rigid,—those of nature are compressible; and though it is clear a very slight alteration of form might throw the pressure of one arch-stone almost entirely upon a very small part of the one adjoining, we do not know enough of the nature of materials even to *guess* at the law of distribution. Again, if one part of an arch be overloaded, but prevented from falling by the friction and cement, a new form not contemplated in the preceding theory is is exerted upon the remainder, and again we are thrown out. Upon the proper thickness of the arch stones, for arches of different spans and forms, authors write with great caution, and no determined rule exists; but all who have attempted the solution differ in opinion as to the dimension. That some idea may be formed of the discrepancies which have arisen from calculations of this dimension, I may remark that Palladio makes the arch-stones one-seventeenth of the span, Gautier makes them one-twelfth, and Belidor gives one-twentyfourth of the span as proper. Peronnet makes his arch-stones at the springing much deeper than at the crown—say one-half deeper; and then he takes one-seventeenth of the span as the depth of the key-stone. But these dimensions depend upon the nature of the material of which the arch is built, and upon the figure of the arch, for the flatter the arch the greater the pressure at the crown; and the softer the material the sooner will it crush, so that a greater area of surface, or, what is the same thing, a greater depth of voussoir, must be given to prevent such a catastrophe.

Palladio tells us that bridges ought to have the same qualities that are judged necessary in all other buildings—viz., that they should be convenient, beautiful, and lasting. To be convenient, the slopes or grades of the approaches should be easy, and the width of the carriage-way ample. To be beautiful, it is necessary that they be in good proportion: *i. e.*, all their parts being *evidently* sufficient to resist the forces brought to bear upon them; and, as I remarked in the beginning, the word *beautiful* applied to engineering works, always means this, and we are not to understand by that term that the parts are *decorated*. And to be lasting, it is necessary that they be built of good material, and have their foundations, by being placed at a sufficient depth beneath the bed of the river (if it be a river-bridge, and the nature of the bottom demands it), secure from any scour that may arise from any cause whatever. Westminster and Blackfriars bridges are falling solely from non-attention to this: their foundations are UPON the bed of the river, not beneath it, and the scour produced by the removal of the old London bridge has undermined the caissons, and left them without a leg to stand upon. To *build* a bridge and to *design* a bridge are different matters: nothing but practice can teach you the former; but understanding the latter, which you can be made to do through lectures, you will be able to appreciate what you see put into practice more readily than if you went upon works ignorant of the general principles of the subject. To this end, therefore, lectures are useful; but you must investigate the subjects at leisure, and be careful to understand one thing before you begin another; you will thus avoid confusion, and feel satisfied that you have not thrown away your time.

A considerable amount of prejudice exists, in the profession, against Engineering classes; and if the lecturer pretends to teach his students to be engineers, this prejudice is unquestionably well founded: but he may teach them how to study that they may become engineers, with less labour than those who go into the field ignorant of first principles. I therefore again say, that lectures confined to proper subjects are useful; and if I succeed in pointing out a tolerably direct system of study to my listeners, I shall be perfectly content to think myself a finger-post.

ON DRINKABLE WATERS IN GENERAL.

By M. MARCHAND, of Fécamp.

[*Translated from the 'Repertoire de Pharmacie' for the 'Chemist.'*]

1. The physical and chemical constitution of waters varies every day of the year, and every instant of the day.

2. When the temperature is the highest, the density of the water is also the most considerable. A sudden variation in the temperature causes likewise one in this density.

3. This physical property of water is also influenced by atmospheric pressure, but in inverse ratio to that caused by the preceding influence. The greater the pressure, the weaker the intensity. Nevertheless, when an augmentation of pressure corresponds to an elevation of temperature, the density is very often still farther augmented.

4. The variation of the proportion of the gaseous principles dissolved by waters not only causes modifications in their density, for the saline and earthy principles which they hold in solution vary equally in their proportions under the influences which I am about to mention.

5. The waters of the ocean contain chloride of lithium and 0·0092 gramme of iodide of sodium per quart; but they contain no trace of nitrate, although these salts are poured in abundance into the sea by the currents of fresh water which flow into it.

The cause of this singular phenomenon is due to two different actions which take place simultaneously:—1st, under the reductive action of sulphuretted hydrogen excreted by certain mollusca existing in the depths of the ocean, the nitric acid of these salts is transformed into ammonia and water; 2nd, under the influence of the respiratory act of the fish, an analogous phenomenon is manifested, likewise giving an ammoniacal product; the ammoniacal oxide, formed in these circumstances, eliminated in its turn from the water, under the form of ammoniaco-magnesian phosphate, which is found again in the muddy deposits which accumulate at the bottom of the sea and on the sides of rivers.

6. Rain and snow waters generally contain appreciable traces of all the mineralising agents of the waters of the ocean. The former always retain indications of sulphuretted hydrogen.

7. The waters of the antediluvian soils generally contain lithia, and probably also phosphates as well as fluorides proceeding from the decomposition of mica, more or less abundant traces of which will be found in all these soils.

8. The waters which arise among calcareous soils always contain appreciable traces of ferruginous carbonates often accompanied by carbonate of magnesia.

9. Iodine and bromine are found also, except in some peculiar circumstances which I am about to mention, *in all natural waters*. We can easily and rapidly recognise their presence, even in rain and snow water.

10. These two principles may disappear from water by passing in a saline state, under the influence of the vital forces, into the number of the mineral principles fixed by vegetables. Terrestrial plants, but particularly forest trees, as well as fresh water plants, contain iodine and bromine.

11. The origin of these two bodies in atmospheric and terrestrial waters should be attributed above all to the diffusion of these same principles, now condensed, in sea water, whence they are carried off, some in the saline state, by the vapours and aqueous particles which perpetually escape from it, as well as in the state of free hydrated acids with sulphuretted hydrogen which also exhale from it.

12. The endemicity of goïtre and cretinism should not be attributed to the use of calcareous, magnesian, or selenious drinks, but solely to the more or less complete disappearance of the iodine, originally dissolved in the water which the persons affected with goïtre and cretinism use for their alimentation, this principle having been absorbed by the numerous vegetables which these waters have bathed. The enlargement of the thyroïd gland is not manifested as an endemic, excepting in very wooded countries, and particularly in those whose drinkable waters wash or have washed a great number of plants.

13. That in populous cities, the watering of streets and public places during times of choleraïc epidemics should be severely prohibited, as well as the flowing of public or private fountains into rivulets or in open places.

14. That the waters of springs and rivers are purified by flowing on the surface of the soil, by the volatilisation of the carbonic acid, which allows the insoluble carbonates to separate; by the influence of vegetative life; by the vivification, under the influence of the luminous rays, of the organised matters which they contain; finally, by the successive decomposition of these same matters, which decompositions then take place by causing also the reduction of the nitrates of the fresh waters, and their conversion into ammonia.

15. That in calcareous soils at least, but probably in all, the volume of the water from springs, contrary to the received opinion, is all the more abundant as the vegetation is more active, and that it decreases in amount in proportion as vegetable life becomes extinct, above all in countries where the superior soil is entirely devoted to agriculture. In our countries the springs attain their *maximum* in quantity about the 15th August, and they sink to their *minimum* about the end of January.

16. Then proceeding to the natural waters of the Arrondisse-

ments of Havre and Yvetot, I deduce from their analyses that all these waters which, without exception, arise in calcareous soils, contain especially carbonate of lime, the proportion of which varies between 0·153 gr. and 0·381 gr. per quart, salts of magnesia, sulphate of lime, but in variable proportion, and corresponding to the nature of the soils which produce them, so that the alimentary waters of the agglomeration of Havre are, with those of the wells of Fécamp, the most selenious in the country, which is, moreover, explained when we know that they issue from the inferior soils of the secondary formation; whereas all the other waters in the country have their sources in the superior stage of the chalk, or at the verge of the chalk glauconies.

All these waters contain likewise nitrate of lime, the proportions of which, varying between 0·00081 gr. and 0·22625 gr., become more considerable in those which flow from the inferior soils of glauconious formation.

Finally, all these waters contain appreciable traces of salt and manganese, salts of potassa and lithium, iodine and bromine, phosphate of alumina, and perhaps, I believe, even indications of *fluoride of calcium*.

MILLOWNERS' RIGHT TO UNDERGROUND SPRINGS.

In the cause of Dickinson *v.* the Grand Junction Canal Company, tried in the Rolls Court on the 2nd ult., the Master of the Rolls pronounced judgment, and said, it was a motion for an injunction, which, by the consent of the plaintiffs and the defendants, had been treated as the hearing of the cause, and upon which his decision was to have the effect of a decree made upon the hearing of the cause upon the evidence produced. The object of the suit was to restrain the defendants, the Grand Junction Canal Company, from further excavating and using the waters of a well sunk by them near Tring, in Buckinghamshire, at a place called the Cow-roast Lock, and to restrain them from pumping any water out of the same into the summit level of the canal, and from digging or sinking any other well whereby the sources and supplies of the water of the rivers Bulbourne and Gade, or either of them, might be obstructed from flowing down to the mills of the plaintiffs. The questions on the motion and in the cause were substantially the same, and the arrangement mentioned had been come to, much, he considered, to the advantage of either party. The plaintiffs contended that they were entitled to the full and unrestrained supply of water to their mills both by contract and by common law, and therefore entitled to the injunction. On the other hand, the defendants submitted that they were justified in what they had hitherto done, and therefore that no injunction ought to be issued; but there was not much difficulty in arriving at what he considered a proper conclusion. The Bulbourne was a stream rising in the neighbourhood of Tring, and, proceeding by Berkhampstead to a place called Two Waters, fell into the Gade, which itself afterwards fell into the Colne. The plaintiffs were the owners of four mills called Apsley, Nash, Home Park, and Croxley, for the purpose of manufacturing paper, situate at King's Langley, Abbott's Langley, and Rickmansworth, which had cost about 95,000*l.*, independent of various additions they had made to the buildings, and it was not disputed that they were ancient mills, existing prior to the act of 1793. These mills were supplied with water power through the aid of the rivers Bulbourne and Gade. In April, 1793, the first act, 33rd George III., chap. 80, was passed for the making of the canal, by sections 35 and 36 of which act it was provided that reservoirs should be made by the Canal Company for the purpose of gathering flood-water and supplying the rivers Bulbourne and Gade, when required for the use of the millowners, with as much water as should be taken therefrom for the use of the canal. The canal was completed, but the reservoirs were never made, and in 1809 and 1811 the plaintiff Dickinson became the purchaser and owner of the mills. After the plaintiff became the owner of these mills he brought three actions against the defendants in 1816 and 1817 for the withdrawal of water to an injurious extent upon the supply of the rivers, in all of which he proved actual injury, and recovered damages—in one of 2000*l.*, in another of 2800*l.*, and in the third of 3000*l.* A suit was also instituted in this court, in which Sir William Grant thought, as there had been unnecessary delay, the plaintiff was not entitled to the relief he sought; but this was not material to the present question. A fourth action was brought in 1817, which was referred to arbitration, and, in order to put an end to such a course of expensive litigation, a compromise was come to, and articles of agreement of the 11th of September, 1817, were entered into by and between the canal company and the plaintiff and his partner, Mr. Longman, by which the company covenanted to apply to Parliament for power to make a deviation of the canal, by which it should be united with the river shortly above the mills of the plaintiffs. The second clause contained a covenant that the company would not make any further alteration of the state of communication between the canal and the rivers Gade and Bulbourne, above the Nash mill, but should continue it as then existing, subject to the proposed alteration. This contract was embodied in an act of Parliament, 58th George III., chap. 16, which was obtained in the next session, and which, after reciting that disputes had arisen which it was desirable to settle, enacted by the third section that it should not be lawful for the canal company, upon any pretence whatsoever, to deviate more than thirty yards from the plan therein named, nor to make any alteration in the state of communication between the canal and the rivers Gade and Bulbourne other than as authorised by that act, nor to divert any of the waters of the said rivers, or any of them than as diverted at the time of passing the act.

No further dispute or contest arose between the parties until 1849, when the company, who had hitherto been in the habit of pumping water raised from the chalk stratum on the north side of the summit level near Tring into the canal, in order to avoid the large expense occasioned by that practice, sunk a large well 70 feet deep at a point near the Cow-roast Lock, to which they attached a steam-engine, and proposed to pump water from the well to the highest level of the canal at the rate of a lock of water per hour for twelve hours per day. It was contended by the plaintiffs that this practice emptied the water from the source of the Bulbourne to exactly the same extent the water was pumped from the well. The defendants alleged that the water being used at the summit level could not injuriously affect the plaintiffs, and what they lost in the one they gained in another; but the plaintiffs, although they admitted that the water was pumped into the canal at the summit level, denied this for two reasons—that it did not remedy the evil, inasmuch as one-half of the water passed off to the north and the other half to the south; and even if it all came down to the south it did so only when a barge ascended or descended on that side, and, in consequence, the lock of water so liberated passed through all the steps of the canal and found its way to the Thames without augmenting the supply to the plaintiffs' mills, whereas if the water flowed through the Bulbourne, which it would do by percolating through the chalk if it were not diverted, it would keep up a constant and adequate supply to the plaintiffs' mills. In confirmation of this it was alleged that the stratum being chalk no overflow of the river was ever seen, and that the soil gave out gradually through the summer the water that fell during the rest of the year. It further appeared that the amount of water which had fallen during the preceding months could be ascertained by the rain gauge, and the supply of water thereby regulated, and, as was alleged, all this would be destroyed by the continuance of the practice adopted by the defendants with relation to their well. In this state of things the bill was filed on the 21st of April, 1849, and on the 11th of June following Lord Langdale made an order for certain experiments to be tried, under the direction of Mr. Cubitt, for the purpose of observing the effect caused by the pumping of the water from the well upon the river Bulbourne. Mr. Cubitt reported, on the 22nd of March, 1850, that the experiments he had made showed the fact that, by pumping the water from the well, the stream of the Bulbourne was considerably diminished, and that it might by such means, if continued, be completely dried up for a considerable distance. On this evidence the motion was renewed before Lord Langdale, and in August, 1850, he made an order by which the company were restrained from pumping water from the well except they conveyed one-half of it by pipes, and discharged it near to the plaintiff's mills, which condition the company considered as too expensive to be entered upon as a temporary expedient before the rights of the parties were finally and conclusively ascertained by the proceedings then pending, and that order had the effect of an injunction absolute from that time. In addition to that order Lord Langdale directed a case to be sent to the Court of Exchequer for the opinion of that court upon six questions; and, in answer to the first, the judges were of opinion that by the taking of the water the company had violated the act of 58th George III. as well as the agreement, and had rendered themselves liable to actions irrespectively thereof. On the second question the court was of the same opinion, as to the diversion of the water, which otherwise would have percolated and gone through the intervening chalk, and thus have found its way into the river and to the plaintiffs' mills. The third question was also decided in the plaintiffs' favour; and the remaining three were only variations of the others intended to meet every point of law suggested by the facts appearing on the report of Mr. Cubitt, and were not material.

After a full argument the Court was of opinion that the acts done by the defendants violated the act of Parliament and the agreement; and that even if the act had never passed, and the agreement had never been entered into, the defendants would not have been justified at common law in the acts they had committed, but would have rendered themselves liable to actions for damages, occasioned by the loss of water supply to the plaintiffs' mills. In this state of things the motion was resumed before him (his Honour) to restrain the defendants by injunction from using the well as complained of. On the part of the defendants it was urged among other things that the case for the judges' opinion was imperfectly stated, therefore no just conclusion could be drawn upon it adverse to the defendants, and that no just conclusion could be drawn from Mr. Cubitt's experiments, because, although these ten days' incessant pumping diverted the water, it did not follow that the moderate use of the well would have the effect complained of; that in the one case it was incessant, while the company pumped only during a portion of the day, and, consequently, if the injunction were granted it should be confined to the excessive pumping complained of; and that as the fall between the Cow-roast Lock and the mills was such as would probably render the diminution of water by pumping, as practised by them, imperceptible, the injunction should be so limited as to stop only the pumping, so far as it hindered the beneficial working of the mills. It was also urged that, assuming there was a legal right in the plaintiffs, a mere legal right could not sustain an application for an injunction; and that, supposing the inconvenience on either side could be balanced, it would be found that much greater injury would arise to the defendants and to the public from the stoppage of the canal through the want of water, which would be certain, than that which would arise to the plaintiffs, and which was uncertain and prospective. After giving an attentive consideration to the subject, and reading over an immense mass of documents, he entertained no doubt that the plaintiffs were entitled to a decree in their favour on the contract entered into between them and the defendants on the 11th of September 1817, that they (the said company) should not, nor would not at any time hereafter, make any alteration in the state of communication between the canal and the rivers Gade and Bulbourne, above Nash mill, or any diversion of the waters of those rivers, but the same should continue as then existing; and after this agreement followed the act 58th of George III. The first question that arose was, whether this was such a contract as the Court would restrain parties thereto from violating, and upon this he had not the least doubt. The consideration for it was valuable, and the company obtained the value by the cessation of litigation. The next question was, whether the acts of the defendants were a violation of the terms of the contract as well as of the statute. The report of Mr. Cubitt showed conclusively that, by means of the pumping from the well, the waters were diverted from the rivers; and, independently of the decision of the Court of Exchequer, he should upon that report have entertained no doubt that the company had violated the agreement, and also the provisions of the act, by pumping the water out of the well into the summit level; but the case sent by Lord Langdale, and the answer given thereto, was conclusive upon the subject. It was a contract duly entered into by both parties, and when violated it was no answer by the parties violating it to say that no injury was inflicted by their acts upon the other party. If the plaintiffs had purchased from the company a right to prevent the waters from being diverted in any other manner than as at the time of the passing of the act of 58th George III., it was for them to judge whether the agreement should be preserved, so far as they were concerned, in its integrity, and not the defendants; and, therefore, in his opinion, it was not a matter of any moment in this case that the plaintiffs had not given any evidence of the damage done to them by the acts complained of. Having established that those acts were a violation of the agreement and the act, the plaintiffs were entitled to call upon the court to protect them in the enjoyment of the right which they had so purchased; and he was of opinion, therefore, a perpetual injunction must be issued to restrain the company from further excavating or sinking the well, or from pumping or removing any water from the well into the summit level of the canal, or from digging any other well by which the supplies of the rivers Bulbourne and Gade would be prevented from flowing down to the mills of the plaintiffs. It did not appear necessary to him to order the company to fill up the well; it was only necessary to prevent them from so using it as to create injury to the plaintiffs, and the defendants must pay the costs of the suit as well as of the experiments made by Mr. Cubitt.

A discussion having taken place between counsel as to the terms of the injunction,

His Honour said,—In his opinion, as the well now stood, the water drawn from it was water that would find its way by percolation through the chalk stratum to the rivers Bulbourne and Gade, and the company must, in its present state, be restrained from drawing any water from it. He did not restrain them from making a fresh well, and drawing water, provided it did not divert the water from the Bulbourne or Gade; and his intention was also of course, if the present well could, by further excavation, be carried to a lower level, so as to prevent any injury to the rivers, and thereby to the plaintiffs, that they should not be prevented from so doing. It was difficult to express the order, but the parties might easily arrange it. If the well was to be further excavated, some water must necessarily be taken out; and, therefore, if it was determined to pursue that course, allowance must be made for a reasonable quantity.

THE RECENT LAND-SLIP AT THE MANCHESTER WATERWORKS RESERVOIRS.

In the *Journal* for March we gave an account of the stupendous works in progress for the reservoirs of the Manchester Waterworks, and the threatened damage by the heavy storms which took place at the end of January and beginning of February. It has since been ascertained that the works suffered seriously, and part of them, it is reported, are likely to be brought to a standstill in consequence of a serious land-slip occasioned by the floods. It appears by a report of the Waterworks committee to the Manchester Town Council that "the committee approved of a suggestion made by Mr. Bateman, that he should be authorised to confer with one or more of the most eminent engineers of the present day, as to the course to be pursued in re-arranging the works, or otherwise modifying the scheme, in consequence of a recent land-slip near the Rhodes Wood reservoir; and also determined that the engineers who might be appointed should be requested at the same time to examine the works generally, and the whole scheme as proposed to be completed, and to report their opinion thereon. The committee have made the necessary arrrangements with Mr. Robert Stephenson, M.P., and Mr. Isambard Brunel, to survey and report, and to confer with Mr. Bateman as to any re-arrangement or modification of the works which, in connection with the land-slips referred to, might be necessary or advisable. On Saturday the 27th March, Messrs. Stephenson and Brunel, accompanied by Mr. Bateman, Sir E. Armitage, Aldermen Pilling and Bancroft, and the town clerk, went over the whole of the works, and made such an examination and inspection as, with the plans and sections before them, and the explanations of the engineer, will enable them to perform the important duties which they have undertaken on behalf of the corporation. The whole of the works between the Godley reservoir and Ardwick, including such reservoir, the Mottram tunnel, the Denton reservoir, and the mains laid down between Godley and Ardwick, have been some time ago delivered up as complete by the engineer to the corporation, and are now under the charge and control of the committee, and have been placed under the immediate superintendence of Mr. Wilson, the out-door superintendent in the waterworks department."

Mr. Bateman, the engineer, also made the following report:—

"*Manchester, March 30th*, 1852.

"Gentlemen,—My last general report upon the state of the works was made in August, 1851. Since that time the works have been making steady progress. The 36-inch and 40-inch main-pipes from Godley and Denton to Manchester have been now for many months completed and in constant use. The Denton reservoirs are finished as far as they can be until the banks are perfectly consolidated, when some of the brick lining now only temporarily laid on will be set in mortar, and permanently laid. One of these reservoirs since August, and the other for several months past, have been holding water for the supply of the town. The Godley reservoir is also finished, and in use for the supply of the town. The Rhodes Wood conduit, which completes the communication with the river Etherow, is also completed, and employed in conveying water to the reservoir for the use of the town, when the state of the river is such as will allow the abstraction of water without injury to the mills. At the Hollingworth and Arnfield reservoirs considerable progress has been made with the stoning of the inside slopes, and all masonry and the formation of the embankments is now resumed. A considerable quantity of water has been stored from time to time in the Arnfield reservoir, for the use of Manchester, and the Hollingworth reservoir is now also ready to hold a large quantity. At the various works upon the river Etherow and in the valley of Longdendale, although much progress has been made, many operations have been retarded by unavoidable circumstances. Everything at the Woodhead reservoir is completed except the upper part of the waste-weir and a branch puddle-trench on the northerly or Cheshire side of the valley, which is being sunk to the shale for the purpose of rendering the reservoir on that side perfectly watertight. This trench has required sinking to a greater depth than was anticipated, but it is now at the bottom, the shale or other watertight foundation having been reached throughout its whole length. It will now be re-filled with puddle as rapidly as possible. At Torside, the branch puddle alluded to in my last report has been put in, and the works at that embankment are proceeding. At the Rhodes Wood reservoir the embankment has made great progress, and is completed for between 40 and 50 feet in height. The works, however, at this reservoir are for the present suspended, in consequence of a land-slip which occurred towards the conclusion of the heavy rain with which this district was visited in the early part of the month of February, and which has materially shaken the masonry of the waste-weir which had just been completed. That land-slips had formerly taken place in the valley was easily discernible by those accustomed to make such observations; but with the exception of a narrow slip of ground about the centre of the Rhodes Wood reservoir which has always been slightly on the move, no movement had occurred within the memory of man in situations likely to be affected by our works. The ground over which the waste-weir was constructed had every appearance of being firm, the strata being apparently *in situ*, or at all events bearing no evidence of recent disturbance. The excessively heavy rain, however, of January and February, amounting in six weeks to 11½ inches, appears to have penetrated the upper portion of the ground, consisting for the most part of rock and dry material, and to have so wetted or lubricated the surface of shale on which it rested as to set the hill-side in motion, which taking a sliding direction obliquely down the valley, disturbed and crushed the whole of the masonry of the waste-weir and watercourse. The extent of ground moved is about thirty acres, measuring about a third of a mile along the valley, and 300 or 400 feet in height. This mass was moved altogether, the extent of motion being apparently from 6 inches to 1 foot. An examination of the line of fracture clearly indicates the existence of an ancient slip upon the same site, which has, probably, some time occurred from the same cause which set the ground in motion now. The quantity of rain which fell upon its surface from the 3rd to the 9th of February was 6½ inches, to which must be added all the water which, penetrating the rocky escarpment at the summit of the slope, would break out as soon as it reached the shale beneath the moved material, and probably find its way, for the most part, between the original surface of the hill-side and the underside of that which had slipped over it from a higher elevation. The best measures for adoption under the circumstances are now under consideration, in connection with Mr. Stephenson and Mr. Brunel, whose advice the waterworks committee have allowed me to obtain. No other damage was sustained during the heavy floods, the whole water having been passed with safety, although towards the conclusion of the rains I began to be apprehensive that our power of storage would be exhausted. The quantity of water which passed through the reservoir from the beginning of the year to the 13th of February was upwards of 800,000,000 gallons. All the watercourses and the masonry in the valley of Longdendale in connection with the various reservoirs, are nearly completed. The reservoirs have been constantly used for supplying the mills, and as the works become further advanced, a still greater quantity can be delivered.

"J. F. Bateman."

An appendix by Mr. Shorland states that 100 miles and 583 yards of pipes have been laid within the borough up to February 28th, 1852; there have been fixed to new and old mains 3930 new hydrants; and 19,886 additional houses and buildings have been supplied with water.

The following is a summary of the expenditure incurred up to the present time:—

				£	s.	d.
Expenses connected with obtaining the two acts..				13,262	14	3
Legal and deputation expenses incurred since the acts were obtained				2,934	6	6
Expenses: borrowing money, stamps, &c.				1,794	19	0
Interest upon borrowed money				17,714	1	4
Borrowed money repaid				178.886	12	6
Purchase of land, compensation, &c.				98,205	19	8
Paid contractors for works, reservoirs, watercourses, weirs, bridges, &c.	£136,660	2	1			
Paid for ironwork	5,974	3	5			
Paid for trench cutting	5,034	15	1			
Paid for iron pipes	58,083	16	6			
Paid for valves	6,052	11	0			
Paid for lead for pipe laying	2,145	8	2			
				213,950	16	3
Work done under the direction of Mr. Bateman	£54,973	13	2			
Engineer's charges	10,400	0	0			
				65,373	13	2
Damage done by floods				2.646	4	3
Miscellaneous payments				4,651	14	8
Total				£599,421	1	7

REGISTER OF NEW PATENTS.

WROUGHT-IRON TUBES.

T. Kenrick, of Edgbaston, Warwick, ironfounder, for *improvements in the manufacture of wrought-iron tubes.*—Patent dated Sept. 4, 1851. [Reported in *Newton's London Journal.*]

The patentee states that the interior surfaces of cast-iron tubes have been heretofore enamelled and glazed by the application of two coatings—one for the body, and the other for the glaze. He claims the enamelling and glazing, in the manner hereafter mentioned, of the interior surfaces of wrought-iron tubes only. The exact proportions of the materials, below given, in the recipes for the two coatings, are not essential, but may be varied.

Two coatings are applied, the first being a composition to form the body of the enamel, and the second forming the glaze. When the inner surface of the tube has been cleaned, the first composition (presently described) is poured through the tube, which is at the same time turned round, to insure an even coating upon every part; and the composition is allowed to set. The composition is prepared by mixing 100 lb. of calcined flint, ground to a fine powder, with 75 lb. of borax, ground fine, and then fusing the mixture; when it is cold, 40 lb. of the fused matters are ground in water with 5 lb. of potters' clay, and brought to such a consistence that, when an article is dipped therein, a coating of about 1/16-inch thick will be left upon it, forming the first coating or body, to support the glaze. After the first composition is set, the second composition or glaze-powder is poured through the tube, which is turned round, so as to cause the powder to cover every part of the first composition. The second composition, or glaze-powder, is made as follows:—100 lb. of Cornish stone, ground to a powder, 117 lb. of borax, ground fine, 35 lb. of soda-ash, 35 lb. of saltpetre, 35 lb. of sifted slaked lime, 13 lb. of white sand, and 50 lb. of white glass, pounded fine, are mixed together and perfectly vitrified; when cool, the mixture is ground very fine in water, and afterwards dried, and then 45 lb. thereof and 1 lb. of soda-ash are mixed together in hot water (being well stirred), and dried in a stove, by which means a fine glaze-powder is produced. The glaze-powder having then been poured through the tube, the latter is put into a stove, heated to about 212° Fahrenheit, to dry it; and, after this, the composition is fired, by placing the tube in a kiln or muffle, heated to a sufficient temperature to fuse the glaze. When the glaze is fused, the tube is withdrawn and examined; and, if the interior is not perfectly covered, a second coating of glaze-powder is applied (by pouring the powder through the tube whilst it is hot), and the tube is again replaced in the kiln until the glaze is fused.

GLASS, PORCELAIN, AND ARTIFICIAL STONE.

W. Hodge, of St. Austell, Cornwall, for *improvements in the manufacture of glass, porcelain, earthenware, china, and artificial stone.*—Patent dated October 2, 1851.

For the purposes above specified, hornstone porphyry is adopted by the patentee as a material which has not been hitherto used.

Claim.—The application of this material, called elvan, to the manufacture of glass, porcelain, earthenware, china, and artificial stone.

For the manufacture of glass, it is powdered, washed, and mixed with other pulverised materials in the melting-pot.

For the manufacture of porcelain, &c., it may be used alone or in combination with other materials. It is powdered, brought to a plastic state, moulded, dried, and fired in the usual way. It can likewise be employed for making glazes.

For the manufacture of artificial stone, it is used alone or combined with broken stone, and reduced to a plastic condition, moulded into blocks, dried, and fired in the usual manner.

HEATING AND VENTILATING.

D. Henderson, of Glasgow, for *an improved apparatus for generating gas, which apparatus may be used for heating and other similar useful purposes; and other apparatus for heating and ventilating.*—Patent dated October 23, 1851.

Claims.—1, the combining an apparatus with a kitchen-range, or heating or drying stove, for the manufacture of carburetted-hydrogen gas, in such a manner that the first liquid products in the manufacture of gas are returned into the retorts for further distillation, whereby a greater quantity of gas is produced; 2, the placing a hydraulic valve on the tube that conveys the liquid products, to prevent the escape of gas; 3, the arranging the hydraulic main condenser, &c., so as to cause the products to pass into the retorts by gravitation; 4, the application of a safety-valve described, to prevent too great a pressure of gas in the retorts; 5, an apparatus for heating baths; 6, an apparatus for ventilating churches, &c.

The apparatus for heating baths (shown in fig. 1) consists of a cylindrical tube E, communicating by the tubes G, and H, with the bath F. C, are gas-burners, which, being ignited, heat the water in the upper part of the cylindrical tube, and, being lighter than the water in the bath, it rises up the tube G, into the bath; the displaced water passing through the tube H, into the lower part of the cylindrical tube E. The heated air caused by the combustion of the gas, circulates in the portion of the framework A, and assists in heating the bath. B, is the portion of the framework supporting the bath.

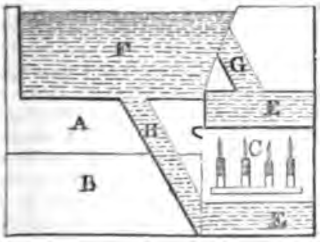


Fig. 1.

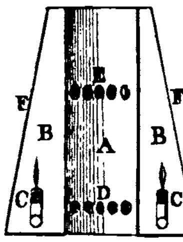


Fig. 2.

The ventilating apparatus (shown in fig. 2) is placed at the upper part of the room roof, the lower portion open to the room and the upper to the atmosphere, and is formed of a circular inner casing of iron or earthenware A, and an outer casing of a conical shape F, both connected at the top and bottom; round the lower portion is placed a ring of gaslight jets C, which are ignited, and, being supplied with air through the openings D, heat the space B. The warm air issues through the holes E, and causes a strong up-draught, which is assisted by the radiation from the circular casing A.

CASTING AND ANNEALING.

W. Onions, of Southwark, Surrey, engineer, for *improvements in the manufacture of nuts, mills and dies for engravers, lathe and other spindles; also of weft forks, shuttle tongues and tips for looms, by the application of materials not hitherto used for such purposes.*—Patent dated October 16, 1851. [Reported in the *Mechanics' Magazine.*]

Claim.—The manufacture of nuts, mills and dies for engravers, lathe and other spindles, and shuttle tongues and tips for looms, from metal of the kind to be described, by casting the same into the forms of the several articles, and then annealing these castings in the presence of oxide iron ore, or oxide of iron.

The improvements consist in manufacturing the several articles above-mentioned in metal which is capable of being rendered malleable by annealing in the presence of oxide iron ore, or oxide of iron. The metal which the patentee uses is composed of two parts of hæmatite iron ore, four parts of steel of the ordinary make, and ninety-four parts by weight of iron, made from Cumberland or other similar ore. These several matters are melted together, and as it is found desirable to cast the articles to be made direct, instead of running the metal into ingots, and remelting it, the patentee prepares, from accurate metal patterns, sand moulds of the required shape, into which he casts the molten metal. The castings thus obtained are then annealed by placing them in an annealing kiln in boxes, in contact with powdered oxide iron ore, and afterwards dressed and reduced to the exact required sizes and shapes of the several articles to be produced, by any of the means ordinarily employed for that purpose. The time required for the annealing will vary with the thickness of the articles under operation, as is well understood.

ON METALLIC CONSTRUCTIONS.

By W. Fairbairn, C.E., F.R.S.

[Paper read at the Mechanics' Institution, Manchester.]

It is nearly half a century since I first became acquainted with the engineering profession, and at that time the greater part of our mechanical operations were done by hand. On my first entrance into Manchester there were no self-acting tools; and the whole stock of an engineering or machine establishment might be summed up in a few ill-constructed lathes, a few drills and boring machines of rude construction. Now compare any of the present works with what they were in those days, and you will find a revolution of so extraordinary a character as to appear to those unacquainted with the subject scarcely entitled to credit. The change thus effected, and the improvements introduced into our constructive machinery are of the highest importance; and it gives me pleasure to add, that they chiefly belong to Manchester, are of Manchester growth, and from Manchester they have had their origin. It may be interesting to know something of the art of tool-making, and of the discoveries and progress of machines, which have contributed so largely to multiply the manufactures, as well as the construction of other machines employed in practical mechanics. In Manchester the art of calico printing was in its infancy forty years ago; the flat press, and one or at the most two coloured machines were all that were in use; the number of those machines is now greatly multiplied, and I believe some of them are capable of printing eight colours at once; and the art of bleaching, dyeing, and finishing, have undergone equal extension and improvement. In the manufacture of steam-engines there were only three or four establishments that could make them, and those were Boulton and Watt, of Soho; Fenton, Murray, and Wood, of Leeds; and Messrs. Sherratts, of this town. The engines of that day ranged from 3 up to 50, or at most 70 horses' power; now they are made as high as 500, or in pairs from 1000 to 1200 horse. An order for a single engine at that time was considered a great work, and frequently took ten or twelve months to execute; now they are made by dozens, and that with a degree of dispatch as to render it no uncommon occurrence to see five or six engines of considerable power leave a single establishment in a month. In machine-making the same powers of production are apparent. In this department we find the same activity, the same certainty of action, and greatly increased production in the manufacture of the smaller machines than can possibly be attained in the larger and heavier description of work. The self-acting, turning, planing, grooving, and slotting machines have afforded so much accuracy and facility for construction as enable the mechanical practitioner to turn, bore, and shape with a degree of certainty almost amounting to mathematical precision. The mechanical operations of the present day could not have been accomplished at any cost thirty years ago, and what was considered impossible at that time is now performed with a degree of intelligence and exactitude that never fail to accomplish the end in view, and reduce the most obdurate mass to the required consistency, in all those forms so strikingly exemplified in the workshops of engineers and machinists. To the intelligent and observant stranger who visits these establishments, the first thing that strikes his attention is the mechanism of the self-acting tools; the ease with which they cut the hardest iron and steel, and the mathematical accuracy with which all the parts of a machine are brought into shape. When these implements are carefully examined, it ceases to be a wonder that our steam-engines and machines are so beautifully and correctly executed. We perceive the most curious and ingenious contrivances adapted to every purpose, and machinery which only required the attendance of a boy to supply the material and to apply the power, which is always at hand. This subject is an art—I would call it a science—which has occupied the attention of the greatest men from the days of Newton and Galileo, down to those of Watt and Smeaton, and it now receives attentive consideration from some of the ablest and most distinguished men of the present time. And of these I may instance Poncelet, Morni, Humboldt, Brewster, Babbage, Dr. Robison (of Armagh), Willis, and many others, to show the interest that is taken by these great men with the advancement of mechanical science. It must appear obvious to those who have studied and watched the unwearied invention and continued advancement which have signalised the exertions of our engineering and mechanical industry, that neither difficulties nor danger, however formidable, can stand against the indomitable spirit, skill, and perseverance of the English engineer; nor will it be denied that the ingenuity and never-failing resources of our mechanical population are not only the sinews of our manufactures, railways, and steam-boats, but the pride and glory of our country. A great deal has been done, but a great deal more may yet be accomplished, if by suitable instruction we carefully store the minds of our foremen and operatives with useful knowledge, and afford them those opportunities essential to its acquisition. We must try to unite theory with practice, and bring the philosopher into close contact with the practical mechanic. We must try to remove prejudices, and to encourage a sounder system of management in the manufactures, design, and projects of the useful arts. When this is accomplished, we shall no longer witness abortions in construction, but a carefully, well-digested system of operations founded on the unerring laws of physical truth.

To the student in architecture, engineering, and building, there is scarcely any acquirement more essential to professional success than a knowledge of the properties of materials which are used in construction. It is more important than either skill in design or correctness of proportion, whatever the character of the structure—be it a house, a ship, a bridge, or a machine. Before we enter upon its construction, and before we can attain a due and correct proportion of the parts, we must, as a preliminary inquiry, make ourselves acquainted with the material of which it is composed. We must study this material's powers of resistance when exposed to the varied strains of tension, torsion, and compression. We must know something of its elasticity and its powers of restoration under the strains and changes to which it may be subjected; and we must then apply that knowledge by distributing it in such form and quality as will best meet the requirements of the case, and without incurring the charge of an unnecessary or wasteful expenditure. All this knowledge appears to me to be indispensable before we can attain anything like perfection in the art of construction, and no professor of the useful arts, whether he be an architect, engineer, or builder, can ever lay claim to sound principles of construction, unless he is acquainted with the natural properties of the material with which he deals. I shall, therefore, lay before you, in a tabulated form, a short summary of experimental facts, which you will, I think, find of some importance in their bearing upon the particular construction to which I allude.

Resisting Powers of Cast-Iron.—From a number of carefully conducted experiments on cast-iron, I have selected the following results. They are the highest in the order of their powers of resistance to a transverse strain, and as in each instance the bar is reduced to exactly 1 inch square, the results may fairly be estimated as a criterion of the resisting powers of the different irons of Great Britain:—

Transverse Strength of Cast-Iron Bars, 1 inch square, 4 ft. 6 in. between the Supports.

	Name and No. of Iron.	Breaking weight in lbs.	Deflection in inches.	Power to resist Impact.
Welsh.	Ponkey .... 3 C....	581	1·747	992
	Beaufort .. 3 H....	517	1·599	807
	Beaufort .. 3 C....	448	1·726	747
	Mean	515	1·691	848·6
English.	Low Moor .. 2 C....	472	1·852	855
	Butterley .. H....	502	1·815	899
	Elsecar .... 2 C....	427	2·224	992
	Old Park .. 2 C....	485	1·621	718
	Mean	471	1·778	863·5
Scotch.	Muirkirk .. 1 C....	418	1·570	656
	Carron .... 3 C....	443	1·336	593
	Monkland .. 2 H....	403	1·762	709
	Gartsherrie 3 H....	447	1·557	998
	Mean	428	1·556	739

The letters C signify cold blast; H, hot blast.

From the above, it will be perceived that the average transverse strength of eleven specimens of English, Welsh, and Scotch iron is 471 lb. on 1 inch square bars, 4 ft. 6 in. between the supports. These again give a mean deflection of 1·675 inches, and a power to resist impact of 817. Similar irons will resist a tensile strain and a crushing force per square inch as follows:—

Experimental results to determine the ultimate Powers of Resistance to a Tensile and Crushing Strain: Specimens each 1½ in. high.

Description of Iron.		Tensile strength per sq. in. of section.	Crushing strength per sq. in. of section.	Ratio of Tension to Compression.
Low Moor,	No. 2	6·901 tons..	41·219 tons..	1 : 5·973
Clyde,	No. 2	7·949	45·549	1 : 5·729
Blenarvon,	No. 2	7·466	45·717	1 : 6·123
Brymbo,	No. 3	6·923	34·356	1 : 4·963
Mean	. . .	7·309	41·710	1 : 5·707

In the foregoing experiments, the Clyde and Blenarvon indicate the greatest powers of resistance, either as regards a tensile or a crushing strain.

In addition to the irons given above, which are those in common use, Mr. Stirling's mixed or toughened iron exhibits considerably increased powers of resistance to every description of strain when compared with the unmixed irons. Mr. Stirling has patented a process for mixing a certain portion of malleable with cast iron, and when carefully fused in the crucible the product is equal to resist a tensile strain of nearly 11 tons per square inch, and a compressive one of upwards of 60 tons, the specimens being 1½ inch long and 1 inch square. This mixture, when judiciously managed and duly proportioned, increases the strength about one-third above that of ordinary cast-iron. As the strength of wrought-iron is not only a subject of great interest at the present moment, but is likely to become more so every year, I shall have to trespass longer upon your attention than may be agreeable. It is, however, imperative that I should do so, as I shall have occasion before the close of my remarks, to refer to facts, and to deduce therefrom conclusions for the elucidation and illustration of my subject. The importance of an inquiry into the art of shipbuilding will be appreciated by you all, and when you bring to mind the dreadful casualties of navigation—the hardships of shipwreck, and the horrors of fire—you will admit the vast importance of selecting the strongest and safest materials for the construction of our ships. It is chiefly for this reason that I have selected this subject, and ventured to impose upon your attention a few dry figures, in order that you might become acquainted first of all with the strength and natural properties of the materials of which ships are ordinarily composed, and attach due weight to their judicious application and distribution in the attainment of a powerful, buoyant, and durable structure. I would not have ventured upon this critical and difficult subject without some practical experience, but having taken an active part, as well as a deep interest, in the earliest stages of the application of iron as a material for shipbuilding, and having until the last two years been extensively engaged as a practical builder, I am perhaps the better able to offer a few suggestions on the advantages and superiority of iron in our war as well as in our mercantile marine. It is well-known to the public that the naval department of the government abandoned, a few years back (I think improperly so), the construction of iron vessels as ships of war. The Admiralty, in my opinion, arrived at a very hasty conclusion in condemning the use of iron, after the very limited number of experiments which had been tried upon iron targets and old iron vessels as to the effects of shot. At several of these experiments I was requested to be present, and although the results were certainly unexpected, and perhaps discouraging, yet they did not, in my opinion, justify the abandonment of a material not only the strongest and lightest for such a purpose, but offering infinite security under all ordinary and many extraordinary circumstances. Even in war-steamers when in action the chances are in favour of the iron ship, as it is not only secure from fire, but is much stronger, and will sustain more strain when assailed by storms and hurricanes. Steamers can back out of difficulties and dangers when sailing vessels must remain exposed; they can assail the enemy at a great distance, and take up any position they choose; and with their great guns and long range inflict severe punishment, and do great execution without receiving a single shot. Speed being thus admitted to be an important element in our war marine, the iron ship, from its lightness and buoyancy, has another evident advantage over the wooden one, as an equal amount of power will propel it faster through the water. In the event of a war, the steam marine of this country should have great command of power, to enable the ship to manœuvre at sea with almost the same geometrical precision as a squadron of horse on parade. They should have the power to advance and retreat as circumstances may require, and the new system of tactics which eventually must come into operation, should inspire confidence in the crew as well as the commander, that the iron steamer is not only formidable but safe, as embodying all the elements of offensive and defensive warfare. In our mercantile marine we are progressing with better prospects and greater certainty; but the decision of the Admiralty to limit the construction of iron vessels in the mail and packet service is, according to my views, uncalled for, and, to say the least of it, inconsiderate. I trust the lords commissioners of the Admiralty will see the necessity, the absolute importance, of rescinding that order, and that we shall not only witness the introduction of iron for that service, but more particularly when steam-power is employed in all and in every condition of an effective and a safe marine.

The Effect of Shot on Iron Vessels.—Although at first sight alarming, they are, on more mature consideration, such as might be reasonably expected. A number of experiments were undertaken some years since at the arsenal, Woolwich, to determine the effect of shot upon the hull of an iron vessel, and also with the view of providing means for stopping the passage of water through a shot-hole near or below the water-line. The gun used in the experiment was a 32-pounder, at the distance of 30 yards from the targets, and was loaded with the full charge of 10 lb. of powder and a charge of 2 lb. to produce the effect of distance, or a long shot. At these experiments I was present, and the results—some of which I may venture to mention—were exceedingly curious and interesting. The initial velocity

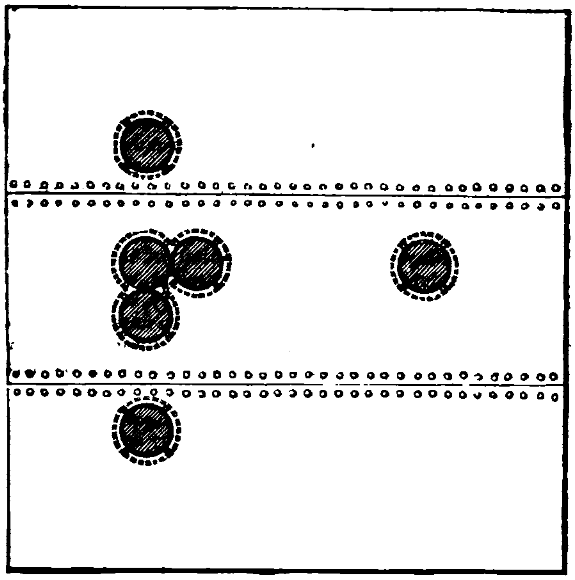


Fig. 1.—Side View of Iron Target.

of the ball, 6 inches diameter, with a full charge of 10 lb. of powder, is about 1800 feet per second, and with 2 lb. of powder about 1000 feet. In these experiments there were five or six targets, about 6 feet square, composed of different thicknesses

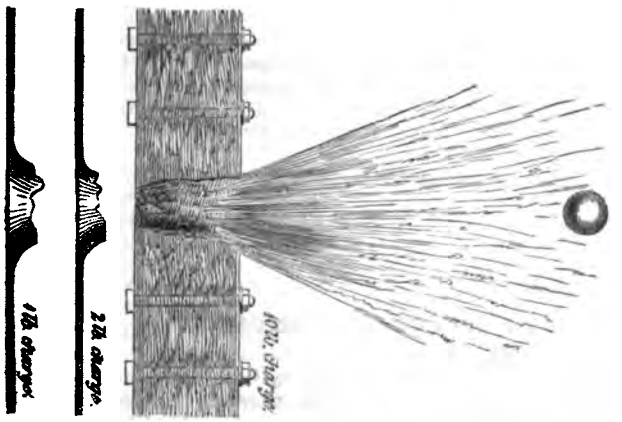


Fig. 2.—Section of Iron Target, showing the Effect produced by the Shot.

of plates, and variously arranged so as to represent in effect as well as appearance a portion of the side of an iron ship. The engravings (figs. 1, 2,) represent a side view and section of the plates and fastenings of the targets, and the effect produced by the shot as it passed through the plates, and in three or four experiments through a lining of india-rubber and cork-dust, which was specially introduced to absorb or receive the splinters.

Whilst laying before you such information as I possess on the subject of iron shipbuilding, it is not my intention to trench upon the province of the marine architect as respects the lines, and other detail required in construction. This field is already occupied by men of superior talent, and the one that lays more immediately open before me is that which refers to the proportion of the parts, the distribution of the material, and the equalisation of the powers of resistance to strain in all parts of the structure. These are considerations which, to a greater or less degree, affect almost every description of mechanical construction. If we study the laws of nature, we shall find in the endless varieties of construction in the animal and vegetable kingdoms no waste of material; that every animal and every plant is adapted to its purpose; its organisation is perfect; every joint, muscle, and fibre, is suited to the work it has to perform, and the utmost harmony, economy of material, and due proportion of the parts are the prominent features of the great teacher of all arts—Nature. With such examples before us, with such a wide and wonderful range of objects, why should we blunder and hesitate when we should analyse and investigate? There is no mechanism so intricate but what we find its compeer in nature, where we may find a rule for our guidance. We have, therefore, only to study the great Architect of the universe, and we need never be at a loss for examples, and, above all, close approximations to the laws which govern all constructions. As our present object is, however, to inquire into the laws which guide the experienced shipbuilder in the prosecution of his art, it will be proper, in the first instance, to ascertain the nature and strength of the material he may choose to employ, in order to show the way it should be disposed to produce at a minimum cost the greatest possible effect. For these objects I am fortunate in having before me a long series of experiments which I made for the same object more than ten years ago. They have elicited a great many facts, of which the following is a short abstract, and which I trust may be equally beneficial in this as they as they have been in other constructions.

Resistance of Wrought-Iron Plates to a Tensile Strain.—In these experiments, which were made on five different sorts of iron, the tensile strengths in tons per square inch are as follow:—

Description of Iron.	In direction of fibre.	Across the fibre.
Yorkshire plates	25·770	27·490
Yorkshire „	22·760	26·037
Derbyshire „	21·680	18·650
Shropshire „	22·826	20·000
Staffordshire	19·563	21·010
Mean	22·519	23·037

Or, as 22·5 : 23, equal to about $\frac{1}{45}$ in favour of those torn across the fibre. In following up the same investigation on timber, I found, according to Professor Barlow, of Woolwich, that the cohesive strength of different kinds of hard wood were—

Box	20,000 lb.	Beech	11,500 lb.
Ash	17,000	Oak	10,000
Teak	15,000	Pear	9,800
Fir	12,000	Mahogany	8,000

Assuming Mr. Barlow to be correct, and taking the main strength of iron-plate, as given in the experiments, at 49,656 lb. to the square inch, or say 50,000 lb., we have this comparison in pounds between wood and iron:—

	Timber.		Iron.	Ratio.
Ash	17,000	:	50,000	or as 1 : 2·94
Teak	15,000	:	50,000	or as 1 : 3·33
Fir	12,000	:	50,000	or as 1 : 4·16
Beech	11,500	:	50,000	or as 1 : 4·34
Oak	10,000	:	50,000	or as 1 : 5·00

Hence it appears that malleable-iron plates are five times stronger than oak; or, in other words, their powers of resistance to a force applied to tear them asunder is as 5 to 1, making an iron-plate ½-inch thick equal to an oak plank 2½ inches thick. In marine constructions, where the material is iron, our knowledge of its resisting powers would be incomplete, if we did not consider it in its union and all its bearings as regards its application to shipbuilding. Unlike timber, which has to be caulked between the joints, with a tendency to force them open, the iron ship is a solid mass of plates, which, if well riveted, will resist forces—such as the action of the seas—that no timber-built ship, however strong, would be able to withstand. The iron-built ship, when constructed with butt-joints, with interior covering plates, and smooth exterior surface, is superior as regards strength, buoyancy, and lightness, to any other vessel, of whatever material it may be constructed. In all these combinations it is, however, a desideratum to have the parts, the joinings, and the connections, as near as possible of equal strengths. This in practice cannot always be accomplished; but with due regard to a correct system of riveting and careful formation of the joints, a near approximation to uniform strength may be obtained. As a practical guide to these objects, I shall append a short summary of the experiment indicating the relative strengths of different forms of riveting, and in what they differ from the strength of the plates, taking the whole as one continuous mass without joints. The results obtained from forty-seven experiments on double and single riveting are here recorded, the first column showing the breaking weight of the plates, the second the strength of single-riveted joints, and the third that of double-riveted joints, both of equal section to the plates, taken through the line of the rivets:—

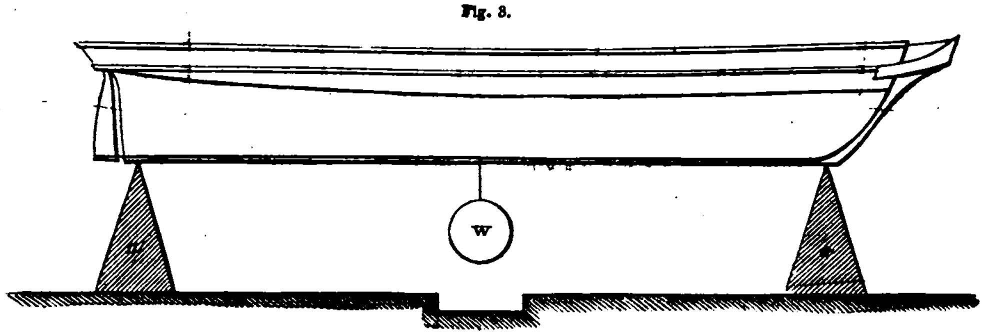
	lbs. per sq. inch.	lbs. per sq. inch.	lbs. per sq. inch.
	57,724	45,743	52,352
	61,579	36,606	48,821
	58,322	43,141	58,286
	50,983	43,515	54,594
	51,130	40,249	53,879
	49,281	44,715	53,879
	43,805	37,161	—
	47,062	—	—
Mean..	52,486	41,590	53,635

The relative strengths will therefore be—for the plate, 1000; double-riveted joint, 1021; single-riveted joint, 791; which shows that the single-riveted joints have lost one-fifth of the actual strength of the plates, whilst the double-riveted joints have retained their resisting powers unimpaired. These are convincing proofs of the superior value of the double-riveted joints; and in all cases where strength is required this description of joint should never be omitted. In a previous analysis the strengths were as 1000 : 933 and 731; but taking the mean, we have 1000 : 977 and 761 for the double and single riveted joints respectively. From these we must, however, deduct 30 per cent. for the loss of metal actually punched out for the reception of the rivets; and the absolute strength of the plates will then be to that of the riveted joints as the numbers 100, 68, and 46. In some cases, where the rivets are wider apart, the loss sustained is not so great; but in iron ships, boilers, and other vessels which require to be watertight, and where the rivets are close to each other, the edges of the plates are weakened to that extent. Taking, however, into consideration the circumstances under which the results were obtained, as only two or three rivets came within the reach of experiment, and taking into account the additional strength which might be obtained by an increased number of rivets in combination, and the adhesion of the two surfaces of the plates in contact, we may reasonably assume the following proportions, which, after making every allowance, may be faily considered as the relative value of wrought-iron plates and their riveted joints. Taking the strength of plates at 100, we have for the double-riveted joint 70, and for the single-riveted joint 56; which proportions may safely be taken as the standard value of joints, such as are used in vessels required to be steam or watertight, and exposed to a pressure varying from 10 lb. to 100 lb. on the square inch.

Having thus established correct data as respects the strength of materials, either singly or in combination, we shall have less difficulty in their application to the construction of vessels exposed to severe strains, such as boilers, bridges, or an iron ship; and notwithstanding the boasted declaration that the "wooden walls of Old England" are our surest defences, we shall not, in my opinion, seriously injure, but greatly benefit our position by pinning our faith to the "iron walls of the sea-girt isle." This, I am satisfied, will be the case if we persevere in the use of a material which must eventually supersede every other in the construction of vessels calculated to maintain the ascendency of the British marine.

Iron Shipbuilding.—In the construction of iron ships three important considerations present themselves. First, strength and form; second, security; lastly, durability. To the first of these considerations it will be necessary to ascertain for what purpose the vessel is to be used. Let us assume it to be one of the Atlantic, or other great ocean steamers, and we have a

Fig. 3.



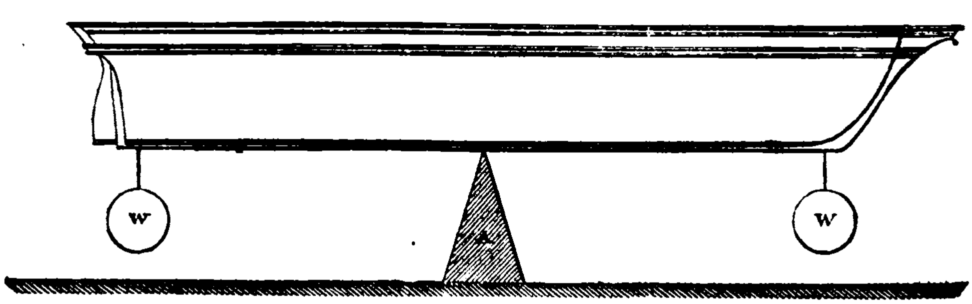


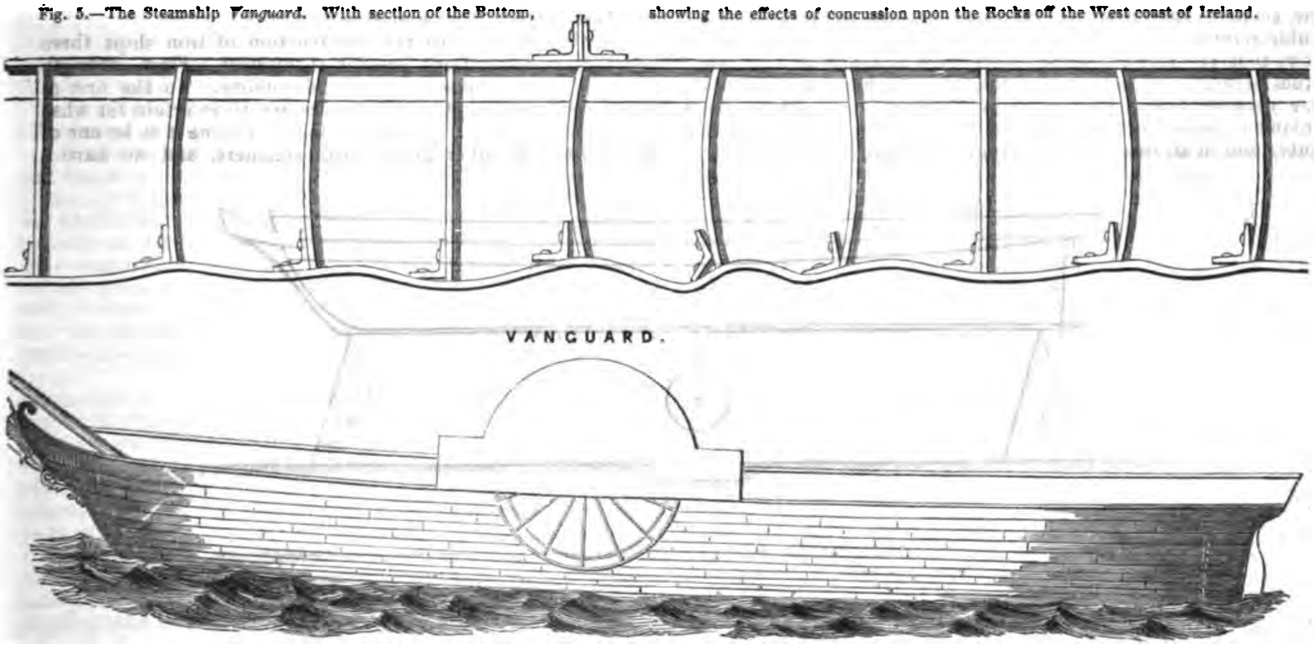
Fig. 4.

model both in form and tonnage, that would become equally formidable as a war-steamer, or useful and commodious as a packet calculated to shorten the distance between the extreme points of a lengthened voyage. We must consider this important part of the question in all those varied forms and conditions to which vessels are subjected under strain, whether arising from a tempestuous sea, or from being stranded on a shore, under circumstances where they are not only seriously damaged, but where wooden vessels frequently go to pieces, and are entirely lost. In the former case, that of a tempest, such as a tornado under the tropics, where ships are not unfrequently much strained, we have in the iron ship, if properly constructed, greatly increased security, and provided we take the vessel in its best construction, and regard it simply as a huge hollow beam or girder, we shall then be able to apply with approximate truth the simple formula used in computing the strengths of the Britannia, and Conway, and other tubular bridges. Let us, for example, suppose a vessel of similar dimensions to the *Great Western* (the first steamer that successfully crossed the Atlantic), 212 feet long between perpendiculars, 35 feet beam, and 23 feet from the surface of the main deck to the bottom of the sheathing attached to the keel. Now, assuming a vessel of this magnitude, with its machinery and cargo, to weigh 3000 tons, including her own weight, and supposing, in the first instance, that she is suspended on two points, the bow and stern at a distance of 210 feet, as shown in fig. 3, we should have to calculate from some formula yet to be ascertained by experiment the correct sectional area of the plates, to prevent the tearing asunder of the bottom, and the quantity of material necessary to resist the crushing force along the line of the upper deck. These data have yet to be determined; but the iron shipbuilder cannot be far wrong if he assumes the breaking weight in the middle to be equal to two-thirds of the united weight of ship and cargo. This, in the case before us, would give an ultimate power of resistance of 2000 tons in the middle, or 4000 tons equally distributed along the ship with her keel downwards. Let us now reverse the strains, and bring the vessel into a totally different position, having the same weight of cargo on board, and supported by a wave upon a single point in the middle, as shown in fig. 4. In this position we find the strain reversed, and in place of the lower part of the hull of the ship being in a state of tension, the whole of the parts above the neutral axis are subjected to that strain; and that tension, as well as the compressive strain below, will be found to vary in degree as the ratio of the distances from the centre. In this supposed position, if we calculate the strengths—as I have been in the habit of doing, when the vessel is placed in trying circumstances, whether contending with the rolling seas of a hurricane, or the actual suspension of either portion when taking ground—we arrive at the conclusion that these calculations determine the strength, and that under any contingent circumstances we have given a wide margin, and fully determined the strength of the ship.

I am fully aware that many thousand vessels are now afloat that would not stand one-third of the tests I have taken as the minimum, but that is no reason why we should not endeavour to effect a more judicious distribution of material, and produce a maximum result, where the lives and fortunes of the public are at stake. On the question of security, we have fewer difficulties to contend with, and, so far as regards construction, I have endeavoured to show, that in order to build a ship on principles as near perfectly secure as circumstances will admit, that she must be calculated to withstand the trials I have proposed her calculated to bear. Exclusive, however, of the simple strength of the hull, there are other considerations which require attention, such as the danger from fire, leakage, or total shipwreck.

In naval constructions we have three elements to contend with—fire, air, and water; and although we may effect in iron constructions extraordinary powers of resistance as respects the two latter, we are nevertheless subject to considerable risk as regards the former. It is true the hull of an iron ship will not burn, but the interior fittings, which are mostly of wood, if once ignited, might destroy everything on board, unless the necessary precautions are taken by iron bulkheads to cut off the communication from one division to another. From my own experience as a builder of iron vessels, I have found these bulkheads of inestimable value. They not only strengthen the ship transversely, but in case of injury to any part of the hull, any one of the divisions or compartments might be filled with water, and perhaps even the contents of that part burnt, without endangering the ship. These divisions, in fact, should be so

Fig. 5.—The Steamship *Vanguard*. With section of the Bottom, showing the effects of concussion upon the Rocks off the West coast of Ireland.



arranged as to insure the vessel floating under circumstances of irreparable damage to any one of those parts of the ship. Again, in case of fire, under the lamentable position in which the *Amazon* was placed, it might be advisable to have the extreme stem and stern bulkheads made double, with an air-space between them, and a valve in each to fill them with water up to the line of immersion, and thus prevent the division plates on that side clear of the fire from becoming red-hot, and igniting the timber fittings in that part which for the time might form a place of retreat. Much may be done in this way to mitigate, if not to avert, the calamitous and fatal consequences which ensue on those occasions. Bulkheads of this description, coming up to the underside of the upper deck, might obstruct to some extent the communication between decks from one compartment to another; but I believe a sufficient freedom of access from one part to another might easily be effected by well-constructed iron doors, easily closed in case of accident, when they would become effectual barriers to the spread of destruction. In carrying these objects into effect, we must recur to the use of iron in every case where packet-ships and steamers are employed. They apply with the same force to her Majesty's navy, and particularly to steam frigates, and ships of war with auxiliary power. It is true that the experiments already referred to of the dangerous effects of shot on the iron hull are alarming, but the amount of risk and destruction is always one of degree. I doubt whether the effects of shot on wooden vessels are less terrible, and undoubtedly the security gained by bulkheads and such contrivances are more than the claim to security. Besides, we are not yet satisfied that these effects are so dangerous as has been represented. On the contrary, I am of opinion that they have been greatly exaggerated, and that increased experience will ultimately show that the iron ship, under all circumstances, affords greater security, whether for war or commerce, than any other construction. As a proof of the advantages peculiar to iron as a material for shipbuilding, and the greatly increased security which it offers in comparison with wood, the engraving fig. 5, shows the condition of the steamer *Vanguard*, which ran foul of a reef of rocks on the west coast of Ireland, and continued beating upon them for several days with comparatively little injury. Another instance is that of the *Great Britain*, which stood the action of heavy seas beating her upon the sands and rocks of Dundrum Bay for the whole winter, and that without any serious damage to the hull.

Durability of Iron.—On this part of the subject there is considerable difference of opinion, but a very cursory view of this important question will at once show the great superiority which exists on the side of iron against timber. Although I proposed at starting to treat of metallic constructions alone, I have found it useful to add a few data showing the strengths of different timbers which are used in combination with the metallic frameworks; and have therefore given the comparative strength of iron and the best English oak, in which it is proved that iron as a material is five times stronger than oak. This is, however, not the question which enters into the subject of durability, as the jointing of the one is incomparably superior to that of the other. In the building of the ships of the line, or large merchant vessels, the keel, beams, and timbers, are generally of oak or teak, made of three pieces, ingeniously contrived, and united by scarphs to each other to insure strength. The ribs or frames, which are solid and close to each other, are scarphed and jointed in the same way, and the outer sheathing, which is copper-fastened, is also attached with great care, and by crossing the vertical joints of the frames great strength is obtained. The connection of the deck-beams to the frames by strong iron knees is another source of strength, but with all the care and ingenuity and skill bestowed upon this construction, it is far from perfect in point of strength, as the vessel, when pitching and rolling in a heavy sea, produces motion at every joint, and it not unfrequently happens that the seams open and close to an extent sufficiently obvious as to the nature of the structure and defective union of the parts. Now in the iron ship we may venture to state that when all the parts are soundly riveted together there are no joints. The whole may be considered as continuous, consequently there can be no yielding, except from the elasticity of the mass to the action of the sea. The plates are the same as the planking or sheathing of timber-built ships, and these plates are riveted to strong iron ribs, varying from 12 to 15 inches asunder, and answering the same purpose as the solid framing of a teak or oak vessel. As respects the comparative merits of wood and iron vessels on the score of durability, I am of opinion that the public has entertained very erroneous views with reference especially to oxidation, which for the last twenty years has been the "rock ahead" of every iron ship. The extent of this evil has been greatly exaggerated, for there are instances of several iron vessels built twenty years ago, which are still in existence, with no sensible appearance of corrosion or decay, and what is of equal importance, without having required repairs, if we except a few coats of oil-paint, or the application of some other anti-corrosive substance, to neutralise the effects of the atmosphere upon the material. Nature, however, comes to our assistance in this as in almost every other attempt in the constructive arts, and seems to confirm the proverb that a "bright sword never rusts;" for it is with iron ships as with iron rails when in constant use, there is little if any appearance of oxidation. Taking, therefore, the whole circumstances into consideration, we may reasonably conclude that much has yet to be done in this department of the useful arts, and make no doubt that the iron ship of British origin will yet ride triumphant on every sea, as the harbinger of peace, the supporter of commerce, and the great and only security of our national defence.

If, in my attempt to elucidate a subject of such vast extent, and of such national importance, I have been successful in conveying to your minds in plain words that knowledge which it is important we all should know, I have attained the main object of my appearance in this place.

At the conclusion of the paper, a vote of thanks to Mr. Fairbairn was proposed and seconded, which was very warmly accorded.

REVIEWS.

Manual of Geographical Science, Mathematical, Physical, Historical, and Descriptive. London: JOHN W. PARKER, West Strand. Part I. 1852.

To those who remember receiving their first instructions in geographical science from perusal of the meagre descriptions of the different portions of the earth, and from the brief notices given therewith of the principal mountains, rivers, and cities of each country, which were dignified by their authors with the pretentious titles of 'Grammar of Geography,' 'System of Geographical Instruction,' &c.—although they contained little besides definitions of terms, a few remarks upon the elements of astronomy, together with a table of the relative distances of the most noticeable members of the starry firmament, and some scanty statistical information as to the chief productions and population of the great subdivisions of the earth's surface—the publication of the first part of the work under consideration will afford the means of forming a curious and not uninstructive contrast between the educational systems and requirements then and those of to-day. Society is no longer "content" that its junior members, hereafter to be called upon to take their share in governing the peoples of the earth and in developing the resources of its productive powers, should be left to pick up whatever amount of information they pleased, on the odd afternoon in the week, respecting the characteristics of the first and the nature of the last.

Now, it is necessary to know and clearly understand the principal phenomena connected with the earth:—Its correlation with the heavenly bodies; the laws that govern its movements; the direction of its waters, and of its circumambient atmospheric currents; the vegetable productions of its surface, and their grouping in a FLORA, and the arrangement of the animals dwelling upon it into a FAUNA; and, lastly, the history of its creation and of the successive stages of its growth through prehistoric periods, even almost from the first, when

> "Ante mare et tellus et, quod tegit omnia, cœlum,
> Unus erat toto naturæ vultus in orbe,
> Quem dicêre chaos; rudis indigestaque moles,
> Nec quicquam, nisi pondus iners; congestaque; eodem
> Non bene junctarum discordia semina rerum";—

derived from study of geological remains, and in some cases from casual marks in rock and stones, up to the rich and vigorous development of its ripened age to-day. Very different this from the days when pedagogues deemed it needful to supply their pupils with no more important information regarding the vast steppes of Russia and their boundaries, rich in mineral wealth, than the fact that "a portion of their inhabitants were incorporated with the imperial army—the officers being distinguished from the common soldiers by wearing red boots." Nor could they find anything more remarkable in Parma than "the manufacture of a peculiar kind of cheese called, after the name of the town, 'Parmesan.'"

From these mere hornbooks of schoolboys to the voluminous works of Malte Brun and others of like description, which were too often overloaded with political, statistical, and topographical details, and consequently unfitted for a class-book in our schools and colleges, there was no work of an intermediate character which could be conveniently placed in the hands of students. "Hitherto," says the Editor of the 'Manual,' "those treatises [on geography] intended to be used in education have been rather compendious works of reference, than introductions to the study of a science." The present work is a very praiseworthy and successful endeavour to supply this deficiency, by setting forth clearly the general principles of the science—in previous works most strangely omitted—and "so to classify and systematise the information contained in it, that it may be immediately available both to the teacher and the scholar; and, by the omission of all non-essential details, whether political, statistical, or topographical, to confine the attention to the principal subject."

The information contained in an introduction to Geographical science is necessarily of a varied and comprehensive character. The physical history of the world requires, in order to be correctly understood by its student, a knowledge of several sciences, each more or less connected with the other; and this necessity has contributed as much as anything to retard the more assiduous and wide-spread cultivation of it as a study at once amusing and instructive,—more so probably than "the barren outlines of astronomy and paradoxical problems in the use of the globes, which made this science so unpalatable in our youthful days," to which the Editor, the Rev. C. G. Nicholay, pointedly adverts in the preface. Lest this complex nature of the science should operate to deter unscientific persons from the study of Geography, it is stated that "although the FIRST PART may appear to be composed of distinct and separate treatises, it is presumed that, on consideration, they will be found to form a consistent whole,—each Part, notwithstanding, complete in itself."

From what has been said it will be seen that Geography is not a simple but a compound science, requiring, in order to its thorough comprehension, a knowledge *à priori* of Astronomy, Geology, Physical Philosophy, Meteorology, Hydrology, Optics, Ethnology, and Mathematics, besides, incidentally, numerous others. Instead of being termed a science, it is doubtful whether it would not be more appropriately designated as the aggregate of physical sciences. Such, at least, appears to have been the idea of the projectors of the 'Manual;' and we are glad to add, that not only has the idea been well conceived, but faithfully carried out in the Part before us. Starting from the just and reasonable position that the students to whom they address themselves have had their minds sufficiently disciplined to be able to follow a chain of reasoning, and that they possess, at least, such an amount of mathematical knowledge as will enable them to measure an angle and solve an equation, the other sciences are treated *ab initio* as if they were not known to the reader.

Again, we are glad to see that the compilation of the teachings of these different sciences has not been intrusted to one man, who, however varied may be his acquirements, could scarcely be said to be competent to the task of expounding equally well the doctrines of each; nor to an abstract or generalizing philosophical writer, who, however great may be the charm of his diction and the beauty of his ideas, is not always to be relied upon,—for oftentimes these very beauties are employed to screen ignorance, and to support the assumed character of a scientific Admirable Crichton, to which there is no right or title. How often is this the case? The eloquent apostle of science proves to be a blind guide after all, who gropes his way—thanks to the folly of his followers—to the position he aspired to, and leaves them to wander in eccentric and unprofitable directions, or else to remain immoveable in their ignorance, and blinded by the one solitary ray of borrowed knowledge he flashed across their mental vision.

Nor are sound scientific attainments all that is necessary in a writer to insure success to his explanations. He must be possessed of that often slighted but most important faculty—the knowledge how to teach—how to convey to the mind the requisite amount of instruction clearly, succinctly, and vividly, without overburdening or confusing it.

Such, then, are the requisites, it appears to us, that all elementary treatises of any of the physical sciences should possess, to fulfil the purposes for which it is but fair to suppose they were intended—the advancement of education and the general spread among all classes of students of a correct knowledge of those laws to which all the constituents of the universe are subjected, but which were, till lately, deemed capable of being correctly understood only by a few of the highest mental calibre —men removed from the disturbing influences of vulgar life; while to the οι πολλοι they remained fearful mysteries, of which a faint glimmering was occasionally revealed as "through a glass darkly."

The 'Manual of Geographical Science' approaches nearer to our ideal standard of excellency of a class-book than any that has hitherto come under observation. It is the joint production of gentlemen who, from their professions, must of necessity have considerable facility in the art of teaching, and each of whom has undertaken that branch which has long been his particular province to study and explain. In the first Part of the 'Manual' before us, the chapters on Mathematical Geography are the work of the learned Professor of Natural Philosophy and Astronomy in King's College, London—the Rev. M. O'Brien; and well has he performed his allotted task. His explanation of phenomena, his enunciation of theories and demonstrations of problems, and his descriptions of the constructions and uses of various astronomical and optical instruments, are clear, distinct, concise, and easy of comprehension;—no pedantic display of high mathematical attainments, no affectation of novel or elegant notation in the expression of well-known formulæ, but simplicity in all things, and the avoidance of technical terms as much as possible, so as to render the theories of movements of planets, their actions on each other, and the methods of ascertaining their position in space, and the mode of employing instruments for such purpose, all capable of being readily seized and worked out by any one of very ordinary mathematical acquirements. While upon this subject, we do not hesitate to express our opinion, that it is high time the scientific societies at home and abroad mutually consented to the revision of the terms employed in describing certain motions of heavenly bodies, and explaining the resulting phenomena, in order to render them consonant with the theory universally recognised as correct; and also to make the study of astronomy less difficult and obscure to beginners than it is. Where is the necessity and wisdom of maintaining the fiction—fiction although it is admitted to be—of the motion of the sun, which only serves to confuse and perplex the student? So long as the Aristotelian system was the orthodox one, and the Inquisition had power to ban and stigmatise as pernicious heretics those who doubted its correctness, it was permitted to speak of the circumpolar motion of the sun; but *nous avons changez tout cela*, and now the truth —faintly shadowed forth in the teachings of Pythagoras, Philolaus, and Nicetas, and never wholly lost amidst the darkness and false teachings which overspread the earth till the dawn of letters—is recognised and established, thanks to the unselfish labours of Copernicus, Galileo, and our own glorious Newton. Every one now knows that the sun is the centre of our system, and that the earth revolves round the sun; wherefore, then, tell the student in one page that round the earth revolves the sun, "whose motion in the heavens is the cause of so many important changes to us; those changes from light to darkness, and from heat to cold, which give rise to day and night, and bring about in order the various seasons of the year"—and that, "by the combination of these motions, the sun appears to describe an oblique circle in the heavens, moving backwards (that is, from west to east); moving in this circle, he crosses the equator at the time of the equinoxes, at an inclination to the equator of about 23½°; the circle is called the *ecliptic*, because eclipses of the sun and moon occur only when the moon crosses or comes near the circle"—and then, when the scholar clearly understands this statement, tell him, in the next page, that this is all incorrect, that "the proper motion of the sun is only apparent, being caused by the earth's real motion about the sun"? And, as if these contradictory teachings were not sufficient to bewilder a young beginner, we persist in speaking of the annual motion of the earth round the sun, and, in the same breath, of the passage of the sun over the equator. Surely it were better far, even at the risk of incompleteness of demonstration, to set the truth simply before young minds: to say that the sun is the centre round which our planet revolves; that the axis of the earth is inclined to a horizontal plane, passing through the centre of the sun, in which the earth takes its path round the sun annually; that the intersection of this pathway with the earth's surface is the ecliptic, so called, because when the moon comes in this plane, between the earth and sun, or has the earth between it and the sun, eclipses of the sun or moon occur; that from the inclined position of the earth with reference to the horizontal plane passing through the centre of the sun, it follows that the intersection of the pathway with the earth's surface is inclined to the equator, "that circle, every part of which is at equal distances (*i. e.*, 90°) from each pole;" and lastly, that the points of intersection of the ecliptic with the equator are the equinoxes. We do not offer the above for adoption, but simply as a suggestion, and as evidence that it is practicable to explain the theory of "celestial motions" without the employment of incorrect and absurd hypotheses.

The chapter on Chartography is written by Colonel Jackson, late Secretary to the Royal Geographical Society, and, if we remember rightly, one of the earliest and most earnest promoters of the late College for Civil Engineers. We have selected a portion from this division of the work for quotation, not only because it is most ably written, and evinces a thorough knowledge and perfect mastery of a subject not generally understood, and which we never remember to have seen so well treated of in any previous work, but also because it is sure to interest and likely to prove of no inconsiderable utility to some of our readers, from the fact, that we believe sources of information have been made available in the present instance that before were scarcely accessible. After explaining the different modes of projecting and reducing maps, and the merits of each, Colonel Jackson proceeds to explain the nature and advantages of topographical maps in particular, and gives the following admirable *apercu* of the various methods of drawing and engraving them, so as to represent the undulations of the earth's surface on the flat surface of the map.

Topographical Maps.

Table of the different modes employed in Drawing and Engraving.

Arbitrary.	Etched lines alone, these being	Arbitrary in direction. " " in length. " " in thickness, and " " in distance apart. The light falling at an angle of 45°.		1.
Systematic and Arbitrary.	Etched lines alone, these being	Systematic in direction; being the projections of the curves of greatest slope. Arbitrary in all else. The light falling at an angle of 45°.		2.
	Contour lines and etched lines employed together. This mode is ..	Systematic in the contour lines, which are at equal altitudes, but the altitudes varying according to the scale of the map and the nature of the country. Arbitrary in the etched lines in everything but their length, which is limited by the contour lines, between which they are drawn. The light falling at an angle of 45°.		3.
Systematic.	Contour lines alone	Systematic, as in No. 3, the lines being drawn at equal altitudes, but which vary according to the scale of the map and the nature of the country.		4.
	Contour lines and etched lines employed together .	The contour lines as above. Etched lines.	1. Direction. Length. } Determined. Thickness equal. Spaces one-quarter the co-tangent of slope. No regard to light.	5.
			2. Direction. Length. } Determined Thickness proportional to sine of angle of slope. Spaces as the cosines. Light vertical.	6.
	Etched lines alone	Determined in direction, length, thickness, and spaces.		7.

Besides the above seven modes there are several others, but which must be all classed under the arbitrary, except one, which is mechanical, and of which we shall say a word presently. In some of these the effect is produced by aquatinta shading, in others by stippling. In some maps the hills are represented in perspective; in some the shading is effected by etched lines, straight and waved, and dots, and all other modes which the engraver can devise to produce effect.

Of the several systems above-mentioned, we may observe that, where picturesque effect is all that is wanted, the arbitrary modes are superior to the systematic: indeed, *some maps executed according to this arbitrary method, represent, in the most striking and satisfactory manner, every undulation of the soil, from the gentlest rise to the highest and most abrupt eminences. They accordingly give a very perfect idea of the country, but are of no use for the exact purposes of the engineer, or for the operations of an army.* This is easily conceived. The engineer who has to construct a canal, a railway, or any other kind of road, to form reservoirs, to drain marshes, &c., can be satisfied with nothing less than positive levels, and these the arbitrary modes of drawing hills, however effective they may be, do not supply. In like manner, the general must be able to see upon his map where artillery and other wheel carriages can pass, where his cavalry can act, and where none but his light infantry can advance; what heights command or are commanded, &c.; he therefore, like the engineer, must know the positive amount of the slopes, and must accordingly discard the more beautiful, though to him useless topographical maps, for those where he sees the actual slope and elevation of every foot of the ground.

As an example of arbitrary shading, we may mention the Ordnance Map of England, which can be seen at any time. In this topographical map the effect is produced by etched lines; the light is supposed to fall upon the ground under an angle of 45 degrees, and on the map to come from the left hand upper corner; the shading is regulated accordingly, the greatest depth being given to the loftier and steeper eminences. Another and very beautiful example of arbitrary shading may be seen in the semi-topographical map of Sardinia, lately executed by General Marmora. In both these examples the shading is by etched lines. A map of very excellent effect as regards the hills, and which I shall have occasion to mention for another reason, has lately been executed at Vienna; in it the hills are in imitation of stippling, and the effect is truly excellent.

Of the systematic modes, we shall mention only numbers 4, 5, and 7, of our table; and first, of the method by contour lines alone, or the representation of the elevations of the surface by curves of equal altitude. This method, admitting of a very near approach to geometric accuracy, has for engineering purposes a decided advantage over every other, though in some respects it is not without its inconveniences. As it has been much talked about lately, and is again coming into use, its history, and some details respecting it, may not be unacceptable to the reader.

The first idea of the contour system is attributed by some to Philip Buache, but by La Croix to M. Ducarla, who, he says, considering that if a line were drawn joining all those points on a chart which are marked as having the same depths of water, the contour thus traced would be that of a section cut off by a horizontal plane everywhere distant from the surface of the water by so many fathoms, or feet, as are marked by the soundings—conceived a means equally ingenious and satisfactory of geometrically representing the elevations of the ground, or the *relief* of a country. We shall occasionally employ this term *relief*, because it is both laconic and appropriate, and because we have no other single word, as far as I know, that answers so well. Whether it be to Buache or Ducarla that we are indebted for the first idea of the contour system, it was first published by M. Dupin Triel, in 1784. It consists in projecting vertically upon the plane of the horizon, lines passing through points equally raised above the level of the sea; lines, in fact, which would mark the limits of the ocean, if, by any cause, it should rise to the several heights indicated, in the same way as the lines joining equal soundings would become its successive limits if it were to sink to the depths of those soundings.

The imaginary horizontal planes whose intersection with the elevations of the ground form the curves projected on the map, rise one above the other by equal quantities; the actual amount of the rise, however, depends upon both the nature of the ground and the scale of the map. It is indeed self-evident, upon a little consideration, that in the case of very gently sloping ground, if the altitude of the section be considerable, the curves must necessarily be very far apart from each other, whereas in elevations nearly perpendicular, the projection of sections taken at the same height, one above the other, would almost touch: those of a vertical cliff will in all cases coincide and form but one curve. Accordingly it is found convenient to increase the vertical height of the sections as the hills are more steep, and to diminish it as the ground is more gently undulating.

The necessity of varying the heights according to the scale of the map is evident for a similar reason. For, if while the height of the sections remained the same, the horizontal scale were enlarged or contracted, the same inconvenience would be produced. The vertical distances of the horizontal sections depend also upon the particular purpose for which the map is intended. Thus, while on the plans intended for certain engineering works, the sections may be from two to four or five feet of vertical altitude, in topographical maps they may be much greater. The pure contour system may even be used in general maps, but then the vertical heights are necessarily very considerable. In Dupin Triel's map of France, on a scale of about $\frac{1}{2000000}$th, the first sections, beginning with the sea-level on the coast, rise by ten toises each, where the ground is nearly flat; further inland, where it rises more rapidly, the curves indicate sections taken at twenty toises, then at fifty, then at one hundred. The first are observed in the north-western portion of the country, and the latter in the southern and south-eastern, where the more rapid slopes of the Pyrenees and Jura occur. It is evident that whatever be the scale of the map, contour lines alone cannot convey that expression of relief that results from shading, unless they be exceedingly numerous and close. On a scale of $\frac{1}{10000}$th, or about 6¼ inches to a mile, the relief may be satisfactorily figured by contour lines alone. We do not, however, recommend their adoption where effect is to be studied; they should be reserved for those purposes that require exact levels, as for draining, canal and road making, the *défilement* of fortifications, &c., and in these cases the distances of the curves from each other are much too considerable to picture relief. On the Ordnance Survey the contours lately introduced represent sections taken at the altitude of 25 feet.

When contour lines are drawn upon chorographical maps, it is evident the sections have not been levelled, that is to say, the horizontal planes of equal altitude have not been determined by the usual process employed for small distances. The curves are drawn through points whose altitude has been ascertained by barometrical or trigonometrical means, and the sections are not flat parallel planes, but portions of concentric spheres, whose surfaces are parallel with the convex surface of the ocean. It is much to be regretted that curves of equal altitude, such as those on Dupin Triel's map of France, are not more generally applied; they would throw great light on a vast number of some of the most interesting problems of physical geography. We have a map of Ireland, on the scale of ten miles to an inch, on which five successive curves are drawn at the heights of 250, 500, 1000, and 2000 feet, and the belts between these curves being tinted, produce a very effective picture of the positive and relative elevations of different parts of the country. A map of Hong-Kong has also been contoured in a very successful manner, the scale being four inches to a mile, and the section 100 feet vertical. Indeed, the system we are considering is admirably appropriated for islands, particularly when they are small, for the whole coast-line forms a closed curve, giving the lowest horizontal plane, or starting point, in all directions; whereas in sectional maps, that is, maps of a portion of country, the rectangular edges of the map intersect many of the curves. This inconvenience is in part obviated by the addition of numbers to the curves; the same numbers denoting, of course, the same levels.

Closed curves may represent depressions, as well as elevations, and this is one of the disadvantages of the system; but if the curves are numbered, a little attention will suffice for determining whether the closed curves belong to elevations or depressions. If the number on the innermost or smallest curve be *greater* than that of the curve next to it, the curves are those of an elevation; but if, on the contrary, the number on the innermost curve be *smaller* than that of the curve next to it, the curves are those of a depression. Captain Vetch, of the Royal Engineers, has proposed to add to the contour lines, short etched lines on the side on which the ground falls, which effectually prevents all ambiguity on the subject.

Upon the whole, then, the system of contour lines alone is by no means to be recommended as a means of representing pictorially the inequalities or the relief of the surface on maps; but when positive levels are required, we know of no mode possessing equal advantages. It does not therefore belong to maps constructed for general geographical purposes, but to maps designed for special objects. We now pass on to the consideration of the fifth system of our table.

The French, who attach much higher importance than we do to correct representation of the inequalities of the surface in topographical maps, have at various times considered the subject in committees called together by the government, and composed of the heads of all those scientific departments for whose purposes good maps are essential, such as the état-major, the corps of engineers, civil and military, the mining department, the woods and forests, the department of bridges and highways, and the heads of the several great schools, such as the Ecole d'Application of the Geographical Engineers, the School of the Etat-Major, that of the Mining Corps, that of St. Cyr, &c. These committees have on some occasions sat for three or four years, going most minutely into every detail of the subject, and having the same portions of ground drawn and engraved upon a variety of scales, and according to every variety of mode.

We cannot, of course, enumerate all the opinions that were emitted by these most competent persons, of the respective advantages and disadvantages of the several systems, and their numerous modifications; suffice it in this place to say, that no system has yet been devised that is wholly unobjectionable; that, however, which was at length adopted by the majority, and which is at this moment sanctioned by the government, is that which bears the number 5 of our list.

This system is calculated to offer, as far as possible, the double advantage of geometrical accuracy and picturesque effect. It is a combination of the contour lines with the *hachures* or etched lines, these latter producing the requisite tints of shade, which convey to the eye the effect of relief, and that with so much truer effect, as this very shading is subject to rule, and is determined in strict relation to the contour lines themselves. These latter being determined and drawn upon the map, the space between them is filled up with etched lines, whose length is determined by the distance between two contiguous contours, while their direction is perpendicular to the contour lines; they are accordingly the projections of the lines of greatest slope, of those, in fact, which water, acted upon by gravity alone, would follow in running down the surface. The thickness of these lines is not determined by any rule in the system we are now considering; but whatever it may be, it is uniform throughout, the tint of the shading being effected by the greater or less distance left between the strokes, and this is (except in the extreme cases we shall presently notice) invariably one-fourth of the distance of the two contiguous contour lines between which they are drawn. When the vertical heights of the horizontal sections whose projections form the contour lines of the map are equal, it is evident that the contour lines will approximate so much closer as the slope of the ground is the more rapid; and as the distance between the strokes is regulated by that of the contour lines, it is clear that the nearer the contour lines, the closer will be the *hachures* (etched lines, or stroke of shading) to each other, and consequently the darker the tint or shade produced by their means. Therefore, the steeper the slope the darker the shading, and that without any direct reference to the way, either slanting or vertical, in which the light is supposed to fall. When the contour lines are distant from each other, the strokes of shading, being always one-fourth of the distance between the contour lines, will also be far apart, which of course produces a very faint tint, such as is required for the representation of a very gentle slope.

We have stated that, in extreme cases, the rule of one-fourth of the distance of the contour lines is not observed, and for obvious reasons. So long as the contours run in straight, or nearly straight lines, the strokes which are perpendicular to one of them will also be perpendicular to the contiguous one, and the distance of one stroke from another will be everywhere the same. But when the contour lines form curves, the distance of one-fourth being taken on the upper line, and the strokes drawn perpendicular to it, these strokes naturally diverge as they descend, so that at their contact with the next curve their distance is greater. If the distance between these curved contours be not great, the divergence of the strokes of shading is of little consequence; but if the contours are wide apart, and the strokes therefore long, the divergence becomes an object worthy of attention; and accordingly, in such case, the distance of one-fourth is taken, not upon the contour lines themselves, but on one drawn for the purpose midway between the two, so that the strokes are brought closer together, and the inconvenience of excessive divergence is remedied.

The other extreme case is the opposite of the one just explained—namely, when two consecutive contours approach nearer than two millimètres (about the ·08 of an English inch). In this case, as it would be next to impossible to draw four strokes of shading in so small a distance, the law of one-fourth gives place to an increased thickness in the strokes themselves, by which the very dark tint required for the shade of such rapid slopes as the contiguity of the contours indicates is equally well effected.

Such, then, is an idea of the fifth system on our list, and which is that generally adopted in France, and also in the United States, where they have learnt it from the French; and some of the topographical maps lately executed at New York, according to this system, are extremely beautiful. The sixth system of our table, which is that advocated by Colonel Bonne, was sanctioned by the French government, in 1828, for the Dépôt de la Guerre, more especially for such maps as were to be engraved. It differs from the fifth, but they both combine the two great requisites of geometrical accuracy and picturesque effect. The contours being preserved, are easily traceable by breaks in the continuity of the shading strokes or etched lines; every gradation of level is marked for engineering and military purposes, while the shading figures at once the undulations of the surface and points out the several degrees of inclination of all the slopes of the ground. Let us now pass on to the seventh system of our list.

In Germany and some other countries, the mode of representing the inequalities of the surface in topographical maps, differs essentially from the French systems we have just noticed. That generally adopted, though slightly modified in different places, is known as Lehmann's, or the Saxon method. In it there are no contour lines; the slopes or inequalities of the surface are represented by etched lines, or *hachures*, alone, but then the thickness of these, and their distances apart, are regulated according to scale, so that a determined proportion is maintained between the rapidity of the slopes and the intensity of the shading by which they are represented. The direction of the strokes is that of the greatest slope; their thickness and distance apart is determined as follows:—

The light is conceived as falling vertically upon the ground, and, accordingly, the different parts of the surface will be more or less illumined as they are more or less inclined to the supposed vertical rays of the sun. A horizontal surface receiving the full effect of these rays, will, in nature, be the lightest, and is therefore represented on the map without any shading; while a highly inclined cliff, receiving few of the vertical rays, will be very dark in nature, and is accordingly represented by a very dark shading on the map. To determine a regular gradation, however, between the most and the least illumined surfaces, the following system was determined on.

The angle of 45° was regarded as the greatest natural slope of the ground, and this was supposed unilluminated. From this inclination down to the horizontal, all intermediate slopes were supposed to be illumined inversely as the angles of elevation, and hence the angle of any slope less than 45°, and its supplement, or what it wants of that number, were considered as the proportional terms of light and shade on any declivity. Thus the proportion of light and shade on a declivity of 5° was said to be as 40 to 5, or 8 to 1;—on a declivity of 10° as 35 to 10, or 3½ to 1;—on a declivity of 15°, as 30 to 15, or 2 to 1, &c. These suppositions,—viz., that a slope of 45° is the greatest natural slope of the ground—that such a slope receives no vertical light—and that the quantity of light received by all slopes of less inclination than 45° is in proportion to such inclination, are perfectly gratuitous, the facts being—1. That 60° is the greatest natural slope of the soil;—2. That a slope of 45° receives a very considerable quantity of vertical light; and 3. That the amount of vertical light received by any slope whatever is exactly in proportion to the cosine of the angle of such slope. Hence it is clear, that though the Saxon method of representing the relief of the ground be systematic, it is by no means natural: it is, in fact, a conventional system, whose practical execution is thus effected:—

All slopes of 45° and upwards are represented on the map by absolute black. All slopes below this, down to the horizontal, are represented by graduated tints of shade growing lighter as the declivity is less, till, at the horizontal, the paper is left perfectly white. As it would be impossible to represent every minute difference of inclination from 45° to horizontality, or to pass from absolute black to perfect white, so that the eye could at once detect the difference between contiguous shades, the tint is effected by nine different grades of shading, each indicating a difference of 5° in the slope. The mechanical means employed to produce these nine different tints is by *hachures* drawn in the direction of the greatest slope, and the thickness of these *hachures*, or etched lines, bears the same proportion to the white space left between them that the angle of the slope to be represented bears to what it wants of 45°. Thus—

Angles.		Hor.	5°	10°	15°	20°	25°	30°	35°	40°	45°
Proportion of	Black	0	1	2	3	4	5	6	7	8	9
	White	9	8	7	6	5	4	3	2	1	0

If the slope to be represented be one of 30°, its complement, or what it wants of 45°, is 15°, which being the half of 30°, the black lines will be twice as thick as the white spaces left between them, and as 45° is represented by perfect blackness, and from this to perfect whiteness is divided into nine grades of shades, it is clear, each of these grades becomes lighter than the other by one-ninth; 45° having the whole nine parts black, 40° will have eight black and one white—35° will have seven black and two white—30° six black and three white, and so on, as in the above table; whence it is seen that, while the shading for a slope of 30° is produced by *hachures* whose thickness is to the space between them as 6 to 3, or 2 to 1, that of a slope of 15° is produced by *hachures* whose thickness is to the white space between them as 3 to 6, or as 1 to 2. The tints thus become successively lighter as the rapidity of the slope diminishes, and although the progression is not a natural one, it is invariably determined by a conventional scale, so that, if strictly adhered to in practice, not only the relative steepness of the hills is picturesquely represented so as to produce the sentiment of relief, but the positive amount of the inclination is shown; and further, as the length of the slopes on the maps is the horizontal projection of such slopes, it is evident that this, the Saxon, or Lehmann, system, supplies the means of obtaining as correct a profile of the ground as the contour system of the French. Unfortunately, however, the practice of this method does not answer to the theory. In the first place, it is exceedingly difficult in execution. No draughtsman, whatever skill he may have acquired, or however careful he may be, can keep strictly to the thickness of the strokes, and to the distance between them, required by the scale, and without the most perfect accuracy in this respect, the system loses its chief advantage. The labour of drawing such myriads of small strokes fatigues the eye, and diminishes its faculty of discriminating the thickness of the strokes and the breadth of the spaces between them; the hand becomes unsteady, the pen wears thicker, the ink evaporates while you are working, and thus, insensibly, you are drawing a slope of 5°, 10°, or 15° greater steepness than you should do; and even supposing the most favourable case of very exact and clever draughtsmen, there is seldom uniformity between the several parts of the same map when executed by different persons; the engraver may also falsify the whole; and if we add, that when the slopes are not taken in the field with instruments, but merely by the eye, they cannot be mathematically correct, and that, accordingly, a profile drawn from the map, may give heights very different from what they are in nature—it will be evident that the German method, though ingenious, though systematic and beautiful when carefully executed, is liable to so many defects in practice, as still to leave room for something more perfect, more easy of application, less tedious, less expensive, and more readily understood by the public at large, for whom, after all, maps are made.

We must confess, we fear, that in addition to the intrinsic worth of the chapter, we have been led to select the preceding passage for quotation from the fact that it contains the truest estimate we have met with for a long time of the proper value, to practical engineers and surveyors, of the Ordnance Map, which has cost the nation so much money, and of which we have heard so much boasting in certain quarters. We certainly knew that, except for "pictorial purposes"—to show a projected line of railway in a district in which "no engineering difficulties existed," and thereby dazzle a select committee of the House of Commons, and fascinate reliant shareholders, to the great benefit of the promoters—the Ordnance Map of England was of no utility; but we certainly were not prepared for the preceding frank avowal contained in the two passages we have printed in italics.

The other portions of the first Part of the 'Manual'—embracing "Physical Geography," by Professor Ansted, whose excellent treatise on geology was noticed at the time of publication in this *Journal*, and "Theory of Description and Geographical Terminology," by the Editor—we must defer noticing till the publication of the second Part.

Designs for Monuments and Tombs.—By D. A. Clarkson. 1852. Parts 1, 2, and 3.*

The professed object of the author of 'Designs for Monuments and Tombs' is meritorious in a twofold point of view—to induce the more general adoption of artistic forms in the monuments themselves, and the due subordination of their accessories, so that all things in a cemetery may be in keeping with the mournful purpose to which it is devoted.

Although not a subject likely to attract very considerable attention, nor to create any great amount of interest, there are few disinterested parties, we imagine, to be found who will venture to deny that some sort of authority—municipal by preference—is needed, which, without adopting a course of action at once officious and offensive, shall yet command sufficient respect, or, if necessary, power to effect a reform in those laws and customs which regulate the interment of the dead. We do not allude to the thrice-vexed question of burial *intra muros*, although that is most important, for within the walls of a busy city cannot be deemed fit resting-place for those who "sleep the last sleep." Our present purpose is to deal with structures *in memoriam*, which, from their gross violation of the simplest canons of art and laws of propriety, desecrate some of our noblest devotional edifices, and even the poorest churchyards.

The indifference to these matters of those high in place and in authority, who should set an example—which is amply evidenced by the grotesque and outrageous productions in St. Paul's and elsewhere—has induced Mr. Clarkson to address himself directly to the public, in the belief, we fancy, that as it is with them the improvement will originate, it will be much facilitated by bringing under immediate observation specimens of artistic and appropriate designs. The Parts already before us are very creditable samples of his good taste, both in design and treatment of the subject, and will serve as admirable text-books and authority not only to those who have the erection of sepulchral monuments, but also to those who have the supervision of our churches and cemeteries. If carefully perused, as they deserve to be, we may hope to see workers in stone controlled by the principles of good taste, and the writers of epitaphs subjected to the rules of common-sense. As an apt example and lesson to us, Mr. Clarkson quotes the practice of the Romans: "Faithful to the consistency of good taste," he says, "they never conceived (as has been witnessed lately in some cemeteries) the revolting and ridiculous idea of enlivening them. They excluded from their sepulchral decorations the myrtle and rose, consecrated to love and banquets; and the hyacinth and hawthorn, which are appropriate to Hymen. Neither would they have introduced sculpture associated with heathen mythology—the butterfly, the circular serpent, the sepulchral lamp, and the reversed torch—in Gothic sepulchres."

* Published by the Author, 5., Regent-street

Tables for Calculating Cuttings and Embankments required in the construction of Rails, Railways, Canals, Dams, &c.; applicable to every variety of ground, and extending for heights or depths every tenth of a foot, from one-tenth up to seventy feet, with Explanations and Examples. By James Henderson, C.E. and Architect. London: Weale. 1852.

The Practice of Embanking Lands from the Sea. By John Wiggins, F.G.S. Parts I. and II. London: Weale. 1852.

Since the publication, in 1847, of Mr. Bashforth's tables for calculating earthworks, engineers and surveyors have been favoured with several productions of a like nature, all professing to have for their immediate object the diminution of the labours of practical men, by the simplification of formulæ, the reduction of operations, and the construction of tables, which while compressed within an easy limit, are capable of being rendered very comprehensive. The fact of such publications appearing we look on as most satisfactory and cheering evidence that students of the abstract and transcendental sciences are becoming gradually more alive to the wisdom and duty of their rendering their studies useful and available to some practicable purpose. To Mr. Bashforth belongs the honour of the initiative; and we rejoice to see that his example has been also followed by gentlemen who have risen to eminence in their profession, and to have proof that they are desirous to place the results of their matured knowledge and practical experience at the disposition of their humbler brethren. With this view Mr. Henderson has published his "Tables." They possess the merit of being concise and simple, for while in tables computed from the present formula for calculating the sides of cuttings or embankments—$\frac{1}{3}(a^2 + a\,b + b^2)$ L, a and b being the height and depth of the cutting or embankment at each end—it is necessary to give separate quantities for every variation of a and b, in tables computed from the new formula, the adoption of which is advocated by Mr. Henderson—$(H^2 + \frac{1}{12} D^2)$ L, H being the mean height or depth, and D the difference of height or depth—only one quantity is required for all heights or depths having the same mean, and one for all heights and depths having the same difference.

Again, "to carry out a table for the pyramidal or side parts of cuttings and embankments, based on the old formula, for every tenth of a foot of height or depth, from one-tenth up to fifty feet, upwards of 125,000 different quantities are required; but by means of the new formula the whole can be comprised within 1000."

To our professional readers, the preceding sketch of the advantages which these tables promise to realise, by simplifying the solution of engineering problems, will be sufficient to enable them to appreciate the value of Mr. Henderson's proposed formula. For ourselves, we believe that it has only to be known to be adopted.

The great impetus which the development of railways has given to the theory and practice of constructing earthworks generally, cannot fail, we think, to exercise a most beneficial influence upon that branch of civil engineering which has for its object the reclamation, by means of embankments, of land from the sea. These great and national undertakings have gradually led the way to the scientific investigation of the best forms to be given to banks to enable them to support great weight and resist the pressure of large bodies of water, whether flowing from land springs or the sea. The result of the superior knowledge and practical skill thus acquired will tend to simplify and facilitate the construction and reduce the cost of all sea embankments as compared with those of former periods. At a time, too, when the completion of our system of railways will naturally compel engineering talent to look to other channels for useful and profitable employment, we know of none to be preferred to that which will augment the too narrow limits of our country and increase its productive powers. The appearance, therefore, of Mr. Wiggins' admirable treatise (Parts I. and II. of Weale's Rudimentary Series) upon 'The Practice of Embanking Lands from the Sea,' we hail as peculiarly opportune, as likely to direct the attention of landowners and capitalists to the subject. With this view we subjoin the following extract:—

The best soil for an intake, therefore, is that clayey earth whereon sufficient marine herbage grows to afford sheep-feed of some value, and this will be above the level of ordinary tides.

The next best is silty earth, with sheep-feed like that already mentioned as found on the Lincolnshire coast.

The third is mud-banks with samphire, over which the spring-tides always flow.

The fourth is mud, over which the tide always flows more or less, and this is eligible in proportion to its clayey matter.

The fifth is what is called sheer sand, which is almost barren, except as to a few plants, such as the *eringo*, the *sand-rush*, &c.; but sometimes even this sand is rendered to a certain degree fertile by the calcareous matter of comminuted shells, or may be rendered fertile by raising on its surface the marly substance sometimes found beneath.

A sixth class may be designated in those sandy and shingly dunes, which continue for ages bare of vegetation, and are not worth embanking on account of local value; and these must be deeply covered with mould to enable them to grow anything.

LAMBETH WATERWORKS.

The Lambeth Water Company, who have heretofore had their works on the banks of the Thames between Waterloo and Westminster Bridges, have been compelled by force of circumstances to meet the public demand, to remove their works for the purpose of giving a purer and better supply of water. The new works are situated at Ditton, on the south bank of the Thames, and at a short distance above Kingston; they have been erected, at a great expense, under the advice of the Company's engineer, Mr. James Simpson. The works were opened for the first time on March 30th, the occasion being commemorated by the attendance of a numerous body of members of parliament, directors, scientific gentlemen, and others connected with the parish.

The new works are erected on a piece of ground which has been embanked for a considerable length by piling, and parallel thereto, at a distance of 20 or 30 feet, have been constructed the filterers; there are four, each having two longitudinal chambers with segmental ends, 45 feet wide by 75 feet long at the springing, and 90 feet long including the circular ends; they are 30 feet deep, but the upper 13 feet is carried up for keeping out the flood water only. The water is taken in from the river through two vertical cast-iron gratings, with fine copper-wire screens placed inside; and thence through a 36-inch culvert running between two filterers, and with a branch on each side furnished with 30-inch sluice-valves for delivering the water into the filterers on either side, where it is received in a semicircular chamber carried up to the top of the filtering media. As the water flows into this chamber, it gradually rises and flows over on to the surface of the filtering media. The reservoirs are 31 ft. 7 in. deep, including 1 foot foundation of concrete, 3 inches brick paving, 4 feet storage for filtered water, 4-inch slate slabs with open joints, upon which is laid the filtering media, consisting of 18 inches of coarse Thames ballast, then 18 inches of cockle shells, then a layer of coarse sand, and lastly fine Thames sand—in all 5 feet thick; over which there is a body of water, 5 feet deep. As the water percolates through the filtering media, it passes into the storage below, and thence through 30-inch culverts furnished with 30-inch valves to the well under the engine-house.

The superficial area of each filterer is about 7800 feet, and of the four 31,200 feet super; and if ½-pint of water be allowed to each superficial foot per minute, it will give a total filtering power of about 2¾ million gallons per day of 24 hours, supposing all are in action. Of course, if a larger quantity be filtered per minute, then the quantity we have taken as the total filterage will be increased.

The engine establishment consists of four steam-engines constructed from the designs of Mr. James Simpson, the Company's engineer; they are of 600-horse power collectively, and are capable of pumping 10,000,000 gallons of water daily into the Company's reservoirs at Brixton, and they can be linked so that any two of them may be worked as one engine of 300-horse power. They are of the kind known as the double or compound cylinder (high and low pressure) expansive engine, with all the latest improvements, among which may be particularly mentioned the patented improvements of Messrs. Pole and Thomson. They are economical in fuel, and possess considerable advantages in all other respects, and they are excellently adapted for pumping purposes, and meet the peculiar requirements of the present case—one of considerable difficulty, owing to the great length of the pumping main. The engines have compound cylinders for working high and low pressure steam. The smaller cylinder is 24 inches diameter and 5 ft. 6 in. stroke, which receives the steam at 30 lb. pressure; it then passes into the larger cylinder, 48 inches diameter and 8 feet stroke, and by expansion is reduced down to 5 lb. steam, when it passes into the condensers. The engine-beam is 28 feet long, connecting-rod 24 feet, and cranks 4 feet radius, fixed on to a rotary shaft, with a large fly-wheel for each pair of engines.

The pumps are double-acting, with bucket and plunger, requiring only two valves (instead of four valves, with side pipes, as in the ordinary double-acting pump). The outer cylinder is 23⅜ inches diameter, and 7 ft. 8 in. stroke, and the plunger 16½ inches diameter, inside measure. The pumps are connected to the engines in such a manner that when any two are worked together, a constant and regular flow of water is insured through the main pipe. The water passes through the barrels of those pumps, direct into the main, without the stoppages and concussions incident in the ordinary four-valved double-acting pump. The engines and pumps, and the apparatus connected with them have realised all the expectations of the Company's engineer, particularly as regards steadiness and quietude of motion and the equable flow of water in the main, the oscillations of pressure when the pumps are at work being scarcely perceptible. The engines, boilers, and pumping machinery, have been constructed and erected under the immediate superintendence of Mr. David Thomson, the manager of Messrs. Simpsons' Works, Pimlico.

The boilers are nine in number, are cylindrical, 31 ft. 6 in. long, and 5 ft. 6 in. diameter, each having an internal furnace tube running its whole length. The boiler fittings are so arranged that any one or more boilers can be shut off while the rest are at work. The engines and boilers are placed in fire-proof buildings adjoining each other. The chimney-shaft is 100 feet high, and is concealed in a square tower. The Company's engineer, by adopting this kind of steam-engine and pump, has been enabled to design these buildings so as to give sufficient strength, and secure perfect steadiness, and at the same time to avoid the expense of great masses of material and to obviate the necessity of resorting to the expedient of a costly standpipe.

The aqueduct or main pipe by which the water is conveyed from the engines at Ditton to the Company's reservoirs at Brixton, is 10½ miles in length, and formed of cast-iron pipes, 30 inches in diameter. The main pipe was cast by the well-known firm of Cochrane and Co., of Woodside Iron Works, near Dudley; the weight of iron in it is about 8000 tons. It is provided at various intervals in the length, with stop-valves, for preventing the back flow of the water, and all necessary apparatus for emptying, draining, and allowing for the escape of air. It has been laid by Mr. William Baker, of Bristol, under the superintendence of Mr. John Brough Palmer, the resident engineer.

PILBROW'S WATER WASTE PREVENTER.

This article, manufactured by Guest and Chrimes, of Rotherham, is introduced for the purpose of detecting and preventing waste of water supplied to the inhabitants of towns by waterworks, whether such waste be wilful (as is too often the case amongst the inconsiderate occupiers of cottage property), negligent, or accidental from leakage or bursting of pipes, leaving open taps, &c., and is especially applicable, and may be said to be almost indispensable, where water is supplied on the "high-pressure" and "constant-supply" system. When it is considered that under this system, at a pressure of say 150 feet, the smallest tap in ordinary use—viz. ½-inch, will, if left open for only one night of ten hours, waste from four to five thousand gallons of water, it will be most manifest that any article which will prevent a waste of such serious magnitude is one that must fairly claim immediate attention, and insure extensive adoption.

The Water Waste Preventer is calculated and guaranteed not only to remove this difficulty, but also to obviate the necessity of stop-cocks, as these will be no longer required for the purpose of shutting off water whilst repairs are being made to taps and pipes in consequence of leakage, the removal, or repairs of broken taps or service pipes, bursting of pipes from frost, or any other ordinary cause.

FIG. 1.

FIG. 2.

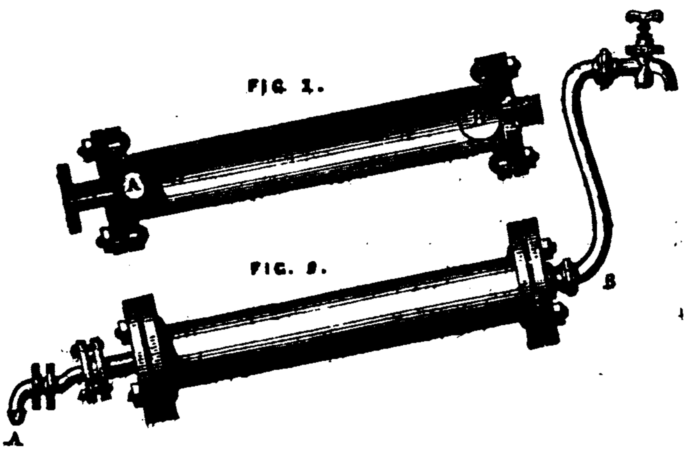


Fig. 1 shows "the Preventer" in section with the ball in two positions, one as when the supply of water has been drawn, and the ball thereby brought to the top of the tube, closing the service aperture, as at B; the other when all is shut off, as at A. Fig. 2 shows "the Preventer" with ferrule for connecting to the main pipe, as at A, and to the service supply pipe, as at B. It consists of a tube of cast-iron, or other material, having flanges at each end, one to attach to the main supply pipe, the other to the service supply pipe; a ball of peculiar material and gravity is inserted in the tube. The tube when attached to the main supply pipe, is laid at an elevation varying according to the pressure at which the water is supplied, the service end being the highest; if there is no leakage or draw upon the pipes, the ball will be, and remain at the bottom of the tube, as shown at A; but when water is required to be drawn, and the tap is opened for that purpose, or should the pipe be burst, or water running to waste from any cause, the ball immediately and gradually ascends until the quantity of water the machine is intended to deliver has taken place, when the ball will have moved to the top of the tube (as at B), and closed the aperture of the service supply pipe, and the delivery will have ceased until the tap be closed, or the defects remedied, when the ball will return again to the bottom of the tube, and further deliveries in succession may be obtained. From this it will be seen that waste of water from the taps being left open for a longer time than while the required and limited delivery is taking place, IS IMPOSSIBLE. After such delivery has taken place, and whilst the tap continues open, the ball will remain at the top of the tube, closing the service pipe aperture so as that the merest driblet can escape. And this will be the case under all the circumstances from which undue waste of water arises—whether from wanton mischief done to the pipes or taps—from bursting or other leakage of pipes—from taps in houses, yards, or water-closets being left open, or any other cause, wilful or accidental.

ON FIRE-ARMS AND PROJECTILES.

By G. Buchanan, C.E.

[*Paper read at the Royal Scottish Society of Arts, March 8th.*]

This paper gave an account of some experiments made on the Minié rifle at Dalmahoy Moss, by Messrs. J. Dickson and Son, gunmakers, Edinburgh, and was introduced with some observations and experiments by Mr. Buchanan on the general subject of gunnery, which, he observed, had engaged the attention of the most eminent philosophers and mathematicians of modern times, but the history of which, more than that of any other science, read to us the sober lesson of caution in scientific inquiries, and the necessity of combining with our researches a continual reference to practical experiments. It was in the year 1638, just about the period of the dawn of knowledge in Europe, that the illustrious Galileo proved, from the doctrine of falling bodies, then discovered by him, that every projectile must move in the curve of a parabola: a striking, and no doubt beautiful law of motion, and quite true in an unresisting medium, but totally inapplicable, as it turned out in practice, from the neglect of one element—the resistance of the air—which in those days, though weighed for the first time in a balance by Galileo himself, was yet commonly considered, if material at all, far too thin and aerial to have any influence in comparison with the explosive force of gunpowder. Half a century after this, we find the celebrated Dr. Halley—no doubt from imperfect experiments—still maintaining before the Royal Society the parabolic theory as a safe guide. Some allowance might be made in small shot, but the rule would hold, he says, in "shooting great and weighty bombs," as if "this impediment (the air's resistance) were absolutely removed." Practice and experience showed the fallacy of this opinion, and the profound researches published shortly afterwards in the 'Principia' of Newton, on bodies moving in resisting media, led to more correct notions. From the weight of the air, it was by these calculated that the resistance to a leaden bullet ¾-inch diameter, and weight 1⅛ oz., would not be less than 4 lb.—an amount not to be overlooked, being fifty times the weight of the ball itself. This resistance is not surprising, when we consider the effects of a hurricane of wind, which never exceeds forty or fifty miles an hour, while the ball, as it issues from the piece, generates against itself something like a blast, exceeding a thousand miles an hour. Still the calculations of Newton, though true enough in slow motions, came far short of the reality, by not considering the extraordinary swiftness of the projectile; and it was not till the celebrated researches and practical experiments of Benjamin Robins, at Woolwich, confirmed by those of Hutton, that the true law of projectiles was developed and established on a sure basis. Robins showed that the resistance on a three-quarter inch bullet, instead of 4 lb. exceeded 18 lb.—being 120 times its weight. These discoveries changed the whole aspect of gunnery. The Galilean theory, with the initial velocity, now accurately determined, would have given a range of fifteen or sixteen miles, but actual practice had never exceeded two miles, or three miles at the utmost, in any case. But another unexpected and equally important discovery was made—that the air not only retarded and circumscribed the range of the projectile, but created, by its unequal resistance, the most extraordinary deviations from the line of aim to the right or left, and this even to a still greater extent than the contraction of the range in the vertical plane. This is the true cause of the limited power and uncertain aim of ordinary musketry, in regard to which some careful experiments were made with percussion muskets at Chatham in 1846, which show this effect in a striking light. At a range of 100 yards, the deviation from the mark amounted to 4 ft. 8 in.; at 200 yards it was 9 ft. 9 in.; and at 300 yards no less than 19 feet. Nor was this owing to any inaccuracy of aim. With the musket fixed on a stand, and pointed precisely on the object, still at 200 yards, not one ball in ten struck a target 11½ feet high and 6 feet wide. Hence it appears that, beyond 150 yards, the fire of a musket is quite uncertain; and at 500 yards the chance of striking any one man is so exceedingly small as to be next to impossible. These irregularities are ascribed partly to a rolling motion acquired by the ball in the smooth barrel, and partly to the unequal effect of the air's resistance on the different sides of the ball, whereby there arises a whirling motion, which Robins discovered in every ball, of a very irregular character, and causing a most devious in place of a direct course. To correct these evils, the idea was conceived, but by whom is unknown, of launching the ball from the piece with a determinate rotatory or whirling motion, communicated by means of a spiral groove cut within the smooth surface of the barrel. This constitutes the principle of the Rifle, by which the ball, instead of being allowed, as formerly, to whirl at random, receives a rotatory motion on an axis parallel to the line of fire, and by which its aberrations are confined within narrow limits. If the ball, for instance, makes only half a turn in a barrel 2½ feet long, it will make a whole rotation every 5 feet. Any deviation, therefore, in this little interval, instead of going on as formerly, extending and accumulating in proportion to the distance, is corrected, and the ball brought back to its true path. This principle, therefore, is extremely simple, and one more ingenious is scarcely to be found in the whole range of mechanical invention. It is difficult, not in the field, to exhibit the effect practically; but Mr. Buchanan gave a striking illustration, by a simple experiment of dropping from the ceiling disks of thin wood or card, on the principle of the parachute. These, when dropped simply, deviated from the vertical line, and fell on the floor greatly to the right or left of the mark, in consequence of the disk having a lean to one side, whereby the air's resistance acting obliquely, turned the disks aside. The same disks, with the same lean to the side, being dropped with a whirling motion communicated by the fingers, fell right down on the centre of the mark. From the singular effects of this principle of rotation, it was suggested whether it might not have some part, on a great scale, in preserving the regularity of the earth's and planetary motions, where we see the principle of rotation prevailing universally—ordained, no doubt, for other grand purposes, but still, possibly, contributing in this manner, in subordination with other laws, to that wonderful harmony which pervades the system. In regard to the rifle, the soundness of the principle has been tested and proved by the use and extension of this weapon all over the world. Hitherto its application in military practice has been limited, owing to the loss of time and careful adjustment required in loading the piece. But improvements have been long going on, particularly on the Continent; and the great object has been to introduce balls, such as have been long used in rifles, of an elongated or cylindro-conical shape, and small enough to pass easily, like the musket-ball, down the barrel. This was tried many years ago by Delvigné in France, by dropping the balls into the chamber and then enlarging them by blows from the ramrod so as to fill the grooves. Another plan, in the musket termed "Carabine à tige," was to form a hollow in the after-end of the long balls, and drop them on a small stem standing up though the breech, and this penetrating the hollow, and there acting as a wedge, enlarged the sides, and pressed them into the grooves. This plan was liable to objections. But the last and greatest improvement appears to be that of Captain Minié, of the French service, by introducing a small iron cup to close the hollow in the after-end of the ball, and the explosion of the charge driving this cup into the hollow and compressing the included air, the effect is to expand the whole body of the ball, and press it effectually into the grooves of the rifle. From these improvements, and the great attention which has been paid to the subject on the Continent, particularly in France, Norway, and Prussia, and the remarkable accounts which have been given of the successful results in actual warfare, it appears as if the general introduction of this improved firearm is not far distant; and no doubt, for good or for evil, it seems destined to bring on important changes in military tactics, and the formation of armies. On these accounts, and from the general interest now excited, Mr. Buchanan had requested Messrs. Dickson, whose attention had been much turned to the subject, to give the Society an account of their views and most interesting experiments at Dalmahoy.

Mr. Dickson then addressed the meeting. After adverting to the efficient use of the rifle in the hands of a steady marksman, he gave an interesting account of the practice in Switzerland, where the rifle is used as a pastime as well as a truly national amusement—the landholders as well as the peasants mingling in the competition for the prizes; and by the spirit of emulation thus excited, the natives of this mountain range have attained a perfection exceeding that of any other country, and forming a band of efficient men, ready, at a moment's notice, to turn out for the national defence. Rifle companies, in this country, would no doubt form a powerful auxiliary to the regular army. As to the best rifle for convenience and quick loading, there were many conflicting opinions. The subject had long engaged their attention, and they would give shortly the result of their experience. Since the days of Robins, all sorts and shapes of balls have been tried; and, indeed, as far as they know, out of the many brought forward, few can be called new. The reported success of the Chasseurs de Vincennes in Africa and at the siege of Rome, and the accuracy of their shooting, has raised a spirit of deeper inquiry into the subject than formerly. The description and principle of the rifle they had just heard from Mr. Buchanan. Oval balls had at one time many friends, and were used in India for buffalo shooting, but are now out of repute. Four-grooved balls were also in great esteem—both conical and spherical; they did not answer for long distances, owing to the increased friction in the barrel retarding their flight. Three-grooved balls had also their advocates a few years ago, but after repeated trials, they were rejected on similar grounds. About twelve years ago, after long and repeated tests, Messrs. Dickson had adopted the two-grooved rifle, and found, in regard to the degree of spiral, that a quarter turn in a barrel of 30 inches was preferable to any other, that being sufficient to give the rotatory motion, with the least possible friction, the ball only turning on its axis once in seven yards. A full turn shoots as correctly at a short distance, but at a long range varies much more. The conical ball has a decided advantage over all others for correct shooting at a long range, and to the sportsman is quite invaluable; but as a projectile in active warfare, it is totally useless, the lobes or projections on the sides requiring correct fitting into the barrel, not attainable in the hurry of warfare, or under any excitement; and this has been borne out by the experience and bitter disappointment of our gallant Rifle Brigade in the hour of need. They would now advert to what had excited such a sensation, namely, the Minié ball and rifle-musket which was shown, being one of those intended to be introduced into the service; there was also shown drawings and models on a large scale of this and other forms of ball. The Minié ball has a hollow in the back part which serves to throw the centre of gravity forward and assist the ball in its flight. Into this hollow is inserted an iron cup, which, on the ignition of the charge, is forced up into the hollow, causing the ball to swell out and fill the rifle grooves. For the purpose of general warfare, this rifle and ball is preferable to any now in use, chiefly from the great facility—equal to that of an ordinary musket—with which it could be loaded, and it was shown how easily the ball on entering the muzzle could drop into its place in the chamber. Anxious to try the effects and ascertain the truth of the many statements circulated about it, Messrs. Dickson and Son procured this musket (one of those about to be introduced into the British army), and, through the kindness of the Earl of Morton, they got permission to use his grounds at Dalmahoy Moss, where they had, in presence of Colonel Montgomerie of the Artillery, and other competent judges, a fair trial along with their two-grooved and other rifles. The target was five yards square, and the shooting at 900 and 1100 yards. The Minié rifle-musket and Minié balls shot with surprising accuracy, the balls being carried well forward, and at the end of the shooting the target was fairly riddled. The ordinary two-grooved rifles shot as well, and with this advantage, that the balls went quicker to the object, taking as near as could be calculated 2½ seconds for the 900 yards, while the Minié balls took from 3½ to 5 seconds for the same distance. The result might be summed up thus:—The Minié rifle-musket as a weapon of general warfare, is a decided improvement on the old musket; still the Minié musket shown to the meeting might be greatly improved to insure its efficiency, as well as to render it a weapon easier to handle, without detracting from its powers; and if a body of men were picked out of each regiment, properly trained to its use, and practised at the long range, they would be a great acquisition to the regiment, besides well fitted for the annoyance of artillery, and even cavalry, at a distance; and, for guarding a pass or defile, powerful and effective auxiliaries. A good deal having been said lately on the Prussian needle-igniting musket, they showed one of these, and explained its properties, and the serious defects to which it was liable.

Mr. Mortimer, at a subsequent meeting of the Society, brought under notice his improved mould for Minié bullets, and commented upon the Minié and other balls, showing the advantage of the former, and their applicability to every description of rifling. He stated that, by casting the Minié ball with a certain shape of cavity, he found no occasion to use the iron capsules at all, because the ball expanded quite as well without it, and shot as truly. The cavity in the lead was not made so deep. He also mentioned that it was quite a common thing to find that the iron capsule falls out of the ball after it is fired off, and frequently also turns half round in the cavity of the ball. Upon the whole, then, Mr. Mortimer considered that the capsule may be advantageously dispensed with. Mr. Mortimer illustrated his subject by a diagram, showing various forms of bullets, and gave an account of various interesting experiments carried on by him during the last three months, at distances varying from 150 to 1000 yards—at which latter distance the target was struck by his improved Minié ball nine times out of ten consecutive shots.

INSTITUTION OF CIVIL ENGINEERS.

March 30.—James M. Rendel, Esq., President, in the Chair.

The Paper read was "*An Account of the Drainage of the Town of Richmond, Surrey, under the authority of the Metropolitan Commissioners of Sewers, in* 1851." By George Donaldson, Assoc. Inst. C.E.

The drainage of Richmond, extending over an area of about 320 acres, was undertaken by the Board in the year 1849, on the application of some of the principal inhabitants, when the author was appointed to report on its then state, and to propose some general plan for its improvement. At that period, all the sewage was collected into cesspools, the liquid contents of which were allowed to drain into the earth, causing offensive exhalations from its surface, and contaminating the water in the adjacent wells, from which a large portion of the house water-supply was drawn, whilst the cesspools themselves were seldom emptied. In many of the streets, however, there were brick drains, which had been from time to time constructed, for carrying off the surface and storm waters; but these were not deep enough to receive the house drainage, which it was determined to effect by means of tubular stoneware pipes, entirely independent of and separate from the brick drains, thus practically carrying out a system on which very different opinions had been entertained. At present the outfall of the sewerage was into the Thames, near the railway bridge; but eventually a main outfall sewer was to be constructed to connect Richmond with the general system of sewerage of the metropolis. The pipe sewers were about 50,000 feet in length executed at a cost of about 7500*l.*, rather more than half consisting of minor or branch sewers. The branch pipes, as far as the kerb of the foot-pavement, were laid down at the same time as the main pipes, each junction being formed at an acute angle, and so arranged as to receive the drainage of three houses. Before being laid in the trenches, the pipes were fitted together and marked, and afterwards packed solidly round with earth. In some of the wet sandbeds it was considered advisable to lay the pipes on 2-inch deals, 4 inches deep, fastened to stakes. The joints were made with well-tempered clay and cement, and it was very important that they should be watertight, for otherwise one of the chief advantages of pipe sewers over brick drains would be lost. After their completion, the pipes were proved, by allowing a flush of water to pass through each separately for about fifteen or twenty minutes. All the inlets to the house drains were trapped with syphons, or bell-traps; and the works generally had been perfectly successful.

In the discussion which ensued, the comparative merits of the systems of separating the storm water from the house sewerage, and of combining them in large sewers, were argued at great length. It was admitted that the separate system had not yet been tried for a sufficient length of time to arrive at definite results; but, as far as experience had hitherto gone, there was a general impression in favour of the combined system in main sewers of brick, not less than 4 feet high, in order, not only that men should pass easily up them, but that they should be able to work in them. The pipe drains even of 21 to 24 inches diameter were liable to be choked by deposit, and their areas had been so reduced, even where the separate system had been employed, that stoppages had continually occurred; thus proving that the exclusion of road-drift was not entirely efficacious. It was shown, also, that whenever it was necessary to cut into the pipe drains, there was great injury from breakage, and they were ultimately more expensive than brick drains. Attention was directed to the inaccuracy of the published experiments of the Board of Health, on the discharge of water through pipes, very carefully conducted experiments having produced results widely different from those issued by the Board.

April 6.—The discussion on the above paper occupied the whole evening. The system of pipe sewers and house drains, of small area, as compared with that of main brick sewers of considerable area with pipe house drains as feeders, was fully discussed; and it was shown that the latter system was much to be preferred, inasmuch as the small area of the newly-introduced pipe sewers rendered them incapable of carrying off the sewage; that they very frequently became stopped up by accumulated matter from the houses; that when this occurred, as their dimensions prevented a man from passing through them, great expense was incurred in breaking up the streets, the pipes were broken to a great extent, and at hazard, in seeking for the stoppage; and that even the weight of the earth in sinking frequently destroyed these pipes. The system of back drainage, through different private properties, was objected to. Brick drains above 15 inches in diameter, were shown to be less expensive than pipes of the same area, and their durability to be much greater. It was stated that, in spite of constant streams of water through the pipe drains, it was not possible to keep them free from accumulations caused by grease, hair, and other extraneous matters, even at Richmond, which was perhaps as favourable a locality for the trial as could have been found; the removal of the stoppages frequently cost as much as the original laying of the pipe drains, in consequence of the liability to aggregation in them, as already stated. The street sewers should, in general, and especially where the declivity was small, and the depth underground was considerable, be of sufficient dimensions to allow a man to pass up easily, to discover and remove obstructions.

With respect to the alleged advantage of the diminished friction from the smooth interior surface of the pipe drains, it was shown that considerable misapprehension existed on that part of the subject, for that, in point of fact, fluid friction was not dependent upon the so-called smoothness of the surface, and was practically the same in a rough cast-iron pipe, smooth-drawn lead pipe, a pot drain, and a brick sewer; but protuberances might have the effect of obstructing the motion of heavy solid substances adventitiously present. It was also shown that the form of the transverse section of the sewer had much less influence on the action of the sewer than had been recently asserted by certain public authorities.

The experiments on the flow of water through pipes, as detailed in a recent blue book of the Board of Health, with the expressed object of demonstrating the ignorance of civil engineers on this subject, were brought under review. Some of the experiments had been repeated by Mr. Hawksley, with the utmost attention to minute accuracy. The results were found to be so utterly contradictory of the statements made, and the doctrines taught by the General Board of Health, and so strikingly in conformity with formulæ well known to engineers, and with deductions from philosophic principles, as well as the determinations of practice, as to fully warrant all persons engaged in sewage and other hydraulic works, in continuing their adhesion to the established data. The experiments were shown, and the formula was given.

April 13.—The first paper read was "*Account of a Swing Bridge over the River Rother, at Rye, on the Line of the Ashford and Hastings Branch of the South-Eastern Railway.*" By C. May, M. Inst. C.E.

This bridge, which was constructed from the designs of Mr. P. W. Barlow, by Messrs. Ransome and May, of Ipswich, although similar in principle to others previously erected, presented some difference in the construction—in the arrangement of the tie-bars, in the rollers, and in other details. The girders were 112 feet long, 3 ft. 6 in. deep in the centre, and 2 ft. 6 in. at the ends, made up in four lengths, one joint being in the centre, immediately over the support, and the others between the centre and the ends. These girders were secured together at their ends, by means of cross girders, the underside of which were planed, and inclined, so as to be slightly lifted, when swung home to their places, on girders secured to the land piers. Provision was made on the underside of the main girders at three places on each side of the centre of the bridge, for receiving the tie-bars, which all tended to one point over the middle. Each tie-bar was four inches by one inch in section, and was adjustable for tension by a right-handed and left-handed screw, the nut of one end of which was in the tie-bar, and the other between two plates of wrought-iron resting on the side standards, or A frames, which were connected together by a wrought-iron arch. The turning of the bridge was effected by means of spur gearing, worked from a platform projecting from the face of each girder. Two men could with ease open the bridge in two minutes; the total weight of metal, in the moving part, exclusive of the roadway, was about 130 tons.

The next paper read was "*A Description of the Lattice-beam Viaduct to carry the Waterford and Kilkenny Railway across the River Nore, near Thomastown, county Kilkenny.*" By Captain W. S. Moorsom, M. Inst. C.E.

The span of the bridge was extended to 200 feet, chiefly in order to avoid the interference of the Inspecting Officers of the Board of Works (Ireland), whose proceedings had, in other cases, been so vexatious as to cause great delay in the execution of works; and, in one instance, of a small arch of twelve feet span, crossing a stream, with a bottom of firm limestone rock, they had insisted on the excavation of this rock to a depth of 6 feet below the bed of the stream, and caused the foundations to be brought up in masonry from that depth. The length of the girder enabled the piers to be constructed on the banks without the aid of cofferdams. The foundation was strong loam and gravel, for an average of about 10 feet, at which depth the limestone rock was reached. The river was subject to floods, which, rising rapidly, spread across the valley for a breadth of 180 yards, and to a depth of about 16 feet in mid-channel. The progress of the structure was delayed by the financial affairs of the railway company; and on the original contractors resigning the work, it was completed by several others, among whom was Mr. R.

Mallett, M. Inst. C.E., whose able assistance, in the execution of the work, was deservedly eulogised by the author.

Details were given of the limestone piers, the material for which was quarried contiguously to the bridge; as also of the lime, and the modes of working. The timber used for the lattice-beams, or girders, was Memel fir. The whole was worked to templates and gauges, and the beams were constructed with a curve, or camber, regulated by cleats spiked to the staging on which the beams were built. The intersections of the diagonals were all accurately fitted, and double spiked; the waling pieces were drawn close by bolts, and the joints made water-tight; the diagonal flooring was then bolted and spiked down, and on the trial of the beam, it was found that, on knocking away the cleats, the deflection was about 3 inches, which gradually increased to 3½ inches; after passing several trains across, at speeds varying between twenty miles and thirty miles an hour, the ultimate deflection (without a load) became 5½ inches. The maximum load had been 65 tons. The Government Inspector however tested it by a train of loaded wagons, extending the entire length of the arch (200 feet), and weighing 146 tons. The result of this was, that the beam deflected 2½ inches under the heaviest load, and rose again 1½ inch, thus leaving a permanent deflection, after the trials were concluded, of about 6½ inches. The shrinking of the timber, and the regular traffic, produced a further sinking, so that now the entire amount was 7½ inches; but the engineer had calculated and allowed for a subsidence of 9 inches.

Details were given of the quantities of materials of all kinds used in the bridge, the entire cost of which was about 8100*l.*; that of the timber arch alone was about 15*l.* per foot run, and the cost of the whole mass, taken as a solid, averaged 3*s.* 3½*d.* per cubic yard.

April 20.—The paper read was "*The Economy of Railways as a means of transit, comprising the classification of the traffic, in relation to the most appropriate speeds for the conveyance of passengers and merchandise.*" By Braithwaite Poole, Assoc. Inst. C.E.

After referring to the influence which cheap and rapid communications had on the prosperity of a nation, the author alluded to the rise and fall of the railway system in this country, expressing the belief that it would have been economical and wise if the legislature had, in the first instance, determined the lines on which the system of railways should have been constructed throughout the kingdom, so as to have avoided the present ruinous competition. The passenger traffic now exceeded, annually, four times the entire population of Great Britain, and was conveyed at three times the speed and one-third the fares formerly charged by the old stage, or mail coaches; whilst the cost of conveyance of merchandise, minerals, and agricultural produce had been reduced full 50 per cent., as compared with the rates charged on canals and turnpike-roads fifteen years ago. The ordinary fares for passengers ranged from 2¾*d.* to ½*d.* per mile; and for merchandise, from 1*d.* to 6*d.* per ton per mile.

The author then proceeded to consider the economy which might be introduced into the working of railways, and divided the subject into sixteen different heads, each of which referred to some particular point where it was thought a reduction of expenses might be made. The principal point advanced was the amalgamating or working of all the railways in four great divisions, and insuring unity of management in every department, in the maintenance of the permanent way, and of the rolling stock, as well as in their manufacture, several improvements in the construction of the wagons being suggested. If a general classification of trains were arranged throughout the kingdom, separating each class, and running them at different speeds whenever practicable, it was thought that it would be conducive to the interest of all parties, as it was urged to be a manifest injustice towards those who paid the highest fares to find third-class passengers arriving at the same time with them. Punctuality and regularity required to be strictly attended to for the maintenance of a certain definite speed.

Numerous instances were adduced to show the vast advantages and economy of the railway system, without which the Penny Postage could not have been achieved, or the Great Exhibition rendered available to the multitude; the produce of the land and sea in vegetables, fruit, meat, fish, all provisions and fuel, would have remained as limited in consumption as heretofore, and the poor man's fire-side in the rural districts would never have been warmed by coal.

April 27.—The paper read was "*Railway Accidents; their cause and means of prevention; detailing particularly the various contrivances which are in use, and have been proposed; with the regulations of some of the principal lines.*" By Captain Mark Huish, Assoc. Inst. C.E.

The author first considered those points connected with the road, and the machinery employed upon it, from which loss of life, and injury to person and property most generally arose. With regard to the road, or permanent way, from which fewer accidents occurred than from any other cause, its complete effectiveness was the basis of all safety in railway travelling; and for keeping it up constant vigilance was necessary, especially when any great and sudden change of weather took place, as then the weak points were sure to show themselves. It was a very rare occurrence for trains to run off the line; and when they did so, it was more generally due to obstructions designedly placed on the line, than to any neglect of the superintendents, or the platelayers. It was little suspected how frequent, how ingenious, and how varied the attempts had become, to inflict a fearful injury by these means; and though, providentially, but comparatively trifling damage had resulted from such causes, yet it was lamentable to find, that in addition to all ordinary risks, so diabolical a mode of wreaking a petty vengeance, or gratifying a mischievous disposition, had to be guarded against. Of late the punishment for such offences had been made more severe; and it was to be hoped that this would have the effect of lessening their number. Owing to the rapid development of the traffic, and particularly of the heavy goods traffic, on the main arterial lines of the country, increased siding accommodation had become necessary; in the case of the London and North-Western Railway alone, upwards of fifty-three miles had been laid down within the last few years, although by multiplying points and crossings, this had, *pro tanto*, doubtless increased the liability of accident; for it might be received as an axiom, that anything which broke the continuity of a rail tended to develope danger. As, however, there were no means of avoiding these frequent "turns out," judicious regulations combined with effective signals must be relied on, and now that facing points were reduced in number, the liability to danger had been diminished. The use of self-acting switches was attended with evils of no trifling magnitude, and many accidents had occurred from reliance on them; indeed, as a general rule, machinery to supersede personal inspection and manipulation was fraught with danger.

With respect to the rolling stock, it appeared from a return of one thousand cases of engine failures and defects, within two years, on the London and North-Western Railway, that burst and leaky tubes nearly doubled any other class of failure, and that these, with broken springs and broken valves, amounted to one-third of the whole number; and though they caused no direct danger to the public, yet as producing a temporary, or permanent inability of the engine to carry on its train, they might be the remote cause of collision. The passenger carriage, from its perfect manufacture, presented almost complete immunity from accident; for during the last four years out of the large stock of the London and North-Western Railway only six wheels had failed; and though at first some annoyance and alarm had been experienced from heated axles, yet by the recent introduction of the patent axle-box, it had been much reduced. The same praise could not be bestowed on the merchandise wagon, as in no portion of the system had so little improvement been made; the fracture of axles was frequent, the mode of coupling very defective, and the want of spring buffers, or even of buffers of the same height and width, rendered the destruction of property enormous. No loss of life from fire, either from heated coke, or spontaneous combustion, had occurred to a passenger train, but there had been some narrow escapes. These and other circumstances had led many persons to suggest various contrivances for communicating between the passengers, the guard, and the engine-driver, almost all of which were identical in principle, consisting of a connecting wire or rope. This plan had been tried and failed. A more feasible and favourite one was that recommended by the Railway Commissioners, which was to continue the footboards so as to form a narrow platform from end to end of the train, but a committee of railway officials had subsequently expressed their unanimous condemnation of the measure. The plan now adopted on the London and North-Western Railway, was for the guard's van at the end of the train to project about a foot beyond the other carriages, so that the guard looking through a window in this projection, might notice the waving of a hand or a handkerchief; this was, of course, useless at night.

NOTES OF THE MONTH.

Harbours of Refuge.—A parliamentary document of 19 folio pages, issued on the 28th ult., gives a detailed statement relative to the harbours of refuge at Dover, Harwich, Alderney, Jersey, and Portland, with the quarterly reports of the engineers for the year ending the 31st of March last. At Dover 245,000*l.* is the estimated cost of a pier of 800 feet. The works are contracted for, and will be completed in three years. The sum of 34,000*l.* a-year will be required. At Harwich the estimated expense is 110,000*l.* The works are contracted for, and will be completed in about one year. At Alderney the estimated cost is 620,000*l.* The works are contracted for, and will be completed in seven years. 50,000*l.* to 60,000*l.* per annum will be required. At Jersey, 700,000*l.* is the estimate; 25,000*l.* to 30,000*l.* per annum will be required. At Portland the estimate is 588,959*l.*, including 30,000*l* for the purchase of 474 acres, &c. An expenditure of 54,805*l.* is contemplated for the present year.

Mr. Thomas Allason.—The demise of this able architect took place suddenly, on the 9th ult., in the 62nd year of his age. He was brought up in Mr. Atkinson's office, and obtained the gold and silver medals from the Academy. He laid out the gardens at Alton Towers, furnished the designs for the Alliance Assurance Company, and was surveyor to the Stock Exchange and many estates. He was also a Commissioner of Sewers.

Drought at Manchester.—A drought of extraordinary continuance is exposing the inhabitants of the suburban Manchester townships to great inconveniences for want of water. The corporation supply from the new works having failed to some extent, the waterworks committee have had to purchase 20,000,000 gallons from the Manchester, Sheffield, and Lincolnshire Railway Company, who supply it from their Peak Forest canal reservoirs. The price for this large quantity is 150*l.* All the rain-water cisterns have long been exhausted, and there are families so destitute that they can with difficulty procure enough to meet household requirements. Less than three-tenths of an inch of rain has fallen within the district during the last two months.

Aldborough Harbour of Refuge.—The lords of the Admiralty have just reported to the House of Commons on the proposed construction, by the promoters, of this harbour in Suffolk, and on the improvement of the drainage of the lands on the banks of the rivers Ore and Alde. These rivers, at time of high water, approach at Slaughden Quay within 100 yards of the sea, and from which they are only separated by a bed of sand and some beach, which it is proposed to remove, and thus form a harbour. The report states that the Admiralty, having fully considered the scheme, are of opinion that the works proposed will not effect the objects intended, either as regards a permanent improved navigation, or drainage of the land; and that the intended proposal of imposing a toll on vessels passing in front of Aldborough is a measure quite at variance with the interests of shipping, and ought on no account to be sanctioned. The cost of the works is estimated at 60,000*l.*, which it is proposed to raise entirely by loan; and there appeared to be no subscription contract. Their lordships, however, are of opinion that the rivers Ore and Alde possess qualifications by which their navigation may be improved and made valuable for commerce, and in some respects for shelter, and state they will be glad, at a future time, to lend assistance to a well-devised scheme for a new and permanent entrance to the river.

The River Severn.—The report of Mr. J. Walker, the engineer to the Admiralty, has just been printed in a parliamentary paper. It is on the improvements that can be effected in the navigation of the river, to which subject his attention has been given.

Harbour of Refuge at Wick.—Mr. Rendel, C.E., is on a visit to Wick, for the purpose of surveying the locality, in order to enable him to report on the proposal submitted to government on the construction of a breakwater across the Bay of Wick, so as to form an extensive harbour of refuge for shipping.

Arterial Drainage in Ireland.—The total amount annually expended on these works is 165,104*l.* 9*s.* 2*d.*, the amount of the original estimate being 1,179,374*l.* 12*s.* 11*d.* The sum required for their completion is 683,794*l.* 8*s.* 3*d.* The area by original survey over which these drainage operations are to be made is 288,253 statute acres; but by the revised survey 214,579 acres.

Submarine Operations on the Rocks, near New York.—We last month (ante p. 119) gave an account of the successful operations of M. Maillefert on the Pot Rock, and have now to record a very singular catastrophe connected with the blasting, which we quote from the *New York Journal of Commerce*:—"M. Maillefert, with two boats, in one of which were three men, and in the other himself and brother-in-law, was taking advantage of the slack water at high-tide to make several blasts. He usually makes four at a tide, and had already made one; in attempting the second the accident happened, to explain which we must detail the process of blasting. Each charge is a large canister, containing 125 lb. of powder. Several of these canisters are taken in a boat, and one at a time they are let down upon the rock. When one is let down, Mons. M. comes up with his boat, takes the end of a long wire which is fixed in the canister, and rows off, paying out the wire as he goes. The other boat also rows off. When both boats are 60 or 70 feet distant from the place where the powder was sunk, Mons. M. places the end of the wire to the pole of a powerful galvanic battery which he keeps in his boat, and a dull, heavy shock is felt, the water is thrown up 40 feet or more, and large portions of the rock are detached. In this case, by some unexplained accident, Mons. M. received the wrong wire, and placing it to the battery exploded a canister in the other boat instead of the one under water. Of the three men in the boat with the powder, two were blown completely to atoms, and of the third it is not probable that he can recover. The boat in which these men were was shivered into the smallest fragments; not a piece as large as a walking cane could be found. It is thought that there were three canisters of powder on board, but whether they were all exploded or not we cannot ascertain. In the other boat were Mons. Maillefert and his brother-in-law. The latter had several teeth knocked out, and was otherwise bruised. Mons. M. was badly but we hope not dangerously hurt."

Mr. Frank Forster.—We have the deep regret to announce the death of this well-known mining and civil engineer, who recently held the post of engineer-in-chief to the Metropolitan Commissioners of Sewers. He was in the act of writing a letter when he was struck with apoplexy, and almost immediately expired, on the 13th ult. His health had been much impaired by the harassing fatigues and anxieties of official duties, which were not lightened to him by the want of harmonious support within the board. The funeral took place on the 20th ult., and the *cortège* was attended by Messrs. Stephenson, Locke, Rendel, Sir W. Cubitt, and numerous other members of the profession. He was buried at Highgate Cemetery.

Monument to the Earl of Powis, K.G.—Mr. E. Richardson has completed, from a design by Mr. Scott, this beautiful alabaster memorial. It has been placed in its arch of Caen stone, carved by Phillips, in the north wall of the chancel of St. Mary's Church, Welchpool. The figure represents the Earl, recumbent, in the Garter robes, resting on a richly diapered table, with shields of arms, and raised brass inscription, with ruby ground, by Waller. The likeness and robes have been most carefully studied.

LIST OF NEW PATENTS

GRANTED IN ENGLAND FROM MARCH 25, TO APRIL 22, 1852.

Six Months allowed for Enrolment unless otherwise expressed.

William Thompson, of Salford, Lancaster, machine-maker, and John Hewitt, of Salford aforesaid, machine-maker, for improvements in machinery for spinning, doubling, and twisting cotton, and other fibrous substances.—March 27.

Jean Jacques Bourcart, of Guébwiller, France, for improvements in preparing, combing, and spinning wool, and other fibrous materials. (A communication.)—March 27.

James Melville, of Roebank Works, Lochwinnoch, Renfrew, North Britain, calico-printer, for improvements in weaving and printing shawls and other fabrics.—March 29.

James Timmins Chance, of Handsworth, Stafford, glass manufacturer, for improvements in the manufacture of glass. (A communication.)—March 29.

Charles Jack, of Tottenham-court-new-road, for improvements in machinery for grinding pigments, colours, and other matters.—March 29.

John Whitehead, of Holbeck, York, machine manufacturer, for improvements in machinery for preparing, combing, and drawing wool, silk, and other fibrous substances.—March 29.

John Flack Winslow, of Troy, New York, United States of America, iron-master, for improvements in machinery for blooming iron.—March 31.

Moses Poole, of London, gentleman, for improvements in fire-arms. (A communication.)—March 31.

William Earnshaw Cooper, of Mottram, Chester, tallow-chandler, for certain improvements in the manufacture of candles and candle-wicks, and in the machinery or apparatus employed therein.—April 2.

Joseph Pimlott Oates, of Lichfield, Stafford, surgeon, for certain improvements in machinery for manufacturing bricks, tiles, quarries, drain-pipes, and such other articles as are or may be made of clay or other plastic substances.—April 6.

Samuel Fox, of Stocks Bridge Works, Deepcar, near Sheffield, for improvements in umbrellas and parasols.—April 6.

William Watson Pattinson, of Felling New House, Gateshead, manufacturing chemist, for improvements in the manufacture of chlorine.—April 6.

Moses Poole, of London, gentleman, for improvements in covering wires for telegraphic purposes. (A communication.)—April 6.

John Walter De Longueville Giffard, of Serle-street, Lincoln's-inn, barrister-at-law, for improvements in fire-arms and projectiles.—April 6.

Charles William Siemens, of Birmingham, engineer, for an improved fluid meter. (A communication.)—April 15.

François Joseph Beltzung, of Paris, France, engineer, for improvements in the manufacture of bottles and jars of glass, clay, gutta-percha, or other plastic materials, and caps and stoppers for the same, and in machinery for pressing and moulding the said materials.—April 15.

Edwin Pettitt, of Kingsland, Middlesex, civil engineer, and James Forsyth, of Caldbeck, Cumberland, spinner, for improvements in machinery for twisting, drawing, doubling, and spinning of cotton, wool, silk, flax, and other fibrous substances.—April 15.

Alfred Vincent Newton, of Chancery-lane, mechanical draughtsman, for improvements for preventing the incrustation of steam-boilers, which invention is also applicable to the preservation of metals and wood. (A communication.)—April 15.

Charles Seely, of Lincoln, for improvements in the manufacture of flour.—April 15.

Thomas Ellwood Horton, of Priors-Lee-Hall, Salop, iron-master, and Elisha Wylde, of Birmingham, engineer, for improvements in apparatus for heating and evaporating.—April 15.

Simon Davey, of Rouen, France, merchant, and Adolphe Ludovic Chann, of Paris, France, merchant, for improvements in explosive compounds and fusees, and also in methods of firing the same.—April 15.

Henri Gustave Delvigne, of Brixton, Surrey, gentleman, for certain improvements in fire-arms, and in the methods of discharging the same; also improvements in projectiles.—April 17.

William Edward Newton, of Chancery-lane, Middlesex, civil engineer, for improvements in machinery or apparatus for cutting paper, pasteboard, or other similar substances. (A communication.)—April 17.

William Edward Newton, of Chancery-lane, Middlesex, civil engineer, for improvements in the method of and apparatus for indicating and regulating the heat and the height and supply of water in steam-boilers, which said improvements are applicable to other purposes, such as indicating and regulating the heat of buildings, furnaces, stoves, fire-places, kilns, and ovens, and indicating the height and regulating the supply of water in other boilers and vessels.—April 17.

John Gillett, of Brails, near Shipston-upon-Stour, Warwick, agricultural implement maker, for certain improvements in ploughs.—April 17.

Alfred Vincent Newton, of Chancery-lane, Middlesex, mechanical draughtsman, for improvements in the manufacture of lenses.—April 17.

William Henry Dupre and Clement Le Sueur, of Jersey, for improvements in certain apparatus or apparatuses for preventing smoky chimneys, applicable to other purposes of ventilation.—April 17.

Clemens Augustus Kurtz, of Manchester, manufacturing chemist, for an improvement in all preparations of every description of madder roots and ground madder, in or from whatever country the same are produced; also of munjeet in the root and stem, from whatever country.—April 17.

Henry Stothert, of Bath, engineer, for improvements in the manufacture of manure. (A communication.)—April 17.

William Hyatt, of Old-street-road, Middlesex, engineer, for improvements in obtaining and applying motive power.—April 17.

John Knowles, of Little Bolton, Lancaster, cotton spinner, for improvements in certain machinery for preparing cotton and other fibrous substances, for reversing the direction of motion in and regulating the speed of machines.—April 17.

John Trotman, of Dursley, Gloucestershire, for improvements in anchors.—April 20.

Robert Griffiths, of Clifton, engineer, for apparatus for improving and restoring human hair.—April 20.

Robert Reyburn, of Greenock, chemist, for improvements in printing on silk and other fabrics and yarns.—April 20.

William Maddick, of Manchester, manufacturing chemist, for the production of a liquid extract from madder, and its preparations, suitable for the purposes of dyeing or printing, and a new treatment of spent madder, garancine, or garancaux, or other preparations of madder, to render them available for the like purposes.—April 20.

John Ridgway, of Cauldon-place, Stafford, china manufacturer, for certain improvements in the method or processes of ornamenting or decorating articles of glass, china, earthenware, and other ceramic manufactures.—April 20.

William Hindman, of Manchester, gentleman, and John Warburst, of Newton-heath, near Manchester, cotton dealer, for certain improvements in the method of generating or producing steam, and in the machinery or apparatus connected therewith.—April 22.

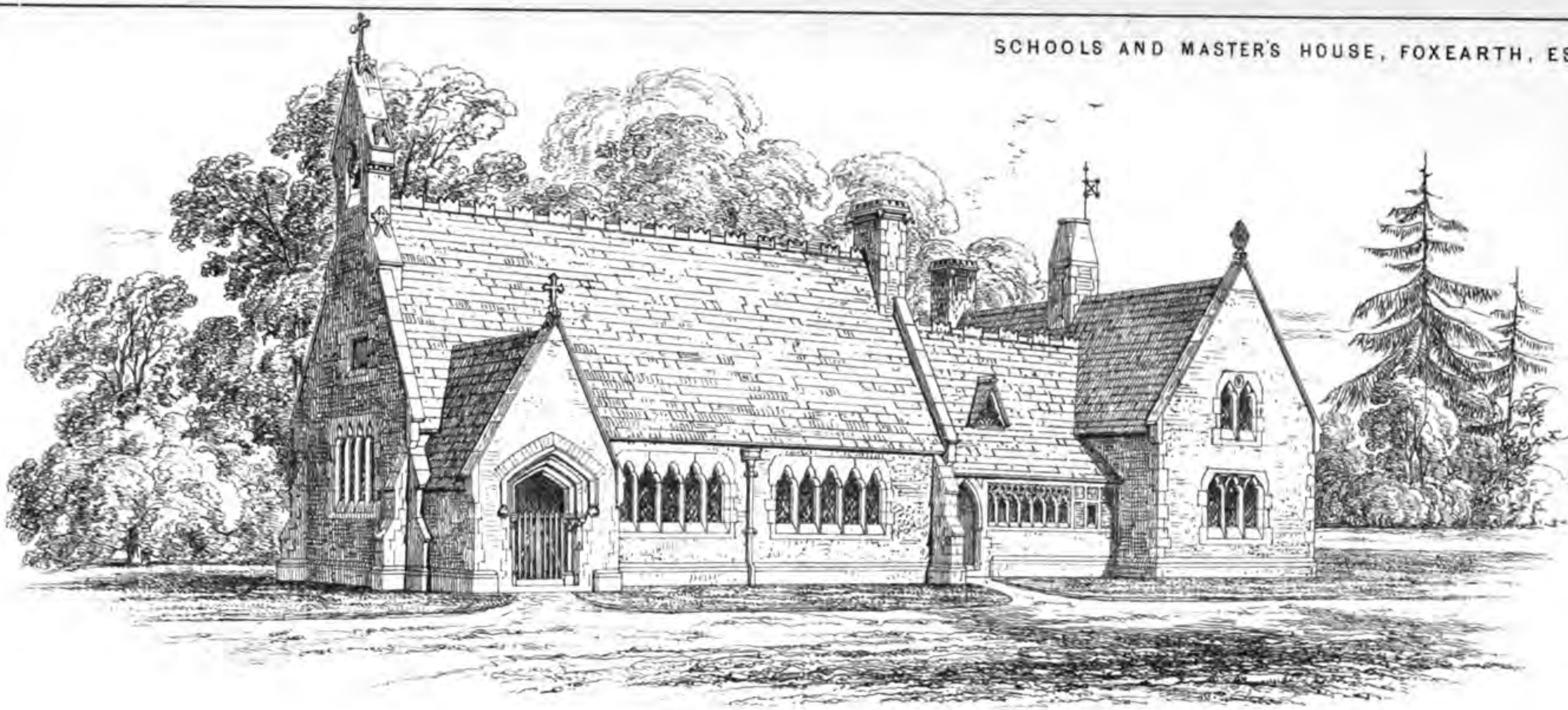
Edward Hammond Bentall, of Heybridge, Essex, ironfounder, and James Howard, of Bedford, ironfounder, for improvements in the mode of chilling cast-iron.—April 22.

James Stevens, of Birmingham, glass manufacturer, for improvements in lamp-glasses.—April 22.

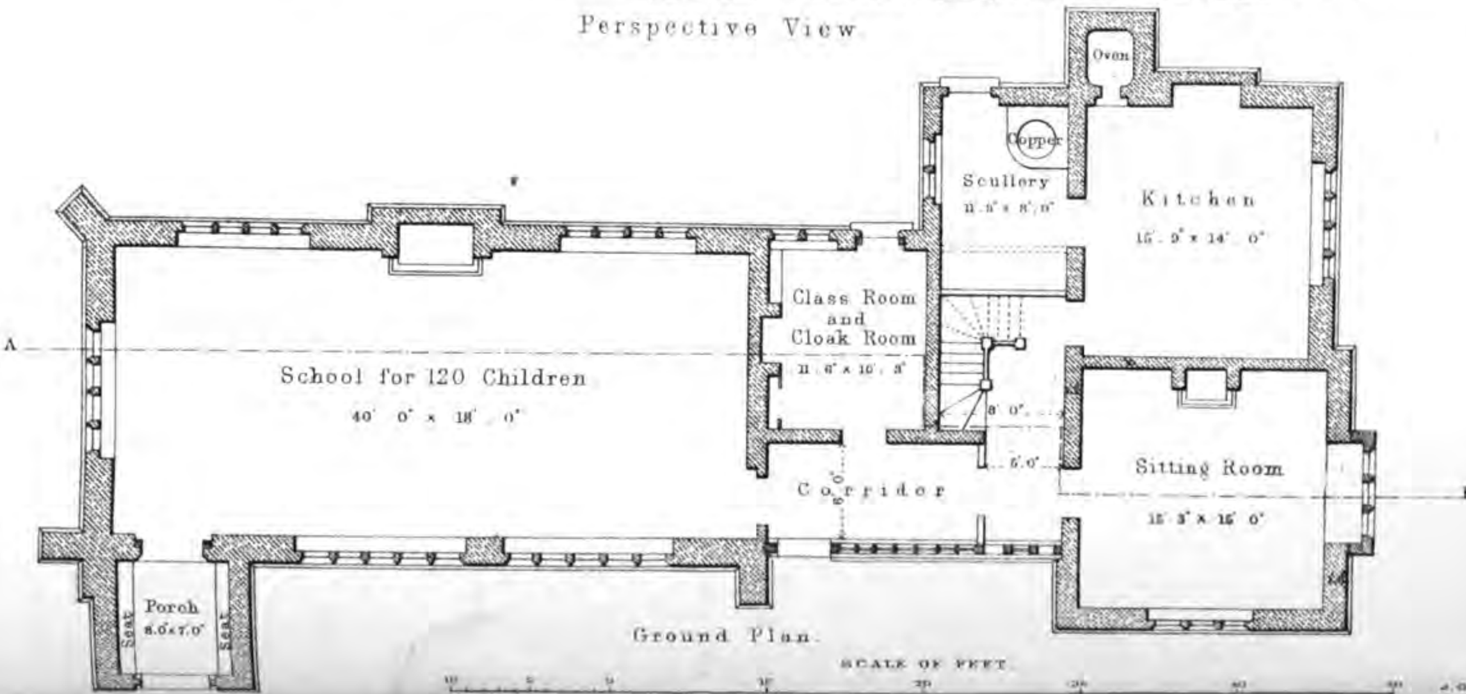
Alfred Vincent Newton, of Chancery-lane, Middlesex, mechanical draughtsman, for improvements in the method of manufacturing, and in machinery to be used in the manufacture of wood screws, part of which improvements is applicable to the arranging and feeding of pins and other like articles, and also improvements in assorting screws, pins, and other articles of various sizes. (A communication.)—April 22.

Alfred Vincent Newton, of Chancery-lane, Middlesex, mechanical draughtsman, for improvements in the mode of priming fire-arms. (A communication.)—April 22.

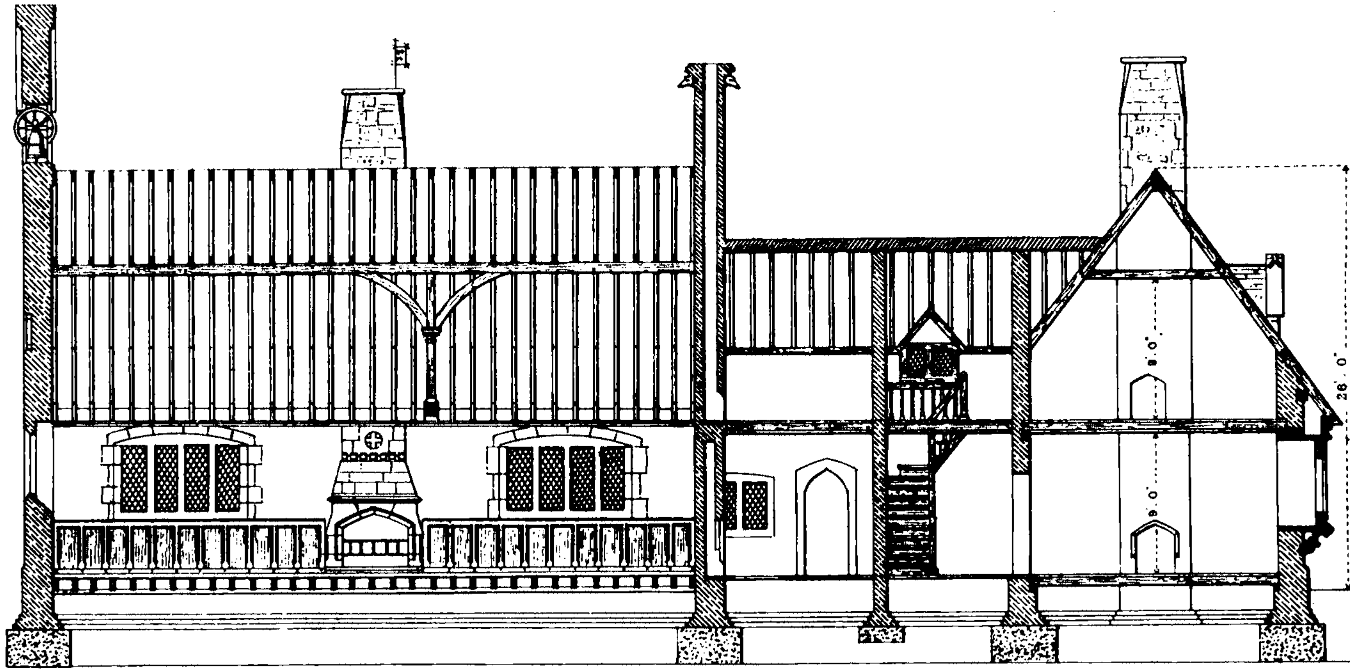
SCHOOLS AND MASTER'S HOUSE, FOXEARTH, ESSEX.



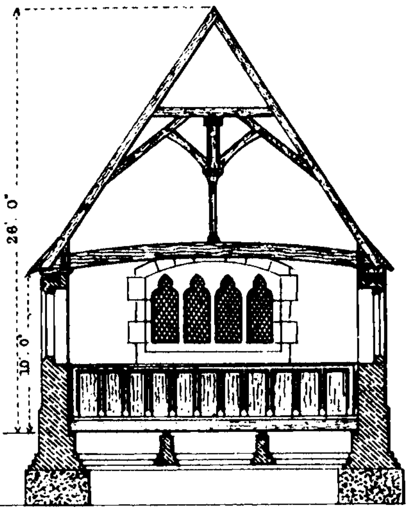
Perspective View.



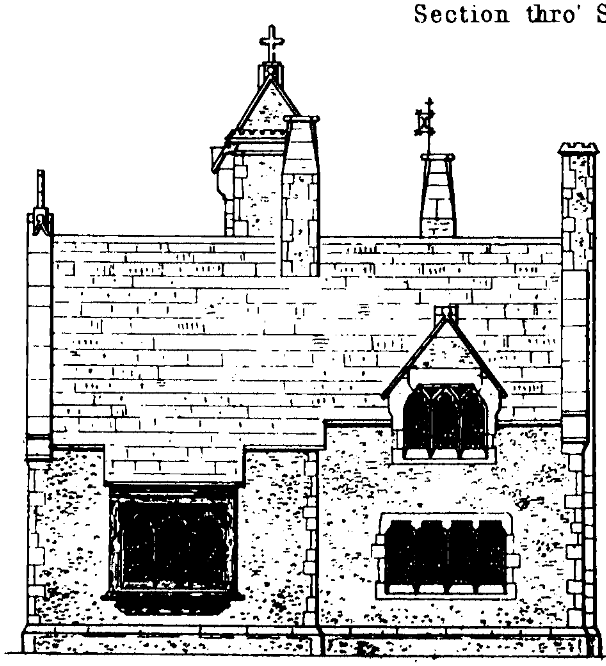
Ground Plan.



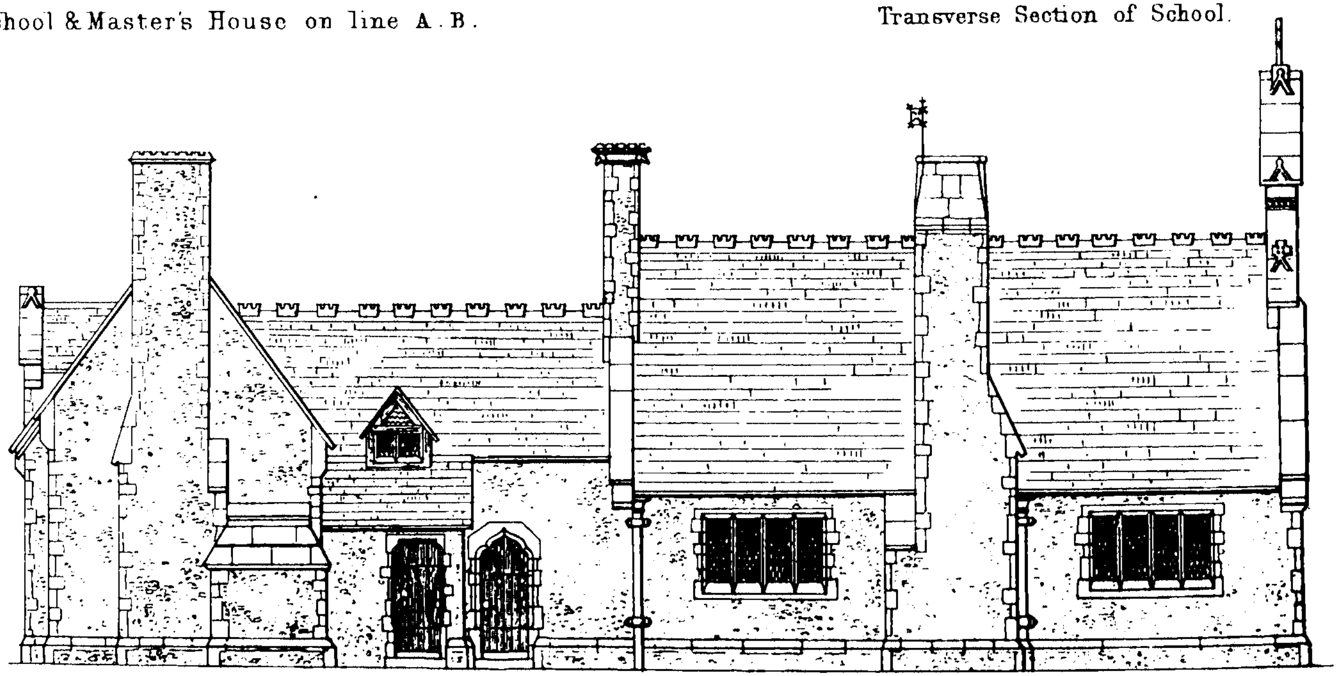
Section thro' School & Master's House on line A. B.



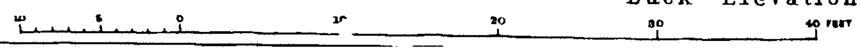
Transverse Section of School.



Side Elevation.



Back Elevation.



SCHOOL ARCHITECTURE.*

(*With Engravings, Plates* XIX. *and* XX.)

Among the most gratifying proofs of recent progress is the increase of public schools. Such a building is now to be found in every considerable village, and an impulse has been given to general education which cannot fail to receive its full development. The operations of the Committee of Council on Education have had a material influence in producing this result, a stimulus having been given to private exertion by judicious contributions from the public funds. In the expenditure so created the architects have had a share; and although the class of buildings erected is not of an expensive character, yet the opportunity afforded for professional exertion has not been without value. Opportunities for large expenditure are to be desired, because they offer considerable emolument to the practitioner; but we question whether, so far as the body of the profession are concerned at the present moment, the erection of a small schoolhouse be not of as much general benefit as that of a church. Every one thinks that in the construction of a church or great building competent professional assistance ought to be obtained, but it is not so fully admitted that minor constructions equally admit of professional supervision. It is very desirable the public should be impressed with this fact, because for each expenditure of five thousand pounds in a single building, there is as much as fifty thousand pounds spent in small edifices, for many of which it is too customary to dispense with professional aid. In the schoolhouses the advantage of this aid has been already acknowledged, and under peculiar circumstances. When the erection of schools on an extensive scale was determined upon, it was thought desirable by some parties to economise the architect's fees, under the plea that there would not be enough to pay him, though, in truth, with the view that he was not worth paying. It was therefore provided, for the convenience of local committees, that stereotyped plans should be furnished by the Committee of Council, such as might, without trouble or with very little exercise of wit, be copied everywhere.

This experiment presented many apparent advantages, for besides that of economy, there was the prospect of having the very best plans by the very best men. It had, however, one disadvantage, which is unfortunately attendant upon most of the centralising schemes of government officials—it did not rest upon a practical basis. A lithograph of a schoolhouse is a very convenient thing, but when the local committee have got it, comes the question of where the schoolhouse should be placed; and as this can only be satisfactorily decided by the professional man, the local committee are no better off by this provision of plan, but rather in the position of the individual who possessed himself of the patent mouse-trap without knowing how to bait it. Practical men, who have watched the results of government scheming, will not be surprised to learn that the schoolhouses constructed on the series of model plans of the Committee of Council on Education have already proved to be a series of signal failures. Indeed, the competent authority whose book we now have before us designates these designs "as unsuitable in every way." Thus the very contrivance for superseding architects has ended in affirming the necessity of employing them.

Had the power of the government prevailed, their crotchet plans would have been exclusively adopted; and had these even been good, we should have been shut out from the improvements introduced by the many men of talent who have been employed on these works. This, indeed, is one of those cases where the multitude of counsellors brings wisdom. One man can hardly construct a building worse than the general standard; but he can hardly fail, however mean his capacity, to introduce some improvement derived from his experience in other employments.

We look upon the schoolhouses as a very satisfactory test of architectural capacity, because, notwithstanding it was thought that a school could not afford to employ an architect, nor an architect to give his time to a school, the end has been that schools have been artistically and economically built, such as will prove of permanent utility, and in many cases of ornament to the localities in which they have been erected. The inference to be fairly drawn by the public from this experience is, that if an architect can be usefully employed on a small school costing only 120*l.*, he can be usefully employed on a small cottage of like outlay. In the case of a schoolhouse, facts have shown that it is better and cheaper to call in the architect at once, to determine and arrange the site, and to design a suitable plan; for, notwithstanding the ingenuity of an encyclopædia of government plans, yet such do not meet the minute shades of expenditure; and in many cases the architect will save his own commission by a judicious selection of materials, or by a modification of structure suited to special foundations.

One hundred and twenty pounds is to be spent on a village schoolhouse—a very little matter, and easily to be done: yet, how much is said in that word "schoolhouse" when we come to think about it! Site, proximity, aspect, drainage, arrangement, warming, ventilation, materials, have all to be considered, and to be carefully investigated and decided upon. Those architects who have had to design a plan for a schoolhouse, are aware of the labour which is involved in arriving at a satisfactory determination; and just as much in the case of a small building as of a large one. In the aggregate, the class of school architecture assumes importance from the fact, that the buildings erected and to be erected form part of a total of twenty thousand schoolhouses required for the wants of the local population in these islands. We have therefore seen with much pleasure the publication of a work on schools by an architect, Mr. Joseph Clarke, who, being employed by the diocesan boards of education of Canterbury, Rochester, and Oxford, has acquired great practical knowledge on the subject. Influenced by the impression of the utility of a work on schoolhouses, he has published a volume of views, plans, details, and descriptions, which give the architect all he requires for the comprehensive study of this branch of construction. Mr. Clarke's experience has been so far fortunate that it embraces every variety of edifice, from the humble village-school, costing 120*l.*, to what he aptly calls the collegiate arrangement of the Schools at Leigh.

In a general resumee of the subject, Mr. Clarke has offered some practical suggestions which will be read with interest. He says:—"In erecting a school, the promoters should, after first meeting every local difficulty, see that the site is suitable for building on. It often happens this is given; but sometimes the liberality intended becomes nugatory, from its position with regard to the population. It is either too uneven—perhaps a piece of common or waste land—or the fencing, drainage, foundations, roads, must be formed at a great expense—or it may be difficult to obtain water; so that it is found, when too late, it would have been cheaper to have purchased a site, with perhaps a choice of locality, than to have accepted the gift. In many cases this is different; still, whenever a school is to be built, it becomes of essential consequence to determine where it should be. The plan should always be formed to the *site*, and reference had to local materials; the design of the school, again, should conform to the materials. Brick and stone each require their separate uses, and so their several applications. Every point should be well considered separately. The best position for the school-room is to the north and east; the desks should be placed to a north light, and, if possible, the classes formed to the east; at the same time, the entrances should always be to the south or south-east. The living-rooms of the schoolhouse should face the south, or a little to the east; but, if possible, the bed-rooms to the east or south. All close corners and projections should be avoided on the north side of the buildings, and great care taken to drain the walls, more particularly on this side, and the water carried to a distance. It is too common to place the necessary outbuilding and cesspools close to the school: if the site is very much cramped, this cannot, in some cases, be avoided; but, in the country, this is seldom the case, and it is impossible to tell the injury arising from this system. In selecting materials, where a choice can be had, it seems, as an invariable rule, that the best are always found in the oldest buildings; and the parish church will generally furnish this information. If stone is used, the dimensions usually adopted for brickwork must not be used, and *vice versâ*. Where brick is used, sound and proper bond is necessary, and on no account must the walls be less than one brick and a-half thick; and even with this thickness it too often happens that the bricks or the mortar are so bad as to offer no resistance to the wet; and in a short time the walls become rotten and decayed. In stone or flintwork the walls should be at least one-fourth thicker than in brick, but this must depend a great deal on the nature of the stone: no cement should be used to bond in the courses; and with these materials it is necessary to use more

* 'Schools and Schoolhouses: a series of Views, Plans, and Details, for Rural Parishes.' By Joseph Clarke, Architect. London: J. Masters, New Bond-street, and G. Bell, Fleet-street. 1852.

care, and to allow some time in building. All inner walls, particularly to the south or south-west, should be lined inside with brick, which is better than battening. In the construction of a building, by the proper arrangement and disposition of materials, a saving is often gained by those whose knowledge is the result of experience; and they are enabled, at the same cost, to erect a more significant and extensive structure than would seem possible for the outlay. The fact is now happily established, that taste and real art go hand-in-hand with true economy; it need not any longer be deemed a ruinous expense to attempt to give to our village schools that character and association which so naturally belongs to them. Everything should be plainly but suitably constructed.

"In woodwork, the gift of green timber should be avoided; rather let it be sold, and invested in sound Memel timber. If well-seasoned oak can be obtained, it is preferable to deal, but not where it is cut in the same spring, or less than three or five years old; but one year of English winter-felled oak, before the spring sap rises, is worth years of spring-cut oak, in which every fibre rives from the emptying of the sap arteries, and is so weakened in the grain as to twist, crack, and warp more than almost any other of our native timber. Let all timbers be large enough to be morticed, and not halved, or nailed side to side, depending on their own cohesion. Floors require ventilation under, but not through opposite walls: if possible, the openings should be on one side to the external atmosphere, and on the other inside the building. The floor-boards should be grooved, and tongued with oak tongues, but not with metal. A low skirting should always run round all the rooms. For the sake of ventilation—it need not be said for appearance—as well as sound, all roofs should be of a high pitch, and open. Boarding is better than plastering under the tiles or slates; but great care must be taken, if boarding cannot be afforded, in not plastering to the tile laths or battens. For the covering of roofs, much must depend on the locality. If tiles can be had, they make the most picturesque appearance. It often happens that old tiles are difficult to procure, and new tiles are so bright as to be unpleasing; but, by using a solution of manganese, into which the tiles should be dipped before placing in the kiln, this is quite obviated. Great care is necessary in securing the ridge and hip tiles; and the valley tiles require much care in laying. The joiners' work should be of the plainest description, but framed with care; the windows should have window-boards, and lined round when these cannot be used; and where angles occur, these should be protected by wood beads rather than plastered.

"Warming and ventilating are most important matters, and ought to be very carefully attended to. Nature must not be too much influenced by the theories of art. Schools for country children require, perhaps, more in the way of pure ventilation than in the introduction of heat: in this respect they differ widely from the requirements necessary to be attended to in schools for the manufacturing districts; and therefore a pure and dry atmosphere should be kept up, and the school not too much heated in winter.

"It is desirable that good and separate playgrounds should be provided for the children, and, in some instances, gardens have been formed, and seem to answer very well, being let to the best children, to be cultivated by them, as a reward. The master should have as large a garden as can be spared; and, if possible, a patch round his house, which, if nicely cultivated, adds cheerfulness to the whole structure."

Being desirous of laying before our readers some more efficient means of judging of the character of the work than any description of our's could afford, we have inserted two Plates referring to the Schools at Foxearth in Essex, and of which Mr. Clarke writes as follows:—

"Foxearth is a very pretty village in Essex, about four miles from Sudbury. Till within the last few years it had fallen into decay, but the present rector, on his succeeding to the living, at once restored the church in a costly and appropriate manner, and then proceeded to erect new schools; these great improvements have been the means of causing such a change in the village, that in its present neat and cheerful appearance it can scarcely be recognised as the same place.

"The schools occupy the site of the village ale-house, which the rector purchased, with the double object of appropriating it to the beneficial purposes of education, as well as removing the source of idleness and intemperance. They are constructed in the most substantial and durable manner. The walls, from the nature of the site, are built on a thick bed of concrete, and are constructed of flint, lined with brick, the outer facing being of the pebble flint of the country, set whole—the joints raked out, so as to show no pointing. This makes an excellent face, but it is necessary to employ the workpeople of the locality, who are accustomed to the work. The dressings, externally, are of Bath stone, and inside of Caen, worked in a superior manner. The detail is richer, and the whole building partakes more of mediæval character and composition than can be usually adopted. The roof over the school is taken from one of the few good examples of domestic buildings which we have remaining of the fifteenth century; the timbers are exposed, and stained, and, as well as the other roofs, covered with old tiles, with a ridge cresting. The school-room is panelled in oak round the walls, and has a fire-place of stone, projecting boldly into the room. Leading from the school-room to the class-room is an open corridor, communicating with the house, which has more accommodation than usual, being intended for the occasional residence of the curate. The outer framing is of oak, filled in with parget. An oven is attached to the kitchen —a desirable convenience in rural districts, and, in some cases, might advantageously be added, to combine industrial training with educational teaching, which, to some extent, is carried out in these schools, the children being instructed in the duties of everyday life, to fit them the better for the positions they may be expected hereafter to fulfil.

"The cost of these schools, which were erected entirely at the expense of the rector, without any assistance from public grants, was considerable, the amount, exclusive of the purchase of the site, being more than 900*l.*"

THE ROYAL ACADEMY EXHIBITION.

Some of our readers may have thought our remarks harsh and unadvised in reference to the Royal Academy and its architectural exhibitions; but if any still think so, we say let them go to Trafalgar-square. Those who have heretofore hesitated as to the course of events can suspend their judgment no longer. We have noticed for years, with anxiety, the policy of the Academy with regard to architecture, and we have therefore from time to time spoken out. We saw that justice was not done to architecture by the Academy, and that no hope of amendment existed in that quarter. We have, therefore, leaned favourably to an independent architectural exhibition, and the final separation of architecture from the Academy.

In promoting these views, we were influenced by no ill-will to the Academy, though we think architects have just right to complain. We have a high respect for the Academicians, and for their character as artists; but we cannot blind ourselves to the fact, that neither as a school nor as an exhibition of architecture does the Academy do its duty to the profession. So far from doing any good, we consider the Academy does harm by placing the profession in a false position, diverting public attention from its true merits, and, by appropriating its resources, stands n the way of efficient organisation.

The representation of architecture by four Royal Academicians has long since ceased to be considered an advantage or a honour, and everyone is now convinced that the Royal Institute of Architects is the legitimate representative and constituency of the profession. The Academy school and medals have likewise ceased to have an independent value, now that practical classes organised on a better system are open at University and King's Colleges, and now that the sittings of the Royal Institute and of the Architectural Society afford a course of superior study for the junior members. The medals of the Institute likewise afford an efficient stimulus to the senior as well as to the junior practitioners.

The Architectural Exhibition, we hope, we may now consider as permanently inaugurated by Earl de Grey, and we no longer entertain any doubt of its superiority, as an exhibition, compared with that of the Academy. It is true that in the beginning we missed eminent names at the former, and we felt almost inclined to make an apology for their absence; though, considering how little aid they afforded to the Academy, we know not why we should, or wherefore a comparison should not have been instituted. It is otherwise now: the two exhibitions are on a par as to names, and the junior has a superiority as to numbers, while the Academy has resolved that the superiority as to arrangement shall likewise be yielded.

It is for architects to consider how long they will support a connection which the other party has abandoned. There are old associations connected with the Academy. It has a professor, and six lectures a-year; once in nine years it gives a scholarship to Academic students; and it has large funds for charitable purposes, if architects can hope to get the chance of profiting by them. The Academy, however, has made for itself a vocation. It is essentially the Academy of Oil Painters, and we cannot blind ourselves to the fact. Setting architecture aside for the nonce, we may see that the water-colour artists have been obliged to leave it and settle in other galleries, though the miniature painters still linger in a room which includes works in oil. The plate engravers have not a single representative,—the medallists but a name; the enamellers take shelter among the miniaturists; the architectural modellers are extinct; gem engravers are not to be found. All the minor branches of art are virtually banished from the Academy. As to sculpture, its departure from the walls of the Academy cannot, we think, be long delayed. The den to which its productions are consigned is sufficient to create prejudice in the minds of the public, and certainly to foster it. In a dimly-lighted sepulchre are entombed ghastly effigies, and many spectators go away strongly opposed to a conventional system of representation, which they hardly believe is within the domain of art. If they give encouragement to sculpture, it is for a posthumous bust or for a monumental tablet, and as a commemoration fitting rather for the dead than as a solace for the living in the enjoyment of divine conceptions of the sublime and beautiful.

Let us now turn to Architecture and the Academy. An Architectural Room no longer exists. The name has passed away, and the "North Room" inters whatever of architecture is still allowed to be exhibited. This, we firmly believe, must be part of a settled scheme; but what can those of our readers who go there say to the way in which the architectural drawings in the North Room are treated? The *line* is taken from them and held by the overflowings of the other rooms, the top and bottom of the walls being almost scrupulously reserved for the architectural drawings. Paintings and sketches of old buildings are brought near the line, and those architectural subjects which require the closest examination are put out of the line of sight. Want of room cannot have been the cause of these proceedings, for this is one of the least effective exhibitions we have seen for many years, and a most inadequate representation of the artistic talent of the country. The arrangement of the architectural drawings must be of settled design and aforethought, and we do hope professional men will take the hint. We trust that as so few have exhibited of late years, the practice of exhibiting will not through these proceedings of the Academy become extinct, but that there will be a determination to maintain architecture before the public in its proper position as a high art.

The vocation of an architectural critic at the Academy is, at all events, at an end. We can give no satisfactory account of the exhibition, inasmuch as we have not been able to see the works. Some very few are on the line, and we are afraid to mention them as we must appear to do injustice by passing over other works of merit which are not within ken. As it is, we can only enumerate titles; and those with the most promising titles are precisely those of which we are least able to give an account. We have said there are no architectural models, and we may state for the edification of our readers that there is not, we believe, more than one plan; and as some of the drawings represent additions and restorations, it is impossible to arrive at any proper judgment.

Mr. Hardwick, as a Royal Academician, is represented by Mr. P. C. Hardwick, the contributions being the "Coffee-Room of the Great Western Hotel, Paddington," the "Royal Freemasons' School" (1193), and "St. Columba College, Dublin" (1175). The sculpture for the pediment of the Hotel is likewise drawn by Mr. J. C. Thomas, and is of very good character. The Coffee-room is interesting from the judicious use of yellow sienna in the columns and consoles, and of white marble in the capitals and accessories.

Mr. Sydney Smirke, as an Associate, supports the exhibition with a "Geometrical Elevation of the Iron Gates of the British Museum." This shows the finish of the standards, and informs us that the pedestals are to receive seated statues of Bacon and Newton. We may take this opportunity of observing that the gates are now in an advanced state, and give very good opportunity of ascertaining the effect. We are confirmed in the opinion that the gates are in themselves artistic compositions, and that they are calculated to do great good as an example in the promotion of embellished metal-work as an architectural accessory. So far as we have seen, we have every reason to be satisfied with the experiment of gilding, and we think it will stand as well here as in Paris; but it will need to be kept clean, as indeed all buildings in London should be. There is no reason why every public building in town should not be as clean as the Bank of England, and every statue as that of the Queen in the Royal Exchange area. With regard to the present effect of the railing on the front of the British Museum, we may observe that it is not in perfect keeping, and indeed it is questionable whether a railing should be there at all. On the other hand, it must be borne in mind that this railing is a compromise for a wall, and that the front of the building cannot be considered in a finished state. The remarks which are now applied to the railing might have been lately applied to the great hall and the pediment. The great hall was a patch on the rest of the building, until the continuance of the internal decoration to the Sculpture Galleries made it part of a leading and prevalent system, to which the rest of the building will in time be brought. The colouring and gilding introduced in the pediment gave the sculpture a seemingly raw appearance; but this is now toned down, and the sculpture standing out well is more effective. We look forward, however, to the period when the whole portico will be similarly treated, and when the railing will become a consistent part of one of the finest architectural features of the metropolis.

We must now enter upon our catalogue. For Wax Chandlers' Hall there are two designs, one by Mr. R. M. Phipson (1149), and the other by Messrs. Wadmore and Mason (1234), but neither being the design adopted, the site for which has lately been cleared. We do not think the authors of No. 1234 showed due regard to situation in their choice of style, which is mediæval, for an Italian street, abutting on Goldsmiths' Hall, and close to the Post Office. Such a choice, however meritorious the style, is in truth a violation of artistic propriety. Mr. G. G. Scott, on the other hand, shows how he proposes to carry out the mass of mediæval buildings at Westminster, by an "Abbey Gateway and Houses in the Broad Sanctuary" (1174), by which we shall gain a mediæval place, bounded by these new buildings, the Abbey, and Westminster Hospital.

Mr. Ambrose Poynter shows an "Interior of a new Entrance Hall at Pynes" (1153); and there are other interiors deserving of attention. No. 1160 is the "Palatine Club," by Mr. Aitchison, jun.; and No. 1196 "A Saloon," by Mr. J. Warwick.

Mr. N. J. Cottingham has a "South-East View of Theberton Hall (1156); and Messrs Ashpitel and Whichcord "A Grammar School" (1158).

Mr. T. Smith has drawings of the magnificent Château, or, truly speaking, Castle at Cannes, in France (1179, 1207).

"A Town House" (1181), by Mr. C. J. Richardson, has a conspicuous feature in a bow projection.

Mr. T. Meyer has a large group of a "Church and Schools at Westbourne Grove" (1192), in which the spire is made a prominent feature, set off by the minor structures, which serve to give it an artistic base.

M. Hector Horeau has a drawing (1195) exhibiting several buildings of remarkable constructive character; but this is put out of sight, as are all those exhibiting new applications of architectural resources. Among these is No. 1202, "Model Buildings for Clerks," by Mr. C. Henman.

Mr. J. Whichcord, jun., F.S.A., shows some "Additions to Birling Manor House" (1209).

Mr. R. L. Roumieu exhibits a "Villa Residence at Esher," (1211).

The "Design for the Seat of D. Jones, Esq., Pantglas, Carmarthenshire" (1213), by Mr. E. L. Blackburne, deserves attention for its application of open porticoes and arcades.

In the "Town Hall and Corn-Market, Hemel Hempstead" (1212), Mr. G. Low has endeavoured to produce a picturesque effect by a small outlay.

The "Cambridge Military Asylum" (1199) is a design by Mr. T. Allom, to which he has applied the Elizabethan style.

Mr. W. Drew has a Villa design (1229), which presents several points of merit in the arrangement of the windows.

The "Buildings now in Progress at Dover Court" (1232), by Mr. W. H. Lindsay, will, if completed, form a very remarkable group. They show two long ranges of terraces, united by a projecting crescent.

Mr. S. W. Daukes has only contributed one design, a small "Church at North Malvern" (1244).

PERMANENT WAY OF RAILWAYS.

Alexander Doull, C.E., *of Greenwich, Kent, Patentee.*

These improvements in railway construction relate, firstly, to the method of securing the wedges of cast-iron chairs in position by means of screws, bolts, and rivets; secondly, to a mode of combining malleable iron chairs with wooden sleepers, or with stone or other rigid sleepers; and, thirdly, to the employment of intermediate sleepers having chairs cast in one therewith, so as to obviate the necessity for bolts or keys.

Firstly—The invention consists in forming the cast-iron chair commonly used in the construction of railways, in the manner represented in elevation, fig. 1. The improvement, it will be seen, is for securing the wedge in position by means of a screw-bolt or rivet, passing in the same direction as the wedge, and passing partly through the wedge and partly through the chair, the head of the bolt acting upon the back of the wedge, and the nut working against the side of the chair. The wedge is screwed into its position, and not damaged, as at present, by being driven home by successive blows of a maul; and it is also retained in its position by means of the screw-bolt, which obviates the necessity for the constant attendance of a plate-layer to examine and tighten the wedge. The liability to accident consequent upon loose wedges will thus be also done away with, and so both economy and safety to a great extent secured. However, it must be observed that this mode of securing the wedge is only applicable to chairs cast expressly for the purpose of this arrangement, and that, to adapt it to the ordinary cast-iron chair of any of the various forms at present in use, the following subsidiary appliances (or others equivalent thereto) must be had recourse to. A small casting must be prepared, similar to that shown in fig. 2, having a notch *a*, to embrace the cheek of the chair, and a longitudinal hole or slit *b*, for the bolt to pass through, the casting acting as a fulcrum to screw home the wedge, and the notch *a*, in the casting securing it to the chair. Fig. 3 shows the small casting A, in its position embracing the chair and securing the wedge.

FIG. 1.

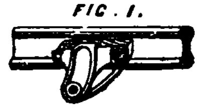


FIG. 6.

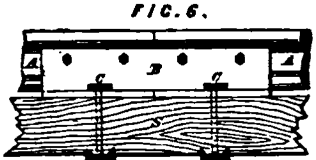


FIG. 3.

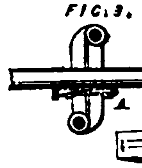


FIG. 2.

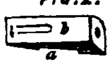


FIG. 4.

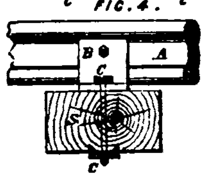


FIG. 5.

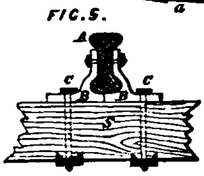


FIG. 15.

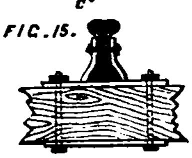


FIG. 9.

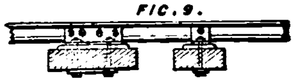
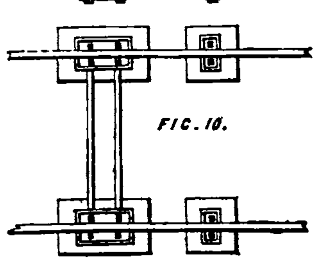


FIG. 16.

FIG. 10.



Secondly—The invention consists in laying the rails on chairs composed of malleable iron, and secured to sleepers of stone, wood, or metal, by bolts or rivets in the manner variously exemplified in figs. 4, 5, 6, 7, 8, 9, 10, 11, 12, and 15. Fig. 5 is a transverse sectional elevation of a line of rails constructed on this plan; figs. 4 and 6 are side elevations; A, is the rail; B, the malleable iron chair; C, the bolts and nuts by which the chairs are secured to the sleepers S, which in the figures are represented as of wood. When the sleeper employed is composed of stone, or any metallic or hard unyielding substance, a piece of wood of any convenient thickness, or a layer of gutta-percha or other elastic substance, is proposed to be placed between the chair and the sleeper, which will serve to neutralise the destructive effects of vibration, and to obviate that rigidity which has been found objectionable in the case of the old stone sleepers, and in most cases also of the recent application of cast-iron to the same purpose.

FIG. 11.

FIG. 13.

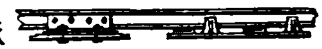


FIG. 12.

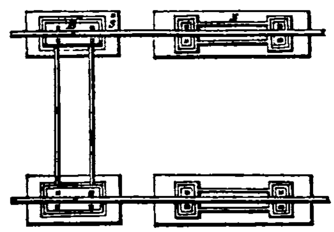


FIG. 14.

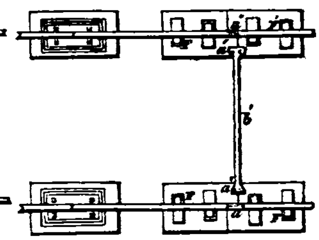


FIG. 8.

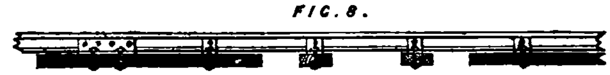
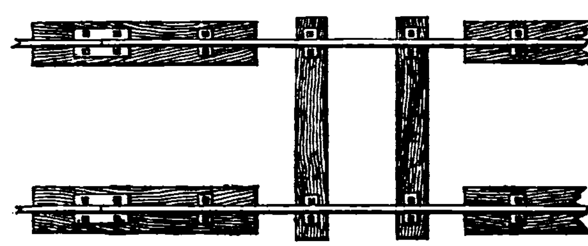


FIG. 7.



The inventor prefers having the malleable iron chair B, composed of two parts, as shown, so as to admit of being rolled into shape and then cut off into the required lengths, and the bolt-holes pierced; but it may also, if found equally convenient, be rolled in one piece, as shown in fig. 15. Joint-chairs should each be about 1 ft. 6 in. or 2 feet long, and secured to a longitudinal sleeper by bolts as well as to the rails, the holes either in the rail or in the chair being elongated so as to admit of the necessary expansion and contraction. Intermediate chairs should be about 4 or 5 inches long, and attached to the sleepers by bolts or rivets, and to the rail also if deemed necessary by bolts or nuts. It is probable, however, that sufficient stability will be obtained by simply bolting or riveting the joint-chair to the rail. In applying the malleable iron chair to sleepers of wood, the patentee recommends the arrangement shown in the plan and section, figs. 7 and 8, where two longitudinal and two cross sleepers are employed for every 15 feet of roadway.

The longitudinal sleeper under the joint of the rail should be about 9 feet long; and, in addition to the joint-chair, there should be placed upon it an intermediate chair on each side of the joint-chair. This arrangement would give great strength and stability to the joint of the rail, whilst the two cross-sleepers to each 15 feet length of roadway would give a sufficient cross-tie to preserve the gauge. By making the sleepers 12 inches broad, the above arrangement would give a bearing of 30 superficial feet to every 15 feet length of roadway. In bolting the chairs to the wooden sleepers, nuts may be used, with the alternate corners turned up, for the purpose of being fixed into the wood, and so preventing them from being turned round when the bolts are being screwed tight (see figs. 4, 5, and 6). Instead of nuts being used, as above, a short bar may be substituted for the nuts, into which the bolts could be screwed; or the bolts might be made to pass through a square hole in the short bar, with the heads of the bolts resting against the bar, and the nuts screwed down upon the malleable iron chair above the sleeper, as exemplified in fig. 15.

Figs. 9, and 10, show the modification which is to be made in this plan of railway construction when the malleable iron chair is laid on to stone blocks. The stone block under the joint of the rail, and which receives the joint-chair, is shown to be 2 ft. 6 in. long by 1 ft. 6 in. broad, and that under the intermediate chair 1 ft. 6 in. long by 1 ft. 6 in. broad; which gives a superficial area or bearing surface of 25 ft. 6 in. for every 15 feet length of roadway, and a thickness of 9 inches. The thickness of the stone might, however, have to be varied according to its quality and the facility of procuring a supply at any particular thickness from the quarry-bed; strong slate about 6 inches in thickness might probably answer the purpose. In attaching the malleable iron chair to stone blocks, the more convenient mode would be to place the heads of the bolts at the underside of the stone blocks, and the nuts above on the chair, the bolts passing through a short plate of iron with square holes to receive the necks of the bolts and prevent them from turning round whilst the screws are being screwed down upon the chair above.

Whether stone blocks or cast-iron sleepers are used, the gauge of the line is in either case preserved by bars of malleable iron, which may be secured in position by the same bolts which secure the chair to the block or sleeper. The number of these bars would be increased on curves; but on straight portions of the line, one bar would be sufficient for every 15 feet length of roadway. A piece of soft wood, or other elastic substance, would be interposed between the stone block and the malleable iron chair, as already explained.

Figs. 11 and 12 show, in elevation and plan, the mode of applying the malleable iron chair to cast-iron sleepers. The joint sleeper S*, will only have a joint-chair B*, attached to it, as its great length will be sufficient to give the necessary bearing surface and stability to the joint of the rail. The intermediate sleepers S, S, will generally be of such a form and size as to admit of two malleable iron chairs being placed on each sleeper; but it may frequently be found more convenient so to proportion the form and size of the cast-iron sleeper as to admit but one malleable iron chair to be attached to each sleeper, according to the nature of the traffic and of the ground upon which the superstructure is laid.

In attaching the malleable iron chairs to the cast-iron sleepers, the heads of the bolts should be placed below, and a square projection cast upon the sleeper round the bolt-hole, into which the head of the bolt would fall, and by which it would be preserved from turning round when the nut was being screwed down. A piece of soft wood or other elastic substance would be interposed between the cast-iron sleeper and the malleable iron chair, as already explained in reference to stone blocks.

Thirdly—The invention consists of a method of railway construction, represented in side elevation at fig. 13, and in plan at fig. 14, in which intermediate sleepers are employed with chairs cast in one piece therewith, so as to dispense with bolts and keys altogether as fastenings for the rails. Figs. 16 is a cross section of rails laid on this plan. The chairs are cast so that the cheeks do not come opposite each other, but they are at such a distance apart, that when the two castings are laid obliquely in contrary directions under the rail, the latter comes between the cheeks; after which the castings are pressed in opposite directions, until the notches at *a*, fit into each other; and when this is effected the cheeks of the chairs will be brought into close contact with the rail, and the interlocking of the notches will prevent the cheeks of the chairs from relaxing the rail. The tie-bars *b*′, *b*′, which are necessary for the purpose of keeping the gauge, are placed at the junction of the two sleepers or castings, and bolted to each of them, as shown at *a*′ *a*′ *a*′ *a*′, fig. 14, and afford additional security that the notches will not be disengaged from each other by the action of the railway trains.

To prevent rigidity, as also the vibration of the trains from transmitting a destructive effect to the chairs and sleepers, pieces of wood (F, fig. 16,) are placed underneath the rails in rectangular cavities or receptacles about ⅜-inch deep, and as broad and long as the casting will admit of, so that a small margin may remain to confine it in its place while being pressed upon the rail. The wood should be about ⅞-inch thick, and there should be a groove or slit leading from any convenient part of the concavity or receptacle, to prevent water or damp from accumulating to injure the wood.—[*Patent dated November 6th*, 1851.]

NON-METALLIC MINERAL MANUFACTURES.

By Prof. D. T. Ansted, F.R.S.

[*Exhibition Lecture delivered at the Society of Arts, May 19th.*]

The subject was treated under the following subdivisions:—1, marble and stonework; 2, cements, scagliola, and artificial stone; 3, bricks, terracottas, and other works in clay. In speaking of the first division, Mr. Ansted compared our wealth in the best quality of the raw material with the discreditable examples that are to be found in the public monuments of our metropolitan and provincial towns, which he attributed to the prevalent rage for cheapness. The Exhibition has, however, induced a greater demand for good stone, and in particular the Derbyshire marble (specimens of which from the works of Messrs. Lomas, of Bakewell, were presented to the Society), is becoming much used for articles of domestic requirement.

An important branch of industry now exists in Derbyshire, in imitation of the method of inlaying known as Florentine mosaic—viz., in coloured marbles on a black ground; and here, again, Professor Ansted was able, even at this short period, to point out a most unquestionable improvement arising from the Exhibition, at the same time that he called attention to the comparative cheapness of this Derbyshire mosaic. Lastly, he noticed the manufactures of Devonshire marbles, and of fluor spar or "blue John."

In the marble manufactures of other countries, Italy claimed the first mention; and here interesting details were given of the method of executing, and the various merits of the different branches of alabaster, *pietre dure*, Florentine mosaic, &c. The objects sent from Malta were indicative of great anxiety to take a high position, both in plain stonework and in mosaic. In France, Belgium, and the smaller countries, there was little to notice; the case of Russia, however, was far different. All our readers are familiar with the gorgeous works in malachite, the imitative fruits of other articles from this empire, but it may not be as generally known that the cost of the former material is as much as 14*s*. per pound, 2 lb. being wasted for every 1 lb. used; and that for the well-known doors, no less than 3000 lb. of rough malachite were required, at a cost of no less than 2000*l*., exclusive of labour. Mr. Ansted's opinion on many of the Russian objects was, that the difficulties surmounted had been so rather by patience than genius.

In treating of the *Cements, &c.*, Mr. Ansted gave a general account of the raw materials used, before noticing the exhibited specimens: this account must be read in its extended form. The principal cements shown were Roman, Parker's, Atkinson's, and Portland; and the general deduction from experiments instituted by the exhibitors was, that the Portland artificial cement was stronger than the natural Roman, as two to one. The artificial stones were divided into those of a silica base, and those containing sulphate of lime, as Keene's, Martin's, and Parian cement. These last were spoken of in terms of high praise. Some tables of an elaborate plaster mosaic from Tuscany attracted much attention, but bore so high a price as to render their introduction unlikely.

The *Clay goods* of the third division included, besides Mr. Minton's tiles (which will be more particularly treated of on the 2nd June by Mr. Arnoux), various kinds of bricks of different shapes and sizes, hollow, &c. The most important were those used in the building of His Royal Highness's model lodging houses. Terracotta differs from brick in being of the finest clay with crushed pottery and calcined flints, burnt at a heat little short of fusion. Many interesting examples of those from British clays were exhibited, and the French specimens attracted much attention and favourable judgment. Bricks were shown in Austria, from an establishment where 5000 persons are employed, and 100,000,000 of bricks made annually, with great economy.

Mr. Ansted concluded by describing at some length his general impression of the whole of this department of the Exhibition, which, with regard to England was, that the English as a nation are wanting in the good taste to select the right material for any required purpose of decoration, and are apt to forget that what is beautiful in one material or for one purpose becomes preposterous and offensive when executed in another ill adapted for it, or for a purpose altogether distinct; but that the improvement wanted does not depend on the manufacturers, but mainly on the public whom they supply, and by whose requirements they must be guided.

ENGINEERING WORKS IN NEW YORK.

The *New York Courier and Inquirer*, in a sketch of the works in progress at the principal establishments in that city, asserts that there are no foundries in England that cast such massive pieces of machinery as those executed in New York; and, in proof of this, enumerates the operations of several of the firms, as follows:—

Messrs. Mott and Ayres, of the Chelsea Ironworks, have just cast twelve iron columns for the Manhattan Gas Company, which are the largest ever cast by 10 ft. 8 in., measuring 50 ft. 8 in. in length, 3 feet diameter at the base moulding, 2 feet at the cap moulding, and weighing 27,360 lb. each; they have been erected about the gasometer, and are surrounded by girders 45 feet in length. They are also preparing an iron steamer as a passenger vessel on the Magdalene river. Her hull is of iron, riveted together, and the deck is composed of white pine; she measures 167 feet in length on deck, 30 feet beam, and 7 feet hold, and is calculated to carry 70 tons while drawing only 2 ft. 9 in. water, showing great buoyancy in a vessel of that description; when heavily laden she will carry nearly 350 tons.

Milligan, of the Warren-street Foundry, has invented what he entitles the 'Vertical Flue Boiler," which he has patented both in England and America. The construction of this boiler is such that double the quantity of fire and surface can be got in the same compass over the boilers now generally in use, and it is claimed to be more effective. All other boilers have horizontal flues and vertical tubes. One very great advantage is in the boiler being half the ordinary size, taking less room, and, as a matter of course, requiring but half the quantity of water; the strength of the fire acting on the surface of the water has the effect of making steam with less fuel; and in making the steam at the top of the flue it escapes more rapidly into the chamber. He is completing a boiler of this description for the firm of T. Surrell and Co., to be used in their moulding and planing mills, with an engine of 100-horse power. The boiler is 13 feet long, 7 feet wide, and 9 feet in height.

Cunningham, Belknap, and Co., of the Phœnix Foundry, are fitting the boat *General Taylor* with a condensing engine, 70 inches diameter of cylinder and 14 feet stroke, and four boilers. This steamboat was built, about two years ago, by G. Collyer, and she is now being fitted up for an opposition boat between New York and Albany.

W. Small is casting a number of large engines for steamers; and also a variety of very heavy and peculiar pieces of machinery for the Naptha Company, at Brooklyn, to be used in manufacturing oil from resin. These castings are entirely original, and are called "stills."

Rodney, of the City Foundry, besides several large engines for steam-ships, has recently completed, and sent to their destination, four engines and stamping mills for quartz crushing in California.

G. Birkbeck has finished the machinery for a harbour towing boat, called the *Peter Crary*. The engine is 22 inches diameter of cylinder, and 6 feet stroke. Also, the machinery for a barge, belonging to Griffith and Tillingbast. She takes a condensing engine, 26 inches diameter of cylinder, and 26 inches stroke. Also, two 7½-feet propellers, with boilers to match. Putting machinery in barges is a new experiment. Barges have always been towed by the steamboats and propellers in use for that purpose, but some of the transportation companies contemplate fitting their barges as the one above. By the adoption of this plan quicker passages will be made up and down the river, and freight will command a better price.

Hogg and Delamater are principally engaged in constructing "Ericsson's Caloric Engine," a mammoth combination of machinery. It has very heavy pieces of metal, the cylinders, four in number, being 14 feet in diameter, and about 8 feet in depth. Three of these massive tubes have been cast, and are quite a curiosity. The engine will have no boilers, and no water will be used to drive it, the propelling agent being heated air, which (by the devices, substances, and arrangements of the machinery) is saved. The piston is 8 feet stroke. The principle advantages claimed by the inventor over other engines are economy of fuel and safety. The regenerators are arranged in single vessels, and the metallic substances contained therein take up the caloric from the air that leaves the working cylinder or vessel, and return the same to the air that enters the working cylinder at each stroke. The regenerators will alternately take up and give out caloric, by which the circulating medium will chiefly become heated, independently of any combustion, after the engine shall have been once put in motion.

Morgan, of the Morgan Ironworks, besides two beam-engines of 72 inches diameter of cylinder and 12 feet stroke, for two boats on Lake Erie, is constructing a 44-in. 11 feet beam-engine for an iron vessel, to be built in Vienna, for the Danube Steamboat Company. He has also completed the repairs of the steam-ships *Philadelphia* and *Illinois*, of the U.S. Steam-ship Company's line.

Lecor and Breasted, of the Allaire Works, have on hand orders for a pair of marine beam-engines 60 inches diameter of cylinder and 10 feet stroke, for Vanderbilt's Nicaragua route, to run in connection with the *Prometheus*, *Daniel Webster*, and *Northern Light*. They are also constructing a marine beam-engine, of 65 inches diameter of cylinder and 10 feet stroke, for the Californian trade, to run from New York to Chagres.

BURNLEY MECHANICS' INSTITUTE—RETROSPECTIVE CRITICISM.

Sir—I must ask the indulgence of a small space in your pages, to notice an article in your last number, entitled "Retrospective Criticism." As I do not quarrel with your correspondent "C," for having criticised my design for the Burnley Mechanics' Institute, neither with the terms in which his remarks are expressed, I trust my reply will be such as to convince him, I have swallowed his censures without any indigestible or bilious result.

Like a skilful general, it must be confessed, he commences his attack on the most vulnerable point. The raking balustrade was always, in my idea, such a disagreeable appendage to the design, that, in working out the building, I have dispensed with it altogether; and this summary mode of disposing of it is, I admit, a much more agreeable one than its defence would be by any "speciousness of argument."

Had the site been level, or nearly so, and had the building been required exclusively for the purposes of an Institute, that architectural uniformity so pleasing to the eye might doubtless have been more satisfactorily attained; but, unfortunately, neither of these desiderata were practicable. The streets occupied by the two principal fronts have a considerable inclination,—and it was moreover requisite, in carrying out the views of the promoters, that one-half of the *side-front* should be devoted to *two shops*, which, so far as I am aware, seldom add much to a good architectural composition.—By a slight error of your engraver, the base line in this front is shown *continuously through*, thus making all the openings appear as *windows*, whereas the second and fifth are arched doorways; hence the apparent irregularity complained of in the arrangement of the windows.

I do not coincide with "C's" remark, that the solidity, real or apparent, of the first story has been forfeited by the number of openings, which are indispensable to the rooms. The character of strength is not so much preserved by the absence, or by a small number, of openings, as by the way in which they are treated: a bold and decided arch has all the essential qualities, and conveys as much appearance of strength as a solid pier.

Still less am I disposed to agree with the suggestion, that the columns of portico ought to have been placed "on the level of the top of area balustrade:" this would have placed them *below* the base line of the building,—a perversion of good taste I should not like to see "perpetrated." When we consider that the portico itself is 25 feet high, and the stylobate on which it is "hoisted" only 6 feet, the disproportion is scarcely so great as to make the columns appear insignificant.

And now one word as to criticism. I am one of those who consider sound, impartial criticism, either in art or literature, to be not only beneficial and instructive in its tendency, but wholesome in its effect; for whilst stern truth unrelentingly lays bare the faults and defects on the one hand, justice and candour as readily acknowledge merit on the other. Holding these sentiments, and having an earnest desire for the progress of the true principles of architecture, I will freely give to "C," and every other reasonable critic,

"Liberty
Withal, as large a charter as the winds,
To blow on whom they please."

I am, &c.

May 17th, 1852. J. Green.

SCHINKEL AND THE CATHEDRAL OF COLOGNE.

By Herr Blömer, of Cologne.

Setting aside its huge proportions and deep-wrought art-beauty, the Cathedral of Cologne has, of late, become the centre of the architectural tendencies of Germany, and when completed, will be the grandest mediæval monument of Europe. Since, however, the last strokes of the mason had resounded here, at the beginning of the Reformation, this splendid structure had met with the most absolute neglect. It was George Forster, who, in his 'Views on the Nether-Rhine' (published in 1790), first dilated on the merits of this work;—but in a strain of deep melancholy, that this symbol of a great past reflected the more intensely the insignificance of our own works. The great art-philosopher, Frederic Schlegel, next took up the sacred cause, and urged this invaluable relic on the attention of the German nation. It was his writings on this and similar subjects which attracted the notice of the subsequent minister of state, Baron Stein, who introduced them to the notice of some members of the court of Prussia. Next came Sulpice Boisserée. To him the Cathedral of Cologne became a life-scope, and all that has been subsequently said and done in this respect is his own undoubted property. It was he, indeed, who led Goethe to a proper estimation of this noble structure; because, when Goethe first saw the perspective ground-plan of the Cathedral, his opinion was, that "it exhibited the idea of the unfeasibility of such a gigantic undertaking, and recalled to one's mind the fable of the Tower of Babel transplanted on the banks of the Rhine." In the year 1812, Goethe published his autobiography, and most warmly recommended the patronage of the vast undertaking of Boisserée. This recommendation fortunately coincided with the brightening prospect of the political affairs of Europe, and, in November 1813, the drawings and plans of Boisserée were sent for by a message from the head quarters of the allied army, then at Frankfort, where they were viewed with deep interest by the warriors and statesmen then congregated, and more especially by the crown-prince of Prussia, now Frederic William IV. M. Boisserée states that the king had vividly retained this first impression up to the year 1842, when the first practical endeavours towards its restoration came into life. In the summer of 1815, Goethe visited the dome accompanied by the minister Stein, which event was described in his journal, 'Rhenish Art and Antiquities.'

But while all these endeavours of statesmen and writers were struggling on, the Cathedral of Cologne presented but a huge, hopeless ruin, made so by the neglect of centuries; and the question, whether this work could be at all preserved, and how carried out, awaited still a *practical* solution. Thus, the then building privy-councillor Schinkel, afterwards raised to the supreme direction of the buildings of the state, being the first technical authority in Prussia, obtained orders in 1816 to examine personally the condition of the Cathedral, and to report thereon to the higher authorities. It was in August and the following month of that year, that he devoted himself to the task. The thing was done, or rather *undone*, if Schinkel had but pronounced his veto against the restoration and completion of what, after all, could only be called the parts of a building, —if he had thought that the extraordinary expense and labour of the restoration was not in proportion to the real art-worth of the building. And surely such doubts would have been anything but unfounded and timid, as the following extracts of his report will amply prove. It will teach the architect and artist a useful lesson, of how many of our present ancient buildings, whose restoration is despaired of, are also capable of the same process, if undertaken with skill and energy.

"The destruction of the timber-work of the roof has become very dangerous, the greatest portion of the beams and rafters being decayed, and a general sinking and breakage of the timber works has taken place. The buttresses formerly erected against the walls of the Cathedral for avoiding serious accident, have only increased the damage, as the ultimate destruction of the lateral walls has become inevitable by the pressure of the supports exerted against single points. The experiments made to effect the flow of water from the drains in the planes of the roof proved that a complete destruction of the buttresses was inevitable, the fluid percolating through every crevice as also the adjacent parts of the walls; the whole slate covering and the leaden tubes being covered with thick moss, like the walls of natural humid grottoes. The peril of such a condition is clear to every one who can understand the system by which the masses of such a building are kept together. The daring of the plan consists mainly in the accurate poising of opposing quantities and forces, which in their proper arrangement act appropriately; but any one of these quantities being taken away, destroys the whole system of equilibrium. The consequences can be guessed if the buttresses erected for the support of the lofty vault of the choir were to crumble to pieces. The great quantity of water collecting in the angles of the groining of the choir is so great, that its effects are perceived even in the interior of the Cathedral. Each rainy day convinces me, how the water drips down through the vaults of the lateral naves, and, passing along the pillars of the high choir, everywhere decays the brickwork. The effects of the winter season are still more calamitous, as the interstices, already filled with the water, are still further enlarged and disrupted by the expansion of the ice; and when the numberless channels and gutters have become filled with ice and snow." M. Schinkel concludes by saying, that "although it cannot be stated with accuracy, when an irremediable disaster may befal the building, yet the causes for such an event *are* extant to a frightful degree."

In the face of such circumstances, the talented architect did not hesitate to pronounce for the conservation, the continuing, and completion of the Cologne Cathedral. He says: "Whatever we may think of the vocation of our age for the continuation of this building—laying aside the necessity of its preservation—it still is undeniable, that the present age is deficient in amplitude of intellectual view with regard to art, by which alone, however, art can be made to progress. But even if such art-scopes were at hand, we could only, in our present position, perform the part of good and intelligent imitators, and yet not thereby become possessed of that creative genius which appertained to the Greeks and our own ancestors on the banks of the Rhine. In such a position, one of the most appropriate occupations of the architect is to *preserve*, with all care, that which the genius and power of previous ages have left us; as there will be consolation in thus passing over an epoch which affords so little opportunity for any other original exertions and actions."—In the same manner as Schinkel had exerted himself for the preservation of the Cathedral of Cologne, he subsequently submitted to the minister Altenstein, in 1825, his plans for the completion of the building, and up to his death (1841) remained the chief supporter and adviser of this noble work.

Many of our readers will recollect the superior title-vignette which adorns the work of Sulpice Boisserée on the Cologne Cathedral. It will be interesting to know how much thought Schinkel bestowed on every one of his productions, as will appear from the following extract from one of his letters to Boisserée. "I intended to show the entire situation of Cologne along the banks of the Rhine, whereto belongs its connection with Deutz; to exhibit the view around and from the Cathedral, especially the Siebengebürge (the seven mountains). For that purpose the sight from the Cunibert's Church seemed the most appropriate. Here, we perceive Deutz and the majestic windings of the Rhine up to the Seven Mountains; to the right expands the town, in whose centre rises the Cathedral, and towers, ramparts, and gateways are rendered appropriate accessories thereto, while surrounding gardens and foliage make the view pleasant and smiling."

We cannot conclude this sketch better than by stating, that the exertions for the completion of the Cathedral are going on prosperously, and promise the ultimate success of this vast and laborious undertaking.

L.

The Sewers Commission.—It is with regret that we have to announce the death of Mr. Lawes, the Chairman of the Metropolitan Commission. This is the third death in this Commission within a very short period, and we regret to state that the harrassing cabals that are constantly going on in this Commission have greatly aggravated, if not hastened, the death of the lamented engineer, Mr. Forster, and Mr. Lawes, the Chairman. It is what we long since anticipated, and we feel assured that the two bodies of Military Engineers and Civil Engineers cannot act together; and we trust that Mr. Stephenson, in conjunction with his colleagues, Mr. Rendel and Sir Wm. Cubitt, will be firm in resisting the pretensions of parties who are looking forward for appointments. We do contend that it is highly improper that any member of the Commission should be constantly putting forward his own schemes, instead of settling and judging those which are brought forward by their own officers.

APARTMENT HOUSES.

A House, to be let out in Apartments for Families, Hotel non Garnie,—at Vienna.

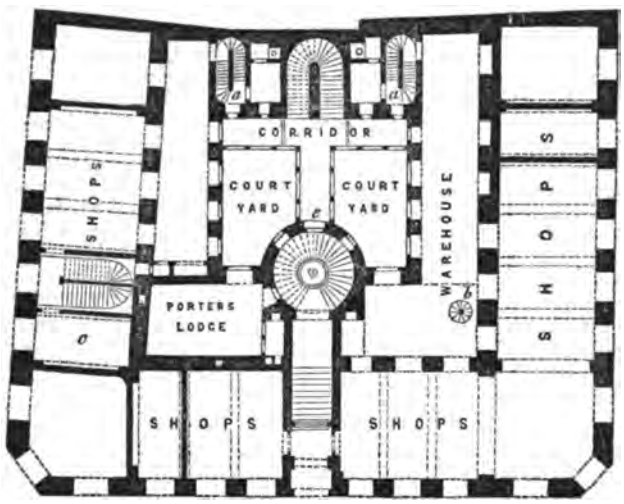
Professor C. F. L. Förster, Architect.

(*With an Engraving, Plate* XXI.)

At page 88, we gave a Plate with the elevation of one of the large houses constructed at Vienna by Professor Förster, Architect to the Imperial and Royal Government, the editor of the *Bauzeitung*, and an eminent writer on architecture.

This building is situated in one of the most animated parts of the city, with a frontage to three streets—Wollzeile, Riemer, and Schuler streets. It was erected upon the site of an old house in the years 1848-9. Ground-rents being very high, and the former house producing a large rental, it was particularly required so to arrange the distribution of the plans that the capital bestowed upon the new building should pay interest, without lessening the rent which the old house produced. These conditions were answered by the execution of the annexed plans; and no expense was spared for the exterior and interior ornamentation.

Fig. 1.



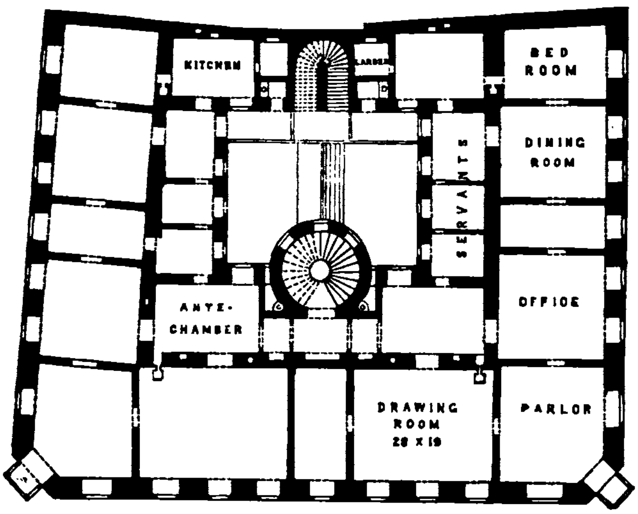


Fig. 2.

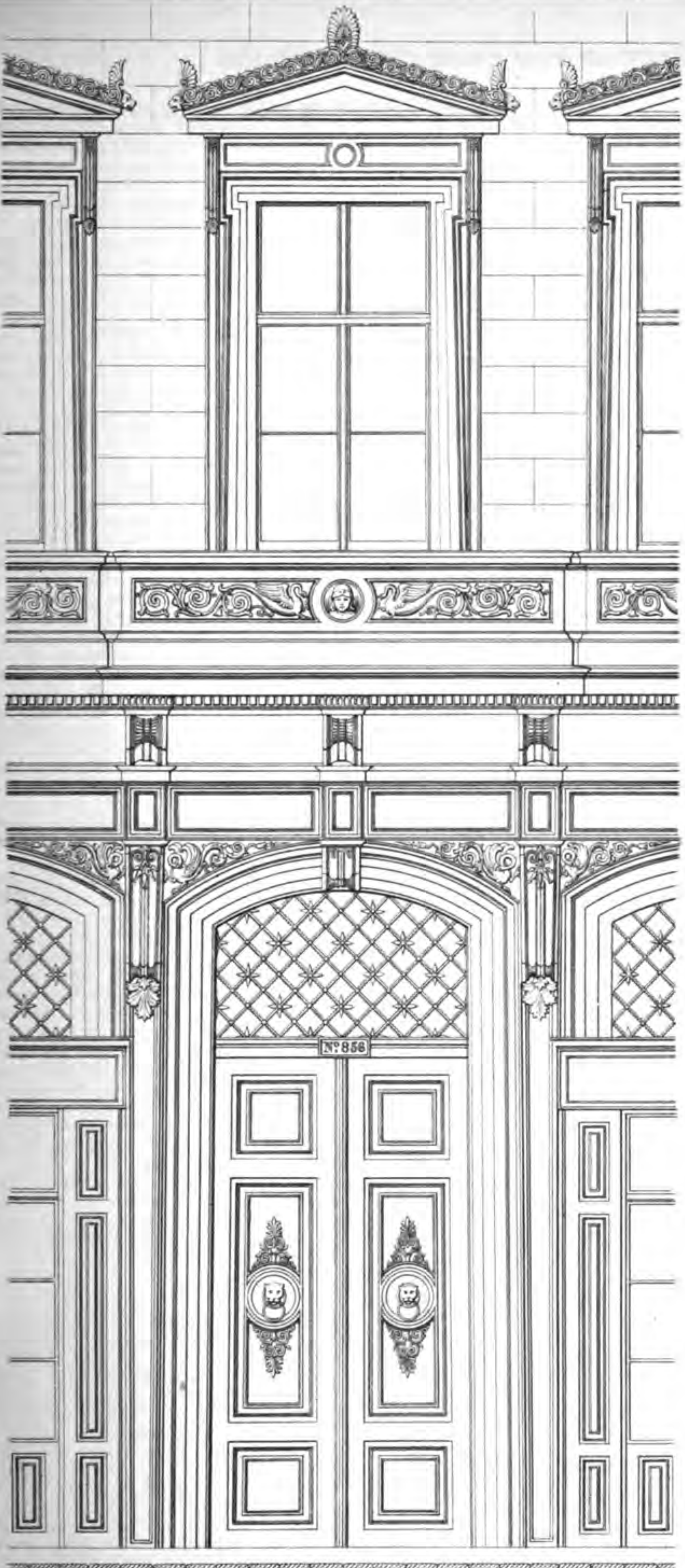
It is matter of experience, that a house in the city of Vienna only pays when the ground-floor is arranged for shops, which pay as much rent as the other four floors. It was the endeavour, therefore, to get as much room as possible for shops, and to connect the cellar and mezzanine with them, and to bring the thickness of the walls to the minimum of the dimensions required by the Viennese building regulations. Figs. 1, and 2, show the distribution. Behind the shops are warehouses, which are connected with the mezzanine and the cellars. The rooms in the cellars are light and dry, because the pavement of the court-yards is on the same level with the floor of the cellars. Two small staircases *a*, and an iron winding staircase *b*, fig. 1, serve as means of communication between these three stories. The apartments *c*, are intended for dining-rooms, and are therefore in connection with the cellars (level with the kitchen), and with the ice-wells underneath. Thus there are two stories under the level of the street. The ice-well in the first cellar is furnished with three pumps. The sewer, 2 feet wide and 2 ft. 6 in. high, could not be laid lower, on account of the situation of the main sewer in the street. It takes up the rain-water from the yards and roofs, which passes first through the cast-iron pipes of the waterclosets. A decorated entrance-hall having several steps within, connects the principal staircase directly with the street. That principal staircase, 5 feet wide, is round, to economise space. A door *e*, leads through the corridor to another staircase, for the use of the servants of the tenants on the first and second floors, and to the inferior lodgings of the third and fourth floors. The first and second floors are divided into two sets of apartments; and the third and fourth into four separate lodgings for families. The corridor is formed of stone flags, supported by cast-iron columns and wrought-iron arches, between which there are wooden partitions with windows. The balconies, which project out from the corners, are planned because they must be cut off for the better communication with carriages, as the streets are very narrow. These windows assist much in the decoration of the outside. The balcony over the entrance was not only required by the Von Rieger family, to whom the building belongs, but it was also the desire of the architect to render the entrance more prominent, and to enable visitors to step dry-shod from their carriages into the house. All ornaments of the façade and the entrance-hall are of burnt clay, from the manufactory of Herr Brausewetter at Wagram. The building is constucted in the ordinary manner prevalent at Vienna; but no doubt, eventually, lighter constructions will take the place of the present too substantial ones.

The Engraving, Plate XXI. contains an enlarged view of the principal entrance door, window, and balcony over, showing the architectural dressings.

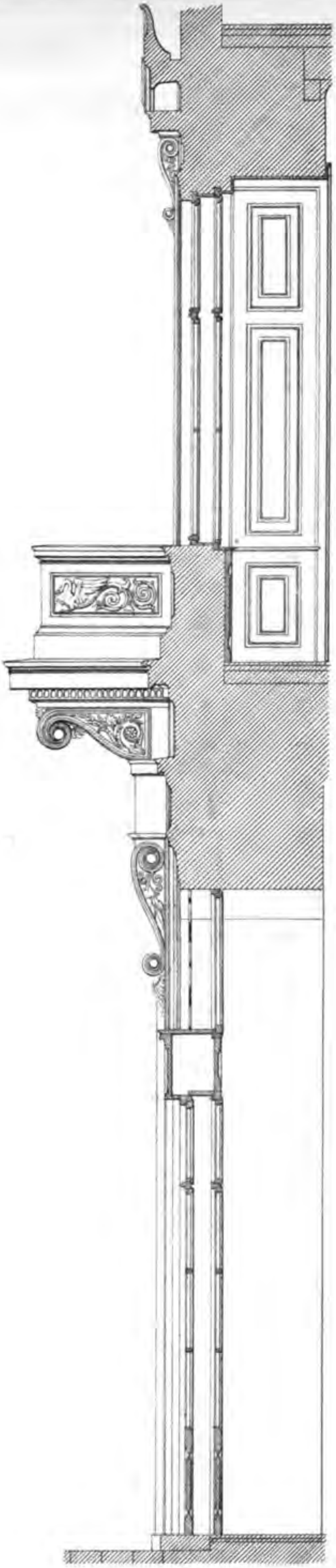
It will be seen that each suite of apartments on the principal floor has access to two staircases, and includes an office, ante-room, dining-room, parlour, and drawing-room, of good dimensions; a kitchen, best bed-room, three servants' rooms, a hall or study, cellar, and two waterclosets. One set has a secondary bed-room over the entrance. The rooms are well lighted and of lofty proportions. The drawing-room is high, 26 feet by 19 feet on the floor, lighted by three windows, and communicating with the sitting-room and parlour; and in case of need, one suite is formed from the secondary bed-room through the drawing-room, parlour, office, hall, and dining-room, to the best bed-room; the whole length of this suite is nearly 90 feet. The doors are so placed that, when the rooms are *en suite*, a person standing in the parlour has a vista of 50 feet through the drawing-room, and of nearly 70 feet through the dining-room. The lighting by chandeliers or gas contributes to this effect.

The distribution here adopted is not wholly suitable to English habits, but it affords some hints as to a mode of construction which is likely to be extensively adopted in London, on which account we have considered it highly desirable to lay these examples before our readers.

Concrete Houses.—On a recent professional visit to East Cowes, Isle of Wight, we were much pleased with the economy displayed in the construction of two houses now being built on this beautiful estate near to Osborne House, under the direction of Mr. Langley. On the spot is some excellent gravel, which has been very advantageously turned to account, by building a pair of cottage villas entirely of concrete, composed of one part of Francis' Medina Cement mixed with six parts of coarse gravel, and two of hoggin or coarse sand. The walls are carried up, as well as the chimneys, by fixing two or three boards vertically, and filling-in the concrete between, about 12 to 14 inches thick, by which method, in consequence of the quick setting of the cement, the walls are carried up and the boards shifted within three or four hours after the wall is built. Even the arches are all turned with it, and no bricks are used. This cement, which is manufactured on the island by Messrs. Francis, is well deserving the notice of the profession; it is largely used in the works at Dover Harbour, and is quite equal to the best Roman Cement. We may add, that in Sandown Bay, in the Isle of Wight, a sea groyne, of 200 feet in length and about 7 feet in height, has been built in the same material, at right angles with the shore, for the purpose of forming a breakwater in protection of the land, and that it has achieved its object to the satisfaction of the owners of property, where everything else had been swept away. The groyne has now stood twelve months exposed to all the violent gales we have had in the Channel, and it was lately inspected by order of Sir John Burgoyne, on the part of the government.



FRONT ELEVATION.



SECTION.

DETAILS OF DOORS AND WINDOWS IN DWELLING HOUSE FOR FAMILIES. VIENNA.

HERR FÖSTER, ARCHT.

INS.12 6 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 FEET

J.R. Jobbins

TOWERS AND SPIRES OF THE CITY CHURCHES: THE WORKS OF SIR CHRISTOPHER WREN.

By John Clayton, Architect.

[*Extracts from a Paper read at the Royal Institute of British Architects, April 5th, and 26th.*]

In bringing under your notice the Towers and Spires of the City Churches, it will be my object to give some of the results of the observations which I made while engaged in taking the measurements for the geometrical drawings and views now exhibited. It is hardly necessary to remind you under what circumstances these admirable specimens of architecture were designed and carried into execution. The catastrophe of the Great Fire as an historical event, and the name of Wren as the renovator of this metropolis, will probably outlive these enduring monuments of his fame. Well-known, however, as they have been, as the pride of this city for nearly two centuries, it is a remarkable fact that they have hitherto received very little practical attention, though frequently represented in works of a pictorial character, which do not convey those correct ideas of form and proportion that are so valuable to the architect. Had these edifices been situated farther from home, we should, in all probability, have had long ere this, most accurate measurements of every portion of them; for, as Colin Campbell observes, "the general esteem that travellers have for things that are foreign is in nothing more conspicuous than with regard to building, though perhaps in most we are equal, and in some things surpass our neighbours." In confining ourselves to the towers and spires, it must be borne in mind that the interiors of Wren's churches are not less worthy of attention. The crowded and irregular forms of the different sites called forth the fertility of Wren's talents and ingenuity in overcoming numerous difficulties, out of which he contrived to produce effects full of beauty and excellence as the happy results. Other styles than those in which Jones and Wren designed have exclusively been termed *ecclesiastical:* but it may be safely asserted that the plans of the city churches designed by Wren are the best adapted to the protestant ritual, and that the instructions which he has left with regard to church building are well worthy the attention of all intrusted with the direction and control of such matters. Of the exterior of these churches there is but little to notice, facing, as they do, narrow lanes and courts, which allow no space for architectural display. It was Wren's wish to keep each church detached by setting back the surrounding houses; he was, however, prevented from accomplishing his object, so that many of his churches have but one front, and that only visible at the distance of a few yards. The want of opportunity for the display of any architectural façade has been, however, in most instances, compensated for by the importance given to the towers and spires, which are placed in the most favourable position, and rise fairly upwards from the solid ground, instead of being perched on the roof of the main building, or of the projecting portico, as is the case in too many later examples.

No church seems complete without a tower or spire. Wren, writing on this subject, observes: "Handsome spires or lanterns, rising in good proportion above the neighbouring houses (of which I have given several in the city, of different forms), may be of sufficient ornament to the tower, without great expense for enriching the outward walls of the churches, in which plainness and duration ought principally if not wholly to be studied. When a parish is divided, I suppose it may be thought sufficient if the Mother Church has a tower large enough for a good ring of bells, and the other churches smaller towers for two or three bells, because great towers and lofty steeples are sometimes more than half the charge of the church."

The distinction between a spire and a lantern may be said to depend on the form and outline, and more particularly on the proportion which each respectively bears to the supporting substructure or tower. In a spire, this proportion is about that of equality; in a lantern, the superstructure is about one-half the height of the tower beneath. The towers, without the spire or lantern, will be found to vary from four to five times their breadth in height. It is hardly possible to conceive a greater variety than Wren has exhibited in the designs of his Towers and Spires, all of which are based on principles distinctly laid down in his writings. These buildings may be classified for consideration under the following heads:—Stone Spires; Stone Lanterns; Lead Spires; Lead Lanterns; Towers; a tabular list of which, with their dates and dimensions, is subjoined.

	Date.	Height.	Base.
Stone Spires.			
1. St. Bride's, Fleet-street	1700	230	30
2. St. Mary-le-Bow, Cheapside......	1680	223	32
3. St. Vedast's, Foster-lane	1697	160	20
4. St. Antholins', Watling-street	1682	158	20
5. Christ Church, Newgate-street....	1704	160	23·3
Stone Lanterns.			
1. St. Stephen's, Walbrook	1672	130	20
2. St. Michael Royal, College-bill ..	1694	135	20
3. St. James, Garlick-hill	1683	125	20·3
4. St. Mary Magdalen, Old Fish-street	1685	86	16
5. St. Dunstan's-in-the-East	1698	171	20
Lead Spires.			
1. St. Margaret Patten's, Rood-lane..	1687	200	22
2. St. Swithin's, Cannon-street	1679	150	20
Lead Lanterns.			
1. St. Magnus', London-bridge......	1705	185	30
2. St. Peter's, Cornbill	1681	141	20
3. St. Benet's, Gracechurch-street ..	1685	148	20
4. St. Benet's, Thames-street	1683	115	16
5. St. Benet's Fink	1673	100	18 9
6. St. Mary's, Abchurch............	1686	150	20
7. St. Martin's, Ludgate-hill........	1684	170	22
8. St. Margaret's, Lothbury	1690	142	18
9. St. Mildred's, Bread-street	1683	150	18
10. St. James's, Westminster	—	155	24
11. St. Edmund the King	1690	136	17
12. St. Michael's, Queenhithe	1677	140	18
13. St. Austin's, Watling-street	1695	140	20
14. St. Nicholas', Cole Abbey	1677	120	19
15. St. Lawrence's, Jewry	1677	160	25
16. St. Michael's, Bassishaw	1679	140	21
17. St. Anne and St. Agnes'	1673	95	14
18. St. Stephen's, Coleman-street	1676	85	—
19. St. Mary's, Aldermanbury........	1677	90	—
20. St. Michael's, Wood-street	1675	90	—
Towers.			
1. St. Andrew's, Holborn	1704	140	23
2. St. Mary's, Somerset	1695	110	20
3. Allhallow's, Watling-street	1697	104	17·6
4. St. George's, Botolph-lane	1674	72	16
5. St. Michael's, Cornhill	—	135	27
6. St. Mary's, Aldermary	1711	135	24
7. St. Clement's, Eastcheap	1686	88	16
8. Allhallow's, Lombard-street	1694	105	21
9. St. Bartholomew's, by the Exchange	1679	90	—
10. Allhallow's, Thames-street	1683	88	22
11. St. Dionis' Back Church, Feuchurch-street	1684	101	20
12. St. Andrew's, Blackfriars	1692	80	18
13. St. Matthew's, Friday-street......	1685	74	16
14. St. Olave's, Jewry	1673	83	—
15. St. Sepulchre's, Newgate-street....	—	140	—
16. St. Mildred's, Poultry	1676	73	16
17. St. Mary-at-Hill	1672	96	—
18. St. Clement's, Strand, left a Tower by Wren	1682	116	—

The dimensions of height are given up to the top of the vane, or finial.

Of the above list, it may be observed that the Stone Spires and Stone Lanterns are the objects most worthy of consideration.

With reference to the skill displayed, both in the design and in the construction, it will be seen that St. Bride's is a composition of equalities in which there is a pleasant succession of vertical and horizontal lines, beauty being obtained by agreeable repetitions, and not, as in most other instances, by harmonious varieties. The spire, which is formed of a series of open arches rising in succession above each other, shows how well Wren could repeat forms without at the same time rendering them monotonous. The construction of this spire materially differs from any other—Italian, or Gothic. The arches form vaults or cells within, which are firmly bound together by the central spiral cord or staircase, and thus equally distribute the pressure over the surface below, imitating in a beautiful manner some of the strongest forms of nature. The provision made for carrying this spire is excellent. Within the belfry are angle corbels with flat surfaces which contract the square to the octangular form, which is reduced to a circle by a bold rounded moulding level with the top of the external cornice. The circle measures 17 feet in diameter, and above it rises a lofty conical dome, measuring 14 ft. 6 in. to the crown. The sides of this dome are somewhat of an ogee form, but nearly flat to within a very short distance of the apex; and it should be distinctly observed that the joints of the masonry do not radiate, but are kept perfectly horizontal, each layer corbelling over, with a slightly bevilled surface, until within a few courses of the keystone. Had any other construction been adopted, even metal bands would not have long retained the whole together. The masonry of this part is extremely massive and carefully connected, the depth of the keystone being not less than 4 ft. 9 in. The spaces between the sides of the dome and the exterior measure nearly double this dimension, and it is probable that voids are left at intervals within, though there is now no opportunity of ascertaining the fact.

The spire of Bow Church, on the other hand, is a composition of varieties—the solid and the open, the square and the circular, the vertical, the horizontal, and the flowing. The solid square tower and the light circular spire with its beautiful peristyle, where the columns are lost in succession, the flowing lines of the open arches above, the return to columns on the next story, and the finish by repeating the flat forms of the tower, the play of light and shade, and the elegance of the outline, render it a masterpiece of its kind, which will probably never be surpassed. The walls of the tower are 7 feet thick as high as the belfry. The terminations in the form of scrolls placed at the corners of the tower, and surmounted by vases, have great beauty of form, and admirably prevent any abruptness in the transition from the square tower to the circular spire. The spire, the centre of which is a cylinder of masonry 9 inches thick, is supported on a dome resting on massive moulded corbellings in the angles of the belfry. The dome is circular on plan, and 20 ft. 8 in. diameter at the base. It is slightly curved in section, and rises to a height of 18 feet above the springing. The joints in the masonry of the dome are horizontal, as may be observed in the entrance to the upper part, which passes through one of the sides.

St. Vedast's spire, too, is a charming composition of varieties; the square, the concave, the convex, and the square repeated in the pyramidal termination, give hard and soft shadows most agreeably distributed.

Christ Church spire is a composition of light work contrasted with solid, on the square plan throughout.

St. Antholin's spire is an octagonal composition of a solid character, being a skilful adaptation of the ordinary Gothic spire to the Italian style.

The manner in which the towers supporting the spires are treated, has great influence on the effect of the whole composition, or steeple. In the examples mentioned, it will be seen that the number of apertures, their forms and proportions, the subdivision by bands and cornices, and especially the decoration of the belfry story, are so arranged as to form a suitable substructure to the upper portion or spire.

Among the Stone Lanterns, those of St. Stephen, Walbrook, St. James, Garlick-hill, and St. Michael Royal, are fine specimens. The two first are square in plan, and present the peculiarity in their construction of being carried on domes springing from piers in the internal angles of the belfry, which piers are built independent of the walls, and transmit the weight to the thicker work below.

The lantern of St. Michael Royal is octagonal in plan, and is supported on a dome resting on deep corbels in the angles of the belfry. In this instance, the assistance of strong iron tie-rods is required, to resist the outward thrust of the arches beneath the dome.

The lantern of St. Dunstan's-in-the-East is a remarkable production, both for construction and symmetry. No ancient example can compare with it in these respects. That of St. Nicholas, Newcastle-upon-Tyne, almost the only ancient example remaining since the destruction of old St. Mary-le-Bow, would not be worthy of mention if placed by its side. In St. Nicholas', the wide span across the tower, and the low rise of the lantern and flying buttresses above the battlements, appear to overpower the resistance to their thrust. On the other hand, St. Dunstan's stands easy and graceful, every portion appearing to be at rest, and conveying the full impression of enduring as an undoubted masterpiece of its kind. From each angle of the parapet, but fairly within the pinnacles, rise the graceful flying buttresses which support the lantern. These measure 2 ft. 5 in. by 1 ft. 8 in., and rise with the same dimensions to the curve immediately below the lantern, where they are gathered round a circular aperture 3 ft. 6 in. diameter. The lantern, externally, is not less than 6 feet across, and the distribution of the joints of the masonry at this point is the most delicate part of the construction. The flying buttresses, the joints of which slightly radiate in the upper part above the battlements, are carried on long flat corbels 28 feet deep, reaching to the bottom of the belfry and to the thicker walls of the story below.

St. Dunstan's is a remarkable edifice, though it cannot be praised for what is called good Gothic detail, for Gothic was a style little understood or cared about in Wren's time; it nevertheless possesses so many compensating qualities as to be well worthy the attention of the most refined mediæval critic. Wren has been censured for building in a style of which he was not perfect master; it must, however, be recollected that he did not adopt Gothic but in cases of necessity like the present, and that he gave a decided preference to what was considered a new and a better style.

Next to the stone spires of St. Bride's and St. Mary-le-Bow, the lead spire of St. Margaret Patten's, Rood-lane, is the loftiest attached to the city churches. It presents a good outline, equal to some of the most approved Gothic examples. The timber framing of which it is formed deserves notice, strength and security from torsion being obtained by the skilful disposition rather than from the scantlings of the timbers.

St. Magnus', London-bridge, displays the loftiest and handsomest of the lead lanterns. The cupola, which is of masonry below, is of an octagonal shape, and like the tower, measures a foot more in one direction than the other; this irregularity is however so treated as to be imperceptible. It is relieved by large openings, and is finished with a dome and upper lantern of exceedingly graceful contour.

The lead lanterns of St. Peter's, Cornhill, and of St. Benet's, Thames-street, may be named as good examples, and have towers constructed of red brickwork.

Of the towers many were doubtless designed to carry cupolas, which, indeed, in one or two instances, are said to have been removed. Of those intended to remain as towers, the most worthy of notice are—

St. Andrew's, Holborn, which is a fine example with deeply sunk and enriched belfry windows, a strong cornice, having coupled trusses at the angles and elegant scroll pinnacles over.

St. Mary's, Somerset, has eight lofty pinnacles, varying in height, which, though perhaps somewhat too rich for the tower, group well in perspective.

Allhallow's, Bread-street, has open tripled arches and lofty obelisk pinnacles at the angles, and is a very picturesque composition.

Allhallow's, Lombard-street, St. Dionis' Back Church, and Allhallow's, Thames-street, have bold ornamental parapets, and the latter has a block cornice.

The Gothic Towers of St. Michael's, Cornhill, and St. Mary's, Aldermary, were nearly the last of Wren's works; but though last, certainly not least, either as to dimensions or importance. They have each octagonal pinnacles at the angles not less than 7 feet across, but they have this resemblance only, their general appearance and treatment being very different. The outlines are extremely bold and effective, and the latter is by far the best Gothic example of the period.

With reference to the construction of these edifices, it will be hardly necessary to observe that Wren's towers and spires were built "in the most substantial and workmanlike manner," and to adapt the words of modern specifications still further, "the materials used were the best of their respective kinds;" but here ends the similitude. Wren put a different construction on these words from that often given in the present day; with him none of the funds which should be expended in stability were wasted in decoration—a fault which is perhaps mainly attributable to the present defective state of competitions, with which Wren was not troubled. The walls of the towers vary from 5 feet to 7 feet in thickness, and are of solid masonry, sometimes backed up with brick, but generally with stone of a rougher description. The stone is Portland, the timber oak, and the lead must have weighed at least 10 lb. to the foot superficial. The floors in nearly all the towers are carried upon corbels, a preferable mode to inserting the ends of the beams in the walls, as the floors are more readily replaced when decayed, and the walls are not so liable to be injured by fire or strains. The towers have in nearly every instance convenient access to the belfry or parapet by circular stone staircases; and it is worthy of notice that the front line of the steps runs to the centre and not to the face of the newel, as is usual in Gothic staircases; this perhaps occasions a little more work, but gives a much better tread. The block cornices and enriched parapets, which are so frequently imitated in the more modern parts of the metropolis, were first used by Wren.

Wren observes that spires were of Gothic extraction, to which, however, his imitations have no further resemblance than their pyramidal outline. Those nearest approaching Wren's are the Lombardic and Italian campanili, and though Wren does not appear to have visited those countries, still he was doubtless well aware of their existence and forms; they are however quite a distinct species, are of vast dimensions, and have different proportions. The earlier campanili date from more than 1000 years before Wren's time; their upper parts are divided into a number of equal stories, enriched with arches, and the upper stories were subsequently frequently broken into the octagonal form and covered with a spire; from these were derived the Norman, and afterwards the beautiful Gothic steeples, as at Boston, Louth, and Salisbury. When the Gothic was exhausted, the Italian architects of the revival returned pretty closely, but with greater refinement, to the forms of the early campanili, though but few if any of their works can be called spires, so that it remained for Wren to rival these Gothic edifices—but in the Roman style and detail. It will thus be seen, architecture being more a science of growth than of positive invention, that spires were first derived from Roman architecture about 1000 years ago, were continued and perfected in Gothic architecture during a space of 500 years, and were afterwards re-transplanted in their original style, in which the genius of Wren has made them flourish with equal success. In a paper read before the Institute, Mr. I'Anson observes with respect to campanili: "Perhaps there are no finer modern instances to be met with than the beautiful compositions of our countryman Sir Christopher Wren," and having paid probably more attention to this subject than any one, I can most completely concur in Mr. I'Anson's statement.

The great difference between Wren's spires and the revived Italian campanili is, that the former have a lofty pyramidal outline, are divided into three, four, or five stories, and are enriched with open stages of columns or pilasters. The columns used in this elevated position are differently treated than when placed near the ground, and the orders have a much bolder description of detail. To design a spire in this style requires a good knowledge of perspective, for as Wren observes—"Everything that appears well in orthography, may not be good in model, and everything that is good in model, may not be so when built; but this will hold universally true, that whatsoever is good in perspective, will hold so in the principal views, if this caution only be observed, that regard be had to the distance of the eye in the principal stations."

With reference to their composition, Wren also gives some further valuable information. "Things seen near at hand may have small and many members, be well furnished with ornaments and lie flatter; on the contrary, all this care is ridiculous at great distances; there bulky members, and full projections casting quick shadows are commendable; small ornaments at too great distance serve only to confuse the symmetry, and to take away the lustre of the object by darkening it by many little shadows. There are different reasons for objects whose chief view is in front, and for those whose chief view is sideways."

In this branch of design, it should be noticed that Wren has had many able followers, foremost among whom stand his pupils Gibbs and Hawksmoor, then Vanbrugh, Dance, Archer, James, and Flitcroft. Gibbs built St. Martin's-in-the-Fields, and St. Mary's in the Strand; Hawksmoor, St. George's, Bloomsbury, and St. Mary's, Woolnoth; Dance built St. Leonard's, Shoreditch; Archer, St. Phillip's, Birmingham; James, St. George's, Hanover-square; and Flitcroft, St. Giles-in-the-Fields. All these are very beautiful examples, more especially the two first by Gibbs and Hawksmoor. Dance, in the spire at Shoreditch, has imitated the outline of St. Mary-le-Bow, but on a smaller scale, the circular peristyle of columns, which is perhaps the weakest part of the latter, being strengthened by arched walls returning from the columns to the cylinder within. The story above has a domed covering instead of open flying buttresses, by which it gains in solid appearance, but loses in lightness and elegance. These examples have all their relative excellence, but taken as a whole, they cannot be compared to Wren's best examples, St. Mary-le-Bow, St. Bride's, and St. Vedast's.

Discussion.—Mr. Fowler stated that he had examined closely the spire of St. Dunstan's-in-the-East, and could confirm what Mr. Clayton had said as to the joints of the flying buttresses. These were not at right angles to a tangent of the curve as in ordinary archwork, but were continued horizontally up to very near the conjunction of the four flying buttresses, so that the higher or upper joint seemed to him to occasion some little weakness. It was, of course, a balance of consideration between the benefit to be gained by spreading the lateral thrust, and the danger incurred by the weakness of the stone at the acute inner angle. No doubt it had been a matter of great study on the part of the architect, and his conclusion was perfectly judicious. It was remarkable in the churches of Wren, that where the tower stood against the street, it was always perfect from the base to the summit; not like St. Martin's in the Fields and others, growing out of a pediment or standing on a roof. Although Wren's details were all Roman, his outlines were strikingly Gothic. He appeared to have been imbued with the importance of retaining the ecclesiastical form of composition in Gothic buildings, and to graft upon it the details of what he thought the more legitimate architecture of Italy.

Mr. Billings was entirely at variance with Mr. Clayton as to the merit of the tower of St. Dunstan's-in-the-East, which was not to be compared with those of St. Nicholas at Newcastle, St. Giles's, Edinburgh, and King's College, Aberdeen. There was nothing wonderful in the construction of St. Dunstan's, but in the others there was involved a series of nicely adjusted calculations of what a flying buttress would bear upon its point; whilst at St. Dunstan's the pressure was almost vertical. The spirit, however, of Wren's Gothic was beautiful, but the detail was excessively bad. Although Wren did not like Gothic architecture, he did not hesitate to adopt its principles—a fact which was strikingly shown by the flying buttresses within the screen wall of St. Paul's. Though giving Sir C. Wren all the credit justly due to him, he would say, with all deference, that many of his spires were far from faultless. He did not speak of Bow, of St. Bride's, of St. Vedast's, or of St. Dunstan's. Many of Wren's churches were extremely beautiful; and those he referred to were merely not quite so beautiful as the rest. The fact was that Wren was an overworked man, and his genius was at last worn out. Indeed, Mr. Billings could hardly understand how the man who had produced the spires of Bow Church and St. Bride's, could have afterwards produced the spire of St. James's. While the detail of the towers of Westminster Abbey was wretched, the spirit of those towers was good, and undoubtedly Gothic. The great ability shown by Wren in effecting the junction of his towers with their spires was a point of the highest merit, and a study for all architects. Their variety showed, indeed, that as many variations could be made in the towers and spires as in the tracery of a Gothic panel. The extraordinary manner in which the plans of Wren's churches were adapted to the streets they were placed in was remarkable. Professor Cockerell had pointed out an instance of this to him, in the church of St. Antholin, Watling-street, which was adapted to the previous bend of the street, the line of which had been altered.

Mr. Fowler mentioned as another instance of the same careful adaptation to local circumstances the church of St. Magnus, London-bridge. Originally the lower part of the tower was closed, but when public convenience rendered it necessary to carry a way through it for passengers, it was found that in the construction of the work, Wren had anticipated and provided for such a measure, by leaving a straight joint in the masonry.

Mr. Nelson drew attention to the campanili, or western towers of St. Paul's, which had not been mentioned, but which he had always regarded as extremely beautiful. By M. Quatremère de Quincy* they were quoted in disparagement of Wren, but as seen from Ludgate-hill (and he hoped they would some day be better seen, and the cathedral be thrown more open to view), he could not but regard them as highly effective. The mode of construction in the domed part of Wren's spires, by the adoption of horizontal instead of radiating joints, recalled a much more ancient employment of that system in the Treasury of Atreus at Mycenæ, in Greece, which he believed

* 'Dictionnaire d'Architecture.' *Article*, "Clocher."

Professor Donaldson was the first to elucidate. The staircases in the Spires of Bow and St. Bride's were very interesting; he believed the hint for the way in which the latter was carried, and the strength afforded by it was derived from natural objects —from a study of conchology. In conclusion he drew the attention of the meeting to the admirable manner in which Mr. Clayton had arranged and classified the towers and spires of Wren in his drawings.

Mr. JENNINGS suggested that there had been an alteration in the spire of St. Bride's, which did not present the same appearance as when originally designed by Wren. It was reported that a whole story had been removed.

Mr. CLAYTON said it had been lowered 7 feet, chiefly in the obelisk. That dimension would not have admitted another story.

Mr. GARLING inquired whether Mr. Clayton, in his examination of the more lofty spires, had noticed what provision was made for protection from lightning.

Mr. JENNINGS thought there would be no difficulty whatever in the employment of lightning conductors internally.

Mr. BILLINGS said that Wren's spires were as liable to be twisted as any others which had conductors at the top going through the centre of the spire. The spire of St. Martin's was struck about two-thirds of its height from the top.

Mr. CLAYTON said that church had no conductor.

Mr. GARLING said the weathercock itself, which went some distance into the spire, would act as a conductor as far as it went. He thought that conductors placed inside were liable to be severed without attracting notice, which could not be the case if they were outside.

Mr. HESKETH said the present practice was to connect the lightning conductor as much as possible with all the metal-work of the building, and to carry it down into the earth; and this might be done by connecting it with a water-pipe.

Mr. GARLING said that was the case at St. Paul's, where the conductor was connected in numerous places with the rain-water pipes and the lead-work.

Mr. FOWLER observed that damage by lightning only occurred where the electric current was resisted, and all that was necessary was to provide the means of conveying it to the earth.

Mr. C. H. SMITH stated as the result of his examination of the spire of St. Martin's Church, that the lightning appeared to have struck the vane, and run down the rod supporting it; and the mischief began where that rod terminated. The current went from that point to the stone-work in the spire, which was fixed together with very strong iron cramps run with lead; and in its passage through the stone from one of these cramps to another, the masonry was split in a spiral line all round, hardly one of the stones in that line remaining entire. It then made its way to the lead-work of the roof and down the metal pipes inside the pilasters. As to the principle of lightning conductors, it was well known that a bell-wire would serve to transmit the current; but the danger was that so much heat might be generated as would melt the wire; and therefore it was necessary to make the conductor of sufficient substance to prevent its being fused. With respect to the masonry, he observed that Wren had used in some of his churches, as in the porch of St. Bride's and the inside of St. Paul's, a soft and cheap description of stone which came, he believed, from Windrush, near Burford, in Oxfordshire. The Portland stone of Wren's churches, and others, to the year 1740 or 1750, was extremely coarse and full of a species of small oyster-shell. This might be noticed in Hawksmoor's Church (St. Mary's Woolnoth), Lombard-street. This kind of stone had been brought from the eastern side of the Isle of Portland, where a large quantity of it still remained. This was proved by the documents in the possession of the family whose ancestors supplied the stone for St. Paul's and Greenwich Hospital. It was then called "best bed stone," being the best then known, and it still retained that name, although much better stone was now worked. The Portland stone now in use was introduced not long before the time of Sir W. Chambers; and the north front of Somerset-house would be found to be of a very superior kind of stone to that of Wren's time.

Mr. IRVINE explained, from his own observation in drawing it for the Royal Academy, about six months ago, the construction of the upper part of the spire of Bow Church, in the masonry of which (in the solid part of the drum) pieces or dowels of English oak were inserted, apparently to diminish the vibration. He felt sure they were placed there when the spire was first erected. From the want of a proper conductor, this spire was very liable to injury from lightning.

Mr. SMITH said it would be easy to hang a chain of wire ½-inch or ¼-inch thick from the spindle of the vane inside the spire and tower down to the ground.

Dimensions of Italian Campanili.

	Height in English Feet.	Proportion of Height to Base.
Cremona Il Torrazzo	396	—
Square part, ⅗ of whole height	—	6
Venice S. Marco	350	—
Square part, ⅗ of whole height	—	6
Sienna, Torre del Mangia	338	—
Modena, la Ghirlandina	315	—
Bologna, Torre Asinelli	312	12
Florence	273	6
Parma	256	8
Sienna, Cathedral	210	8
Pisa, leaning tower (circular)	178	3
Lucca	177	—
Bologna, Torre Garisendi	161	—
Rome, Sa. Maria in Cosmedin	110	7
Pisa, S. Nicola	109	5

Heights of Western Towers and Spires of some Cathedrals.

	Feet.	Executed.
Cologne	514	—
Ulm (A.D. 1500)	491	237
Strasburg	452	—
Fribourg (A.D. 1122-1152)	415	—
Antwerp (A.D. 1420-1518)	403-7	—
York	195	—
Salisbury (A.D. 1350)	404	—
Old St. Paul's	520	—
Vienna	465	—
Boston, Lincoln (Church)	266	—
Norwich	309	—
Chichester	300	—
Lichfield	252	—
Lincoln	264	—
Canterbury	230	—
Gloucester	223	—

WATER-WHEEL REGULATOR.

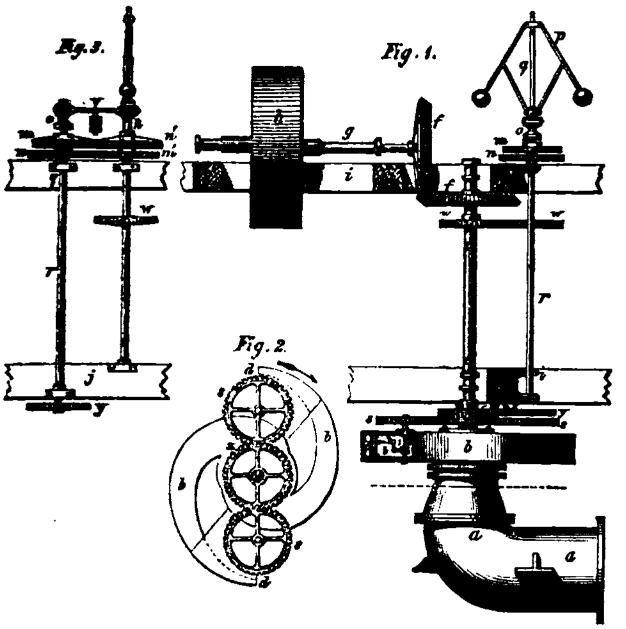
JAMES FINLEY, *of Putnam County, New York, Patentee.**

IN the annexed engravings, fig. 1 is a side elevation of Finley's patent differential governor, as applied to Whitelaw and Stirratt's patent water-wheel; fig. 2 is a plan of the gearing on the top of the water-wheel, in connection with the governor; and fig. 3 is a front elevation of the governor, apart from the water-wheel;—in which figures the same letters refer to the same parts.

b, b, is the water-wheel; *d, d*, the jet apertures; *a, a*, the main pipe; *e*, the water-wheel shaft; *f, f*, the main gearing, by which the power is transmitted to the main shaft *g*, and drum *h*, and from thence by a band to any machinery on which it may be intended to act; *i, i*, and *j, j*, are parts of the framing; *p*, is a revolving pendulum, mounted on a spindle *q*, which in fig. 1 is situated beyond a second spindle *r*, as seen in fig. 3, and is supported by a step on the upper edge of the lower frame at *i*. This spindle is driven from the water-wheel shaft by the cog-wheels *w, w*, and carries two cog-wheels *m' n'*, of different sizes, which gear into two similar cog-wheels *m, n*, on the spindle *r*. These wheels are reversed in position, so as to have the smaller on the one spindle, to gear into the larger on the other; *n'*, and *n*, are keyed fast; *m'*, and *m*, are loose, but are capable of being engaged by the clutch-boxes *o*, and *k*, the prongs of the latter being sufficiently long to engage *m'*, by extending down through betwixt the arms of *n'*. This clutch-box is connected by links to the arms of the revolving pendulum, so as to be drawn upwards or pushed downwards, in accordance with the centrifugal action of the balls consequent upon the variations of the motion; and it is also connected with the clutch-box *o*, by a double-forked lever, moveable on the centre *v*, the result of this connection being to communicate to the clutch-box *o*, the

* From the *Journal of the Franklin Institute.*

upward and downward motion given to the clutch-box *k*, by the arms of the revolving pendulum. The motion thus communicated will be seen to be in opposite directions; the one clutch-box moving upwards, whilst the other is moving downwards, and *vice versâ*. *x*, is a cog-wheel, fitted loosely to a turned seat on the shaft *s*, so as to be at liberty to revolve freely round,



independent of that shaft. It is connected through an intermediate stud-wheel *z*, *z*, with a wheel *y*, which is keyed fast on the bottom of the spindle *r*, and consequently must partake of any variation of motion that may be given to that spindle; *s*, *s*, are cog-wheels, which gear also into *x*, below *y*, and *z*. These wheels are mounted on short spindles, which revolve in bearings attached to the water-wheel, and have screws formed on the lower end, one of which is seen at 2, fig. 1. On this screw there is a nut with two projecting ears, which are embraced by the forked-end of the horizontal arm of the bell-crank 1, the vertical arm of which is connected by the link 4, with a movable adjusting-plate, which forms the inside of the jet aperture at *a*. It will now be obvious, that if the cog-wheel *x*, be made to revolve in either direction, the wheels *s*, *s*, with their spindles, will revolve accordingly; and by the action of the screws, the nuts held by the forked-ends of the bell-cranks will either ascend or descend, in accordance with the direction of the motion given to *x*, and will act on the adjusting-plates through the agency of the bell-cranks and links, so as either to push them outwards and diminish the width of the jet apertures, or draw them inwards and increase that width.

Such being the general arrangement of the parts of the governor, its action may be thus explained. Assuming thirty-seven revolutions per minute to be the proper speed of the water-wheel, and also the proper speed for the revolving pendulum, let it be supposed that the water-wheel, having been put in operation, is making thirty-seven revolutions per minute; it will transmit the same speed to the spindle of the revolving pendulum through the equal-sized cog-wheels *w*, *w*, and draw up the clutch-box *k*, and also the double-forked lever in connection with it, to the exact position at which they will stand under those circumstances. But by the same action the fork on the opposite end of the lever will push down the clutch-box *o*, on the spindle *r*, to a corresponding distance. In this state of things the lever is supposed to stand in a level position, holding both clutch-boxes out of gear with their respective loose wheels *m'*, and *m*, as represented in fig. 3. It will be obvious that no motion can in this case be transmitted from the spindle *q*, to the spindle *r*, and consequently no motion can be transmitted to the wheel *x*. So long, therefore, as this state of things continues, no change can take place in the widths of the jet apertures.

Suppose now a part of the resistance to be thrown off the water-wheel, the speed will then begin to increase; but the moment that this takes place, the balls of the revolving pendulum will, by their increased centrifugal action, recede further from the centre of motion, and raising up the clutch-box *k*, will push down the clutch-box *o*, so as to engage the wheel *m*. The consequence will be, a speed transmitted through the spindle *r*, to the wheel *x*, as much greater than the speed of the water-wheel as the wheel *n'*, is larger than the wheel *m*. But the wheel *x* being free to move, independent of the water-wheel shaft, and being driven in the same direction, will have a relative motion round that shaft precisely equal to this difference of speed. For instance, should this difference be five revolutions per minute, the wheels *s*, *s*, will each make five revolutions per minute, which, acting through the arrangement of parts already explained on the adjusting-plates *d*, *d*, will communicate to them an outward motion, tending to increase the width of the jet apertures; and this action will continue until the water-wheel resumes its proper speed, when the lever and clutch-boxes will return to their former position, until another change of resistance calls for a renewed action of the governor.

Let it now be supposed that the resistance taken off has been again put upon the water-wheel, and it will be seen that an action precisely similar to what has been already described will take place, but in a contrary direction. The wheel *x*, will then have a relative motion in a contrary direction to the motion of the water-wheel, and an action will consequently be transmitted to the adjusting-plates, to draw them inwards and increase the width of the jet aperture.

MARINE-ENGINE BOILERS.

By Andrew Lamb, of Southampton.

[*Paper read at the Institution of Mechanical Engineers.*]

(*With Engravings, Plate* XXII.)

The Peninsular and Oriental steam-ship *Ripon* is an iron vessel, of 1650 tons burthen, and has two oscillating engines of 450 nominal horse-power. She was built by Messrs. Wigram, in 1846, and was supplied with her machinery by Miller, Ravenhill, and Co., of London, since which time she has been almost constantly running for the conveyance of the Indian Mail from Southampton to Alexandria. Her average speed for the whole of this time has been 9·1 knots per hour. The boilers fitted to her by Messrs. Miller were of the ordinary tubular construction. They were in six pieces, had twelve furnaces, and 744 iron tubes, 3½ inches outside diameter, 6 ft. 6 in. long. The total fire-bar surface was 212 square feet, and the heating surface in tubes 3798 square feet, reckoning the whole of the inside surface of the tubes as effective.

The sectional area through tubes equals 36¼ square feet; ditto through ferules, 28 square feet. These boilers were loaded to 10 lb. on the square inch, but in consequence of being deficient in steam, the actual pressure attained at sea very seldom exceeded 4 lb. to 6 lb. when full steam was admitted to the cylinders; of course the engineers found it to their advantage to keep it up to its full pressure by working the expansion apparatus. This deficiency of steam was found to be an increasing evil, the cause for which may be satisfactorily explained by a little consideration of the *modus operandi* of the sea-going tubular-boiler. When commencing running with the boilers new, for a short period, dependent on the species of coal consumed, the tubular-boiler offers its greatest advantage, and is in fact (when properly constructed) as good an apparatus for evaporating water as can be imagined applicable to marine purposes. The tubes give an immense amount of heating surface, and in small compass, and from their form are capable of resisting great pressure; but after three or four days' steaming these advantages diminish. The tubes have an accumulation of soot and light ashes inside them which, by reducing their sectional area, sometimes from 50 to 75 per cent., diminishes the draught through the furnaces in the same proportion, and also reduces the effective heating surface to the same serious extent. This accumulation depends in quantity very much upon the coal. On one occasion the author was present in a vessel with tubular-boilers, burning Scotch coal, and they actually came to a dead stand, after only sixty hours' steaming, the tubes being nearly choked up, and requiring to be swept. When tubular-boilers have made a few voyages at sea, the outside of the tubes become incrusted with saline matter, which gradually accumulates upon them, chiefly upon their bottom sides, and which, hitherto, it has been found impossible to remove by any other means than scaling them mechanically. The situation of the tubes (row after row) prevents this being accomplished, excepting upon the upper tiers, and the consequences are that the tubes become coated with a crust ¼-inch or ⅜-inch thick, and the tube-plates also, which, from its non-conducting nature, greatly retards the transmission of the heat through it, and the tube-plates becoming hot, crack and blister, and deteriorate very rapidly.

The boiler to be described in the present paper, invented and patented by the author in conjunction with Mr. Summers, has, it is stated, the following advantages over its tubular competitor:—

1st.—That, while it possesses an equal amount of heating surface in the same space as tubular-boilers, it is free from the evil of choking with inside deposits of soot and ashes, because the flues being in one sheet for their whole depth, the deposit falls into the bottom of the flues, and is swept by the draught through into the uptake, and thence into the chimney.

This improved boiler, as adopted in the *Ripon*, is shown in the engravings, figs. 1, 2, and 3, Plate XXII. Fig. 1 is a transverse section, fig. 2 a longitudinal section, and fig. 3 a plan, all taken through the flues. A A, are the improved flues, which are fixed in the same position as the tubes in an ordinary tubular-boiler, forming the return-passage from the back of the fire-grate at C, to the uptake at D. E E, are the smoke-box doors, and F, the fire-doors. The flues A A, are flat rectangular chambers, 6 ft. 9 in. long, and 3 ft. 3 in. high, open at each end where they are fixed to the boiler. There are seven of these flues to each fire-grate; the smoke-spaces are 1¾ inch wide, and the water-spaces 2⅝ inches. The sides of the flues are ¼-inch thick, and they are supported by the stays B B, fixed inside the flues. From this circumstance of there being no stays or other projections in the water-spaces, an important advantage is gained—that no nucleus is offered round which the scale can collect, and no impediment to interfere with the complete and rapid cleansing of the water-spaces from scale by means of the ordinary scrapers.

In another arrangement of these boilers, adapted for large screw steamers, and also for war steamers, the flues are placed alongside the furnaces and at the same level, instead of over the furnaces as in the engravings, which arrangement protects the boilers from shot, by keeping them below the water-line.

In these improved boilers, the same amount of heating surface can be obtained in the same capacity of boiler as with tubes; the only difference is, that if the tubes are $\frac{3}{16}$-inch thick they will of course be rather lighter than ¼-inch plates; but this difference, as compared with the gross weight, is so small as to be unimportant. In the event of any accident to any of the flues, they may be taken out, separately or collectively, to be repaired or replaced with new ones; but from the facility with which they can be kept clean, they ought, as in the old-fashioned flue-boilers, to wear out the shell, the length of time being remarkable that a *thin* plate will last, if kept clean and never overheated.

The last boilers of this construction examined by the author were those of the *Tagus*, 280-horse power, and in those boilers, after six days' steaming, the deposit was only 3 inches deep in the bottom of each flue; and the total depth of the flues being 3 ft. 8 in., it follows that she had only thus lost about 6 per cent. of sectional area.

2nd.—That the improved flues, from having no projection either of rivet-heads or stays in the water-spaces, offer no obstructions whatever to the scaling tool, and are as easily kept clean as any part of a boiler can possibly be, thereby entirely removing the evil of a loss of heat through non-conducting deposits, and very much increasing the durability of the boiler.

3rd.—That the water-spaces between the flues being comparatively large, and the sides of the flues perfectly vertical, the circulation of water in the boiler must necessarily be much more perfect than amongst a number of tubes (amounting sometimes to thousands), where the water has to wend its way in and out in curved lines. This greater perfection of circulation, the author thinks, must add greatly to the effectiveness of the heating surface in the improved flues.

It must be here mentioned that these advantages do not now rest upon theory only, and that they have been fully realised by experience. The first boilers fitted with these flues were those in the *Pacha*, in October 1849, similar to those shown in the engravings, and up to the time of her unfortunate loss these boilers gave entire satisfaction. Then followed a small boat, in January 1850, and the *Tagus*, in August 1850, since which their success has been rapid; as a proof of which, numerous vessels of different companies are being and have been fitted with them. The *Tagus* has now the oldest of the boilers, and there is in no part of them any signs of deterioration whatever; in fact, they are in every way perfect. There has never been any leakage, and the consumption of fuel is less than with her former tubular-boilers.

The improved boilers now fitted to the *Ripon* were manufactured by Messrs. Summers, Day, and Baldock, of Southampton, and are in four parts; the boilers being placed in the wings, two forward of the engines and two aft, the stokeholes are thus in midships. The space occupied by these new boilers is the same as the old ones, the arrangement mentioned having economised as much room as the increased size of boilers required, so that the same quantity of coal is carried in the same space as before. The new boilers have sixteen furnaces and 246 square feet of fire-bar surface; 112 flues, 3 ft. 9 in. deep × 6 ft. 3 in. long, being 5440 square feet of heating surface, reckoning the whole inside surface (as in tubes); the sectional area through the flues, deducting the stays = 54 square feet. This large sectional area can be diminished at pleasure by a grating damper, which is hung at the front end of the flues, and extends about 10 or 12 inches down them, and which is worked by handles placed outside the boiler and between the hinges of the smoke-box doors. The engineer can thus regulate the intensity of his draught at pleasure, according to the variety of coal in use, &c. The new boilers of the *Ripon* are loaded to 13 lb. per square inch; the flues, being strongly stayed inside, would of course resist a far higher pressure with perfect safety; in fact, if required, they might easily be sufficiently stayed to resist steam of any pressure. The *Ripon*, at the same time that the boilers were altered, had her common radial paddle-wheels replaced by feathering ones, which consequently added much to the speed of the vessel. The best speed of the engines of the *Ripon* with the old arrangement was about 15 revolutions per minute, and that of the vessel about 10 knots per hour when quite light. On the trial at the measured mile, December 1851, the vessel was drawing 16 ft. 3 in. forward, and 16 ft. 7 in. aft; she had all her coal (422 tons) on board, her water, and some cargo, and consequently was pretty deep loaded. The speed of the engines was 19½ revolutions per minute, and of the vessel 11·3 knots per hour. Had she been light, as in the former trial, she would have probably gone over 12 knots. It appears, therefore, that the improvement in speed may be fairly stated as 2 knots per hour. The cylinders of the engines are 76 inches diameter × 7 feet stroke. Their nominal horse-power, formerly at 15 revolutions, would be 404, and at 19½ revolutions, 526-horse power, so that the new boilers have given 122-horse power more steam, of an increased pressure of 3 lb. per square inch, than the old ones. As the *Ripon* is now making her first voyage with the new boilers, the author cannot speak with any certainty about her consumption, but will give some details of the Peninsular and Oriental steam-ship *Bentinck*, which has made one voyage to Alexandria and back with these improved boilers and feathering wheels.

The *Bentinck* is a wooden vessel, built by Wilson, of Liverpool, in 1844; and has side lever engines, by Fawcett and Preston. She is 2020 tons burthen, and her engines are 520 nominal horse-power; her original boilers were of the old flue construction, and were loaded to 6 lb. per inch pressure; her average speed at sea was 9 knots per hour, and her engines about 14 revolutions per minute. The speed of the *Bentinck* is now over 11 knots per hour. The former consumption was about 37 cwt. per hour; the present consumption averages about 38 cwt. per hour.

It must be noticed that the Peninsular and Oriental Company had tubular-boilers, with brass tubes, made for this vessel by Messrs. Bury, Curtis, and Kennedy, and that they were brought to Southampton, and placed in the *Pottinger*, a sister ship of the *Ripon*, and of 450 nominal horse-power, with common paddle-wheels. These boilers are of exactly the same size as the patent boilers made for the *Bentinck*, and they are both loaded to the same pressure—viz., 12 lb. per square inch; they have each made a passage to Alexandria and back, and, contrary to all expectation, the *Bentinck*, although her engines are 70-horse power nominal more than the *Pottinger*, and are working up to 103-horse power more, has consumed 128 tons less coal than the *Pottinger*, and performed the same distance in 68¼ hours less time. This result of diminished consumption is undeniably a fair triumph for the improved boiler; as for the improved speed of the vessel, it must share the honours with the feathering paddle-wheel—the *Bentinck* has made the fastest passage on record between the ports mentioned.

In conclusion, the author can only say that he believes the improved boiler described in the present paper will become the marine boiler generally adopted, as its merits are evident, and its cost is not greater than tubular boilers; while its durability will, he thinks, be very much greater. He will be happy to show these boilers to any of the members of the Institution who may have an opportunity of seeing those that may be in port, or at Mr. Summers' Works at Southampton, where there are now five sets in course of construction. It may be added also that the screw steam-ship *Glasgow*, by Messrs. Todd and McGregor, which has made the fastest run across the Atlantic of any screw steamer, is fitted with these improved boilers; Messrs. Todd and McGregor have made a considerable number of them, and they are also being manufactured by several others. It is intended also to adopt these boilers in the *Himalayah*, now building for the Peninsular and Oriental Company, of upwards of 3000 tons burthen, to be propelled by oscillating engines of 1200-horse power.

Note.—The details of construction of the flues are shown in figs. 4, 5, and 6, Plate XXII.; fig. 4 is a transverse section, fig. 5 a plan, and fig. 6 a longitudinal section of a portion of the flues A A, shown on an enlarged scale. They are constructed of two flat side-plates G G, ½-inch thick, flanged outwards at each end to meet the plates of the adjoining flues; the top and bottom of each flue is formed by the curved connecting-piece H H, which is riveted to each side-plate, and flanged outwards at the ends. The stays or studs B B, are 1¼ inch diameter, and are riveted at each end through the side-plates. The rivets connecting the plates together, and the stays, are all put into their holes simultaneously, and riveted cold by machinery. These rivets have countersunk heads and points, and when placed in their holes in the plates a steel bar is inserted, which fills up the space between the heads of the two rows of rivets, and acts as a bolster to the riveting tool. By this means one stroke of the machine closes two rivets at once, and in the most efficient manner. The flues are afterward riveted together with covering strips I I, at their ends, and they are inserted into the boiler in sets of seven or eight, according to the size of the furnace. Any one of the flues can be readily extracted from the others if necessary, by cutting away the two rows of rivets at each end, and drawing it out through the front smoke-box doors E. The experience which they have had of the durability of the flues has, however, satisfied those who have employed them, that unless gross negligence of the engineer should (through want of water) allow them to get red hot, the flues will in all cases outlive the shells in which they are inserted.

CONTINUOUS EXPANSION STEAM-ENGINE.

By James Samuel, C.E.

[*Paper read at the Institution of Mechanical Engineers.*]

(*With Engravings, Plate* XXII.)

The economy of working steam expansively is well known, but the application of the expansion principle is practicable only to a limited extent in most forms of engine, from practical difficulties in their mode of working which prevent the attainment of the full economy of which the expansive principle is capable. The greatest useful effect is obtained from the steam, when it is allowed to expand in the cylinder until its pressure upon the piston just balances all the useless resistances of the friction of the engine itself, and the resisting pressure on the back of the piston (whether the pressure of the atmosphere in a high-pressure engine, or of the uncondensed vapour in a condensing-engine), the surplus power beyond these useless resistances being alone available for the purposes to which the engine is applied. But in driving machinery, so great a uniformity of motion is essential that any great variation in the moving power throughout the stroke of the engine is inadmissible, as the fly-wheel would not be able to absorb enough of the excess of power to equalise the velocity sufficiently, by giving it out again at the deficient part of the stroke; consequently, though two engines are often employed working at right angles to each other, for the purpose of diminishing the variation in total moving power, the expansion principle can only be carried to a portion of the extent to which it is theoretically applicable. Only in such engines as the large Cornish pumping engines can the expansion be carried practically to its full theoretical limit, as the variation in the velocity of the load moved is of much less importance in those engines, and the very unequal amounts of moving power that are developed in equal times, by the full carrying out of the expansive principle, which would produce the most prejudicial and inadmissible variations of velocity in the engine, are controlled within prescribed limits by the great weight of material to be moved by the engine in the pump-rods and balancing machinery, forming as it were a distributing reservoir for the moving force developed.

In the Locomotive Engine there are practical difficulties in carrying out the expansion principle efficiently, beyond a moderate extent, in a single cylinder, from the shortness of stroke and rapidity of reciprocation, and the construction of the valve motion; but the ultimate extent to which it could be carried would be limited by the maintenance of the blast, which requires that the jets of steam discharged from the cylinder into the blast-pipe should not be reduced below a certain pressure at the moment of discharge. Otherwise, the limit to which expansion might be carried would be the resistance of the atmosphere to the discharge of the steam, added to the friction of the engine, say about 10 lb. per inch above the atmosphere. The steam is cut off usually by the link-motion at from one-third to two-thirds of the stroke, and the steam is consequently discharged into the blast-pipe at about from 30 lb. to 60 lb. pressure above the atmosphere, supposing it be supplied to the cylinders at 100 lb. per inch above the atmosphere. It appears that the lower of these pressures is sufficient, or more than sufficient for the purposes of the blast, to maintain fully the evaporative power of the boiler under general circumstances, and that a portion of the steam discharged can be spared from the blast to be subjected to a greater extent of expansion.

But in the Continuous Expansion Engine, the subject of this paper, the steam from the boiler is supplied only to one cylinder; a portion of it is expanded into the second cylinder, which is of proportionately larger area, so as to equalise the total moving power of the two cylinders; and it is there further expanded down to the fullest useful extent, and then discharged into the atmosphere, the portion of steam remaining in the first cylinder being discharged as a blast at nearly the same pressure as the ordinary engines. The economy, therefore, consists in obtaining from such portion of the steam as can be spared from the blast the additional power of expansion remaining in it, which is thrown away in the ordinary engine.

Figs. 7 and 8, Plate XXII., show the continuous expansion engine as applied to a locomotive. A, is the first cylinder into which the steam is admitted from the steam-pipe C, by the valve D, in the same manner as in the ordinary engines. The steam is cut off at half-stroke, and a communication is then opened with the second cylinder B, through the passages H, and F, by the opening of the slide-valve G. The second cylinder B, is about double the area of the first cylinder, and the same length of stroke, but the cranks are set at right angles, as in ordinary locomotive engines; consequently, at the moment of the steam being passed into the second cylinder from the first, the piston of the second cylinder is at the commencement of its stroke. The steam continues expanding in the two cylinders until the first piston A, has nearly completed its stroke, when the valve G, shuts off the communication between the two cylinders, and the valve D, opens the exhaust-port, and communicates with the blast-pipe L, discharging the steam remaining in the cylinder A, to form the blast in the ordinary manner. The second piston B, has then arrived nearly at half-stroke, and contains nearly one-half of the total quantity of steam originally admitted to the first cylinder; this steam is further expanded to the end of the stroke, and then discharged into the blast-pipe L, by the valve E, opening the exhaust-port. The return-stroke of both pistons is exactly similar to the foregoing, so that about half-cylinder full of high-pressure steam (or such other portion as may be desired) is supplied to the first cylinder at each stroke, and between half and two-thirds of that steam is discharged at the pressure required to produce the blast, and the remainder of the steam is expanded down in the second cylinder, so as to give out all the available power remaining in it. For the purpose of enabling the engine to exert an increased power, if required, at the time of starting a train or otherwise, the slide-valve I, is inserted in the centre passage F, to close the communication between the two cylinders for a short time when required; and the steam from the boiler is then admitted by a pipe and cock into the steam-chest of the second cylinder B, which is then worked independently of the other cylinder, like an ordinary engine.

The comparative quantity of steam or of coke required to perform the same work in the several engines, under the circumstances stated above, is given by calculation as follows:—

Continuous Expansion Engine			....	100
Ordinary Engine, cutting off at			$\frac{1}{3}$-stroke	120
Ditto	ditto	ditto	$\frac{1}{2}$-stroke	154
Ditto	ditto	ditto	$\frac{2}{3}$-stroke	185
Ditto	ditto	ditto	$\frac{7}{8}$-stroke	220

These figures represent the relative economy in the employment of the steam in the several engines; consequently, the ordinary engine, with the best degree of expansion, or cutting off the steam at one-third of the stroke, consumes 20 per cent. more coke than the continuous expansion engine, to do the same work, and from 54 to 85 per cent. more coke with the more usual degrees of expansion; again, an engine cutting off the steam at only one-eighth of the stroke from the termination, as many engines were formerly made, would consume 120 per cent. more coke to do the same work. This plan has been tried upon two locomotives with satisfactory results, and the blast was found to be quite sufficient; but the trial has not been sufficiently complete to afford a definite comparison of consumption.

In the application of the expansion principle to stationary engines, it is requisite to consider the amount of variation in the moving power or labouring force of the engine, and the limits within which it is necessary, practically, to confine this variation. The annexed engravings, figs. 9, 10, and 11, Plate XXII., show the variation in the moving power that takes place between the commencement and the end of the stroke in each of the several engines, all drawn to the same scale and on the same principle, so that the comparison of the diagrams will show the relative effect of the steam in the several engines, the same total power being represented in each case.

Fig. 9 shows the variation of power in the Cornish engine when the steam is expanded down to the limit of useful effect; this is shown by the curved line A G C. The vertical height of the first division A D, represents the relative total moving force developed by the engine, in the direction of the revolution of the crank-pin, during the first 15° of revolution from the commencement of the stroke. The heights of the succeeding divisions in fig. 9 represent the corresponding amounts of force developed by the engine during each successive motion of the crank, through equal angles of 15° each to the end of the stroke C, and the half-revolution of 180°, the force shown being in all cases the amount that would be produced in the circular direction of the revolution of the crank-pin, not in the rectilinear direction of the piston. If the amounts of force in these several divisions were all exactly *equal to one another* (and the engine, having attained its state of uniform velocity, were employed to overcome a constant resistance to circular motion, such as driving a corn-mill or spinning-mill, &c.), then the crank-arm would have a perfectly unvarying velocity, and no fly-wheel would be required. And the approach to constancy of velocity, in any engine applied to overcome resistances to circular motion, will depend on the approach to equality which these amounts of work produced through equal angles make to one another. The average line D E, shows this average equal height of all these divisions, consequently the rectangle A C E D, represents the equivalent uniform development of power that would produce an unvarying velocity of rotation, and therefore the area of the shaded space being the deficiency in filling up this rectangle of uniform power by the actual working of the engine (also equal to the portion H, of the curved figure that is above the average line D E), will represent the total amount of variation from the average in the moving force of the engine throughout the stroke. The area of the shaded portion in this diagram is 43 per cent. of the total area; consequently the *total variation* from the average in the moving power of the Cornish engine is 43 *per cent.*, and the *greatest variation* at the extreme point G, amounts to 189 *per cent.* of the mean power.

Fig. 10 shows in a corresponding manner the variation of moving power throughout the stroke in the continuous expansion engine, where the steam is cut off at half-stroke in the first cylinder, and expanded in the larger cylinder down to the limit of useful effect. The total variation from the average power is only 13 per cent., and the extreme variation 55 per cent.; consequently the *total variation* in the moving power in the Cornish engine is $3\frac{1}{3}$ *times* as great as that in the continuous expansion engine, and the *extreme variation* is $3\frac{1}{2}$ *times* as great.

The dotted line B B, in fig. 9, shows the effect of coupling together two Cornish engines, exactly similar to that shown by the full line in fig. 3, but of half the total power each. The total variation from the average power is 20 per cent., and the extreme variation 58 per cent.; the *total variation* in the moving power being $1\frac{1}{2}$ *times* as great as in the continuous expansion engine, and the *extreme variation* about equal. This arrangement would of course be much more expensive than the continuous expansion engine, as it involves two complete engines.

Fig. 11 shows the variation of moving power in a Woolf's double-cylinder engine, where the two pistons work simultaneously in the two cylinders, commencing each stroke together, and the steam is cut off at half stroke in the first cylinder, and afterwards expanded in the larger cylinder down to the limit of useful effect, as in the foregoing Cornish engine. The total variation from the average power is 27 per cent., and the extreme variation 90 per cent.; consequently the *total variation* in the moving power is *twice* as great as in the continuous expansion engine, and the *extreme variation* $1\frac{2}{3}$ *times* as great.

The dotted line F F, on fig. 10, shows the effect of coupling together two of the continuous expansion engines at right angles to each other; and the result of this arrangement is a remarkably near approach to perfect uniformity of moving power. The total variation from the average power is only 3 per cent., and the extreme variation 8 per cent.

The dotted line F F, on fig. 9, shows in a similar manner the effect of coupling together three of the Cornish engines with cranks at 120° to each other. The total variation from the average power is 9 per cent., and the extreme variation 22 per cent.; *both* being about 3 *times* as great as in the continuous expansion engine.

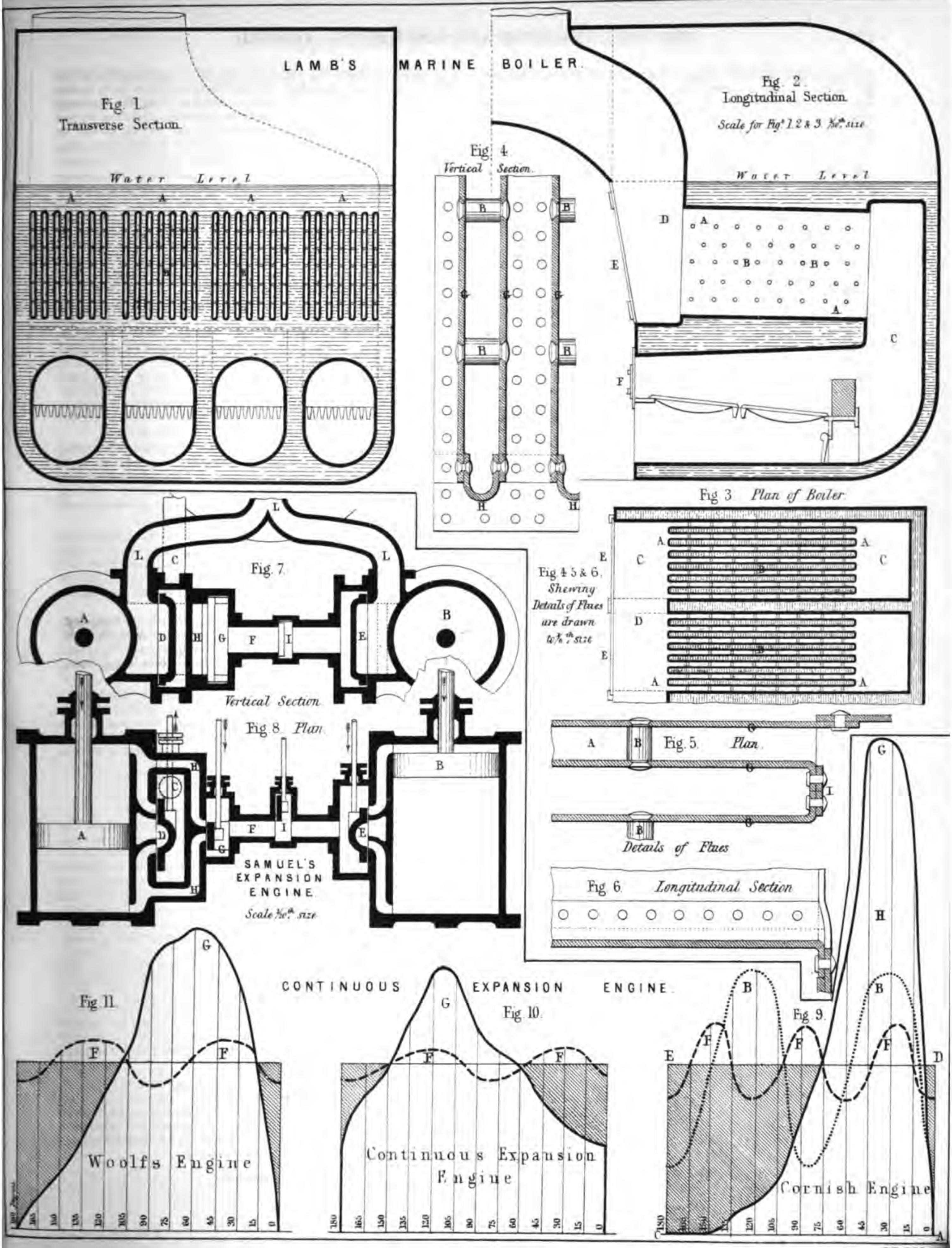
Fig. 11 shows also, by the dotted line F F, the effect of coupling together two of the Woolf's engines at right angles to each other. The total variation from the average power is 5 per cent., and the extreme variation 13 per cent.; *both* being about $1\frac{1}{2}$ *times* as great as in the continuous expansion engine.

The comparative amount of work performed by the several engines, with the same quantity of steam or of coal in each case, under the circumstances stated above, and taking the pressure of the steam admitted to the first cylinder at 50 lb. per inch above the atmosphere, is given by calculation as follows:—

Continuous Expansion Engine	....	100
Woolf's Engine	....	109
Cornish Engine	....	111

The general result of the above comparisons is, that the *Cornish engine is* 11 *per cent.*, and *Woolf's engine is* 9 *per cent. more economical* in expenditure of fuel than the *continuous expansion engine*, when the expansion of the steam is carried to the *extreme limit* in each case; but that this economy cannot be obtained practically in those two engines, on account of the great irregularity in their moving power, the *average irregularity* being, in the *Cornish engine* 30 *per cent.*, and in *Woolf's engine* 14 *per cent. greater* than in the continuous expansion engine; and the *extreme irregularity* being 134 *and* 35 *per cent.* respectively *greater*. Consequently it appears that, although the expansion of the steam cannot be *theoretically* carried to so great an extent in the continuous expansion engine as in the other engines, yet, from the moving power being so much more uniform throughout the stroke, the expansion can be carried *practically* to a considerably greater extent; and a greater amount of economy may be practically obtained within the same limit of uniformity in the moving power.

A working model, one-third size, of the engine as applied to a locomotive, was exhibited to the meeting. At the conclusion of the paper a desire was expressed to know the particulars of the trials that had been made, but the discussion was adjourned to the next meeting, to afford an opportunity for the attendance of Mr. Samuel, who was unavoidably absent.


LAMB'S MARINE BOILER.
Fig. 1.
Transverse Section.
Water Level
Fig. 2.
Longitudinal Section.
Scale for Figs. 1. 2 & 3. 1/40th size
Water Level
Fig. 4.
Vertical Section.
Fig. 3. Plan of Boiler.
Fig. 4. 5 & 6. Shewing Details of Flues are drawn to 1/8th size
Fig. 7.
Vertical Section.
Fig. 8. Plan.
SAMUEL'S EXPANSION ENGINE.
Scale 1/40th size
Fig. 5. Plan.
Details of Flues
Fig. 6. Longitudinal Section.
CONTINUOUS EXPANSION ENGINE.
Fig. 11.
Fig. 10.
Fig. 9.
Woolfs Engine
Continuous Expansion Engine
Cornish Engine
180 165 150 135 120 105 90 75 60 45 30 15 0

J. R. Jobbins

PHILOSOPHICAL INSTRUMENTS AND PROCESSES.

By James Glaisher, F.R.S., F.R.A.S.

[*Exhibition Lecture delivered at the Society of Arts.**]

In proportion as it is necessary to the interests of science, that theory, observation, and experiment should march hand-in-hand, so is it equally essential that theoretical and practical men of science should come into contact with each other, and both into contact with men to whom must be intrusted the construction of instruments necessary to the completion of their views. A scheme more conducive to this end could scarcely have been designed than the collection both from this and foreign countries of instruments and their makers, to receive the criticism and judgment of individuals selected from among those in whose hands could the instruments exhibited prove chiefly serviceable; thus securing competent and impartial judges of their merits. The effect of this concentration of mind, both English and Foreign, has been, and will still more be, to give direction to physical inquiry and mechanical skill, point out existing deficiences and their remedies, and cause the conversion of heretofore suggestive into real practical improvements; thus creating an interchange of information between nations, and so contributing to the advantage and wealth of all.

Astronomical Instruments.

That large astronomical instruments should be much represented in the Exhibition was not to be expected, and particularly from distant lands; their removal is at all times hazardous; and equally injurious, probably, would have been their exposure for any length of time; hence, we find that, with the exception of the large equatorial by Ross, there was not one; and in this case, the divided circles, or delicate portions, were not large. This instrument was principally remarkable for its solidity, good distribution of strength, and fewness of parts. It was furnished with clock motion, and was a fine specimen of engineering casting.

As regards the instruments exhibited by Simms, they were distinguished, not only by excellent workmanship, but also for new contrivances, greatly facilitating observation; and, when it is considered how many men of a high order of mind have devoted themselves to the construction of astronomical instruments, any decided improvement indicates a very high order of merit: some of these improvements I will enumerate.

To two equatorials exhibited by Mr. Simms, he has adapted their equatorial axes for the application of a level, and thus greatly simplified their adjustments, besides making them more useful instruments. To one of them was applied a clock-work motion, by means of which the motion of the telescope was made to counteract that of the earth, thus enabling the observer to look upon a moving object as though it were not moving.

To an altitude-and-azimuth instrument, a telescope furnished with spider lines was placed in the centre of its azimuth axis, for the purpose of acting as a central collimator and constant referring point.

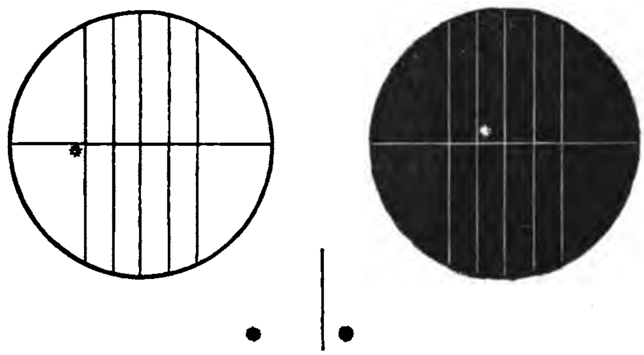
Another novelty was the conversion of the axis of a transit instrument into a telescope, thus affording a ready means of examining the form of its pivots, as well as readily adapting it to the observation of stars, both in the meridian and in the prime vertical.

To a small transit circle, furnished with one lamp, was shown a mode of illuminating the divisions on the micrometer head, on the limb and the field of view, in such way that the observer should have complete power, either over the illumination of the entire field or of the wires alone, the field itself being in darkness. The observer is thus enabled to record the position of a star whose light is so feeble that the amount of light merely sufficient to illumine the field is more than enough to drown that of the star. It is, in fact, an arrangement by which our optical power is increased by our present optical means.

It would be well to dwell for a few moments on the different modes of illumination. As you all know, the field of view in the telescope of an astronomical instrument is furnished with a system of one or two horizontal, and of five or seven vertical wires, as shown in the annexed diagram, which exhibits the appearance of the field of view when under full illumination, and when the wires only are illuminated.

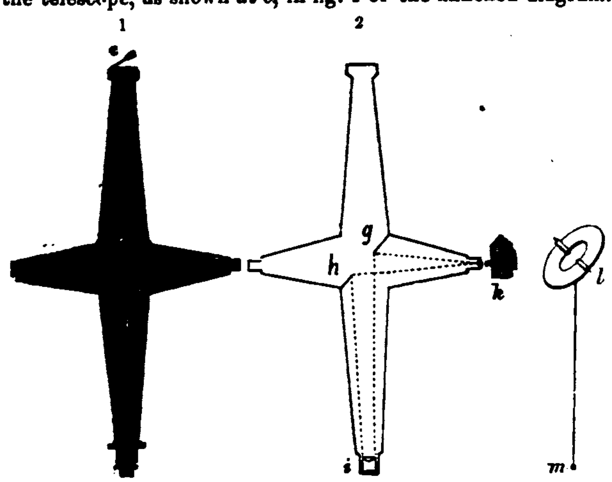
* We have given only an abstract of this paper, many of the astronomical instruments at the Exhibition having been described in the *Journal*, Vol. XIV., p. 435, *et seq.*

An "observation" by an instrument placed in the plane of the meridian consists in directing the telescope so that the star is bisected by the horizontal wire (to determine its north polar distance), and by noting the times at which it passes the several vertical wires (to determine its right ascension), these times



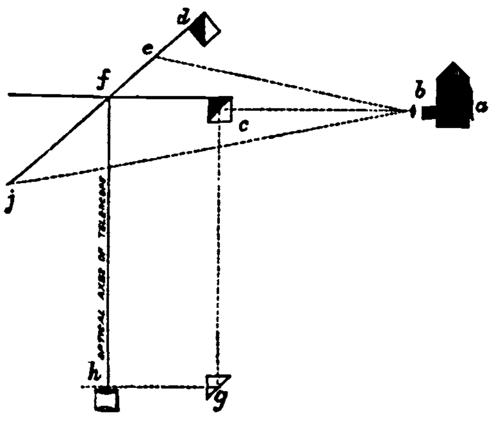
being determined by mentally dividing into ten parts the space traversed by the star in one second, and deciding that tenth of the second when it crossed the wire, as shown in the example subjoined to the above diagrams.

As there are but few object-glasses large enough to show many stars during the day, it is necessary that the field of view be illuminated in order that the wires be distinctly seen at night. This was done formerly by placing a small oval reflector in front of the object-glass of the telescope—a plan not only objectionable on account of some part of the aperture being cut off, but because, on change of altitude, it was necessary to rearrange the distant lamp or candle, so that the light should fall properly upon the reflector for convergence to the wire-plate of the telescope, as shown at *c*, in fig. 1 of the annexed diagram.



The introduction of a diagonal reflector, placed within the axis of an astronomical telescope at an angle of 45°, was a very great improvement upon the preceding method; the light in this case passes from a lantern *k*, placed near one of the pivots of the axis upon which the telescope turns, perforated to receive a convex lens: by this arrangement, the rays of light, after crossing, diverge upon and are spread over the surface of the reflector *g*, *h*, by which they are turned at right angles, and are thus made to illuminate the field of view. The degree of illumination necessary is dependent upon the brightness of the object, and hence the necessity for a means of varying the amount of light; this has been effected in various ways—such as by turning the lantern out of the direct line of the axis, by introducing an adjustable aperture between the lantern and the perforated end of the pivot, or by placing an expanding diaphragm between the eye-piece and the diagonal reflector. But Mr. Simms has effected all this much more simply and effectually by giving motion to the reflector itself, which is made to turn upon pivots (as shown in fig. 3), by means of a rod *m*, proceeding from it and terminating beyond the tube of the telescope, at or near the eye-piece, and consequently near the observer's hand. By this means, the maximum illumination is given when the reflector is situated at an angle of 45° from the axis of rotation and the optical axis of the telescope, the whole of the light being reflected perpendicularly upon the diaphragm; but if the reflector be turned to that position which is parallel to the axis, no light whatever is reflected from it. It is therefore evident, that between these two positions all degrees of illumination can be obtained. But there are some objects, such as comets, nebulæ, small planets, and stars, which are visible only when all light is excluded from the field. To ascertain the position of such objects was one of great difficulty; the means usually adopted were—the insertion of very thick bars of metal in the wire-plate or diaphragm, instead of fine wires, and in observation to hide the star behind the horizontal bar to determine its north polar distance, the times of its disappearance behind the several vertical bars being noted to determine its right ascension: but such observations were little better than guess-work, and were very unsatisfactory. Another method, certainly much better, has been employed, the object of which was to illumine the wires, only leaving the field in darkness. This was done by opening a channel in the tube, nearly in the plane of the diaphragm, through which light was admitted from a lantern generally attached to the eye-end of the telescope. This arrangement, though certainly much better than the preceding, was open to grave objections, and leads me to the last improvement exhibited, which answers admirably, inasmuch as it places the degree of illumination under the command of the observer, who can instantaneously alter it in such manner as the case may require.

This very great improvement is effected by the attachment of one or more prisms to the adjustable reflector in such way, that when the reflector is in the position to reflect the largest quantity of light in the direction of the optical axis of the telescope, and consequently to fill the field of view with light, the prism is out of action; but that as the intensity gradually diminishes as the reflector approaches to that position parallel to the axis where no light is reflected, at that instant the prism takes up the middle pencil of rays proceeding from the lamp, and reflects it to another prism situated in the plane of the wire plate, by which it is finally reflected, and illuminates the wires only, leaving the field in darkness, so that the observations of an extremely faint object can be as easily obtained as those of a bright one. This arrangement is explained in the following diagram.



Let $f\,d$, and $f\,c$, represent the (axis of) moveable reflector in its two extreme positions—viz., that in which it reflects the maximum quantity of light, and that in which it reflects no light whatever; h, the diaphragm upon which the cross-wires are fixed in the focus of the eye-piece; g, a prism so placed as to reflect upon and diffuse over the diaphragm such rays of light as enter it in the direction $c\,g$; and $b\,e$, $b\,c$, $b\,j$, rays of light proceeding from the lantern $a\,b$. When the reflector is in the position $f\,d$, the rays $b\,e$, $b\,j$, are reflected in the direction of the optical axis of the telescope, and consequently fill the field of view with light, and give the appearance shown in the first diagram. As the reflector approaches the position $f\,c$, the intensity of the light gradually diminishes, and when the position $f\,c$, is attained no light whatever is reflected; at this instant the prism d, which has dropped from d, to c, takes up the middle ray $b\,c$, and reflects it to g, causing the field of view to assume the appearance shown in fig. 2 of the diagram.

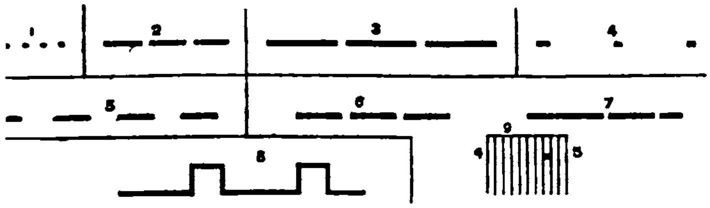
Mr. Simms exhibited a diagonal transit instrument of the same form as that so much used on the continent; in this construction the cone of rays which pass from the object-glass do not proceed directly to a focus, as in the ordinary telescope, but are reflected by a prism or speculum placed within the axis, and form an image in one of the pivots, in which also the wire-frame and eye-piece are placed. The advantage over that ordinarily in use is, that the observer is seated with all ease at his instrument, and has no change of position to make whatever may be the altitude of the object under observation; the serious objection to its use has hitherto been the defective means obtained for illuminating the field of view, as was to be seen in the instrument shown by Ertel in the Exhibition, where the old method was still adhered to—viz., placing a small diagonal reflector in front of the object-glass, as shown in diagram 2—a plan to which there are many objections:—1st, the difficulty of throwing light at all upon the reflector; 2nd, the trouble of re-adjusting it for every change of position; and 3rd, part of the object-glass is cut off. In the instrument exhibited by Mr. Simms, he has most ingeniously overcome these difficulties by introducing in the other pivot a convex lens, and at the back of the prism a second convex lens, the diameter of the latter being such that three segments of it project beyond the sides of the prism. In this arrangement the rays of light from the lantern, first converged by the small lens, after crossing, again diverge and fall upon the larger lens, by the refractive power of which they again suffer convergence and are diffused over the field of view.

It is remarkable that not a single astronomical instrument was furnished by France.

I must be permitted a digression in order to complete my description of the novelties exhibited in this section. In the year 1800 Volta discovered that voltaic electricity was generated by the immersion of two metals in an acid which acted on one of them: in 1820, Oersted linked together the sciences of electricity and magnetism, and proved that the one acts upon the other, not in straight lines, as other forces do, but in a direction at right angles: so that, if bodies be invested with electricity, they possess a tendency to place magnets in a position at right angles to themselves, whilst, on the contrary, magnets have the effect of placing bodies conducting electricity at right angles to themselves, and, consequently, an electric current exercises a magnetic action at right angles to its own direction; if, then, a wire be coiled in a spiral form, and electrified, it becomes a magnet; and if within this coil be placed a core of soft iron, which has the effect of concentrating its power, it becomes a very powerful magnet, and by making and breaking its connection with a galvanic battery, thus alternately making and destroying the action of magnetism, we can instantly unmake this magnet and obtain a moving power, which it is evident, when once produced, is capaple of application to many purposes by suitable mechanism.

The Americans, with their characteristic energy, have extensively used these physical laws in their electric telegraphs, and have also applied them to astronomical purposes, and to the determination of the difference of longitude. In the American department, Bond exhibited an apparatus for observing transits by means of a galvanic circuit. It consists of a break-circuit-clock, battery, wires, and a cylinder around which paper is wrapped. This cylinder is mounted on a delicate axis, furnished with friction-rollers, and revolves once in a minute; the circuit is broken and restored by the seconds pendulum, so that 60 sec. are recorded on one line: there are sixty lines on each sheet of paper. The armature of the electro-magnet carries a glass pen supplied with ink from a small reservoir, and the records are made as the paper revolves under this pen.

In ordinary transit observations the observer takes a second from the clock-face, counts the beats whilst the object passes the wires, records these times by the clock to the tenth part of a second, writes them in a book, still counting the beats of the clock, and after the transit of the last wire, continues counting on till he can look at the clock-face; but, in the new method, the coincidence of the wire and the object is noted, at which instant a key is touched with the finger, this touch causing an impression to be made on the recording apparatus, of a dot if the touch be momentary, of a series of dots separated by equal spaces if the intervals of time between successive touches be equal, as shown in fig. 1 of the annexed diagram, of lines of different lengths if the times of pressing the key be variable, as shown in figs. 2 and 5; of equal lengths if the times be of equal duration, or at equal intervals, as shown in figs. 3, 4, and 6. In this manner may be generated a series of dots, lines, and blanks of all varieties of lengths.

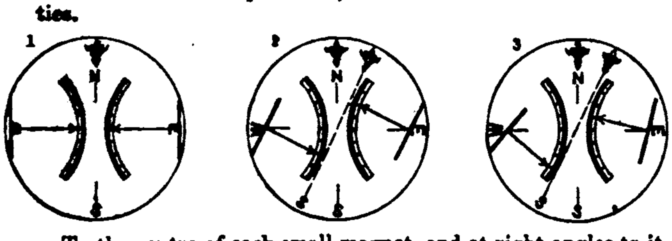


Lines of equal length, or spots equi-distant, may be registered by the movement of a clock alternately making and breaking the circuit, as well as by the finger of the operator, and lines as in fig. 3, or spaces in fig. 4, may be made, corresponding to intervals of one second, and thus the clock be made to mark seconds of time. If, then, an operator should make contact at the instant of the occurrence of any phenomenon, as that of a star passing a wire, one of these spaces would be broken, as is shown in fig. 7; and it is easy to estimate the tenth of a second at which the contact was made, and hundredths of a second may be estimated by the use of a transparent scale, as in fig. 9, whose length, just equal to that of one second on the paper, being divided into ten parts, and made to cover the whole second, as in fig. 9, where the register appears between four seconds and five seconds, it is seen at a glance that the occurrence happened between $4\frac{7}{10}''$ and $4\frac{8}{10}''$. The apparatus exhibited registered an unbroken line, as shown in fig. 8, but the principle of operation is the same. There may be many different modes of recording. In practice, the recording apparatus may be either near to the observer or at a great distance; either at a few yards or at a thousand miles. In the former method, the eye and ear are brought into play; and in the latter, the eye and hand. The question is, whether there be a closer connection between the nerves of the eye and ear, or between those of the eye and the finger. The latter operation seems to be the more simple, inasmuch as the observer has not to listen to a clock, and to write down one time whilst he is counting another. The practicability of thus recording observations is placed beyond a doubt, by such having really been recorded in America, at Washington, and other places, and apparently with greater accuracy than by the old method.

As before remarked, the recording surface may be at a great distance from the observer, so that the galvanic telegraph is obviously applicable to the determination of differences of terrestrial longitudes by connecting one station to another far separated by means of a wire; but it becomes imperatively necessary to ascertain whether the time occupied by an electric current traversing the wire be appreciable or not, and whether it really passes from station to station in less time than human means can detect. Experiments to determine this have been made on the long lines in America; and the last results I have seen show that the electric current passes through a copper wire at the rate of about 12,000 miles in one second; and, consequently, that the time occupied in its progress *is* an element to be taken into account in determining longitude.

Nautical Astronomical Instruments.

Of nautical astronomical instruments the Exhibition did not furnish many illustrations. Of ordinary nautical instruments, the American department furnished a fine collection by Ericssen, mostly of a new construction; also a very ingenious compass by St. John. The peculiarity of this instrument consists in the addition of two small magnets, moving freely upon fine points attached to the compass-card, near its east and west extremities.



To the centre of each small magnet, and at right angles to it, is placed a brass indicator, which points to the *centre* of the card when *not* under the influence of disturbance, as in fig. 1; and *from* the centre at other times, as in figs. 2 and 3. The deviation from the centre indicates the amount of disturbance which, if local, is shown by the one of these indicators pointing farther from the centre than the other, as in fig. 3. The amount of these deflections is measured by semicircular scales fixed over the centre of the card.

Levelling and Surveying Instruments.

Instruments for levelling and surveying were furnished from England, France, and Belgium: generally well made, but not exhibiting any novelties or excellencies. Germany furnished several, all well made, in which Breithaupt's useful method of covering the divisions with a thin plate of brass, for the purpose of protecting them from dirt, oxidation, and mechanical injury was generally adopted. Breithaupt himself exhibited a level with a contrivance for greatly facilitating its adjustments, and of great importance; while surveyors continue to assume that the circular collars of a level are equal.

The Imperial Polytechnic Institution of Vienna exhibited some beautiful surveying instruments constructed under the direction of Professor Stampfer. The greatest improvement was the means afforded for measuring a vertical angle of 8°, by which the difference of altitude between two stations, when greatly exceeding the length of the measuring staff, could be determined—an improvement of great value for work in a hilly country.

America (Burt) furnished an instrument well adapted for surveying new countries, particularly in magnetic districts. It is applicable to the determination of time, latitude, and magnetic declination.

Mr. Yeates exhibited a prismatic compass, of simple construction, adapted for taking both horizontal and vertical angles, and so arranged that the former may be taken, the instrument being held in the hand,—the object, the hair in the vain, and the magnetic bearing being seen at once; it is adapted for fixing on a tripod, and a means is afforded of repeating the observation. It is also adapted for taking vertical angles. It is independent of the magnetic needle, and can be used in districts abounding in iron.

The Austrian levels and theodolites give a surveyor great advantage in increased accuracy, great saving of time, and of one assistant in the use of the chain; in colonies where labour is scarce, in places where the ground is difficult and intersected by hedges and ditches, their advantages are inestimable. In marine surveying, much time would be saved by the use of Ertel's universal instrument, instead of the clumsy transits provided by the Admiralty. Time in such cases must be measured by the cost of maintaining a ship's crew. One instrument and one observer can with it determine time and latitude, and make any triangulites for surveying with more facility, on account of the direction in which the observer looks, than with any other instrument or instruments.

Elliott's altitude-and-azimuth instrument represents the form of the instrument used in the triangulation of the English surveys; Ertel's is the exact instrument used by Struvé in the arc that is to extend from the North Cape to Crete.

Optical Instruments.

Let us now turn our attention to optical instruments. Respecting telescopes, though few in number, they were found to be for the most part good. France (Buron) furnished one whose object-glass was of rock crystal, the performance of which, notwithstanding its property of double refraction, was found to be very satisfactory.

A new kind of glass was exhibited by Maes (France), its base composed of the oxide of zinc and borax: it was extremely clear and free from colour, and promises to be of considerable use in producing achromatic object-glasses of a very perfect description.

The Exhibition also made known a very fair attempt by Wray, United Kingdom, to substitute a solid substance instead of flint glass, which, as a step out of the beaten path and towards the possible revival of fluid object-glasses, is meritorious.

As you all know, crystalline bodies affect light according to their structure, and the transparency of such bodies seems to depend upon their molecular arrangement. Thus, if striæ occur in a disc of glass or lens through which an object is viewed, it is distorted if these striæ be numerous, and the distortion is so great that the form of the object is not recognisable; but if *very* numerous, it is not visible at all; the glass ceasing to be transparent, becoming opaque, though still remaining translucent.

To ascertain the different molecular states of the various discs of glass and object-glasses exhibited was, therefore, a part of the duty of the jury. The modes adopted are detailed in the Report; and, therefore, I will here but briefly refer to the results.

The object-glasses of Simms, which were chiefly of English glass, were found to be good, the definition of the object becoming improved with the increase of power. Those of Buron were good; but some exhibited by this gentleman were not tried, the tubes being wanting. A small object-glass, by Ross, was very good; but in his large equatorial there was none. The discs of glass furnished by Maes (France), and Daguet (Switzerland), were very good; as upon the whole was the noble piece of glass exhibited by Chance, which is no less than 29 inches in diameter, and weighs 200 lb.; and I do hope that the same success will attend the obtaining its achromatic companion, and that the two lenses may be worked into an object-glass.

These are some of the first fruits of the removal of the tax on glass, that great obstacle to the improvement of telescopes in this country, which prevented all attempts to produce glass adapted to the construction of large achromatic glasses, and compelled us to purchase from abroad those we needed at an enormous price. The Exhibition satisfactorily proves that, at all events, we soon shall equal both the far-famed works of Munich and Paris; and let us hope in fair rivalry to excel them.

The microscope, by the rapid advance in microscopic investigations within the last few years, has been enabled to vie in importance almost with the telescope. Since the introduction of achromatic combinations, physiological investigations have proceeded so rapidly, and our knowledge has increased so greatly upon animal and minute anatomy, that it was most gratifying to find so many superior instruments in the Exhibition. The British microscopes were distinguished by the great amount of light obtained, the large angle of aperture, and consequent fine definition; also by the large, flat, and perfectly defined field.

There were two lighthouses exhibited, both entirely of glass; both were furnished with large Argand lamps, lenses, and reflecting prisms. As the object of lighthouses is to transmit all the rays proceeding from the light in an horizontal direction, the reflecting prisms above and below the light were so placed that the incident rays on their second surface fell so obliquely, that they were totally reflected horizontally; thus those rays which would have illumined the sky and the waters of the ocean were made available to increase the equatorial belt of light: the substitution of reflecting prisms will, doubtless, supersede the use of metallic reflectors in lighthouses generally.

Of instruments connected with physical optics there were very few, indeed philosophical instruments of this class were quite wanting in the British portion; France furnished a beautiful series, including stereoscopes, polarimeters, saccharometers, haloscopes, &c., as exhibited by Soliel. Perhaps the most useful of these instruments was the saccharometer. Light, as you are aware, when polarised appears to be transmitted by undulations in planes, and not at all in planes situated at right angles to them. In some bodies, each of the colours composing white light is not polarised in the same plane as in ordinary polarisation, but the plane for each is slightly turned round, so that the whole is spread out; this circular polarisation has been beautifully applied to chemistry, and made a test in the case of saccharine fermentation of the point to which it has reached and of the quantity of sugar formed. Hence this change of direction of the polarising plane is of great practical value, and it ought to supersede the old method by the use of the ordinary saccharometer. That exhibited by Soliel was the only one, though many of the ordinary kind were exhibited in the British section.

Meteorological Instruments.

There were a large number of barometers, thermometers, and other instruments intended for meteorological observations, but the greater part were of a very ordinary kind, and unsuited to the work intended.

Respecting thermometers (for the purpose of forming a correct estimate of those exhibited), let me impress upon you that a good and efficient instrument must be either identical in its readings with an acknowledged standard, or its amount of deviation correctly ascertained, and applied in its use; this involves a necessity for the possession of a standard of undoubted accuracy, the nearest approach to which were the thermometers made by the Rev. R. Sheepshanks, two of which, exhibited by Simms, may be considered as the most accurate in this country. That kind of thermometer most easily rendered identical in its readings, and most amenable to correction, is of slender bore, with small bulb, and graduated on the stems itself; by such a construction the amount of error arising from want of evenness in the bore of the tube, in the cutting of the divisions, or from a want of accuracy in the determination of the zero points, may be determined, and when applied will render the instrument perfectly useful and trustworthy. These corrections, when once determined for such instruments, will remain constant; but no system of correction can restore accuracy to the readings of thermometers whose scales are of ivory. Those of box-wood, a material in general use for maximum thermometers, require corrections which can be determined only by frequent comparisons with a thermometer whose errors are known, the index errors of such instruments being found to vary from day to day.

In maximum and minimum thermometers there was nothing new exhibited, although great need has long existed for an effective maximum thermometer.

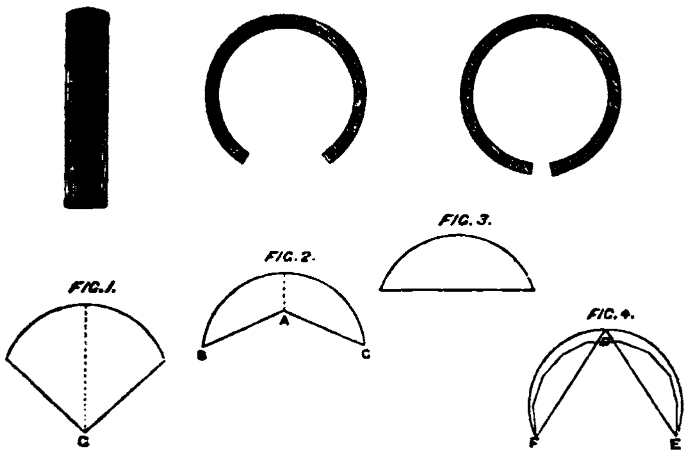
Newman exhibited his well-known barometers, the tubes of which were filled and boiled under a diminished atmospheric pressure. Mr. Newman remarks that he has always found that mercury highly heated in glass tubes becomes oxidised; and, also, that all tubes boiled under atmospheric pressure are foul. (I may observe that my experience has not led me to the same conclusion.)

Orchard exhibited a barometer very similar indeed to Newman's, but with the addition of a thermometer placed in front of the instrument, whose bulb was of the same dimensions as that of the tube.

Griffiths exhibited a barometer furnished with a crook on the top to trap any air which might be above the mercury, for the purpose of insuring a vacuum. Negretti and Zambra also exhibited a barometer with an air-trap glass cistern, with the intention of preventing the entrance of the air; the mercury in neither of these instruments was boiled, an operation that I consider absolutely necessary.

Harris and Son exhibited several self-compensating barometers for the approximate determination of the atmospheric pressure. They are about 1 foot in length, and consist of two reservoirs connected by a bent tube, the one filled with mercury, and the other with gas, the adjacent portion of the tube being also filled with mercury and gas. There is also an arrangement for the approximate correction for the expansion of the gas from heat. An instrument upon this principle, made by Ronchetti, was tried by me some years since, and was found to give tolerably approximate readings for a time—that is, to within 0·1-inch either way, but ultimately failed entirely. Instruments of this kind are of little or no value. Brown exhibited two barometers, at the price of 10*s.* 6*d.* each; one such, upon trial, I found to act well; undoubtedly they were the cheapest in the Exhibition, and were better than any of the ordinary barometers exhibited.

Bourdon (France) exhibited barometers of an original construction, based upon the tendency possessed by a coiled and exhausted tube of thin metal to contract and elongate when subjected to variations of pressure. A description of the method of constructing one of these little instruments may not be uninteresting. The form of tube adopted by M. Bourdon is not circular, but a little flattened and curved inwards, as shown in the annexed cut. The tube in use is quite exhausted of air and hermetically sealed at both ends, and coiled in the form shown in the second figure. As the pressure from without increases upon the tube, it exhibits a tendency to exchange its original form for that shown in the third figure. If the tube be sufficiently elastic, it resumes its former figure as soon as the pressure is withdrawn, and the variations of curvature attendant upon the increased or diminished pressure, communicated to an index moving over a dial-face, give the readings of the barometer. According to M. Bourdon's observations it would appear that the amount of contraction or expansion is proportionate to the sustained pressure; thus, if the two extremities of the tube become separated by the space of 1 inch for a pressure of 20 lb. upon the square inch, they will separate by a space equal to 2 inches for one of 10 lb. pressure, and so on; consequently the graduations on the dial-plate are equal throughout the scale. Mr. Bourdon considers that the same action which brings together each of the ends of an arc, when the chord is bent either in pulling, as fig. 1, or in pressing towards the arc, as in fig. 2, is the same action as that which causes in the metal tube the variations of figure consequent



upon different degrees of pressure; and he observes, that by diminishing the pressure upon the chord at A, it will gradually relax, and both arc and chord assume the form of fig. 3, an action corresponding in its effects with that produced by the withdrawal of the atmospheric pressure, which suffers the tube to reassume the figure in which it was originally coiled. In reference to its amount, M. Bourdon observes, that if the pressure on the chord at A, fig. 2, be increased until it touch the arc of the circle at D, fig. 4, the angle at D, is rendered more acute, and the two ends of the arc necessarily convergent, the amount of convergence being at all times in proportion to the angle formed by the two chords of the arc, the curve of the arc being modified in the same proportion. An effect of the same kind is produced by pressing the chord simultaneously on many points towards the arc as in fig. 4, the withdrawal of pressure being accompanied by the same return to the original figure; and M. Bourdon considers that the same action is induced by the external air, which maintains a simultaneous pressure on every part of the curve. These observations of M. Bourdon, in connection with the principles which he has successfully applied, seem to me deserving of some consideration. The graduations of the instrument are determined by subjecting it to artificial variations of pressure in connection with a standard mercurial barometer, by which means the points of coincidence are correctly ascertained and laid down. I have not had any experience of the working of these barometers, and do not expect that they are applicable to meteorological observations; but I have no doubt that their action as steam-pressure gauges is admirable. Many of these last were exhibited by M. Bourdon, in some of which the converse of the action you have just perceived was obtained by filling the tube with a gas or liquid, in which case external pressure caused an expansion or elongation, in opposition to the contraction you have now witnessed.

The collection of meteorological instruments in the Exhibition would lead us to the conclusion that the conditions of good instruments are better understood and fulfilled by makers abroad than at home. That this will speedily cease to be the case, I feel assured. The opportunity offered to the members of the jury of expressing their disapprobation to the makers, added to the increasing demand for good instruments, and to the fact of the public becoming acquainted with the deficiencies of those usually furnished to them, will inforce a demand for instruments better worthy the investment of their time and money; and when we consider how worse than useless is the labour of the meteorologist when based upon bad or insufficient instruments, and how by these means he becomes instrumental to the propagation of error, this circumstance alone demands increased care in the selection of those used. That the want of good instruments is experienced I can myself testify.

Photography.

The collection of photographs in the Exhibition was well calculated to show the active and experimental nature of the attempts being made to improve its processes—an activity less observable throughout the foreign side of the collection, which established fewer claims to excellence, on the ground of the novelty of the processes adopted, than were established on the British side. This activity was shown in part (to confine ourselves at first to daguerreotypes) in the works of Claudet, who exhibited applications of his focimeter; illustrations of the effects of the spectrum on the daguerreotype-plate, as prepared by him; and pictures which, notwithstanding the loss of light necessary for the operation, were rendered non-inverting; in those of Mayall, who exhibited the crayon daguerreotype, produced by a process of his own; Beard, who exhibited enamelled daguerreotypes, in which the permanence of the picture was secured by a lacquer; in the pictures of Tyree, who claimed the adoption of a peculiar process of his own; and various others which it would be tedious to enumerate.

The daguerreotypes exhibited by America, though not distinguished by experimental attempts at improvement of processes, were remarkable as illustrations of the excellence of those which had been employed.

The almost endless variety and modification of daguerreotypes and talbotypes exhibited rendered it most difficult to obtain, in each case, the nature of the process adopted; and excellence of execution, combined with adherence to the rules of art laid down for the representation of natural objects, became the safest and only criterion of merit.

The nearest approach to this standard of excellence was made by Martens, in all of whose works the elements essential to the process of the art, and to his own method, were so combined and applied that the spectator, losing sight of the means in the end, beheld in them representations of the most perfect beauty, void of artificial effect or technical display; and the mind, impressed with the beauty of nature's own tracings, was not for a moment reminded of the human appliances which had directed the work.

Following Marten's steps, and inferior to him alone, were Bayard and Flacheron; and following after, many exhibitors of talbotypes and calotypes, among whose works were to be perceived specimens of M. Blanquart's process for the production of two and three hundred impressions from the same negative proof; their blotty and heavy appearance was, however, destructive to a great amount of the success of the results obtained; their price was designed to vary from 5 to 15 centimes, according to their size.

In the British collection of sun pictures, some very beautiful results were obtained by Ross and Thomson, of Edinburgh, upon albumenised glass. Mr. Owen contributed a series of calotype pictures upon paper so prepared by him that, by its use, he has been enabled to execute in a single day, in a journey of three hundred miles, ten large-sized talbotypes.

It is no less true than to be lamented, that this collection, the largest that has yet been brought together, and highly illustrative of the art, is by no means indicative of the existing state of photography in England—a defect, the cause of which is equally lamentable with its effect. When writing the report, I ascribed, and I think justly, much of the rapid and successful progress of photography to the comparative absence of patents in connection with it. Since then I have become better acquainted with the restrictive influence exercised over the exhibition of photographs, how distinctly soever allied to Mr. Talbot's process, by that gentleman's patent in connection with it, and which secures to that distinguished photographist the discovery of the fact of a latent impression being made on prepared paper, and the possibility of its development by fresh applications of washes. This patent has been attended with great injury, though less, perhaps, than might have been expected; for having almost, if not entirely, prevented this branch of photography receiving accessions from those to whom profit must hold out the inducement to its pursuit, it has left it almost solely in the hands of gentlemen, the results of whose experiments and investigations are constantly before the public, and who, while rapidly developing this beautiful and important discovery in its various ramifications, consider, and justly too, that new principles, when received as truth, become the common property of mankind.

It may be observed of patents in general, that they frequently cause many attempts to be made for the attainment of the same end by different means, and that of Mr. Talbot proves to be no exception to this rule; the chief claim upon which it is founded is the development of the latent picture by the application of liquids. A picture, therefore, impressed in the camera, to be developed without subsequent applications, became a thing highly desirable to obtain. Accordingly, Dr. Woods discovered a process known as the catalisotype, by which the picture impressed in the camera reveals itself when set aside in the dark, without any assistance from the photographer. This process has been used by Mr. Mayall with very successful results; but the great objection to its use is the difficulty of obtaining paper suited to the process. Very recently Mr. Robert Ellis has obtained a new process, by the use of the proto-nitrate of iron, by which the same result is obtained; the paper being very sensitive, the picture appears in a minute or two after it has been exposed in the camera, but though both these processes (one of which was called into existence by the necessity of a process different from that of Mr. Talbot's, for the purpose of geological investigations), and various others are due to the inforcement of Mr. Talbot's patent, it is believed that the reason the French photographers in the Exhibition excelled our own was chiefly because this patent right does not restrict them. These restrictions consist in the requirement of a large sum for a license to use Mr. Talbot's process for practical purposes, or prosecution for the infringement of the patent. Under these restrictions, M. Martens' beautiful photographs are excluded from the market in this country, and the specimens exhibited by that gentleman were withdrawn again to France, the sale of them in London being at once checked by a threat that proceedings would be instituted against him for the infringement of Mr. Talbot's patent.

Let us now be content to take a more general view of the subject, which affords a striking illustration of the germination of new principles, by showing how the groundwork of a science originated in France has been received among nations, which ever since have been silently promoting its advance and contributing to its improvement, each in a manner suited to its peculiar genius—a germination arising out of the fact, that ever at hand are to be found talent and industry ready to receive new direction and fresh impetus in the acquisition of knowledge, which, when gathered, has rarely been garnered for the benefit of the few, but has been widely scattered for the use of all capable of and willing to appreciate the gift, by which means the bulk of information collected from the date of the Daguerrian invention has been dispersed, to collect again with interest subservient still to its advancement. A great step towards the same end was the collection of photographs in the Exhibition, which afforded to the photologist a larger field of observation than he could have before enjoyed; many of the producing processes have long been common property, but not so their several results. The Exhibition supplied this deficiency as far as existing causes permitted, and placed the inquirer at once in possession of a class of information which before could only have been obtained through the trouble and inconvenience of personal introductions and mutual interchange of specimens; at the same time placing him in possession, not only of a means of estimating their relative merits, but also of emulating any one style it might seem desirable to him to adopt or improve, either of his own or other countries, the characteristics of which were severally attended with some peculiar merit or excellence. A means of studying cause and effect, such as this collection afforded to the practised photographist, can scarcely be unattended with important results; and the public, many of whom have for the first time seen a really good daguerreotype, will be better informed of the power of the art as applied to the purposes of representation. The imperfect application of photography is well represented in the Exhibition, and showed plainly that to please the eye, and administer to personal feelings, is the chief purpose to which a power capable of higher and more useful applications is at present applied. In my report, I have enlarged upon its utility as applied to the purposes of art, science, and literature; but time only permits me to mention that there were no specimens of ancient inscriptions, no delineations of tropical or remote scenery (excepting Claudet's), no specimens of the actinic spectrum on chemical preparations, no magnified representations of the microscopic products of nature, no copies of ancient manuscripts, no miniatures of printed books, no specimens of scotography, or the art of copying engravings by simple juxtaposition in the dark by obscure interradiation, and many other applications to which it is well adapted.

Mr. Whipple, however (U.S.), by exhibiting a photographic image of the moon, has broken ground for its application to astronomy. No photographic image of a star has as yet, as far as I know, been obtained, but great would be the advantages secured, if by merely using prepared paper, the relative position of the objects in the field of a telescope could be made self-registering. I can, indeed, well conceive, that with a good working system of photography, stars, invisible to the eye, may be made to register their position with the same telescope, even looking with a black field, because, with a well-adjusted clock-motion, the same object may be made to occupy the same position on the plate, or paper, for any length of time. By such a system much distressing work in searching for new objects might be avoided, and I think it is a subject which cannot be too strongly insisted upon.

Mr. Brooke exhibited his admirable system for the photographic self-registration of natural phenomena, including apparatus for ascertaining all those elements in magnetism at present considered important to investigate, and also a means of registering some of the elements necessary for meteorological investigations. Thus every change of position in the magnet is recorded, and not only is the change noted, but the peculiarities of its motion also registered. The intimate connection existing between the aurora borealis and magnetism is ocularly shown, and also many particulars which, in the ordinary mode of observing, would necessarily escape detection.*

Acoustics.

In acoustics, the syrene of Cagniard de La Tour, exhibited by Watkins and Hill, was the only instrument of the kind exhibited. This beautiful instrument, in the early part of the present century, was invented by tho Baron de La Tour, who, struck with the belief that musical sounds were produced by a succession of impulses striking the air and producing vibrations, determined to ascertain whether a piece of mechanism so constructed as to strike the air with the same rapidity and regularity would also produce sounds. The instrument now in my hand was the result of this determination; its construction, which is at once simple and elegant, I will briefly explain. The air set in motion, by blowing through this small tube, communicates motion to the circular plate, which turns upon the cylindrical brass chamber beneath. The plate within its circumference is pierced with a series of oblique and equidistant holes, and immediately beneath, on the upper surface of the brass chamber, is a corresponding series. The obliquity of the two series of perforations are similar, but reversed for the purpose of enabling the current to communicate a rotatory movement to the plate; the obliquity of the holes is in itself not necessary to production of sound, but is a conventional arrangement to produce motion without the employment of an additional agent. The disc is thus made to revolve with a rapidity in exact proportion to the force with which the air is impelled through the tube, and by its rapid and regular movement gives to the external air a series of shocks, which produce a sound analogous to the human voice more or less sharp, according as the current turns the plate with more or less rapidity. The moveable disc is carefully centered in the surface of the air-chamber, by means of a slender axis working in a small orifice left for its reception, and is connected with the indices above by a delicate cylindrical tube, terminated by an endless screw, which gives motion to a wheel furnished with 100 teeth, and bearing on its axle an index. A cog on this wheel acts upon another, whose axle likewise carries an index. For every hundred divisions traversed by the index of the wheel with 100 teeth, which corresponds with the same number of rotations performed by the plate beneath, one division is registered by the other of the two indices—an arrangement which affords great facility for reading off the multitudinous vibrations of which each sound is composed. If water be passed into the syrene instead of air, the same sounds are produced, even should the instrument be totally immersed, the same number of vibrations producing the same sound, and hence the name of the instrument.

This instrument in use, as applied to a continuous stream of air, is a means for determining the absolute number of vibrations in a second necessary to the pitch of a note, and may be set in motion by the flow of air or gas from a gasometer, or by

* Mr. Brooke's system of photographic registration is fully illustrated and described in an article by Mr. Drew, given in our last number, ante p. 129.

a stream of water, as already mentioned; and is a beautiful and practical adaptation of a theory which it at once confirms, affording at the same time a key to much that is unknown in the relations existing between sound and its producing causes.

Balances.—Next in order of arrangement, balances claim our attention. It may not be out of place here to mention that the Exhibition made known an application of voltaic action of great value, by T. H. Henry, Esq., by coating with perfect success the beams of two of the balances exhibited by Oertling, the one with palladium, and the other with platina. By this application, a derivative from the electrotype, the inferior metals are coated with the superior—a process applicable to thermometer scales, to the limbs of astronomical and geodetical instruments, and, in fact, to graduated scales of all kinds; nor are its applications confined to these alone, it is useful in the coating of weights, instances of which are now brought before you for the first time, as well as the scale of a thermometer similarly coated. Mr. Henry assures me these great advantages will not involve much additional expense. A want of many years is thus supplied, for I have been long endeavouring to bring into use some substitute to avoid silvering the scales of thermometers—a want which has long been experienced by all who have used metallic scales and know how soon the divisions are obliterated, and who will not fail fully to appreciate this useful application.

Calculating Machines.—Of calculating machines there were several (more or less perfect), by which the hand is made to do the work of the mind, and calculations requiring much strained labour are performed by merely turning a handle. The best was furnished from Russia, by Staffel, and was found to perform accurately and readily the simple calculations of the first four rules of arithmetic, as well as the extraction of the square root, though less readily. The next best, from France, by Thomas de Colmar, was also capable of performing the same calculations.

Electric Telegraphs.—The Exhibition was rich in electric telegraphs, and for the first time the public had an opportunity of inspecting their arrangements. Beyond the spreading of general information, I do not see that the collection of telegraphs will be followed by any particular advantage arising from it, because the earnestness of all gentlemen at present connected with them needs no stimulus to further exertions.

Electrical Machines.—Of electrical machines there was one only requiring particular mention—that of Westmoreland, for generating electricity from gutta-percha bands, and which gives promise of producing electricity to any amount; this, the introduction of a new motive power, opens a new field of philosophical inquiry well worth exploring.

Standard Measures of Length.—A beautiful machine of this kind was exhibited by Mr. Whitworth, for the purpose of measuring to *one millionth* of an inch. Another delicate and beautiful apparatus for the same purpose was furnished from Germany by Bauman. Simms exhibited standard bars and scales. The Conservatoire des Arts et Métiers at Paris, furnished a beautifully divided metre and various standard measures.

Dividing Machines.—Ackland exhibited a dividing machine very ingeniously contrived for the division of hydrometer scales. Perreaux (France) furnished a beautiful straight line-divider.

Tide-Gauges.—Of tide-gauges there were two, both self-registering, by Hewitson and Newman; that of Hewitson was the better; it showed both time and tide, was elegant in appearance, and seemed perfect in action.

Iridescent Films.—Mr. De la Rue exhibited various applications of iridescent films, to the purposes of decoration generally. This is a beautiful illustration of the production of colour on a thin transparent surface by the agency of light, the colours being as bright as those seen transciently in the ordinary soap-bubble. The process is performed by dropping a very small quantity of spirit-varnish upon the surface of water when tranquil, which, spreading in all directions, becomes exceedingly attenuated, and reflects the colours of the spectrum. The object immersed (paper-hangings, card-cases, &c.) is then raised slowly, in such manner that the film adheres to its surface. It is applicable to very many ornamental purposes.

SHEPHERD'S STRIKING ELECTRO-MAGNETIC CLOCK.

By Dr. G. Wilson, F.R.S.E.

[*Paper read at the Royal Scottish Society of Arts, April 12th.*]

Dr. Wilson commenced by stating that his attention had been directed to this clock, by the interest which it had excited in London, where it had been shown to the Society of Arts, and a prominent place had been assigned it in the Great Exhibition. Professor Brande had also brought it before the notice of the Royal Institution of Great Britain, and Mr. Charles V. Walker had it already in action at the Tonbridge Station of the South-Eastern Railway; whilst, with Mr. Airy's approval, it was being erected at the Greenwich Observatory, with a view to send time signals to Paris, and to places in our own island, situated on the telegraph lines. Mr. Shepherd having kindly acceded to the request that he should send one of his clocks for exhibition to the Royal Scottish Society of Arts, and Mr. Alexander Bryson having willingly taken charge of the clock-work, Dr. Wilson undertook to describe the instrument. After a preliminary reference to previous electric clocks, especially Mr. Bain's, which was characterised as simple and ingenious, but which, from the mode in which electricity was employed in it as a moving power, could not but vary in its rate,—Dr. Wilson proceeded to explain the peculiarities of Mr. Shepherd's instrument, which aimed at being a perfect time-keeper. It involved three separate arrangements—namely, one apparatus to move the pendulum; a second to move the works and wheels; and a third to strike the hours. Each of these pieces of apparatus had a battery (or batteries) and electro-magnets for itself. The pendulum arrangement was independent of the other two, so that the pendulum moves though the wheels may be motionless. The wheels are controlled by the pendulum, though moved by their own battery. The bell-stroke is controlled by both the pendulum and the wheels, but is effected by an independent battery. The special peculiarity of Shepherd's clock may be said to lie in the fact, that the pendulum is neither directly moved by the wheels, as in ordinary clocks, nor communicates motion to the works, as in Mr. Bain's electric clock. Mr. Shepherd's pendulum may be quite detached from the rest of the clock, and a single pendulum will suffice for many clocks.

The Pendulum.—It is kept in motion by *four* forces, two of which act *directly*—viz., elasticity and gravity; and two *indirectly*—viz., electricity and magnetism. The action of the direct forces is as follows:—A bent spring let loose in one direction, throws the pendulum to one side, and the pendulum returns by its own gravity. Whilst it is returning, the spring is re-bent, and held back by a detent, or catch, which the pendulum itself raises when near the limit of the oscillation which gravity determines, so as to receive from the spring a second impulse to the opposite side. It will thus be understood that some arrangement must be provided for re-bending and holding back the spring till the pendulum again acquires an impulse from it. This re-bending of the impulse-spring is determined by an electro-magnet, to which a current of electricity is alternately allowed to pass and then cut off, as the pendulum moves to one side or the other. The pendulum is in permanent connection with one pole of a battery. A wire from the other pole is touched by the pendulum-rod as it moves to the one side (so that the current passes), and is separated from it, when it swings to the opposite side, so as to cut off the current. When the current is on, it throws the electro-magnet into action, so that it pulls down an armature or keeper, which, acting on a compound lever, locks back, or re-bends the impulse-spring, so that it is caught by the catch or detent. When the current is off, the electro-magnet becomes inactive, and a counterbalancing weight and spring raise the armature from the electro-magnet, so as to be ready to act again, and re-bend the spring when the current is restored. The electro-magnetic arrangement is thus solely employed to re-bend the spring; and it does not matter how much the electricity, or the magnetism which it induces, may vary in intensity, provided that it is sufficient to re-bend the spring at every alternate oscillation. The release of the spring is effected by the direct mechanical contact of a small arm or point projecting from the pendulum-rod.

The Clock Arrangement.—To move the clock-wheels, two pallets acting upon the teeth of the escape-wheel are fixed upon an axis, at right angles, to which are attached two or more permanent bar-magnets. Beneath each pole of the bar-magnets is placed an electro-magnet. A wire proceeding from a double battery coils round the electro-magnets from the top to the bottom on the one side, and from the bottom on the other, so that when a current passes, the upper ends on the one side are north poles, and those on the other side south poles, and *vice versâ*. Two batteries are employed to actuate the electro-magnets. A wire from the negative pole of the one battery and the positive pole of the other battery are soldered into one wire, which, after passing round the electro-magnets in the way just described, terminates in the pendulum. The *free positive* wire of the one battery terminates in a point of platina on the one side of the pendulum-rod, and the *free negative* wire of the other battery terminates in the same way on the opposite side of the rod, the arrangement being such, that when the pendulum hangs vertically, neither battery is in action; but when it swings to the one side it touches the free positive wire and lets the current from one battery pass, and when it swings to the other side it touches the end of the free negative wire and lets the current of the other battery pass. In this way the poles of the electro-magnets are alternately reversed, the ends which were north poles when the one battery was in action, being south poles when the opposite battery transmits its current. The bar-magnets are thus alternately acted on in reverse directions by an attractive force at one end, and a repulsive force at the other, and by their oscillations work the pallets and move the wheels. The rate, however, at which the wheels are moved, is entirely determined by the pendulum which regulates the intervals at which the alternate opposite currents reach and actuate the electro-magnets.

The Striking Arrangement.—This includes a special battery which actuates two electro-magnets, one of which drives the wheel which determines the number of strokes given to the hour-bell, whilst the other moves the hammer which effects the strokes. It is impossible, without diagrams, to describe the very ingenious apparatus employed for this purpose. It may be stated, however, that a lever pushed back by a pin on the minute-hand, is depressed once an hour by a pin on the seconds-hand, which completes the circuit of a battery, and calls into action the hour-wheel and the bell-hammer. For the working of these the current must be alternately cut off and let on the electro-magnets; and this is effected by making a break in the circuit be filled up every alternate second by the ascent of a thin plate of metal, moved by one of the oscillating bar-magnets. The bell is thus struck every two seconds, the number of strokes being determined by the distance between notches on the circumference of the hour-wheel. The current flows so long as one end of a lever is out of a notch; when it falls into one the current is cut off, and the striking ceases. The lever is not again raised till another hour comes round.

REVIEWS.

Naval Architecture: a Treatise on Shipbuilding, and the Rig of Clippers; with suggestions for a new method of Laying Down Vessels. By Lord Robert Montagu, A.M. London: Colburn and Co. 1852.

Although possessing the largest military and mercantile marine in the world, which has rendered the boast of Englishmen—that unto them belongs the dominion of the seas—not a vain nor empty one, it must be confessed that the theory of naval construction has been but imperfectly developed among us. The science of building ships—so thoroughly studied in France, and so successfully practised in America—has been singularly disregarded in England. Empiricists have travestied it, and "rule-of-thumb men" have voted it all moonshine. The result has been that, until very lately, English ships were built, according to traditional forms, by the mile, and cut off into lengths as wanted.

It is not for us to say how far the absurd system of admeasurement adopted by the Custom-house, and till recently in force, operated to induce builders of merchant ships to neglect all the more essential elements of construction. With the exception of capacity for cargo, the others were entirely ignored: it seemed a matter of perfect indifference to ship-builders and ship-owners, so long as a vessel could carry goods, keep afloat, and, with a fair—very fair—wind, "drag its slow length along," whether she made the voyage quickly or not; whether she was easily handled, or required a numerous and costly crew to work her; and, lastly, whether she was so built as to enable a skilful commander to weather the storm, and diminish the chances of shipwreck. So long as the one condition was fulfilled, the others were seldom or ever heeded; and it would seem never to have occurred to English speculators—so shrewd and far-seeing in other respects—that a ship which combined all these desiderata in the greatest degree, would amply repay, in the first voyage possibly, the additional first cost of construction which might have been incurred by engaging scientific men to lay down her lines, and superintend her building and rigging. In the royal navy the system on which British men-of-war were constructed was even worse, because the dockyard authorities could not plead the vexatious restrictions of Custom-house regulations as excuse for yearly launching ships by the dozen, which scarcely ever fulfilled the purposes for which they were intended,—which could neither sail nor fight, nor carry the requisite complement of men and stores. Sometimes, indeed, when a terrible disaster occurred, and public inquiry was aroused, the Admiralty awoke from its peaceful slumbers to a consciousness that after all it would be as well, perhaps, if British ships could sail a little faster, so as to enable them to overhaul an enemy that had been ruthlessly devastating our commercial establishments, burning our merchant craft, or may be, insulting our shores, as was the case in the Indian seas when Hughes and Suffrein maintained the honour of their respective flags;—that it would not be amiss when a British frigate was opposed by an overpowering force of the line, to be able to show the foe a light pair of heels;—that guns should not draw their ring-bolts at the first broadside, like the *Java*;—and, lastly, that 12-gun brigs should not have a tendency to founder, all standing, in a moderate gale of wind, like the "Forty Thieves."

When the Admiralty resolved to do something to provide against the recurrence of similar disasters, they looked for precedents, and proceeded to move in the same vicious circle as their predecessors. They issued instructions to the shipwrights in each dockyard to lay down the lines of new ships after the model of some fast-sailing prize recently captured from the enemy—our masters in naval architecture. Of late years the *Canopus* has been the favourite, and ship after ship has been built after her, but never with success. The causes of failure are easily understood. When the master shipwrights set about their work, in one dockyard it was suggested to increase her length to give more room between the guns, in another to increase the height between deck for the convenience of the crew. Sometimes the ship, it is discovered just before being launched, would be improved by being lengthened at the stern, now at the stem, then by her being cut down and lengthened amidships; at other times she is to be shortened. But in no case is the copy built and rigged precisely after the model. The partial rigs, and the bows, bottoms, and sterns of different models are, for aught we know to the contrary, often combined in one specimen. Instead of investigating the causes of success of French naval architects, our builders ignorantly copy their works. They appear incapable of thinking or acting for themselves. If the Admiralty does adopt an original course of action, it is only to order the immediate construction of ships after the crotchet of the first lord (who has great parliamentary influence), before one of the class has ever been seen, much less tried. A notable instance of this kind will be found in the history of the "Forty Thieves," not one of which that escaped foundering being worth anything except to break up.

Within the last few years a sensible and marked improvement has been made in England in naval architecture—so far, at least, as merchant ships are concerned. The recent—alas! only very recent—crack productions of one or two of our first shipwrights will bear comparison with American clippers. Aberdeen shares the palm with Baltimore. But, still, English clippers are the exception, and the rest are the veriest tubs that ever floated. These improvements, however, although so marked, are far from enabling us to recover lost ground.

In the royal navy—if one may judge from the lengthening, sawing down amidships, razeeing, and conversion that are constantly going on in the dockyards—the art of shipbuilding appears to be *in statu quo*. We have new ships that won't berth their crews or carry more than three months' provisions instead of six; frigates that won't sail on any tack, and have to be converted into screw guard-ships at great additional cost; war-steamers that break down at the first and every succeeding trip; and troop-ships that won't carry their proper complement, nor can, under any circumstances, make their voyages under less than double the time that one of our ordinary—even our merchant—ships would take under like conditions.

Why such incompetency and blundering should still exist in our national yards it would be impossible to justify or explain, we fancy, except on the ground of systematic disregard—almost contempt—which our authorities have always evinced towards science and her followers. Whether it was for the same cause that the school was suppressed at Portsmouth, or because our naval authorities determined that a naval architect, like the poet,

"* * * nascitur non fit,"

we leave our readers to determine for themselves.

Although we have not hesitated to express our opinions freely upon the backwardness of naval architecture in England, we are not insensible to the merits nor the researches of Beaufoy, Fincham, and White of Cowes, nor disposed to withhold the commendation which their labours deserve. Neither are we inclined to forget entirely the claims that Symonds and Seppings have on our gratitude for their adoption into the royal navy of diagonal bracing, round sterns, and other practical improvements of details. We have now another name to add to this honourable list, that of the author of the work under consideration. Lord Robert Montagu was led, by observation that "the generality of shipbuilders have not acquired a knowledge of the higher mathematics and of the motion of fluids," to inquire what authority they had for their proceedings,—if the principles, on which they asserted their system of construction was based, were sound and scientifically correct,—and if there was some one principle which, being faithfully adhered to in every variety of build, would explain the hitherto incomprehensible fact to the bewildered shipbuilder, that "among the swiftest vessels he sees some with full, and some with sharp bows; some with great beam, others narrow; some with a great draught of water, others shallow; some with much rise in the floor, others comparatively flat; some with little gripe, or the forefoot almost entirely cut away, while others have been improved by the addition of a greater gripe, and a bow lengthened below the water" (p. 10). Last winter he got upon the track of the invention which it is the object of the present work to explain, and which we shall allow him to describe in his own words.

"Builders form their vessels by the water-lines, ribbon-and-buttock-lines; and consider that the curves of these lines are of paramount importance. But they have not asked themselves why they should be so; whether any of them can have much to do with the passage of the water along the vessel's body; whether the water divides, in fact, in the direction of any of these lines. Why have they not inquired into the real direction which the water takes when it divides, and bestowed all their care upon the improvement of these lines? And then they might take the models of famous vessels, and find what shape it was proper to give to the dividing-line, and extract a principle from chaos and confusion; and perceive the unity in a mass of apparently antagonistic facts and conflicting results.

And how then does the water divide? It may be expected, *à priori*, that a flat film of water, from the cutwater, will pass along the body of a ship in the same direction as that which any other flat thing would naturally take—as a thin plank, for instance.* This is not a conclusive argument, but a natural supposition. But there is a fact which materially strengthens this assumption: I allude to the fact that clinker-built vessels have a decided superiority over carvel-built vessels of the same form. Now, if the water does not divide in the direction of the planks, the land of every plank must offer considerable, very considerable resistance to the progress of the vessel. But, on the other hand, if the water does really escape, according to our *à priori* notion, in the natural direction of a plank, then these lands will offer no resistance. And as the mere clinker-building gives a decided superiority, it is clear that the lands do not offer resistance, and that the water naturally divides along the planks. Now, over timbers which are vertical—as in the run of the stern, for instance—the water, or a narrow plank, will pass in a horizontal direction; and over timbers which are quite horizontal, the water or narrow plank would take a line lying in a vertical plane parallel to the line of vessel's motion. In each of these cases, the line described by the plank or by the water in its motion is at right angles to the timbers. And if a timber be forced out a little from the vertical position, so as to make a small angle with the vertical, the line described by the water or plank will take a slightly downward direction. And as the angle of inclination of the timber increases, the water or plank will take a more and more downward direction; but it will always cut the timbers at right angles.

* The plank is supposed to be of indefinite breadth, because the dividing-lines are not parallel. In a clinker-built boat, the planks are cut with a "sney," for this reason, the lower edges only representing the dividing-lines.

(I am of course supposing the timbers to be in vertical planes perpendicular to the direction of the vessel's motion; and I am not at present supposing the surface of the water as anything but a perfectly plane surface.)

The reason why the water passes along the body of the ship in lines which cut the vertical sections at right angles is, that the ship's sides at every point (when the ship is in motion) give an impulse to the water, which impulse is normal to the surface of the side at that point. And therefore the plane, in which the directions of the impulses from two adjacent points must be contained, must of necessity cut, at right angles, the surface of the ship's side which lies between.

View this moreover in another light. It is a philosophical principle that nature performs everything with the least effort; and fluids in motion between two points on any surface will take the shortest line on that surface. Now, the dividing-line is the shortest line which can be drawn on the surface of a vessel from any given point on the stem-post to the stern. This will be manifest if the line in question be projected on a plane parallel to the planes of the timbers (*i. e.*, in the body plan, if the sections are perpendicular to the surface of the water).

Let $B\,l$, $A\,k$, fig. 1, be two adjacent sections; and let $D\,d$, be a dividing-line. Then the line $D\,d$, is the shortest line that can be drawn from the point D, in the circumference of the section $B\,k$, to the circumference of the section $A\,k$; for, if not, let $D\,t$, be shorter. Draw D O perpendicular to the planes of the sections, and let it meet the section $A\,k$, in O. Join $O\,d$, $O\,t$. Then, as the distance between the sections is supposed to be small, and the dividing-lines are supposed to have an easy curvature, we may suppose the arcs $D\,d$, $D\,t$, to be arcs of circles. Now, as the dividing-lines cut the circumferences of all the sections at right angles, and as D O is perpendicular to the plane of $A\,k$, therefore the plane $D\,d\,O$, is perpendicular to the plane of $A\,k$, and at right angles to the circumference $A\,k$; and therefore $O\,d$, is at right angles to the circumference $A\,k$; and $O\,d$, is the shortest line which can be drawn from the point O, to the circumference $A\,k$.

$$\therefore\ O\,d < O\,t$$

$$\text{and}\quad D\,O^2 + O\,d^2 < D\,O^2 + O\,t^2$$

$$\text{or}\quad \text{chord } D\,d^2 < \text{chord } D\,t^2$$

$$\text{and}\quad \text{arc } D\,d < \text{arc } D\,t.$$

Similarly, $D\,d$ is less than any other arc drawn from the point D to the circumference $A\,k$.

The same may be proved with reference to that part of a dividing-line which is intercepted by any other two sections. And hence the whole of any dividing-line is the shortest line which can be drawn from the same point in the stem-post, over the surface of the vessel to the stern.

Fig. 1.

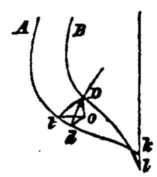
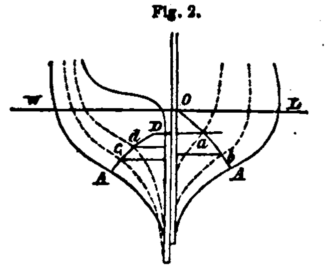


Fig. 2.



This consideration will afford us the readiest way of describing a dividing-line in the body plan of a vessel. Instead of the established system of laying down the plans of vessels by the water-lines, and applying to the water-lines the shapes indicated by experiment to be the best for the dividing-lines, I would propose the following method, deduced from the principles advanced above:—

1. For the sheer-plan, draw the keel, the stem and the stern-post, and mark in the line of flotation, or load-water-line. Then erect the sections at right angles to the load-water-line.*

2. Next determine the shape of the midship section, and lay it down in the body plan. Draw a straight line across it for the load-water line.† From a point in the stem-post, somewhere about the height of the load-water mark, or a little above it, draw a curved line to a point in the midship section, to represent the direction in which the particles of water, from the surface at the stem, are to be made to divide along the body. This is the principal dividing-line.‡ I have said "a *curved* line,"

* If the sections were drawn, as is usually done, at right angles to the keel, the dividing-lines would not cut the sections at right angles. In the copy of the lines which is afterwards made for the use of the builder, the sections may be altered (in the sheer and body plans) so as to represent sections perpendicular to the keel.

† The plane on which the sections are projected, for the body plan, is perpendicular to the water; not perpendicular to the rabbet of the keel, as in the established method. Hence the water-lines in the body plan, are straight lines, and the sections do not terminate in one point.

‡ It must be borne in mind, that a dividing-line is not a single line, like a ribbon-line. The dividing-lines are as numerous as the particles of water which surround the ship. The whole surface of a ship's bottom may be supposed to be made of an infinite number of dividing-lines. But we choose one only to work with, and choose that one which will be about the largest on the whole surface of the vessel. When the drawing is finished, it must be proved with other dividing-lines.

because, if the line were straight, the circumferences of the sections at their points of intersection with this line would be parallel to each other, because any dividing-line cuts them all at right angles. This *is* the case with some vessels, but it *need* not be so. To determine the nature of the curve this must be done:

3. In the sheer plan lay off the points in the stem-post midship section and stern-post through which this line is to pass. Through these assumed points draw a fair curve by means of the batten. Then,

4. In the body plan lay off the heights at which this curve cuts all the other sections, and draw through these several points lines parallel to the water-line. (The intersections of these lines with the dividing-line will, of course, be the points of intersection of the sections with the dividing-line). The form of the curve in the body plan comes now to be determined.

5. This is done by laying off, in the half-breadth plan, the three points already mentioned, through which the line must pass, and drawing through these points the curve which may be given to the batten. This gives the breadths to be measured, in the body plan, along the lines which we have drawn at certain heights parallel to the water-line; and the curve may then be described.

That dividing-line which commences at the load-water mark on the stem-post is now laid down—the greatest dividing-line, most probably, which the proposed vessel will have. In fig. 2, let O A D, be this curve, as determined by the sheer and half-breadth plans; *a, b, c, d*, its intersections with the lines drawn parallel to the water-line.

6. To sketch in these sections is our present object. For this purpose, take for centre the point O (the point on the stem-post from whence the dividing-line is taken), and draw the arc of a circle through the point *a*. Next take *a*, for centre, and draw an arc through *b*. Then take *b*, for centre, and draw an arc through A; if this arc should cut the circumference of the midship section instead of touching it at A, then the point A, must be moved so that the arc should only touch. This operation must be continued for the after-body by taking successively for centres the points A, *c, d*. The circumference of each of the sections must be tangential to each of the arcs respectively at their intersections with the dividing-line. The remaining part of each section is, at first, sketched in by eye, and then proved by other dividing-lines at various elevations. In sketching the sections, a pliable steel spring is of great use. It makes all the sections of a fair and similar curve, and so saves much trouble afterwards in correcting. The whole has now to be proved by water-lines, ribbon-lines, and buttock-lines (according to the established method), and corrected where any inequalities in the surface may appear.

This is the principle which I would propose for guidance in the construction of vessels. This principle explains the success of vessels of such various forms. Vessels with full bows, for instance, have a dividing-line running in such a direction that its projection on the sheer plan shows a greater curvature than that in the half-breadth plan; while the dividing-line of sharp bows shows a greater curvature when projected in the half-breadth plan than in the sheer plan. In each of these cases, however, the curvature, taking all in all, may be the same."

Into Lord Robert Montagu's investigations of the best form to be given to the "Midship Section and Stern," and "Sheer-plan," we do not propose to enter, but prefer quoting his remarks upon "Resistance against a Vessel's Progress," because not only do they display great originality together with utmost freedom from conventionalisms, and high mathematical attainments which are indeed distinctly visible throughout the whole work, but because he takes exception to Mr. John Scott Russell's theory of the wave line, which has lately attracted considerable notice from the earnestness with which it has been advocated.

"Let O B, fig. 3, be an infinitely small part of a dividing-line of the bow (which may be supposed straight). O, the origin of co-ordinates, of which the axis of *x* is in a line with the keel, and the axis of *y* transversely to it. A particle of water impinging on the vessel at O, must, in accordance with our definition of a dividing-line, have no tendency to leave the line O B; but it will travel along the surface of the vessel in the direction O B. Every succeeding particle striking the vessel at O, will do the same. We talk of the particles of water being in motion and meeting the vessel, for this will clearly lead to the same result as the contrary, but will cause less confusion in the consideration. Successive particles of water, then, meet the vessel at O, with a certain velocity, and exert a certain pressure. This pressure consists of two parts:—(1.) The statical pressure, or that which is exerted equally all over the surface when the vessel is at rest (which altogether equals the weight of the vessel, and the resultant of which acts vertically through the centre of gravity); and (2), a pressure due to the velocity with which the particles meet the vessel, and varying with the inclination O B, to the direction of the motion (*i. e.*, the inclination of O B, to the axis of *x*). The direction of this pressure is perpendicular to the plane in which O B, lies, and which is a tangent-plane to the surface of the vessel.

If there were no friction, the velocity along O B, would be the same as the velocity with which the particles impinge (as the pa[illegible] have really no initial motion, there is no momentum to be considered); but the friction, which is generated by the pressure, retards the motion; add to this, that other particles impinge on the line O B, at different points besides O, and hence the particles of water get piled and huddled upon the line O B. The whole surface of the vessel may be supposed to consist of dividing-lines infinitely near each other; and the same takes place on each of them. What, then, is the effect, as far as the bows are considered, of the motion of the vessel? The water at the stem-post is gradually increased in density up to a certain point. But as the water is an elastic fluid, the density is instantly communicated to the water, on all sides, in front of the ship; and also forces up, at the stem-post, numerous particles of water above the surface. The consequence of the former will be, to give the water all about in front of the vessel a certain velocity in the same direction as that in which the vessel moves. The effect of the latter will be a wave, which will rise up at the stem-post and travel with the vessel. But the dividing-lines, as they approach nearer to the middle of the vessel, become less inclined to the direction of the motion, until at last that inclination becomes a minimum. At this place, then, there is no increased density, for the pressure becomes zero (that is to say, the additional pressure, not the statical pressure), and the water flows away much more rapidly. This causes the surface of the water to sink; and the water from the nearest part of that which has an increased density rushes in, with a certain velocity in a direction contrary to that of the vessel, to supply the vacancy.

Fig. 3.

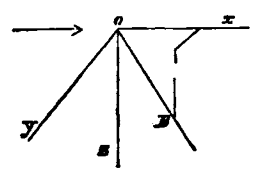
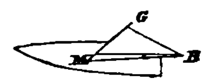


Fig. 4.



In a dividing-line at the stern there is no friction. Nay more, the statical pressure is diminished, so that there is not exerted even the whole of the friction which is due to that. For the particles of water, moving along the curves of the dividing-lines at the stern, tend to leave the line, and fly off at a tangent. And thus the density of the fluid abaft the vessel is decreased. The water immediately behind the midship section rushes in, and thus causes an additional depression of the surface of the water amidships, and gives the water under the stern a certain velocity contrary to that of the vessel. This current meets another current from behind the vessel, which also rushes in to fill the vacuum, and a wave is caused, which follows the vessel at the stern-post.

In these diagrams, I have attempted to show the form of the surface. The object of Mr. Russell, in his wave principle (if I understand aright), was to make the water, for some distance, divide in a direction parallel to the keel; and then to let the increment of inclination be very gradual at first, so that the wave should not be before, but immediately behind the stem-post, and so support the vessel. He increased the stern wave, by making the vessel of such a form that the dividing-lines should close with less taper, supposing that this wave would help the vessel onwards. But, as his mathematics are not always quite correct, it is hard to appreciate the result. And moreover, this object could be obtained by any curve at first parallel to the keel, and gradually leaving that direction, so that I do not quite comprehend why he should fix upon the curve of sines for the *water-lines*. But it seems that an inflected line must offer more resistance than a simple curve. He says, that the wave at the bow is of the form of a curve of sines—that is, the section by a vertical plane presents that curve. Assuming that this be true, why does he apply this curve to the horizontal plane of the water-line? There is no regular publication on the subject from his own pen (except in a periodical in the year 1838),* so that, very likely, he is not rightly understood, and an injustice has been done to him in making him stand godfather to a principle which is not his own.

Would it not, however, be better, perhaps, to apply a cycloidal arc to the dividing-lines of the bows (if such a principle as the above must be adopted), and have the dividing-lines aft much more tapered, and as nearly straight as possible, so that the particles at the stern may not fly off at a tangent; or, in other words, that there be caused as little suction as possible to the stern, and that the statical pressure at the stern should not be decreased. (The reason for mentioning the cycloidal arc as a substitute for the curve of sines in the bow we shall presently investigate).

Mr. Griffiths adopts the wave theory, and attempts to explain it: while he laughs at the principle upon which it is founded. He sneers at Mr. Russell's 'ignorance' for not knowing that steamers have been built in America which are so sharp as to have no wave. The wave may be so lengthened as not to be remarkable; but there must be some wave. However, he saves any one the trouble of contradicting him, for, with a noble generosity, he takes the unpleasant duty on his own shoulders: he finds it a curious thing that these vessels should run aground when

* See C.E. & A. Journal, Vol. II. 1839, and Vol. XI. 1848.—Ed.

passing swiftly over shallows on which there is quite sufficient water to float them when at rest. Is not this the result of the wave at the bow and stern, and the hollow in the water amidships? Let any one watch the *Clasper* eight oars at Cambridge or Oxford. They are longer and narrower in proportion than any steamer; yet the two waves are quite discernible."

The last passage of the treatise which we shall quote is on Sails—a subject which has raised considerable discussion since the inglorious defeat, in English waters, of English clippers by the *America*.

"The sails of the *America* were made of cotton duck, for they are lighter, easier worked, and hold the wind better than common canvas. The only advantage of heavy canvas is that it lies flatter; for this reason the Bermudians use it for the mainsails of their boats. But I am told that in the *America* they soaped or greased their sails for the race, to make them hold the wind, and kept them flat with battens.

But the sails in this country are not so cut as to lie flat; and this is the reason for the practice. If M, fig. 4, be the mast, and M B, the boom, then the gaff will be in some direction M G. Now, if the angle M G, be the best angle for the sail to form with the wind, then the lower part of the sail near the boom would be nearly aback, or at least forming a very bad angle; but if M B, be at the best angle, the sail up aloft would be lifting; and for this reason they make the sail with a great belly, and bring the boom to too small an angle with the wind, so that the belly may be at the right angle. This evil may be obviated by having the gaff much more peaked up, and having the mainsheet nearer to the mast. For, as the vertical height of the boom from the deck is the same (to all intents), but the length of the sheet is increased the further it is placed from the mast, therefore the power of the sheet to keep the sail flat bears a greater proportion to its power in keeping the boom in when the sheet is placed nearer the mast than when it is further off. The advantage of a horse is that it keeps the sail flatter; the disadvantage is a want of play. This plan would attain the advantage of each kind. There are two other advantages in having the gaff much peaked: one is that the play of the gaff is upwards, instead of tending to drive the vessel's head into every sea; and the other is that the head of the sail is smaller, and so the sail is more reduced in size, with less trouble, when reefing. When the sail is very flat, you can afford to lace the foot of the sail to the boom, as the Americans do; if the sail is not very flat, but the gaff goes off at a different angle to the keel from the boom, then this lacing would cause a backsail. In a schooner, if the sails are not flat, the wind from the jib acts against the foresail, and the eddy from the foresail against the main, which in each case tends to retard the vessel's progress.

There might be made some improvements in the rig of our cutter. The mast should be more aft (the beam also, of course, in a corresponding position), and there should be less head sail. The mainsail should be *the* sail of a cutter; and the foot should be much longer in comparison to the head. Also, the present heavy gaff and boom, being nearly horizontal, do not switch up and down when the vessel pitches; they drive her bodily into the seas. They should be peaked up more, and the boom kept much lower; the jaws of the boom should be down almost in the cabin. The gaff should form an angle of 45° with the mast. The bowsprit should be shorter, stouter, and without a bobstay. There should be no foresail (which is a very pressing sail), but only a large jib. And it will be necessary, therefore, in order to work with ease in going about, that the mast should be stayed forward by two forestays to cat-heads out of the bows, instead of one stay to the stem-head. She should have no topmast; but her gafftopsail should be run up with a yard, which should stand up and down the mast, as in American schooners. It is not, I am aware, quite a new thing to omit the foresail; but I do not think my plan of the forestays out to cat-heads has ever been tried.

It would be a good plan, in schooners, to have a boom for the foretrysail, with a jigger and snotter round the mast, instead of jaws, so that it could be brought in when the vessel is in stays, and bowsed out again as soon as she is on the other tack. It would give more play to that sail, and make it stand better. The *America* had a boom (with jaws) which extended only to the mainmast.

No racing vessel should have a gunwale of more than a few inches, for it only serves to catch the wind and send her to leeward. Neither should there be any cabins or bulk-heads below. A piece of painted canvas stretched across the vessel amidships would be quite sufficient."

In taking our leave of the Treatise on Naval Architecture, we cannot but congratulate its author on the success he has achieved. He has produced a work which deserves to be carefully read and digested by every shipbuilder—to serve, in short, as a text-book and standard authority hereafter. He has entered most fully into a calm and able investigation of all the elements that must be combined to produce a fast-sailing and weatherly craft—building, masting, rigging, and ballasting; and has advanced no proposition without proving its truth by elegant yet unpretending mathematical demonstrations, and confirming these by the apt quotation of practical examples.

The Soul in Nature, with Supplementary Contributions. By Hans Christian Oersted. Translated from the German by Leonora and Joanna B. Horner. (Bohn's Scientific Library.) London: H. G. Bohn. 1852.

In the spring of last year a bright star passed from the firmament of science, and faded from our sight for ever. Hans Christian Oersted died in the zenith of his intellectual glory, amid the mourning of his countrymen and the universal regret of the scientific world. The eldest of two brothers, whose ardent spirits, deeply stored minds, unremitting industry, and practical application which they sought to give the direction of their studies, have won a world-wide reputation for them, and who were not the least remarkable and worthy of all honour among that band of intellectual heroes—Oehlenschläger, Thorwaldsen, Berzelius, Steffens, Rask, and Sibbern—who, by their splendid genius, indomitable will, and singleness of purpose, proved themselves worthy descendants of the vikings of old, and won the admiration of the world for their common country. Bleak and inhospitable Scandinavia, who was wont to send forth from her icy depths and iron-bound shores, men, like herself, ruthless and inflexible, to desolate the fairer and more favoured regions of the south, produced, towards the close of the last century, a group of philosophers and artists who, by the humanising influences they have exercised upon society, have in some sort compensated for the injury to the arts and sciences which their fierce forefathers committed during the middle ages. But the one to whom the gratitude of the world is more especially due is, without doubt, Oersted, for to his studies and discoveries are we indebted for the invention of the electric telegraph. At the close of the meeting of the British Association at Southampton in 1836, where the illustrious philosopher was present, Sir John Herschel spoke truly when he said, "In science there was but one direction which the needle would take, when pointed towards the European continent, and that was towards his esteemed friend Professor Oersted. He knew not how to speak of him in his presence, without violating some of that sanctity by which, as an individual, he was surrounded. To look at his calm manner, who could think that he wielded such an intense power, capable of altering the whole state of science, and almost convulsing the knowledge of the world? He had at this meeting developed to them some of those recondite and remarkable powers which he had been himself the first to discover, and which went almost to the extent of obliging them to alter their views on the most ordinary laws of force and of motion. He elaborated his ideas with slowness and certainty, bringing them forward only after a long lapse of time. How often did he (Sir J. Herschel) wish to heaven that he could trample down, and strike for ever to the earth, the hasty generalisation which marked the present age, and bring up another and a more safe system of investigation, such as that which marked the inquiries of his friend. It was in the deep recesses, as it were of a cell, that in the midst of his study, a far idea first struck upon the mind of Oersted. He waited calmly and long for the dawn which at length opened upon him, altering the whole relations of science and, he might say, of life, until they knew not where he would lead them to. The electric telegraph, and other wonders of modern science, were but mere effervescences from the surface of this deep recondite discovery, which Oersted had liberated, and which was yet to burst with all its mighty force upon the world. If we were to characterise by any figure the advantage of Oersted to science, he would regard him as a fertilising shower decending from heaven, which brought forth a new crop, delightful to the eye and pleasing to the heart."

The life of Oersted bears a resemblance to that of Humboldt, distinguished by the same pure love of natural science, the same zealous service in the diffusion of a true knowledge of her laws and harmonious beauties, and the same modesty and simplicity. Born in humble life, in 1777, the son of an apothecary in the little town of Rudkjoking, in the island of Langeland, Oersted was indebted for his education more to his own application and eager search after knowledge than to any efforts of his father, who claimed the assistance of his son, when only twelve years old, in the discharge of his profession. Five years afterwards the two brothers, who through their boyish days had invariably communicated to one another the knowledge that each had respectively acquired, entered into the University of Copenhagen. Denmark, to her honour be it spoken, though the least able is yet the most zealous and efficient instructress of her children of all the states. The painstaking habits of study and modest demeanour of the young Oersteds, soon attracted the attention of the government authorities, which led to the award of some pecuniary assistance. With this sum, and what they earned by giving lessons, they were enabled to complete their academical career, and take their degrees. About 1800, the elder brother, who had just set up as apothecary and lecturer, received information of Volta's discoveries. Into the study of this new and wonder-working science, Oersted plunged with all the eagerness and enthusiasm of his nature. The result was his discoveries "with respect to the powerful action of acids during the production of galvanic electricity, and of the relation of the opposite effects developed through the conductor of the battery to both poles; whilst he proved that both acids and alkalies are produced in proportion as they mutually neutralise each other." Two journeys to Germany and France, the advancement to the professorship of Physics in the Copenhagen University, and numerous publications—among the most remarkable of which are: 'The Series of Acids and Bases,' 'Observations on the History of Chemistry;' 'Manual of Mechanical Physics;' 'Views of the Chemical Laws of Nature;' a theory of national (German) scientific terminology;—together with the invention of a galvanic copper-cell apparatus and a new blasting process, and a geological examination of the island of Bornholm, were the principal features of his ever-active life, up to the year 1820, "from which may be dated Oersted's great fame, and called by himself the happiest year of his life. In this year he discovered electro magnetism, or the "law of reciprocity between electrified bodies and the magnet." After the theory had been developed in a course of private lectures, and proved to be correct by repeated experiments, a short account of it, in Latin, was sent to all the European scientific societies, the majority of whom honoured themselves by giving him their suffrages. Our Royal Society sent him the Copley Medal, and the Institute of France, as an extraordinary acknowledgment, a mathematical class prize worth 3000 francs. In 1823 and 1836 he visited England, among other countries, and was everywhere received with the respect and admiration due to his genius.

After a life full of honour, and spent in the unselfish prosecution of the studies of science and the revelation of the laws of nature, and within four months after the jubilee held in honour of the fiftieth anniversary of his long and eminent services at the University of Copenhagen, Hans Christian Oersted died, after a short illness—so short, in fact, that he may be said to have died in the fulfilment of his duties, to have fallen like a soldier at his post—on the field of victory.

In this necessarily brief retrospective glance at the life and labours of Oersted, we have had scarcely space to do justice to his literary abilities, and yet they were of the highest order. But his philosophical researches and discoveries were so important that they absorbed public attention entirely. The appearance, therefore, in Bohn's valuable series, of 'The Soul in Nature,' is exceedingly opportune and acceptable, as calculated to induce the public generally to regard Oersted in a new point of view, and render him justice for those literary talents which his discoveries in natural science, like Aaron's rod, had swallowed up. As a sample of his style and mode of reasoning, we quote the following from his essay on the Natural Philosophy of the Beautiful; the most likely to interest our readers, although probably not the best we could have selected.

The Natural Philosophy of the Beautiful.

"1. When we make mathematical figures and formulæ for the use of science, we produce something which bears an acknowledged stamp of beauty. The same, though in a much higher degree, occurs in our experiments for the discovery of the laws of nature. These facts, concerning two different branches of science, might appear at a hasty glance to have but a slight connection in common, but upon a closer investigation, we perceive that they are on the contrary very intimately connected, and that the explanation of this matter must be reckoned among the tasks of natural science. In an attempt to solve this problem, the importance of natural science for general education, which is becoming more and more acknowledged, will appear in a still stronger light; and though the first experiment may be far from satisfactory, it will, nevertheless, have pointed out an important task to be performed for the sake of higher culture, which can no longer be delayed.

2. Our inquiry does not commence with determining the nature of beauty; but, pursuant to the proceedings of experimental skill, we must search and investigate the laws by which something is produced which satisfies the sense of beauty. It is evident that we must begin with those objects which can be most easily penetrated—namely, mathematical figures; but beauty in these is so simple, so little developed, so elementary, if we may venture to use this expression, that to many we might seem to be searching for beauty where it does not exist. The method in which we proceed with our continued inquiry must justify us from such a contradiction. We must limit ourselves here to answer provisionally, that, in daily speech, the most simple forms which agree with good taste are not called beautiful, unless they are placed in direct opposition with something ugly; just as the most simple and generally received truths are not distinguished as being reasonable, if no contrast demands it.

3. Every one must feel that lines and figures which express thought, the straight line, the circle, and figures formed of straight lines of equal size, are pleasing to the eye; but this is felt most strongly and decidedly when they are compared with careless scribbled strokes.

4. We need only observe with accuracy this mental experience, to be convinced that the greater satisfaction we derive from the contemplation of figures which express thoughts is not produced by thinking, but is connected with the direct apprehension of the thing. It is an inward sensational apprehension, a mental perception. We are not astonished to find this harmony between reason and sense, as they both spring from the same high origin.

5. Every apparent object, however simple, contains a variety (we may almost say, an infinity) of thoughts, which thought must elaborate by separation, union, and arrangement, before it can grasp it in its oneness. Perception, on the other hand, receives an impression from it as oneness, and therefore complete, strong, and clear; but not with the penetrating consciousness of the inward nature of the thing, similar to what is produced by thought.

6. When we represent a mathematical line or figure, whether it is only for inward perception, or also for the outer sense, we let ourselves be determined by a thought, without at the moment turning our attention to its development; but that which is represented, nevertheless, contains the expression of all the thoughts which have been elicited during the development. While we represent the straight line, our thought is merely turned to the oneness of the direction. But if, on the contrary, we submit that which is represented to reflection, it is manifest that there is a similarity of each part, even the smallest, with the whole; the capability of an infinite prolongation; simple, unconnected motion; the shortest distance between two points; the fundamental measure for all extension. But it is sufficient to have pointed out the inward variety of the straight line. Since brevity, which must be our law here, will not allow us more than *one* circumstantial explanation of this kind, we will select an object which offers a simple and abundant cause for the development of thought.

7. All know that the circle may be described as a line which is everywhere equally distant from a given point. It is also well known, what a variety of properties have been discovered in this figure by geometry. To whichever part of the circumference we may turn our attention, a perfectly corresponding part may be presented exactly opposite; every line which passes through the centre of the circle divides it into two perfectly equal parts; two diameters divide it into two corresponding portions; nowhere can a line be drawn without the possibility of drawing another in exact correspondence in an opposite position. We farther see that the arch is the measure for the inclination of the radii; that the circumference is infinitely divided, but at every point in a similar manner; and that it incloses a greater surface than any other line. This enumeration, incomplete as it is, will be sufficient to lead our attention to the copious thoughts which are expressed in the circle.

8. Geometry, as is known, proves that these properties are not accidentally collected into the circle, but are the necessary result of its fundamental determination; that the distances of the circumference from the centre must be everywhere equally great. This necessary connection will not, however, be deduced from the fundamental thought without the aid of perception, so that we cannot exactly say that the other thoughts lie in the fundamental thought, but rather that they belong to it. Were we to begin with any one of the properties of the circle, we might from it, though frequently with the greatest difficulty, arrive at all the rest. It is therefore hardly possible to find an expression which would represent a thought of which we could say that all those thoughts were contained in it; but we have a perfect knowledge that the circle, which is apprehended by intuitive perception, constitutes a oneness of thought. When the apprehension of reason appropriates this oneness of thought which is expressed in the perception, we have the idea of the thing. And in general terms we may say, the idea of a thing is the oneness of thought expressed in it, when apprehended by reason, though as a perception. We therefore cannot, of course, possess the idea without preparatory thought, nor without the comprehension of the thought in the perception. The impossibility of expressing the idea by a simple expression, does not prevent our having a clear apprehension; but it requires a higher mental exercise than the apprehension of usual scientific conceptions.

9. Now although we cannot apprehend ideas, as ideas, without the exercise of reason, yet the presence of ideas is felt in perception, which is understood by the common origin of rational and perceptive nature (4). This mode of understanding it is, however, only a general apprehension of the case. We must show *how* it is in what follows.

10. The beautiful, consequently, is the idea expressed in the thing, in proportion as it is exhibited to the perception.

11. The idea is a oneness, containing a rich variety, which is not accidental, but has its being in the peculiar development of the idea. We express the same thing, only in other words, when we call this a self-development, and when we see in it a self-legislation, in which, consequently, freedom and determination are united, therefore character.

12. Symmetry alone, which represents no other thought but symmetry, is sufficient to satisfy the sense of beauty. The figure 3 by no means satisfies the eye, whereas the figure Ƹ3 produces a pleasing impression. One part of the figure is not a mere repetition of the other, but its antitype, as it were; the object, and its reflection. The one half is the same as the other, but in the form of opposites. We here see the same opposition as between the thought of the thinking being and thought viewed as something that is thought. Opposites, and union of opposites. Thus the fundamental form of thought meets our perception in symmetry.*

13. The symmetry we here speak of is of the most simple kind. Besides this first order of symmetry, there are many higher and more involved symmetries. Among these may be reckoned the position of the leaves of many plants. In the leaves which are placed opposite to one another, we see symmetry of the first order; those growing alternately, whose stalks preserve nearly the same perpendicular plane, belong already to a more composite order; the alternations, however, frequently do not occur in the same plane, but the positions of the leaves must have accomplished a circular path before an opposition is completed. We know that the number of the leaves which belong to such circular paths is in many cases very determined, and that it only depends on our want of perfect knowledge if we do not always detect it.

14. In every figure which otherwise expresses an entire thought, the symmetry is subordinate to the whole; or, more correctly speaking, is so interwoven with it that it does not indeed appear as if it were independent, but it does not on that account lose its great signification; it reveals to us the inward harmony of the idea, which itself represents the harmony of reason.

15. It will now be easily understood, that a figure which certainly represents a thought, but with an arbitrary addition, does not satisfy our sense of beauty; the inward harmony is disturbed by it, as, for instance, in the completely inequilateral triangle; on the other hand, another thought which still admits of symmetry, may be inoculated into the fundamental thought, which may be seen, among other instances, in the isosceles triangle.

16. After this glance into the idea of the beautiful, so far as it can be developed by the contemplation of the most simple forms, it will be necessary to return once more to the circle, and to represent its properties in expressions which most nearly point to the idea of the same; in this manner we carry our example as near as it is in our power to that which cannot be expressed. If we first proceed from the centre, we obtain the most perfect representation, on a plane, of an expression of activity tending towards all sides, and checked in no direction. If we pursue a point which passes along the circumference, we see an infinite oneness in an infinite change. If we view the relation between its inward and outward condition, we find that its contents are greater than, with unchanged extent of boundary, could possibly exist in any other form. If we regard the development of the thought, we have an inward symmetry with the most entire absence of all opposites. It appears in such oneness, so defined, with such completeness and inward harmony, that it represents to us a little definite world, an image of the world, so far as this can be given on a plane, and with such simple means; we might say that it is the most elementary image of the world. The ancients justly called it the most perfect of all figures (on a plane surface, of course).

If we compare the circle, as it appears amidst the union of the forces of the world, with the higher developed forms of beauty, then it remains faint; but if, as is requisite, we keep thought apart from all that variety, and permit the circle to dwell in the region of thought which we have separated for the benefit of our first contemplation, our views will find assent.

17. Nature frequently produces the same forms as those which have been framed by our thoughts. In crystals, nature exhibits those forms which are bounded by lines and planes; the circle is displayed in waves; the parabola in the fountain; the hyperbola in Chladni's acoustic figures, and so on. In this manner we again meet, in nature, with what was created by our own thought; what were thoughts within us, are, without us, laws of nature. We become most perfectly convinced of this, by a universal contemplation of the whole of natural science. It is there shown that the laws of nature are the laws of reason, that indeed the whole of nature is the revelation of eternal living reason.†

18. Nature, however, does not confine herself to the production of mere mathematical forms. She adds far more. How this happens, and how this acts, we will consider in some of the instances which appear to us most easy of comprehension.

19. If we throw a stone into still water, and follow with our eye the circle of waves which is produced, the impression at once teaches us that we have not alone to do with mere circles, but that these are exhibited to us in a concentric progress of elevations and depressions. We have not passive but moving forms before us. A closer investigation shows us that the portions move in their own circular path, or in vibrations, so that what meets the eye is the result of innumerable inward movements. The same investigation also shows that all these happen according to universal laws of nature.

20. But to this we must add the co-operation of the rest of nature with those effects which are merely the consequence of the expansion of movements. It is a light, as it were, beaming in from the rest of nature. The brightness in the expanse of water, the variety of light and shadow in the portions of the waves, the play of colour produced by the motion, give a life and completeness to the whole, which was wanting in mathematical figures. This variety, added to the original effect, must not be compared with that with which an object is often arbitrarily adorned. It belongs to the connection of reason peculiar to nature, that there is a higher unity in all these effects which nature thus combines.

The question why all nature is not beautiful obtrudes itself here, but its answer must be postponed to the continuation of the researches.

21. A still greater variety arises from the mutual crossings of the circles of the waves; where elevated circles of waves cross each other, a greater elevation is produced; and where depressed circles meet, a greater depression ensues; but where depression encounters elevation, a balance is perceived. These may often please us by a great variety, when, nevertheless, the arrangement is imperceptible. W. Webber has given an experiment in which a remarkable variety springs from one thought. An elliptical bowl is filled with quicksilver, and a succession of drops of quicksilver are allowed to fall into one of the foci, by which a succession of circular waves are formed. Where these hit the sides, they are repelled in such a manner that each wave-radius, after the repulsion, receives a direction towards the other focus. Thus by the repulsion a new centre is produced in the waves, so that now the surface is filled up with two perfectly similarly constituted systems of waves. By the intersection of these waves new curves are formed, replete with differences, yet with the clear stamp of *one* law. In this variety the unavoidable alteration of light and shadow brings with it a new variety, no less accordant with this law, and bearing the stamp of thought as strongly as the curves. A delineation certainly gives an instructive idea of this variety, but yet the sight of the activity itself is infinitely more beautiful; for the motion, and the consequent flashes of light, cannot be given by any delineation."

In noticing 'The Soul in Nature,' it would be unjust to withhold our full meed of commendation from its translators into English—the Misses Horner. With them it has been a labour of love—a homage to the memory of the philosopher "whose youthful freshness, and his almost childlike external demeanour," left an ineffaceable and grateful impression upon their minds. It was Oersted's "earnest wish that a true representation of his views of Nature should be presented to the English public;" and we doubt if he could have found anywhere a more fitting channel for the conveyance of his views than the translation by the Misses Horner.

The Theory, Formation, and Construction of British and Foreign Harbours. By Sir John Rennie, C.E. London: Weale.

The important national work of Sir John Rennie continues its satisfactory progress towards completion, and gives assurance that it will be one of the most valuable productions on this subject, and a permanent standard of reference by professional men. This is one of that class of works which gives dignity and ornament to the professional library, and which is an indispensable and constant guide in studying important designs. It is something to enlist the practical experience of a man like Sir John Rennie, who has himself done so much in hydraulic engineering; but after all, it would more properly be said that this work brings before us the practical experience of all the great men who have distinguished themselves by promoting this branch of their art. The numbers now before us, which continue the detail of Ramsgate Harbour, may be considered as much the authorship of Smeaton and of the elder Rennie as of Sir John; and it is a very valuable circumstance in a volume of

* We can produce many symmetrical figures of different kinds, by doubling a piece of paper, and describing some arbitrary strokes along the folded line; for instance, a name, which we prick on the paper with a needle, without unfolding it. If we afterwards unfold it, we see, within, a symmetrical figure on both sides of the fold. The impression is somewhat disturbed by the circumstance that the little holes have elevated borders on one side; but the inequality is easily removed by a very sharp knife. On that side where the folded lines are elevated, we see the same thing, but the strokes of the pen have here a disturbing influence.

† I have endeavoured to represent this in my introduction to 'Natural Philosophy' (Copenhagen, 1811), of which there is an improved translation in Schweigger's Journal for 1822, vol 36, p. 458. One of the chief points in proof of the above is, that we are able, by thought, to deduce from known laws of nature, others which are actually again found by experience; and that if this does not occur, we generally discover in what manner we have drawn a false conclusion. Hence we perceive that the same laws of thought, by which we have made our conclusions, also prevail in nature.

this nature that it is based upon the reports emanating from the great men who have had the direction of the works. In many cases we are left to conjecture, or to judge from naked results; and we do not ascertain the reasons on which particular operations were based, the difficulties which had to be encountered, or the means which overcame them. Not so with these harbour works, for we have laid before us the best and most authentic evidence, and thereby the volume acquires a peculiarly practical character, not necessarily to be found even in professional publications. We have been none the less impressed with this view in perusing the letter-press and examining the plates of the numbers now before us; and we are happy to add our testimony to that which is, we presume, the common opinion of most of our readers, who are, no doubt, subscribers to the work.

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1. *Comptes et Dépenses de la Construction du Chateau de Gaillon, publiés d'après les registres manuscrits des Trésories du Cardinal d'Amboise.* Par A. Deville. Paris. 1850. 4to. pp. 559.
2. *Auszüge aus den Baurechnungen der St. Victorskirche zu Xanten.* Von Dr. A. C. Scholten. Berlin: Gropius. 1852. 8vo. pp. 95.

The intense interest which the mediæval buildings have excited of late, has also started the momentous question, *how it came* that such huge edifices have sprung up, forest-like, over the whole of civilised Europe—edifices, whose number, extent, colossal proportions, technical execution and rich ornamentation, surpass anything we can produce now-a-days? It is marvellous to think what had been built, sculptured, and painted, from the twelfth to the sixteenth centuries, within the vast limits of European civilisation; so much so, that present time is not even capable of effecting its proper conservation or renovation. If we add to this forest of cathedrals, the other ecclesiastic buildings, huge convents, palaces of princes, and halls of the people, a host of castles (*Ritter-Burgen*), crowning almost every fine site in Europe; if we consider how complete and artistic most of the structures are; and if we take into account, on the other hand, how far inferior mechanical contrivances and means were then, compared with those of the present time: we must needs arrive at the conclusion, that there then existed applications of human power on a large scale, now superseded by the achievements of machinery.

These questions have been partially answered in the above works, which relate to the *accounts* of the construction of the Château of Gaillon, and the St. Victor's Church of Xanten on the Rhine. Such ancient documents clear up not only architecture and art, but also the whole social life of a period. The Comité Historique des Arts et Monuments, at Paris, has published at different periods several bulletins very rich in this respect, and the work of M. Deville, in particular, is issued with great typographical taste.

In Germany, the work of Dr. Scholten is the first of the kind, and it contains copious extracts from the archives of the Church of Xanten, comprising the building-accounts from the year 1356 down to 1555, mostly in Latin. The work exhibits a moving panorama, as it were, of the progress of this splendid building during a period of two centuries; and we can follow with our mind all the greater or lesser accidents which now fostered, now impeded, the undertaking. We may follow here the blocks of stone from their native place near the Drachenfels, where the lord of the castle levied a tax on each corner-stone (*Oirsteen*); others, we perceive, were quarried on the Laachen-See, or in the mountains of the Ruhr.

A whole series of masters of the different arts and trades are here mentioned, amongst whom several masons (*magister lapicida, archi-lapicida*) from Cologne, of whom the last, Johannes Langenberg (1522), saw the Xanten Church brought to its completion. The annual stipend of this master consisted of eighteen gold guilders and one coat, besides which he had in summer six, in winter four, stivers wages. Dr. Scholten makes some lengthened observations in alluding to the daring and confidence of the men of that period, who, with the most trifling means, ventured on such gigantic undertakings. It is certainly curious to see how scanty and precarious were the resources for carrying on these buildings. Estimates they made none, because, if they had done so, and compared them with their capital at command, not one of these many structures of the middle ages would even now be completed. They went on building and constructing with such means as they could best muster at any time, and in many cases bequeathed to posterity the duty of completing their works. Thus, generation after generation gave its mite, and each and every one helped according to his means. One presents the workmaster with a bed, a coat, or some wheat; some journeymen contributed the stakes of a game of skittles (*de ludi Kegelorum*); and what is curious, even the poorest did not exclude themselves—"*de quadam paupercula* xiiij den." In fact, the workmen themselves refunded with one hand part of that which they had just received with the other. It has hitherto also been thought that much of the labour at these mediæval structures was gratuitous. Of this we find no trace in the erection of the Xanten Church; on the contrary, even the most trifling aid seems to have been requited—as, for instance, by refreshments given to the schoolboys for carrying slate out of a ship moored in the Beck river. Other gratifications also (*pro bibialibus*), as well as garments, were given at other times. As in these ages there were neither committees nor other official surveyors, &c., the good people of Xanten resorted to the expedient of calling a noted master mason from Cologne, to inspect the works. ("*Item*, dictus magister Gerardus binies descendit de Colonia......ad visitandum opus et regendum, iij flor. curr. etc.") At another time a master from Wesel was called, who received one florin for his trouble. It need scarcely be observed that such notes, if compared with those of other countries at the same periods, would afford interesting data for statistics of art and social life. But a confusion in the currency obstructs, to a very great extent, any investigation; and even in the Xanten records, several sorts of coin are to be met with. The accounts, as we have stated, were kept mostly in Latin, but there occur, likewise, a number of German technical expressions, many of them now obsolete, but interesting to the archæologist.

A Treatise on the Slide-Rule; with description of Lalanne's Glass Slide-Rule. By Rev. W. Elliott, M.A. London: Elliott and Sons, Strand. 1852.

This pamphlet is intended to give a more complete account of the general theory of the slide-rule, and a full explanation of the *glass sliding-rule* invented by M. Leon Lalanne, and manufactured by Elliott and Sons; with rules and examples to its practical application. The rule contains a vast number of scales, and a great many "constant multipliers" or gauge-points," which will greatly facilitate calculations when a knowledge of the use of this little instrument has once been thoroughly obtained.

The Machinery of the Nineteenth Century. Parts III. and IV. By G. D. Dempsey, C.E. London: Atchley and Co. 1852.

The four parts which are now in our hands give us the opportunity of ascertaining the extent to which Mr. Dempsey has redeemed his promise of giving a comprehensive view of modern machinery. These parts include four steam-engines of various size and construction, a marine-engine, a locomotive-engine, a double-wheel lathe, a forge, a radial drilling-machine, a blast-engine, a tubular crane, a sash-bar machine, a brick and tile machine, a paper-cutting machine, two printing machines, a draining plough, a haymaking-machine, and well-boring tools.

This enumeration shows sufficient variety, and when it is considered the plates are of large size and full of details, the utility of the work to the mechanical engineer can be sufficiently estimated.

Reynolds' Travelling Map of England, with all the Railways and Stations accurately laid down. Constructed from the Surveys of the Board of Ordnance, Railway Companies, and other Authorities. London: Simpkin, Marshall, & Co., and J. Reynolds. 1852.

In this age of almost universal locomotion, any help to solve the mysteries of Bradshaw will prove acceptable to the traveller who, *profugus fato*, is obliged to wander north, east, south, and west, upon devious railroads, before he can reach the place of destination. It was therefore, we conceive, a happy idea of the projectors of the 'Travelling Atlas,' to publish, in a convenient form for the pocket, a companion to those blind railway guides which the public have hitherto had recourse to only. The new Railway Map of England is divided into thirty-one portions, bound up together, and preceded by a general key map of the kingdom. In this form it is much superior for facility of reference to those broadsides which Guide bookmakers will persist in adopting. It has also another peculiar advantage: the stations on all the lines are indicated by marks which render the general appearance clear and simple.

The maps are drawn and engraved by Mr. Einslie in a very creditable manner,—distinct and bold. Not only are the railways constructed and in course of construction, and the main roads, easily discernible, but also the cross roads, county boundaries, post and market towns.

EXPANSIVE ACTION OF STEAM.

At page 117 of Mr. Clark's interesting and useful work on 'Railway Machinery,' appears a table comparing the actual relative efficiency of steam working expansively in locomotive engines, with the possible maximum relative efficiency supposing the back pressure and the clearance to be nothing, the latter quantity being calculated on the assumption that the steam expands according to Boyle's law—that is, that during the expansion the pressure varies inversely as the volume; and from this table it would appear that the actual relative efficiency of steam in locomotive engines, at high rates of expansion, falls very far short of the possible maximum.

Now this table exhibits the practical working of the locomotive in too unfavourable a light, as compared with a theoretically perfect engine; for it is known, that neither steam nor any other gaseous substance can expand according to Boyle's law, unless it be supplied during the expansion with a sufficient quantity of heat to maintain it at its original temperature. Should the steam or other gaseous body receive no supply of heat from without during its expansion, which is nearly the case when the expansion is rapid, a portion of its heat will disappear, bearing a certain known proportion to the work done by the expansion; and the pressure will diminish more rapidly than the density, according to a law which is approximately known. On these principles, I calculated a table which appeared in the 'Transactions of the Royal Society of Edinburgh,' Vol. XX. Part I., and from which I have extracted the values of the possible maximum relative efficiency corresponding to the rates of expansion in Mr. Clark's table.

The following table—in which the first column gives the period of admission in fractions of the stroke; the second, the actual relative efficiency of a given weight of steam, as calculated by Mr. Clark; the third, the true maximum possible efficiency, with no back pressure or clearance; and the fourth, the erroneous value of that quantity computed by Boyle's law,—shows that the actual efficiency of steam worked expansively in locomotives does not fall so far short of its maximum and theoretical amount as the assumption of Boyle's law of expansion would make it appear.

Period of Admission, in Fractions of Stroke.	Actual Relative Efficiency of Steam.	Maximum possible Relative Efficiency, computed by	
		The actual law of Expansion.	Boyle's law.
0·10	2·22	2·91	3·30
0·125	2·15	2·76	3·08
0·15	2·08	2·63	2·90
0·175	2·02	2·51	2·73
0·20	1·96	2·41	2·60
0·25	1·85	2·24	2·39
0·30	1·75	2·09	2·20
0·35	1·66	1·96	2·05
0·40	1·58	1·85	1·92
0·45	1·50	1·75	1·80
0·50	1·44	1·65	1·69
0·55	1·38	1·57	1·60
0·60	1·32	1·49	1·51
0·65	1·27	1·42	1·43
0·70	1·23	1·35	1·35
0·75	1·18	1·28	1·28
1·00	1·00	1·00	1·00

W. J. Macquorn Rankine.

59, *New Vincent-street, Glasgow,*
May 22nd, 1852.

AN ACCOUNT OF THE BILBERRY RESERVOIR, HOLMFIRTH, YORKSHIRE.

By James Leslie, C.E.

[*Paper read at the Royal Scottish Society of Arts, April 26th.*]

It appears from the report of Captain Moodie, R.E., who, on the part of government, made the necessary inquiries into the cause of the bursting of this reservoir, and from the other evidence before the coroner's inquest, that the embankment was originally 96 feet in height above the centre of the valley, 340 feet in length, 16 feet broad at the top, with an inner slope of 3 to 1, and outer slope of 2 to 1, having a puddle wall in the centre 16 feet thick at bottom, and 8 feet at top, and founded 9 feet below the natural surface, with an outlet sluice 67 feet below the top of the embankment, and placed at this level to supply Bilberry Mills, thus leaving about 25 feet of dead water in the reservoir. Embankments having such slopes and dimensions ought, if well constructed, and subject to no unfair play, to be beyond doubt secure. The valley in which the reservoir stood consists of beds of millstone grit alternating with shale, and seems to be of a very pervious nature. There was a considerable spring under the puddle which had never been stopped or carried past, and on that account the puddle was not well put in, being more slush than puddle; there were also several leaks in the bottom, and when the water rose above 44 feet there was a very heavy one, as thick as a man's arm. The escape of water by these leaks was sufficient for the supply of the mills, and it was found unnecessary to draw the sluices after the water had attained the height of 30 feet in the reservoir. A circular shaft, 12 feet diameter, called a waste-pit, placed in the inner face of the embankment, and about 60 feet from the top, brought up from the solid ground, with a tunnel leading from it through the embankment, was intended to carry off the waste water. A shuttle, or sluice was likewise placed at the bottom of the shaft, with an open cut leading into it, for the ordinary discharge. This shaft, which is similar to the waste-pipe of a common cistern, although it affords 37½ feet of waste-weir, is not much to be admired. Its area is reduced and divided into two by a gangway across it for access to the sluice, and it is thus liable to be stopped up by trees, &c. being floated on to the top of it. Besides, the fall of a body of water from a height of 59 feet, might damage the bottom of the shaft and sluice. It does not appear, however, that this waste-pit ever had been of any use, owing to the embankment having sunk 10 feet in the centre shortly after its completion, or 2 feet below the level of the waste-pit, thus rendering it quite inoperative.

Mr. Leslie attributes the cause of bursting to the water in the reservoir overtopping the embankment, and then running down the back slope in a great and constantly augmenting volume, carrying everything before it, when at length the puddle was left exposed, and eventually gave way. This supposition is borne out by the fact that the south end of the embankment—a portion of which is very much sunk—and where there were two large leaks, and the north end, where there was one leak, have both stood perfectly sound. The reservoir, as stated by Captain Moodie, had a drainage area of 1920 acres, and that he computes might yield, in the heavy fall of rain which occurred immediately before the bursting of the embankment, 500 cubic feet a second. This is a large quantity, and may be correct; but Mr. Leslie never knew of more than half that amount run off a similar extent of surface in the same time in the neighbourhood of Edinburgh. The reservoir has been variously stated to cover from 7 to 11 acres, and to contain from 10,000,000 to 11,000,000 cubic feet, so that, even had it been empty, it would not contain more than six hours of such a flood as that spoken of.

The bursting of the reservoir has caused great fears of reservoir embankments in general, but it ought rather to give increased confidence in their stability, if properly constructed, and having sufficiently extensive waste-weirs, so as to make sure that the water shall never rise to a height at all approaching to the top. The embankment which was leaky had slipped, and was not by any means in good repute, yet had stood much more than it had been calculated ever to do by its originators, in having been twice actually overtopped before it gave way.

MODELS OF SHIPS AND BOATS IN THE GREAT EXHIBITION.

By Rev. C. G. Nicolay, Librarian to King's College.

[*Abstract of a Paper read at the Society of Arts, April 29th.*]

Mr. Nicolay's chief object in this "attempt to combine the peculiar characteristics of the most remarkable models of vessels in the Great Exhibition," was to advocate the importance of laying down the lines of vessels on scientific principles, and therefore with safe results, instead of on the empiric and uncertain method at present almost universally pursued. On this point he observes, "no one can have spent hours, not to say days, in our shipbuilders' yards, in our docks and watering-places, or about our harbours, without having been struck with the variety of conformations in the vessels which were around him; a little further inquiry would have satisfied him that not only every nation and every country, but every principal port of our own—might he not say, every builder of eminence—is distinguished by some peculiarity; and that these peculiarities are not the result of abstract principles rigidly adhered to, but of some inference from experience it would not perhaps be difficult to show." This he illustrated by a description of the method pursued by the American shipbuilders, who design their vessels from small models which are cut and carved until they accord with the notion of the builders; the model, made up of thin layers or strata, is then taken to pieces and the lines can be laid down on paper to a scale. These models are carefully preserved by the owners and builders, and are from time to time, as experience suggests, improved upon and modified. The spars are proportioned according to no rule of universal acceptance.

Mr. Nicolay's proposition was still further illustrated by a reference to the extraordinary diversity of opinion that had prevailed as to the causes of the success of the American Yacht, and to the curious results that had followed from that success, "so that a yacht at that time building by a leading firm, had, apparently without reference to her other lines, her bows altered to those of the *America;* or that when an experimental vessel did not quite answer, she was cut and lengthened, in either case altering completely the character and relation of the various curves forming the vessel's mould—a process most strongly commemorative of an amusement popular in our boyhood, and possibly, even yet, in which bizarre forms were formed by putting the nose of one face to the eyes of a second and the chin of a third."

Proceeding to the more immediate subject of his paper, Mr. Nicolay divided the models of the Great Exhibition into three classes:—1, those of the Indian seas; 2, the yacht models; 3, merchant and fishing vessels. Excluding those belonging to the navy and those of boats, "a great similarity is observable among those of the first class, constructed for swiftness."* Models of the Batille, the Cutch Categat, a pirate Prahu, a Bombay dinghee, and the Sincapore Sampan were shown as examples of this class. As illustrating the yachts, models were shown of the *Nancy Dawson*, the *Avenger*, the *Volante*, and the *Cynthia*, but with regard to their merits a prudent silence was observed. In the third class remarkable models were noticed by Sanderson, and Saunders, a Zetland fishing-boat, and a lugger by Twyman of Ramsgate.

"The deduction from a close examination of the foregoing is that the peculiar characteristics of the eastern models is, breadth; of our yachts, depth; of our steamers, length; and that all want capacity. In our best models, wherever they are to be found, the wave-line predominates; the points to be obtained are the combination of capacity and speed; and the success of our northern builders in their endeavours after this, have lately been so great as to ratify the conclusion that we have yet much to learn." With regard to the sails, Mr. Nicolay spoke as follows:—"That the relation of the sails of a vessel to the wind has not been properly understood in this country, has been satisfactorily shown in the case of the *America* yacht, in which two things were in this respect remarkable: 1, that her sails were so spread that the passage of the wind over their surfaces when on a wind, was in a direction opposite to her course at a slight angle with the deck—*i. e.*, rising towards the stern; and 2, that when going free, from the rake of her masts, and specially the size and position of her fore stay-sail, if it is so to be termed, all her sails were lifting sails, and thus the forward position of her foremast, which would otherwise be fatal to so fine a built vessel, was compensated for."

Mr. Nicolay then detailed the result of his own attempt to combine the characteristics of the three divisions into which he had classified the models of the Exhibition—namely, to take "from the eastern models their breadth of beam; from our own yachts their depth in the water; from both their hollow floor and clean entrance; from the schooner alluded to, the Margate boat, and the Batille a principal breadth, if not abaft, at least amidships; from the eastern models the triangular form of the sails, affording a sharp entry to the wind, spreading well to the stern, and to obtain easy motion every way to reduce the number of curves on which the model was formed to the lowest possible limit—viz., two." These were shown in a diagram on a large scale giving longitudinal and cross sections of the vessel designed by Mr. Nicolay, as also a working model which had shown remarkably good qualities, having in fact fulfilled every thing that he had hoped from her.

* This is evidenced by breadth of beam, lightness of draught, hollowness of floor and of entry combined with great sharpness of prow: beyond this the triangular cut of the sails forms the most marked feature.

THE MUSICAL INSTRUMENTS IN THE GREAT EXHIBITION.

By Rev. W. W. Cazalet, Superintendent of the Royal Academy of Music.

[*Abstract of a Paper read at the Society of Arts, May 6th.*]

Mr. Cazalet introduced the first part of his subject by a history of the Organ, as far as it may be gathered from the writings of the later Roman, and the mediæval authors. The first mention of an organ in England is in the tenth century. This instrument was, however, of a clumsy description; although it had only 400 pipes, it required twenty-six bellows, which were worked by 76 men; the keys were 6 inches broad, and the touch so hard that the performer was obliged to use his fists. Separate keyboards appear to have been introduced in the thirteenth century; while the pedals, the great characteristic of this instrument, were invented by a German named Bernhard in 1470. Reed stops first appear in the account, in 1596, of an organ at Breslau, and the instrument was brought into the state in which it is now commonly known by the invention of the swell in the early part of the last century, by an Englishman named Craig.

In the organs of the Exhibition the chief novelties were some new stops and mechanical methods of overcoming the pressure of the wind in instruments of large size.

Messrs. Gray and Davison received a Council Medal for a new method of coupling, and for a stop between a flute stop and a reed, called the keraulophon.

Besides their Tuba mirabilis stop, Messrs. Hill introduced a mode of shifting the stops by means of keys, and a new valve for lightening the touch, as well as a method of conveying the air through the main framing of the instrument.

Mr. Willis, while adopting the pneumatic lever of Barker and of Ducroquet, has further improved on it by the invention of an exhausting valve, and by other modifications, by which means the touch of the organ, whatever its size, may be made almost as delicate as that of the pianoforte.

Certain novelties in a small organ in the Florentine department, by Messrs. Ducci, were spoken of as likely to lead to great improvements and modifications in the instrument. These are the production of a complete chromatic scale from one pipe, and a method of making a stop pipe produce the sound of one four times its length.

The pianoforte, the successor of the harpischord, appears to have been invented about the beginning of the eighteenth century, and to have been introduced into England shortly after.

In speaking of the finger wind instruments, Mr. Cazalet gave at some length a highly interesting account of the early flute, and of the difficulties in its construction which caused it to be an instrument almost under ban. That it is so no longer is due to the perseverance and talent of M. Boehm of Munich, who, by the application of acoustical science to the form of the flute, and the position and shapes of the holes, has produced an instrument in which, says Mr. Cazalet, "perfect equality of tone is for the first time combined with correct intonation."

We are so accustomed to think of music as a fine art only, as to neglect the very important relations which it bears to commerce and manufactures. To call attention to these relations was Mr. Casalet's object in the second division of his paper, and the following are some of the interesting statistics which his researches have enabled him to present:—

The organ builders of England may be taken at 400 in number, and putting their gross returns at 500*l.* per annum each, we have 200,000*l.* a-year in this branch alone. The materials used by them are pine, mahogany, tin, and lead.

The materials employed by the pianoforte-maker are oak, deal, pine, mahogany, and beech, besides fancy woods; baize, felt, cloth, and leather, brass, steel, and iron. Of the two leading houses in this branch, the Messrs. Collard sell annually 1600 instruments, and the Messrs. Broadwood 2300; which, at the very low average of 60 guineas, gives as the annual business of these two firms only, about 250,000*l.* If the whole number of pianoforte-makers of London, about 200, is taken into account, the annual return in this trade cannot be less than 1,000,000*l.* Violins, and instruments of that class are almost entirely imported, the prejudice being in favour of the foreign makers. The annual import duty on them is probably not less than 45,000*l.*

The cost of the wind instruments required for a regimental band, exclusive of drums and fifes, was said to be 244*l.*; and as there are in all about 400 regiments, the capital represented by these is nearly 100,000*l.*

The number of workmen employed by Messrs. Broadwood ond Messrs. Collard respectively, is 575 and 400; these are all more or less skilled workmen, some of them to a very high degree. It is probable that the wages of the artisans employed in this trade do not amount to less than 500,000*l.* per annum.

REGISTER OF NEW PATENTS.

PERMANENT WAY OF RAILWAYS.

C. De Bergue, of Arthur-street, West, engineer, for *improvements in, and in the construction of, the permanent way of railways.*—Patent dated February 7, 1851. [Reported in *Newton's London Journal.*]

This invention consists, firstly, in a mode or modes of constructing iron longitudinal bearers or sleepers, for more effectually supporting the rails of permanent ways. For this purpose, the longitudinal bearers are constructed according to the principles that commonly govern the construction of iron girders (in order to obtain as much strength as is practicable, without unnecessarily increasing the quantity of metal), by so disposing the metal, or disposing and combining the metals of which they are composed as best to resist the strains to which they are subjected, by reason of the inequalities of the ground or ballast—being chiefly tension at the lower portion or base, and compression at the upper portion. In accordance with this object, the bearers are made of such forms that the bases or bottoms shall be considerably stronger or (if wholly of cast-iron) have a greater transverse sectional area than the upper portions; in every case, the upper parts being made of suitable forms to receive and support the descriptions of rails to be placed upon them.

Secondly, the invention consists in the employment, with longitudinal bearers or sleepers, of transverse iron ties or bearers, in cross-section presenting an appearance like the letter T inverted—thus ⊥; so that the ends of any longitudinal bearers or sleepers, having flat bottoms, may rest upon the tie, which will assist in keeping the longitudinal sleepers steady, and prevent them from canting.

Thirdly, this invention consists in certain forms of rails—namely, an angular rail, made so as to fit against one side and on the top of the longitudinal bearers or sleepers constructed according to the first part of the invention; and also a saddle-rail, so formed that the interior or underside of the tread or working surface of the rail shall rest upon the upper part of a longitudinal bearer or sleeper, the sides or flaps of the rail being bent, either to a right angle with the bearing surface of the rail, or to such other angle as may be requisite to make the rail fit upon and be held more securely by the top of the bearer or sleeper on which it is placed; or, for this purpose, instead of bending each of the sides or flaps to the same angle, one side may be bent to one angle, and the other side to another or different angle.

Fig. 1 exhibits a transverse section of the angular rail *a*, supported by the longitudinal bearer or sleeper *b*, to which it is connected by screw-bolts *c*, and nuts *d*. Fig. 2 is a transverse section of one form of saddle-rail, secured upon a longitudinal sleeper *b*, by screw-bolts and nuts. Figs. 3 and 4 exhibit transverse sections of a saddle-rail of another shape, one side of which is formed suitably for fitting close to the inclined side of the sleeper; and, in the other side of the rail, at suitable intervals, are inserted set-screws *e*, the points of which bear against the opposite side of the sleeper. The sleepers shown at figs. 1, and 2, which are wholly of cast-iron, consist of a single vertical web, terminating in a horizontal base-plate, and strengthened laterally by ribs *f*, *g*. The sleeper at fig. 3 is also made entirely of cast-iron, and is composed of two inclined webs b^1, united together at the top, and terminating at the bottom in a horizontal base-plate. The sleeper represented in fig. 4, resembles, in transverse section, the letter Y, inverted; it is made of cast-iron, and is connected at the bottom by bolts or rivets to a plate *h*, of wrought-iron; and it is strengthened laterally by ribs *f*, *g*. If preferred, the sleeper shown at fig. 3, may be cast without the horizontal portion between the joints *i*, *j*, and bolted or riveted to a plate of wrought-iron, like the sleeper at fig. 4. The transverse sectional form of the sleepers may be either as represented at figs. 1, 2, 3, and 4, or any other form which may be deemed best for the purpose, provided that they are constructed upon the principle before-mentioned—*i. e.*, with the base stronger than the upper part.

Fig. 2. Fig. 1.

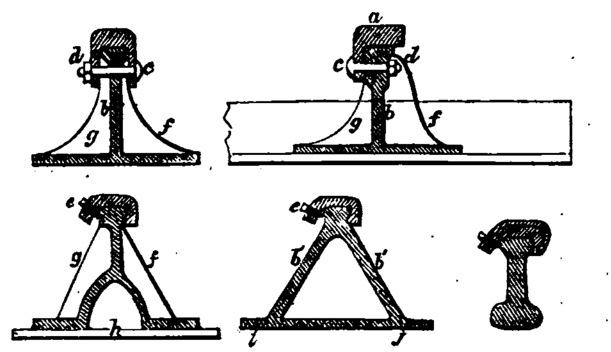


Fig. 4. Fig. 3. Fig. 5.

The improved transverse tie or bearer is shown in side view at fig. 1, with a longitudinal sleeper resting upon it. In shape, transversely, it resembles an inverted T, and is either made of wrought-iron by rolling, or else the ordinary T-iron is used for the purpose. In laying down the longitudinal bearers or sleepers, their ends are so placed as to rest upon the horizontal flanges of the transverse tie, and they are bolted together, provision being made for expansion and contraction by an enlargement in the proper direction of the holes through which the bolts pass.

The side and top of a longitudinal bearer, against which an angular rail fits, should be planed true to receive it; and so, likewise, the upper surface of the webs, on which the saddle-rails rest, should be planed, or otherwise made sufficiently true, to receive them; or a strip of lead or other metal, or other suitable material, may be introduced between the web and the rail. The rails shown at figs. 1, and 2, are firmly connected to their bearers by bolts, which may be either square or round; but, in either case, the holes in which they are inserted should be a trifle wider than the bolts, in order to allow for expansion and contraction. Fig. 5 exhibits a saddle-rail applied to a wrought-iron bearer made from an old worn-out rail of the ordinary shape. The original form of the upper portion of the old rail is as represented by the dotted lines; and, when considerably worn away, it is converted into a bearer for the saddle-rail, by planing or cutting, or rolling and planing or cutting, to the form shown by the full lines.

In laying down the improved permanent way, the longitudinal bearers and rails are so disposed, relatively to each other, that the junction of any two lengths of the latter may be midway, or at some intermediate distance, between the junctions of the former. If ordinary transverse wooden sleepers are preferred to be used instead of the transverse ties above described, the ends of the longitudinal bearers may be made to abut, either square or obliquely, against each other: the latter method will tend to prevent the transverse sleepers from rocking. In either case, the ends of the longitudinal bearers or sleepers are connected to the transverse sleepers by bolts, with a washer above, and a triangular nut below, as practised on the Great Western Railway.

RAILWAY ENGINES, CARRIAGES, AND MACHINERY.

J. Beattie, of Lawn-place, South Lambeth, engineer, for *improvements in the construction of railways, in locomotive-engines and other carriages to be used thereon, and in the machinery by which some of the improvements are effected.*—Patent dated October 22, 1851.

Claims.—1. A compound longitudinal bearer, and compound and other rails.

2. The construction of rails in parts, and the arrangements of these parts in various modes specified.

3. A rail formed of three or more elementary parts.

4. An improved construction of chair.

5. A peculiar combination of longitudinal bearings with ordinary rails.

6. A mode of constructing and applying points and switches.

7. The application and use of friction driving-wheels in locomotive-engines. [The object of these wheels is to increase the speed of the locomotive: a fly-wheel being placed upon the axle of the first wheel, which turning an additional wheel in the same manner as two friction-wheels, the desired end is attained. The benefit to be derived from this improvement, in addition to the above, is a saving in the wear and tear of the engine.]

8. Certain additions to engines for promoting combustion. [An opening under the funnel of the engine is provided, and which runs through the length of the engine, communicating with a bell-shaped cavity under the fire-box, and through which the air passes.]

9. An apparatus for receiving and condensing part of the exhaust steam, and for catching sparks.

10. An apparatus for intercepting and condensing steam from the exhaust-pipes.

11. The application of certain pneumatic apparatus to locomotive-engines.

12. The use of additional fire-boxes. [Two fire-boxes, one on each side of the ordinary fire-box, are connected by a pipe passing through the boiler.]

13. An apparatus for admitting air to the fire-box and ash-pan.

14. An improved piston. [Round the piston a leather packing is placed, and round which packing rings of india-rubber, or other suitable material, are coiled; and these, again, are bound with a flexible band of steel.]

15. An improved slide-valve. [This improvement consists of a combination of steel and fibrous matter, the object of which is to regulate the pressure upon the slide-valve.]

16. A mode of constructing axles or journals.

17. An apparatus for lubricating the journals of axles.

18. Several improvements in wheels. [The principle directing these improvements is that of the combination of several pieces of metal welded together.]

19. A mode of uniting and coupling carriages. [This is effected by means of a box being placed over the buffers of the respective carriages, and which prevents their separation on the breaking of the coupling-chains.]

20. An improved manufacture of wheel tyres. [This consists in two or more bands of metal placed concentrically, and, after being subjected to a white heat, welded together by means of steam-hammers.]

21. An improved arrangement of steam-hammers. [This consists in their being made to work either horizontally or vertically, and in the blow being directed upon a circular table, capable of being moved by means of a lever.]

22. An arrangement of sawing-machinery.

ORNAMENTAL SURFACES.

W. A. Biddell, of St. John's-square, founder, and T. Green, of Trafalgar-square, for *certain improvements in moulding, casting, ornamenting, and finishing surfaces.*—Patent dated October 29, 1851.

These improvements consist in coating, or covering, or overlaying, the surface or part of the surface of a metal frame or skeleton with glass, porcelain, earthenware, or metal, in order to produce a veined appearance, and in finishing the same by enamelling, or enamelling and glazing, so as to produce an ornamental surface thereto.

Claim.—The several combinations of processes for moulding, casting, ornamenting, and finishing articles and surfaces.

The illustrations given by the patentees of their invention are as follows:—They recommend that on a metal plate, perforated with holes, should be laid a covering of porcelain, clay, or glass (either plain or coloured), when in a plastic state. The material employed always cracking when drying, the interstices should be filled up with coloured clay. This should be placed in a kiln to biscuit, and when taken out should be glazed and left to dry (the edges of the metal having been previously scraped smooth). When dry it should be again inserted in the kiln and fused. The appearance of the plate on removal from the kiln will be that of earthenware or porcelain inlaid with metal. The patentees recommend, that in order to unite the materials, a mixture of 8 parts of calcined flints, 6 parts of borax, 10 parts of calcined lead, and 4 parts of calcined glass, should be employed These, combined by means of gum and turpentine, may be laid on with a brush, or the material employed in the invention may be immersed therein.

The method employed in the manufacture of tiles for floors and other ornaments is as follows:—The porcelain or glass being heated, is rolled out to the required thickness; and it may be stamped with the letters or ornaments required, by means of dockers prepared suitably for the purpose, and which may be either plain or representing designs, with their surfaces either raised or lowered. The interstices being filled up with coloured clay, the whole is placed upon a wire-gauze or net, or metal plate, which is then backed up by inferior clay. The mass is then placed in the kiln to biscuit, and on its removal is glazed. A very superior effect may be produced by gilding or colouring the several materials. When glass is employed it should always be in a soft or heated state.

This invention may be applied in the manufacture of shop fronts, gates, railings, and statues, the last of which objects may be made of the natural colour, with glass eyes, to carry out the idea.

Ornamental bricks may be made by laying ornaments made from glass or porcelain on the surface of a brick, and then filling the interstices of the surface with clay of a different colour from that employed in the ornamentation. Wrought-iron may be coated with cast-iron, or cast-iron may be coated with brass, and these objects may be thus attained. In the former case the metal must be heated to a white heat, and then placed in a solution of bismuth, antimony, and muriatic acid, after which it is turned into the mould, such mould being in a heated state. In the latter instance the surface of the metal to be coated is to be inserted in dilute acid, and then immersed while in a white heat in a solution of tin, bismuth, and acid, after which the coating metal is poured on. This method may be applied to the manufacture of cannon.

PUNCHING AND RIVETING MACHINERY.

M. Scott, of John-street, Adelphi, civil engineer, for *improvements in punching, riveting, bending, and shearing metals, and in building and constructing ships and vessels.*—Patent dated October 30, 1851.

Claims.—1. Certain improvements in machinery for punching, riveting, bending, and shearing metals; 2. A method of constructing ships or vessels with two spaces of metals distant from each other; 3. A mode of fixing wood sheathing to iron ships or vessels; 4. A mode of connecting plates in building boats, ships, and other articles; 5. A mode of constructing masts for ships and vessels; 6. A mode of constructing ships and vessels to carry cargo in bulk, such as coals.

The specification, in the first place, relates to a machine on the principle of the hydrostatic press, employed for the purpose of punching metals. This machine is furnished with a spring, to which the punch is attached, and which serves to restore it to its original position after a stroke has been made, and at the same time to force out the water employed in producing the stroke. For the purpose of carrying off waste water a slide is employed, pierced through its width to allow the rush of water, by which the stroke is accelerated, towards the die; and also pierced throughout its length, and curved at the end, in order to meet the passage from the cylinder. To prevent the slide being forced out of its place, which would be the case if worked by hand, the waste water is employed, and for this purpose the slide is furnished with a packing band in two places, which is forced to act as a piston by the water alternately entering and leaving the intermediate spaces, and which it is made to do by means of two pipes regulated by a stop-cock. This machine may be applied in riveting and shearing metals, by furnishing it with appropriate instruments. The pressure employed should always be 1000 lb. to the square inch. The specification also contains an arrangement for increasing the effect produced by a moderate fall of water. This is accomplished by placing an upright pillar or tank of water, and connecting with it a cylinder or cylinders by means of a pipe. The water flowing from the tank into the cylinders causes their pistons (which are all connected by one shaft) to act simultaneously, the power from which is transferred to a ram working in another cylinder, which cylinder is filled with water, by which means a pressure is acquired that may be applied in the working of machinery above described. Also a method of bending and corrugating iron and other metals into any required shape. A metal plate is provided, which is placed upon a die in a cylinder upon a metal floor, and a mould of the required form, pierced occasionally with small holes to allow of the escape of the air, is placed over this, and the whole is bound together with strong bolts. The water is then pumped in from below, which forces the metal into the desired shape.

Second.—A mode of constructing ships or vessels with two thicknesses of metal at a distance from each other. Two sheets of metal, the one straight, the other bent, are fastened together by means of bolts; they are then pressed into the required shape. To preserve the metal from oxidation and consequent loss owing to the damage of so large a space, it should be saturated with bitumen, and the immediate spaces filled with cocoa-nut fibre steeped in bitumen, to render it water-tight.

Third.—The fixing wood sheathing to iron ships or vessels. When the ship is composed of two sheets of metal, a hollow rivet is employed as a connection. The sheathing is then attached by means of bolts or nails driven into a plug of wood inserted in the hollow of the rivet. The same method of sheathing is employed when the sides of the vessels are single, but, instead of hollow rivets, tubes are inserted, and plugs of wood driven therein.

Fourth.—The joining plates employed in building ships and other articles. The edges of the plates are bent backwards from each other, and a gutter-shaped piece of metal is then threaded over their edges; the whole is then compressed with great force between two friction rollers rotating in similar directions, and by these means a secure joint is produced.

Fifth.—The construction of masts for ships and vessels by means of two concentric tubes composed of metal plates fastened together by rivets. The interstices between these tubes are then filled up with cocoa-nut fibre saturated with bitumen or asphalte.

Sixth.—The construction of vessels carrying cargo in bulk, as coals, with two wells, the one forward, the other aft, connected by a tunnel, such tunnel being furnished with a tramway, and doors at the sides and above, for the purpose of facilitating the removal of the cargo. On each side of the tunnel is a raised or false floor, the space between which and the bottom of the vessel may be filled with water for ballast. The benefits to be derived from this interior arrangement are, first, the false floor being riveted to the vessel in the manner hereinbefore described, a greater degree of strength is attained; and secondly, the labour employed in raising the cargo will be diminished owing to the height being lessened.

BRICKS, TILES, AND KILNS.

R. Beswick, of Tunstall, Stafford, builder, for *certain improvements in the making or manufacturing bricks and tiles, or quarries, and in constructing ovens or kilns for burning or firing bricks, tiles, and quarries, and other articles of pottery and earthenware.*—Patent dated November 4, 1851.

The first object is the manufacture of bricks, tiles, and quarries with certain materials; the second object, the constructing kilns or ovens in such a manner as to diffuse the heat, and also to prevent the passage of heat and flame from it.

Claim.—A peculiar combination of materials for the making of bricks and tiles, or quarries; also certain peculiarly-shaped bricks, called caps, and solid-angled bricks, and the use of them in constructing ovens or kilns for burning or firing bricks, tiles, quarries, and other articles of pottery and earthenware. Further, constructing the walls of the flues and compartments of ovens or kilns for burning or firing bricks, tiles, quarries, and other articles of pottery and earthenware.

Equal parts, by weight, of pounded seggars,* red marl, and fire-marl, are mixed together with water, and reduced to the required consistency for manufacturing the bricks and tiles, or quarries, the latter being fired to a greater degree of heat than they will be ever subjected to.

In constructing the walls of the flues and compartments of ovens or kilns for burning or firing articles of pottery and earthenware, the bricks, 4½ inches in width and 2 inches in thickness, are set on end and rabbeted at their edges. A groove is made in the side of the brick, running the whole length. The cement in which they are bedded is pressed into these grooves, which prevents as much as possible the passage of flame or heat through the walls. The walls being of slight construction are strengthened by bridging bricks, 18 inches apart. "Cap" bricks are used for the upper course, so as to prevent the cracking and wearing away of the bricks; at the corners of the flues "solid-angled" bricks are used. The bottom of the floors is covered with two layers of quarries, 1½ inch in thickness each; these are laid upon fire-bricks placed 18 inches above the ground, and at certain distances apart. The cement is composed of equal parts, by weight, of, 1st, common sand, or pounded grit that is used for placing green-ware in the kilns,—2nd, sand that has been used for placing green-ware,—and 3rd, red and fire marl, mixed with water to the consistency required for building.

* The cylindrical case of fire-clay in which fine stoneware is inclosed while being baked in the kiln.

STEAM-BOILERS AND PROPELLING.

W. Thomas, of Exeter, engineer, for *certain improvements in the construction of apparatus for economising fuel and in the generation of steam, and in machinery for propelling on land or water.*—Patent dated November 6, 1851.

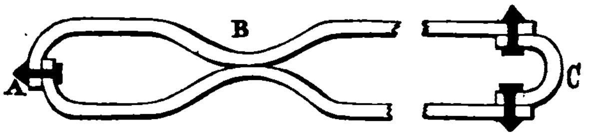
The invention consists, firstly, of a steam-boiler of peculiar construction, having tubes of a syphon-like shape in the interior, which are employed to effect the desired object. The air being admitted into the boiler by means of a pipe at the side, and heated by contact with the fire-box, passes through the bent tubes towards the funnel, the damper of which being closed the air is prevented passing out, and is forced by a draft proceeding from a pipe parallel with the funnel into a tube leading to the fire-box: the principle involved in this invention being the increase of heat in the boiler, by means of the heated air passing through the tubes, and the increase in the supply of air to the fire-box. As regards the economy in the generation of steam, this is effected by a pipe leading from the cylinder of the steam-engine to the cistern of feed-water; through this pipe the waste steam passes into the cistern, and by this means the temperature of the water therein is considerably heightened.

Secondly, the application of fly-wheels to the wheels of locomotives, to paddle-wheels, and screw-propeller shafts, in order to increase their accelerating force, by taking advantage of the centrifugal force generated by the revolution of the said wheels. The novelty of these fly-wheels consists in their being rather heavily weighted, and attached to the driving and other wheels or locomotives, either inside or outside of the framing, and to paddle-wheels either inside or outside of the wheel, or at the centre of the wheel when divided floats are used, and in a control being afforded over these weights whereby the power may be regulated. The means by which this is to be effected is by removing the weight nearer to the boss of the wheel, the consequence of which will be the limitation of the accelerating force.

STEAM-BOILERS AND PROPELLING.

G. Mills, of Southampton, engineer, for *improvements in steam-engine boilers, and in steam-propelling machinery.*—Patent dated November 22, 1851.

Claims.—1. The employment in steam-boilers of flat-sided flues, having indentations or corrugations running therein, touching and abutting against one another on the protuberant sides, and forming water spaces in the hollow sides. 2. An improved arrangement of screw-propelling machinery, being a peculiar arrangement of certain known machinery. 3. The application of chambers to pistons.



Firstly. The invention consists in obtaining a greater amount of heating surface in marine boilers, with increased strength and durability. Indentations or corrugations are made in the tubes of boilers in such a manner that the indentation on one side shall touch or abut the one on the other side, as at B. Two advantages are thereby gained, the abutting of the sides forms a stay, and gives thereby increased strength to the tubes; and by the indentations being arranged side by side, water spaces are formed, which running in a reverse direction to the tubes, increase the evaporation. The tubes are overlapped at the top, and riveted as shown at A, or a circular piece is introduced at the top and riveted at the sides as at C, or common angle-iron may be used.

Secondly. The invention consists in arranging the cylinders of engines horizontally, and, to secure uniformity of motion, setting them at right angles to each other. The motion is transmitted by a vertical crank-shaft with a single crank, through a bevil or pinion to the screw-propeller shaft, causing great speed with comparatively a disproportionate loss of power. This portion of the invention is adapted for war steamers.

THE MANUFACTURE OF RED OR AMORPHOUS PHOSPHORUS.

By Dr. George Wilson, F.R.S.E.

[*Paper read at the Royal Scottish Society of Arts, April 26th.*]

Dr. Wilson commenced by stating that phosphorus had been manufactured in Europe for at least two centuries, but only on the small scale and as an object of curiosity, till within the last twenty-five or thirty years, when the introduction of the lucifer-match led to a prodigious increase in the quantity of phosphorus manufactured, as it entered into the composition of almost all the varieties of instantaneous lights; and in illustration of this it was mentioned, that a single English lucifer-match maker employed nearly five hundred persons, and manufactured more than two thousand millions of matches yearly. The simplest lucifer-match consists of a splinter of wood dipped into melted phosphorus, and then covered with gum or glue. More frequently phosphorus is associated with chlorate or nitrate of potass, and with sulphur or sulphuret of antimony. The employment of such materials necessarily renders the manufacture a very hazardous one, from the risk of fire, and in certain of the Continental states the preparation of lucifer-matches has been absolutely prohibited. Another and quite unexpected hazard was soon found to attend their manufacture. The workpeople were attacked by a very painful and often fatal disease of the jawbones, which became carious, occasioning in many cases death, in several loss of the upper or under jaw, or other severe mutilation and disfigurement, and always much suffering. The German surgeons, who have paid great attention to this distressing disease, refer it to the absorption of the vapour of phosphorus, given off chiefly during the drying of the matches, but likewise at other stages of the manufacture. Phosphorus, also, is well known to act as a poison when swallowed in the solid form, and as it occurs in this condition in lucifer-matches, fatal accidents have more than once occurred from children sucking them.

The red or amorphous phosphorus is much less combustible than ordinary phosphorus, and not at all poisonous. To prepare the new substance, ordinary phosphorus is melted in a peculiarly constructed retort, and kept for some hours at a temperature of about 500° Fah. A very singular change is the result of this heating, during which the phosphorus combines with caloric, and renders it latent, but does not otherwise undergo any chemical alteration. The original phosphorus is a pale yellow or white transparent body, so combustible that it must be kept under cold water, and when brought into the air grows luminous even at the freezing point, and enters into full blaze at a temperature of about 150° Fah. By the prolonged heating it becomes a soft opaque mass, which is easily pulverised, and then forms an uncrystalline powder of a scarlet, crimson, purple-brown, or brown-black colour, so incombustible that it may be exposed in summer in the open air, and handled with impunity; nor does it grow luminous till it is about to enter into full combustion at the temperature of 482° Fah. It is further so harmless to living creatures, that more than a hundred grains have been given to dogs without doing them any injury. Although, in its free state, it is sparingly combustible, yet, when it is mixed with the ordinary ingredients of lucifer-matches, such as sulphur or sulphuret of antimony and chlorate of potass, it kindles readily. In proof of this, matches made with amorphous phosphorus were shown to ignite as easily as those made with ordinary phosphorus; and it was stated that they would soon be manufactured on the large scale, and sold, it was believed, as cheaply as the common matches.

Dr. Wilson then stated that he thought the community were indebted to the Messrs. J. and E. Sturge, of Birmingham, for the attempt which they were now making on a large scale to introduce the new phosphorus, which had the following advantages over the old:—1. It involved much less risk of destruction of life and property by fire; 2. It was more suitable for matches intended for warm climates; 3. It was not poisonous in the solid form, so that matches made with it would be comparatively harmless if sucked or chewed; 4. It gave off no vapour at ordinary temperatures, so that it could not occasion disease in the match-makers. It therefore seemed alike the interest and the duty of the public to encourage, by purchasing them, the manufacture of lucifer-matches made with the new phosphorus. Drawings of the retorts employed by the Messrs. Sturge, and specimens of the red or amorphous phosphorus, were exhibited to the meeting.

Dr. Wilson added that, considering how large an amount of phosphorus entered into the composition of our bodies, and those of other animals, he thought it probable that the amorphous phosphorus would prove a valuable medicine; and he had already ascertained that it would be of great use to scientific chemists in preparing compounds—such, for example, as phosphorus acid, hydrobromic and hydriodic acids, and the like.

ON COPPER ORES, AND THE RECOVERY OF SULPHUR FROM ALKALI WASTE.

By Mr. Longmaid.

[*Paper read at the Society of Arts, April 29th.*]

Mr. Longmaid stated that in a former paper he had briefly described the circumstances which led to the discovery, that when common salt and minerals containing silver, copper, iron, and sulphur are mixed together, and exposed to the combined action of heat and atmospheric air, mutual decomposition ensues, with formation of sulphate of soda and chloride of silver and copper, soluble in the alkaline solution thereof. In the present paper, he showed that every description of ore containing silver and copper might be treated with great advantage by various modifications of these processes, and the silver and copper economically obtained. The waste of sulphur destroyed in the copper works of Great Britain alone, at an enormous cost of labour and coal, was stated to be from 60,000 to 70,000 tons annually. From this, the original idea was to manufacture sulphate and carbonate of soda. Taking the metals as incidental products in the original process, objections had arisen to its application to ores rich in copper. These were now obviated; and the period was confidently looked forward to when it would be applicable to copper ores generally. The chief points adduced by Mr. Longmaid were, the complete separation of silver and copper, and also lead, when these metals exist in the ore; and the great economy of the process whereby the sulphur is rendered available for the manufacture of alkali. His late patent refers to the application of the process to ores rich in copper and silver; ores containing about 25 per cent. of sulphur, and from 5 to 10 per cent of copper, are mixed in such proportion that 32 parts of sulphur by weight are added to 100 parts of common salt. The mixture is ground sufficiently fine to pass through a ten-hole sieve, the material is then calcined in a furnace of four or five beds, commencing at that farthest from the fire, and gradually being advanced by stages to a greater heat; the charge is finished at the bed nearest the fire; the calcined mass, which is called sulphate ash, is conveyed to suitable vats, in which the soluble portions are dissolved, and consist of sulphate of soda and chlorides of silver and copper.

In the rude process of smelting copper ores as at present practised, the sulphur of the ore is not only wasted, but a considerable degree of fuel and labour is employed to destroy this valuable product. The great objection which has hitherto retarded the introduction of these processes into the copper-smelting works arose from a variety of causes. It could only be used practically on a very large scale; the copper-smelters were wedded to a practice by which they had realised such enormous profits, they regarded with distrust schemes which they did not understand, and they had a foolish prejudice against becoming alkali manufacturers: neither could the ordinary copper-works be readily converted into furnaces and apparatus for the patent processes; but the astounding fact that the smelters are destroying property to an extent of 50 per cent. on the value of the ore in their present operations, must sooner or later force these improvements into general use.

PREVENTION OF ACCIDENTS IN COAL MINES.

Sir—Public attention having been fearfully directed, lately, to the want of means for protecting the lives of coal miners, probably some effective measures will shortly be adopted for their security. So long, however, as the "goafs" are permitted to be filled with carburetted hydrogen gas, no available system of ventilation can insure safety; for a sudden fall of the barometer will quickly fill the passages of the best ventilated mines with an explosive mixture of the carburetted hydrogen and atmospheric air. It occurs to me that a very easy and effectual means of, at least, diminishing the present danger would be to explode simultaneously, by voltaic electricity, small cartridges of gunpowder in the fiery parts of a mine, before the men go to work. A single wire, laid down from the pit's mouth to the workings, and a small voltaic battery, would be adequate for the purpose, and the cartridges might be placed ready over night. This would, at all events, prevent the danger that is so frequently fatal arising from the mine passages being filled with firedamp during the night, which explodes when the first candle is exposed.

Even the reservoirs of gas in the goafs might be dispersed by similar means, if a plan were adopted for introducing atmospheric air till the hydrogen attained the explosive point.

I am, &c.

Hampstead, May 17th, 1852. F. C. Bakewell.

STATE OF TRADE.

The demand for iron has slightly increased, and prices of some descriptions have proportionately advanced. In the rail department the quotations are now 10*s.* advanced, and contracts have been concluded on those terms. Further heavy orders are also in the market, and more it is known will shortly be forthcoming; indeed, there appears every probability of a full and steady employment for our rail mills for a considerable period, from the requirements of proposed railways in India, in America, and upon the continent, with the few that remain to be carried out at home, some of them already in construction, and others engaging much public attention. In general descriptions of iron orders have been coming in more freely, and at some works they have accumulated to the extent of full six months' work on hand. Quotations are in consequence creeping up a little towards the nominal prices, and some parties are so sanguine as to hope that there may be grounds for a move in the right direction before the end of the quarter. From Wales and Glasgow the accounts are more satisfactory. In pigs there is little doing, and these, according to make, exhibit the same variation in price which they did at quarter-day. Whatever may have been said respecting the depressed condition of the iron trade in South Staffordshire—and that it has been under a cloud during the winter months no one gainsays—it appears to be sufficiently prosperous to allure masters to the erection of new works. Generally the workpeople of the iron districts are employed, while fresh furnaces are about to be put in blast.

Another advantage is promised by the iron trade of South Staffordshire. Now the manufacture is in a condition so low as to require the exercise of economy in every direction, it is announced that the well-known limestone raised by the Minera Company, in Wales, is about to be introduced on a very large scale. That such a mineral can be conveyed 70 miles by railway, and sold in South Staffordshire at prices which, independently of quality, enable it to compete with that produced on the spot, speaks well for the enterprise of Mr. Owen, of Bilston. Formerly this gentleman was in the habit of bringing into the district large quantities of the Derbyshire limestone; but, in consequence of differences which have sprung up with the Midland and South Staffordshire Railway Companies in the matter of "long weight," the district of South Staffordshire is likely to be provided with a better article than that with which it has hitherto been supplied.

The orders received from North and South America by the last packets are encouraging. Those from the United States more particularly exhibit an interesting demand for Birmingham manufactures, and remittances continue to be highly satisfactory. There is an unusual demand for brass bedsteads—now a most important branch of Birmingham manufacture—for South America and the West India colonies. New and extensive works, devoted to the make of this description of articles, have recently been erected in Birmingham, and they, together with the old ones, are now in active operation. The increase in the exportation of brass bedsteads within the last two years has, indeed, surprised the most sanguine of their inventors and manufacturers.

Some of our factors continue to complain of the dullness of the home trade—and this they do in the best of times—but, taking the entire trades of the town together, their condition may be described as prosperous. Those most depressed are those most subjected to the fickleness of fashion, and the fancy business; but for the heavier descriptions of useful goods the demand for the home market, leaving the foreign trade out of consideration, is extremely good. Every day, if old makes are going out, new and improved inventions are succeeding them, and designers and manufacturers kept thus actively at work. It is not so, however, with the gilt button trade, which appears to be hopelessly depressed. Every attempt to resuscitate this once flourishing manufacture has failed, and, were it not for the foreign demand, it would be almost extinct. The pearl button trade is also drooping, and there does not appear much probability of its revival.

But, if these old branches of Birmingham manufacture are upon the wane, there are others of more importance to the community upon the advance. Those manufactures the prosperity of which denote with the greatest force the activity of an infinity of other businesses are at the present time well employed. In the Soho works, several steam-engines are in course of construction, and the works of Messrs. Fox and Henderson, at Smethwick, are in full operation. The Crown and Plate Glass Works, at Spon-lane and Smethwick, are unusually busy, denoting, as these establishments do, great activity in the building trade, not in this town and neighbourhood only, but of the country generally.

The Recently-discovered Iron District of Cleveland, Yorkshire.—In a paper recently read at the Royal Scottish Society of Arts, Mr. Campbell presented some remarkable specimens of the ironstone which he had got in the north of England, while engaged in the improvements of the River Tees. The beds lie nearly level in this mountain of ironstone, varying in thickness from 12 feet to no less than 20 feet. The most remarkable feature is, that the ore is got by open quarrying; and it is estimated that 10,000,000 tons may yet be got with the same facility. Two furnaces were in blast when Mr. Campbell left the district, and more are in progress. There is no limestone or coal got in the district, though geologists consider that these may yet be reached. The operations were commenced in April 1851, and the traffic of ironstone, up the Stockton Darlington Railway, has since been at the rate of 200,000 tons per annum. Ironstone has been found in Northamptonshire; and, as the future supply of iron ore is at present attracting much attention, the paper concluded with a geological account of the district where this curious ironstone has been so unexpectedly found, which was illustrated by geological and other maps. The Chairman requested Mr. Campbell, as he has business in the district, to communicate to the Society the results of farther experience in the smelting process of this ore, and also an analysis of it, and more minute details of the geology of the Cleveland Hills, where this ore is found.

PROCEEDINGS OF SCIENTIFIC SOCIETIES.

ROYAL INSTITUTE OF BRITISH ARCHITECTS.

May 3.—C. R. COCKERELL, V.P., in the Chair.

At the Annual General Meeting, held on the above date, the report of the Council to the annual general meeting was read and adopted, with the insertion of the following memorial to her Majesty, upon the state of the royal tombs in Westminster Abbey:—

To THE QUEEN'S MOST EXCELLENT MAJESTY.

The Humble Memorial of the Royal Institute of British Architects.

"May it please your Majesty—The Royal Institute of British Architects, who are honoured by the patronage of your Majesty and of H. R. Highness Prince Albert, having had their attention called to the dilapidated and perishing condition of several of the Tombs of your Majesty's royal predecessors in Westminster Abbey, have, with the special permission of the Subdean and Chapter, examined carefully these memorials of an illustrious line of monarchs, and have found many of them in a state of mutilation and decay, threatening destruction within a few years, and derogatory to the memory of sovereigns whose names and deeds are justly dear to the English nation.

"A Select Committee of the House of Commons on National Monuments in a Report, dated the 16th of June, 1841, expressed their opinion that increased attention should be paid to the preservation of those Royal Monuments; and the Members of the Royal Institute of British Architects are strongly impressed with the conviction that unless means be immediately taken, some of these precious and most valuable records of the past history of the kings and queens, and of the arts of this country at periods now imperfectly known, will ere long be irrecoverably lost.

"The Institute, therefore, humbly and earnestly pray that your Majesty will be graciously pleased to direct inquiry to be made into the condition of the Royal Monuments in Westminster Abbey, and to order such steps to be taken as, in your Majesty's judgment, may be best calculated to preserve and worthily perpetuate these venerable and deeply interesting memorials of past sovereigns."

A letter was read, addressed to Earl de Grey, President, from the Hon. Col. Phipps, conveying to his Lordship, by command of the Queen, the entire approbation of her Majesty and H.R.H. the Prince, of the award of the Royal Gold Medal to the Chevalier Leo von Klenze. A letter was also read from the Chevalier Leo von Klenze, acknowledging the honour which had been conferred on him by the award of the Royal Gold Medal.

Special Votes of Thanks were then passed for the services of the President, Vice-Presidents, Members of Council, and the other Office-bearers, during the past year; and the following Office-bearers were elected for the ensuing year:—

President: Earl de Grey.—*Vice-Presidents*: T. L. Donaldson, W. S. Inman, D. Mocatta.—*Honorary Secretaries*: J. J. Scoles, C. C. Nelson.—*Honorary Secretary for Foreign Correspondence*: T. L. Donaldson.—*Honorary Solicitor*: W. L. Donaldson.—*Ordinary Members of Council*: J. B. Bunning, T. T. Bury, G. Godwin, R. Hesketh, J. Jennings, J. T. Knowles, R. W. Mylne, J. W. Papworth, H. Roberts, E. Woodthorpe.—*Treasurer*: Sir W. R. Farquhar, Bart.—*Auditors*: J. H. Good, jun., James Fergusson.

INSTITUTION OF CIVIL ENGINEERS.

May 4.—JAMES M. RENDEL, Esq., President, in the Chair.

The conclusion of Capt. HUISH's paper on "*Railway Accidents*" was read. The author stated that the electric telegraph had greatly facilitated working under variable circumstances, and so beneficial had its effects been, that during the year 1851, out of 7,900,000 passengers, or nearly one-third of the population of England, who had travelled over the London and North-Western Railway, only *one* individual had met with his death (from which casualty the author also suffered), and this was the effect of the gravest disobedience of orders. In the six months during which the Exhibition was open, 775,000 persons were conveyed by excursion trains alone, in 24,000 extra carriages, all centering in a single focus, arriving at irregular hours, and in almost unlimited numbers, from more than thirty railways, without the most trifling casualty, or even interruption to the ordinary extensive business of that line.

The author thought undue importance had been attached to the question of irregularity in the times of the trains, as an essential element of safety, for with perfect signals, and a well-disciplined staff, no amount of irregularity should lead to danger; but, on the contrary, it should, to a certain extent, by its very uncertainty, induce increased vigilance, and therefore greater safety. Accidents very rarely happened from foreseen circumstances, but generally from a simultaneous conjunction of several causes, and each of these was provided for as it arose. The statistics of railways, and the periodical publication of the government returns, drew public attention, very pointedly, to the aggregate of accidents; but it was believed, that if due regard was had to comparative results, if the accidents to steamers, or in mines, to omnibus passengers, or even to pedestrians, were as carefully recorded, that then, whether as regarded the ease and celerity of transit, or the facility of conveying numbers, the railway system, even in its present state, would be found to be incomparably safer than any other system in the previous or present history of locomotion.

A discussion then arose on the above paper, and on that by Mr. Braithwaite Poole, on the "*Economy of Railways*," and was continued throughout the evening. The principal points in the working of railway traffic were carefully discussed, and the modifications, which had been by degrees introduced, were noticed. The necessity for a certain amount of uniformity of construction of the rolling stock, as far as accordance between the centres of the buffers of all carriages likely to be brought together to make up the trains, was admitted; but any attempt to enforce complete uniformity was strongly deprecated. The proposition for dividing the railway kingdom into four parts, and amalgamating the rolling stock for each division, was contended to be impracticable and impolitic.

The question as to the prudence of railway companies becoming manufacturers of engines and carriages, and even as was once contemplated by the London and North-Western Railway, rolling their own rails, was also strongly argued; and it was contended that such an application of the funds of a railway company was not prudent or advantageous; as repeated instances had been shown that companies could not compete with individuals in economy of manufacture. Still, however, there were many good authorities who contended that as long as a railway company did execute its own repairs it would be found economical to fill up the time of the men and employ the tools in making a few engines, and only purchasing the stock required for the new lines or branches.

The greater care exercised in the purchase of materials, and in the manufacture of certain parts, such as axles and wheels, was shown to have produced excellent results; only four iron wheels and two wooden wheels had broken under passenger carriages in four years on the London and North-Western Railway, where the wooden were rapidly superseding the iron wheels. Some curious results of manufacturing locomotive engines were given, and it was shown, that one great firm, the goodness of whose productions was generally admitted, had actually incurred a heavy loss in building engines since 1848; having, however, previously to that time manufactured with profit. How much more likely would a railway company be to make heavy losses than a manufacturer who could devote his whole attention and energy to the economical conducting of his establishment.

It was admitted that the maintenance of way, making gas for the stations and shops, and a few other matters, might be legitimately retained in the hands of the railway companies; but it was contended that the main objects to be attained would eventually be the leasing the working, as well as the maintenance of stock, of all lines by individual contractors; and then, that capital accounts would be closed, and the shareholders would ascertain their actual position.

The discussion, which had taken a commercial turn instead of entering into the question of railway economy, or of railway accidents, occupied the whole time of the meeting, to the entire exclusion of any other subject.

Mr. Ebenezer Goddard, Assoc. Inst. C.E. (of Ipswich) exhibited in the library a small portable asbestos gas stove, for heating apartments, of great simplicity and portability, the apparatus being contained in a box 12 inches by 9 inches, and 3½ inches deep; also a protected gas burner of novel construction, for gas cooking stoves, in which the holes were not liable to be choked up by any means.

May 18.—The paper read was "*Observations on Artificial Hydraulic, or Portland Cement; with an account of the testing of the Brick Beam erected at the Great Exhibition.*" By G. F. WHITE, Assoc. Inst. C.E.

After detailing the experiments made by the late Sir Isambard Brunel, the paper noticed the peculiarities in the practice of the English and foreign engineers in the use of cements and limes. It was stated, that in England, the natural cements were plentiful, and the mode of construction being generally in brickwork, quick setting cements were preferred; whereas abroad, the natural cement-stones were, comparatively speaking, rare, and the use of bricks rather the exception than the rule. In some cases it was found, that even the best natural hydraulic limes did not set with sufficient rapidity, in salt water, to do away with the necessity for using pozzalanos, and some of the attempts made, at various periods, to substitute artificial pozzalanos for the very expensive natural products of that nature, were then described. The unfavourable results of these attempts, and the manner in which M. Vicat explained them, were detailed. A sketch was then given of the course of investigation followed in England by Mr. Frost and General Sir C. Pasley, from which it appeared, that until the introduction of the Portland cements, no artificial compound had been discovered which possessed the same—or greater, powers of resistance than those of the natural cements. The advantages of the Portland cement were stated to be, that it had nearly all the qualities of rapid setting presented by the natural materials of the same class; and in addition, that as it was capable of supporting variable proportions of sand, it could be used as a mortar, the rate of setting of which might be modified at will, and the powers of resistance of which were stated to be much greater than those of either the cements or the limes thus replaced.

A general description of the manner in which the Portland cement was now manufactured, and of the methods of testing the article, were then given; and it appeared, that after seven days, the cohesive strength of the neat cement was equal to about 100 lb. on the square inch; and that after six months, this became equal to not less than 414 lb. per square inch. M. Vicat had stated, in 1851, in a communication to the Annales des Ponts et Chaussées, that by the use of Portland cement alone, or what he termed "overburnt lime," it would be possible to form immense artificial blocks, capable of resisting the action of the waves and of the shingle upon the sea shore, an action which it was well known rapidly destroyed the natural cements, and the pozzalanic mixtures, whether of natural or artificial pozzalanos.

The several applications of the Portland cement as a concrete, as a mortar, and as a stucco, were then alluded to, and reference was made to the early failures in forming large artificial blocks, and an account was given of the mode now adopted in constructing them at Dover and Alderney harbours of refuge, and likewise of those employed to protect the extremities of the breakwater of Cherbourg. At Dover the hearting of the piers, below high-water mark, was executed in blocks of concrete, composed of cement and shingle in the proportions of 1 : 10, and occupying about three-fourths of the volume of the separate materials measured in the dry state. Each block contained from 30 cubic feet to 180 cubic feet, and weighed from 2 tons to 7 tons. At Alderney a species of concrete, composed of cement, sand, and shingle, was placed in a mould, with rubble stone bedded irregularly in the mass, the proportions being about one part of cement to ten parts of foreign materials. At Cherbourg the system adopted was to build immense blocks of rubble masonry of not less than 712 cubic feet, and weighing about 52 tons. These blocks were floated out from the places where they were constructed, and sunk as "pierre perdue;" but this had not on all occasions been able to resist the transporting power of the waves. The manner of using the cement was in the form of mortar, composed of one part of cement to three parts of sand.

It had been stated by M. Vicat, that the powers of resistance to compression absolutely required, in substances exposed to the action of the sea, must be at least equal to 40 lb. per square inch, and of that to tension at least equal to 9 lb. on the square inch. Now, the resistance of the artificial stone blocks, after an interval of nine months, was not less than 1700 lb. per square inch, when the effort was one of compression, or than 200 lb. per square inch, when it became an effort of tension, or little inferior to that of Portland stone itself.

Attention was called to the fact, that the Portland cement adhered more energetically to the Portland stone than to any other material. This degree of adhesion did not seem to depend so much upon the absorbent powers of the substances connected together by the cement, as upon some coincidence in the manner of their crystallisation. The applications of Portland cement to the purposes of stucco for external works were noticed. Its advantages were stated to consist in its agreeable colour, without the intervention of paint or limewhite, its power of resisting frost, and its freedom from vegetation; all which were attributed to the close contact of its constituent parts, and to the surface being perfectly non-absorbent. For the same reason, it was asserted that the Portland cement was eminently adapted for the construction of cisterns and baths, and for the various descriptions of statues and fountains, &c., now made of artificial stone.

The paper concluded by a description of the Brick Beam experimented on at the Great Exhibition of 1851, an account of which has already appeared in the *Journal* (Vol. XIV. p. 510), and from which it was deduced that the strength of Portland cement, as compared with Roman cement, was in the ratio of 2½ : 1. Attention was called to the several tables and diagrams which were exhibited; illustrative of the various powers of resistance of the cement under efforts of compression, extension, and tearing asunder.

May 25.—THE PRESIDENT'S CONVERSAZIONE.

The Session of the Institution was appropriately terminated on Tuesday evening by a Conversazione, which was attended by the members and a numerous and brilliant assemblage of distinguished visitors, who were received by Mr. J. M. Rendel (the President), attended by Mr. Charles Manby (the Secretary), upon whom devolved the duty of collecting and arranging the works of art, models of machinery, and specimens of manufacture with which the rooms were profusely and elegantly decorated. It would exceed our limits to notice more than a few of the principal points of attraction.

In the reception saloons, which were hung with Aubusson tapestry, by Jackson and Graham, and decorated with a profusion of flowers, were Sir Edwin Landseer's "Random Shot," and Ward's picture of "James II. reading the Despatch," both from the collection of Mr. Jacob Bell; Turner's "Blue Lights," with an extraordinary fac-simile in coloured lithography. Around these were placed pictures by Stanfield, Haghe, Egg, Herring, Ansdell, Phillip, Wehnert, Lance, Wood, Crowley, Rothwell, Niemann, Kennedy, Winterhalter, Wilson, and Carmichael.

Sir Emerson Tennent had contributed some beautiful specimens of Ceylonese and Chinese carvings; Mr. Montague a remarkable silver plateau of Maltese filagree work; Mr. Hancock a rich silver vase, made for Lord Ward; Messrs. Elkington a large assortment of beautiful pieces of gold and silver plate, vases, &c.; Messrs. Copeland and Messrs. Alcock, fine collections of Parian figures and groups, china, &c., several of them designed by Alfred Crowquill, who exhibited a new statuette of "The Iron Duke" from life.

Mr. Bailey sent a remarkable life-like bust of Robert Stephenson, M.P., and the modelled design for the statue of the late George Stephenson; and specimens of sculpture by Lough, Thomas, Loft, and others, with bronze by Collus and F. Bramah, were also grouped around.

Mr. Apsley Pellatt sent a large collection of glass, and amidst it was placed a beautiful basket of flowers and insects electrotyped in gold and silver, by Captain Ibbetson.

Mr. Gould contributed some brilliant specimens of his beautiful Humming Birds, which contrasted well with three scenes of "Falconry," by Mr. Hancock (of Newcastle).

The principal room contained a numerous collection of models, many of which were shown at work. Among these may be particularly noticed the anastatic process of printing, exhibited by Messrs. Glynn and Appel, who had recently introduced a method of preparing paper by the addition to it, while still in a state of pulp, of an insoluble salt of copper, and a peculiar preparation of palm oil, so that when an attempt was made to reproduce any document, it became fixed to the plate, and no transfer could be made. Messrs. Napier and Son exhibited an Automaton Sovereign Weighing Machine, which differed from those now in use at the Bank, by its separating the coin into three classes, the too light—those between certain limits, which might be variable—and the too heavy, instead of simply into the light and the full. They also exhibited a Captain's Registering Compass, which showed at a glance the exact course the ship had taken, and the moment when any deviation from the true course had been made.

Mr. W. S. Lacon also explained a very beautiful model illustrative of his ideas as to the management of ships' boats, how they should be steered, and suspended, and lowered in case of emergency—an important desideratum.

Mr. S. Highley's Achromatic Gas Microscope Lamp, a contrivance for combining, or rather modifying, the glaring light common to ordinary gas microscopic burners when making researches, seemed to be an object of great interest.

There were also many models in various branches of engineering; Messrs. Maudslay and Messrs. Penn contributing models of almost every kind of marine engine, and to Captain Henderson was due the collection of a vast number of different kinds of vessels, for the purpose of showing the great discrepancy that existed in different countries in the lines of ships.

In Railways, permanent way seemed to be the point to which inventors chiefly devoted their thoughts, and the various modifications of Mr. W. H. Barlow for a road entirely of wrought-iron, of Mr. Henson for a similar rail supported by longitudinal timbers, and of Messrs. P. W. Barlow, Greaves, Doull, and Reed, for chairs and supports of cast-iron, so as to make the road partly of cast and partly of wrought, but still entirely of iron, were shown. Mr. Henson also contributed a beautiful model of his covered railway goods wagon, by which it was said a saving of at least fifty per cent. in repairs alone over the old wagons with sheets would be effected.

The centre table was devoted to an assortment of every description of fire-arms, from the old Indian and Chinese matchlocks, some of which even were revolvers, down to the Minié rifle, the Colt revolver, and the Lancaster smooth-bored rifle. There were also numerous applications of Mr. Hodges' cumulators, a new mechanical power obtained by the accumulation of elastic force; as well as Mr. Appold's arrangement for showing water below 20° without freezing.

In the ante-room, Mr. Goddard (of Ipswich) explained a gas cooking-stove, and an asbestos fire, in lieu of that formerly produced by platinum, and there was also a combined gas stove, by Mr. N. Defries. On the mantelpiece was one of Mr. Bain's electric clocks, with the most recent modifications, all the power being contained in vases.

An elegant mantelpiece of Llangollen slate stone, showed the capability of that material for receiving the highest polish, and by the new process of imitating marble, the very beautiful workmanship which might be had for a small cost.

The guests remained until a late hour, engaged in the examination of the works of art, listening to the explanation given of the different models, and in enjoying the hospitality of the President in the refreshment room.

On Wednesday the rooms were again thrown open in the middle of the day, for the purpose of enabling the ladies to examine the collection at their leisure, and many noble and distinguished persons, including the Duchess of Sutherland, Ladies Rosse, Douglas, Arabella King, &c. &c., availed themselves of the opportunity. They were attended by Mr C. Manby (Secretary), and by Mr. James Forrest, who explained to them the peculiarities of the various models.

NOTES OF THE MONTH.

Society of Antiquaries.—At the meeting on the 27th ult., Viscount Mahon, M.P., President, in the chair, the proposition of the treasurer and council for reducing the entrance fee to five guineas, and the annual subscription to two guineas, was carried by a majority of 15. Ayes, 55; Noes, 41.

Royal Geographical Society.—The anniversary meeting of this society was held on the 24th ult., when the presentation of the Royal Medals took place, Sir R. Murchison announcing the award of the Founder's gold medal to Dr. John Rae, in the employ of the Hudson's Bay Company, for his survey of Boothia, and for his explorations of the coasts of Wollaston and Victoria Lands.

Government School of Mines.—The first examination for the scholarships in this institution, recently founded by his Royal Highness Prince Albert on behalf of the Prince of Wales, and called "the Duke of Cornwall's Scholarships," was brought to a conclusion on the 22nd ult., after a most severe examination. Mr. Henry Francis Blanford, being at the head of the list, obtained the scholarship (30*l.* per annum for two years); and Mr. Robert Hunt the second scholarship for one year.

Meeting of the Society of Arts at Hampton Court.—It is intended that the present session shall be closed by a meeting of the members and their friends at the Palace of Hampton Court, on Saturday the 3rd of July. A committee has been appointed by the council to make the necessary arrangements, and the further details are to be shortly announced.

Water Colours.—We feel we shall be doing a service to our young professional friends by calling their attention to the Society of Arts' prize water-colours. The box, which only costs one shilling, includes ultramarine, lake, and a complete assortment of colours and brushes. Another praiseworthy result of their exertions, and no less useful, is the prize box of drawing instruments, which is to be had at two prices—half-a-crown and five shillings.

Cremorne.—A private view of the gardens took place on the 21st ult., when a select party of gentlemen met for the purpose of surveying the grounds, and of enjoying an excellent dinner provided for them by the spirited proprietor, Mr. Simpson, who has here spared no expense in catering for the amusement of the public, having made considerable additions to the attractions of the gardens. Several statues, vases, and fountains are distributed all over the grounds; a new gateway has been erected next the Fulham-road, and many other buildings for the purposes of the several exhibitions. Part of the gardens have been laid out with great taste; and the Chinese Temple, in the centre of the dancing platform, has an excellent effect from the brilliancy of the gilding and colours, which well accords with the style of amusement for which these gardens are famed. We could have wished that the same feeling had pervaded throughout, but the Classic character of some of the additions does not harmonise with the general appearance of the other buildings, and there is evidently a great lack of professional knowledge in many of these works, which causes much regret that so much money should be laid out without the supervision of one whose business it is to be "a man of taste."

Portsea Church Competition.—The committee have selected the design of Mr. Raffles Brown and Messrs. Barry and Murray, of Liverpool. Twenty-three designs were sent in.

Morecambe Bay.—The reclaiming of this bay, which was first surveyed sixteen years ago by Mr. Hyde Clarke, and which has been often brought forward in this *Journal*, is at length about to be carried into effect. The right has been purchased from the Admiralty by Messrs. Brogden and Co., and the undertaking will be carried out conjointly with the formation of the Ulverstone and Lancaster Railway. The rivers Crake and Leven will be confined to a fixed channel, and the bay will no doubt be left in a great measure to silt up. This vast tract, which extends from Tridlespoint (near to the Ulverstone canal foot) to Greenodd, comprises an area of about 140,000 acres. The great obstacle hitherto has been the conflicting claims of the Crown and the Duchy of Lancaster, who demanded the most exorbitant terms.

Steam-Boiler Explosions.—An invention has been registered by Mr. Dangerfield, of West Bromwich, for the prevention of steam-boiler explosions. The apparatus is very simple, consisting of a valve, which is screwed to the top of the boiler, over which stands a hollow fluted column about 3 feet high, forming a box to contain the weights on the valve, and a pillar for a wheel, over which works a flat chain connected with the buoy in the boiler, having at equal distances two long links, one on each side of the pillar. Two levers, connected with the valve, and fixed on centres, pass between the long link, so that the water in the boiler, rising or falling beyond a given level, depresses the lever, opens the valve, and permits the steam to escape. An index is fixed on the wheel which gives the height of the water in the boiler; the steam is also weighed without the addition of levers, and the weights are securely locked in the pillar to prevent alteration.

LIST OF NEW PATENTS

GRANTED IN ENGLAND FROM APRIL 22, TO MAY 22, 1852.

Six Months allowed for Enrolment unless otherwise expressed.

Samuel Heseltine the younger, of Harwich, Essex, gentleman, for improvements in engines to be worked by air or gases.—April 24.

William Church, civil engineer, and Samuel Aspinwall Goddard, merchant and manufacturer, and Edward Middleton, manufacturer, all of Birmingham, Warwick, for improvements in fire-arms, in ordnance, and in projectiles to be used with such or the like weapons; and also improvements in machinery or apparatus for the manufacture of part or parts of such fire-arms, ordnance, and projectiles. (A communication.)—April 24.

Armand Jean Baptiste Louis Marcescheau, of Rue de Moscou, Paris, France, gentleman, for improvements in the mode of conveying letters, letter-bags, and other light parcels and articles.—April 24.

Richard Christopher Mansell, of Ashford, Kent, for improvements in the construction of railways, in railway rolling stock, and in the machinery for manufacturing the same.—April 24.

William Exall, of Reading, Berks, engineer, for improvements in the process, composition, or combination of materials, machinery, and apparatus for making bread and biscuits, part of which machinery is applicable to the mixing and kneading of plastic substances in general. (A communication.)—April 27.

Alfred Taylor, of Warwick-lane, London, and Henry George Frasi, of Herbert-street, North-road, Middlesex, for improvements in heating and supplying water for baths and other uses, in the construction of waterclosets, and in supplying them with water, and in cocks for drawing off liquids.—April 27.

William Newton, of Chancery-lane, Middlesex, civil engineer, for improvements in machinery for weaving, colouring, and marking fabrics, (A communication.)—April 28.

Thomas Richardson, of Newcastle-upon-Tyne, for improvements in treating matters containing lead, tin, antimony, zinc, or silver, and in obtaining such metals or products thereof.—April 28.

James Fletcher, of Leyland, Lancaster, bleacher, for improvements in machinery or apparatus for stretching and dyeing woven fabrics.—April 29.

Charles Fisher, of South Hackney, Middlesex, for improvements in transferring ornamental designs on to woven or textile fabrics, and in the apparatus connected therewith.—April 29.

John Lintorn Arabin Simmons, of Oxford-terrace, Hyde-park, Middlesex, Captain in the Royal Engineers, and Thomas Walker, of the Brunswick Ironworks, Wednesbury, Stafford, Esq., for improvements in the manufacture of ordnance, and in the construction and manufacture of carriages and traversing apparatus for manœuvring the same.—April 29.

Peter Bruff, of Ipswich, Suffolk, civil engineer, for improvements in the construction of the permanent way of rail, tram, or other roads, and in the rolling stock or apparatus used therefor.—April 29.

John Hinks, of Birmingham, manufacturer, and Eugene Nicolls, of Birmingham, civil engineer, for a new or improved composition, or new or improved compositions and machinery, for pressing or moulding the same, which machinery is also applicable for moulding or pressing other substances.—April 29.

George Goodman, jun., of Birmingham, Warwick, manufacturer, for an improved method, or improved methods, of ornamenting japanned metal and papier-maché wares.—April 29.

Stewart M'Glashen, of Edinburgh, Scotland, sculptor, for the application of certain mechanical powers for lifting, removing, and preserving trees, houses, and other bodies.—April 29.

John Robinson, of Rochdale, Lancaster, timber merchant, for improvements in machinery or apparatus for shaping wood into mouldings and other forms.—April 29.

John Cumming, of Paisley, Renfrew, North Britain, pattern designer, for improvements in the production of surfaces for printing or ornamenting fabrics.—April 29.

Alexander Parkes, of Pembrey, Carmarthen, chemist, for improvements in obtaining and separating certain metals.—May 1.

Hugh Lee Pattinson, of Scot's-house, near Newcastle-upon-Tyne, manufacturing chemist, for improvements in smelting certain substances containing lead.—May 1.

John Moore, of Arthur's Town, Wexford, for improvements in nautical instruments applicable for ascertaining and indicating the true spherical course and distance between port and port.—May 1.

James Johnson, of Waterloo-place, Kingsland, Middlesex, hat manufacturer, for certain improvements in the manufacture of hats.—May 1.

Thomas Mosdell Smith, of Hammersmith, gentleman, for improvements in the manufacture of wax candles.—May 1.

William Wood, of Pontefract, York, carpet manufacturer, for improvements in the manufacture of carpets and other fabrics, and in apparatus or machinery connected therewith.—May 1.

Charles Thomas, of Bristol, soap manufacturer, for improvements in the manufacture of soap.—May 1.

Edward Gee, of Liverpool, merchant, for improvements in apparatus for roasting coffee and cocoa.—May 1.

Henry Bridson, of Bolton, Lancaster, bleacher, for improvements in machinery for stretching, drying, and finishing woven fabrics.—May 1.

Augustus Siebe, of Denmark-street, Soho, Middlesex, engineer, for improvements in machinery for manufacturing paper. (A communication.)—May 1.

Alfred Vincent Newton, of Chancery-lane, Middlesex, mechanical draughtsman, for improvements in the manufacture of printing surfaces. (A communication.)—May 1.

Richard Archibald Brooman, of Fleet-street, Middlesex, patent agent, for improvements in paddle-wheels. (A communication.)—May 4.

Richard Jordan Gatling, New York, for certain improvements in machinery for seeding grain.—May 4.

George Robins Booth, of the Wandsworth-road, Surrey, for improvements in the manufacture of gas.—May 8.

George Frederick Muntz, jun., of Birmingham, for improvements in the manufacture of metal tubes.—May 8.

Joseph Jepson Oddy Taylor, of Gracechurch-street, London, naval engineer, for improvements in ships, boats, and vessels, and in certain articles of ships' furniture.—May 8.

William Littell Tizard, of Aldgate, High-street, London, brewers' engineer, for improvements in machinery, apparatus, and processes for the preparation of grain, and for its conversion into malt, saccharine, vinous, alcoholic, and acetous liquors.—May 8.

Alexandre Jules Saillant, jun., of the Rue Vivienne, Paris, tailor, for certain improvements in the manufacture of articles of dress.—May 8.

John Campbell of Bowfield, Renfrew, N. B., bleacher, for improvements in the manufacture and treatment, or finishing of textile fabrics and materials, and in the machinery or apparatus used therein.—May 8.

William Gillespie, of Forbane-hill, Linlithgow, Scotland, gentleman, for an improved apparatus, instrument, or means for ascertaining or setting off the slope or level of drains, banks, inclines, or works of any description, whether natural or artificial, or under land or water.—May 8.

William Armitage, of Manchester, for an improved safety envelope, and certain improvements in the machinery to be used in the manufacture of the same.—May 8.

Peter Fairbairn, of Leeds, York, machinist, and Peter Swires Horsman, of Leeds aforesaid, flax-spinner, for certain improvements in the process of preparing flax and hemp for the purpose of heckling, and also machinery for heckling flax, hemp, China grass, and other vegetable fibrous substances.—May 8.

Samuel Hall, of Manchester, Lancaster, agent, for certain improvements in the construction of cocks, taps, or valves.—May 17.

George Frederick Parratt, of Piccadilly, for improvements in life-rafts.—May 17.

William Edward Newton, of Chancery-lane, Middlesex, civil engineer, for improvements in the construction of docks, basins, railways, and apparatus connected therewith for raising or removing vessels or ships out of the water, or on to dry land, for the purpose of preserving or preparing the same. (A communication.)—May 17.

William Watt, of Glasgow, Lanark, North Britain, manufacturing chemist, for improvements in the treatment and preparation of flax or other fibrous substances, and the application of some of the products to certain purposes.—May 22.

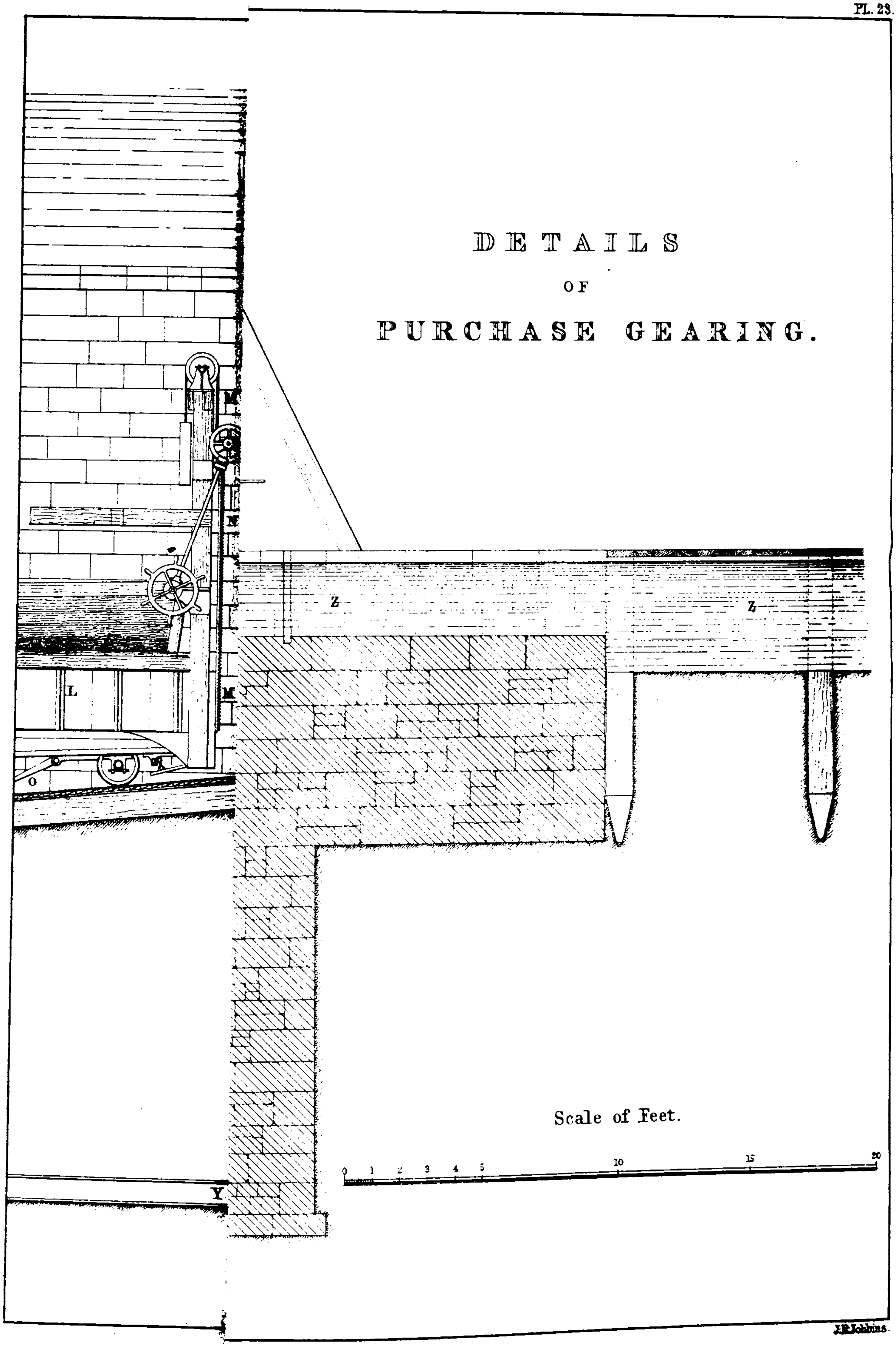
David Dick, of Paisley, Renfrew, North Britain, machine-maker, for improvements in the manufacture and treatment or finishing of textile fabrics and materials.—May 22.

Richard Roberts, of Manchester, engineer, for certain improvements in and applicable to ships, boats, and other vessels.—May 22.

ANSWERS TO CORRESPONDENTS.

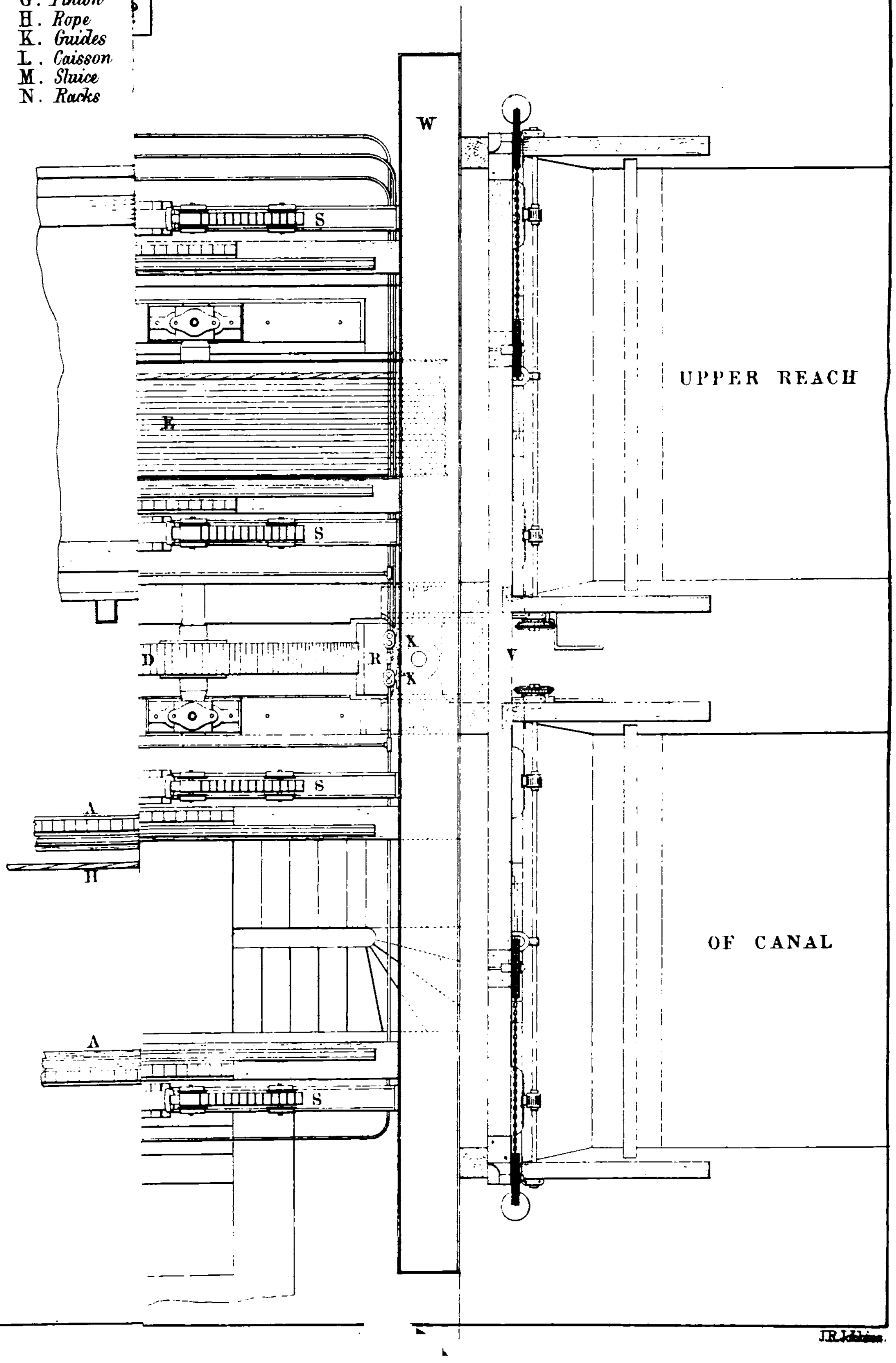
SIR—How do surveyors generally compute the area of land when it is mountainous? For instance, supposing the property measure 30 acres on the level plane, but if measured up hill and down dale it amounts to 100 acres, which is considered the true measurement? And if put up for sale, which measurement will bind the purchaser by the law of the land? Will the level surface or the hill grow the most wheat, supposing the soil to be of equal quality?—A MONTHLY SUBSCRIBER.—[The land must be measured horizontally, and calculated as level. The quantity of wheat grown will be as the horizontal plane.]—ED.

BOOKS RECEIVED.—'Complete Course of Practical Geometry,' by C. W. Pasley, Lieut. Col. R.E. Parker and Co.—'Handbook of Organic Chemistry,' by W. Gregory, M.D. Taylor and Co.—'Railway Machinery,' by D. K. Clark. Part X. Blackie and Son.—'Supplement to the Work on Bridges.' Part IV. Weale.—'Aerial Travelling,' by J. Nye. 'Transactions of Architectural Inst. of Scotland.'

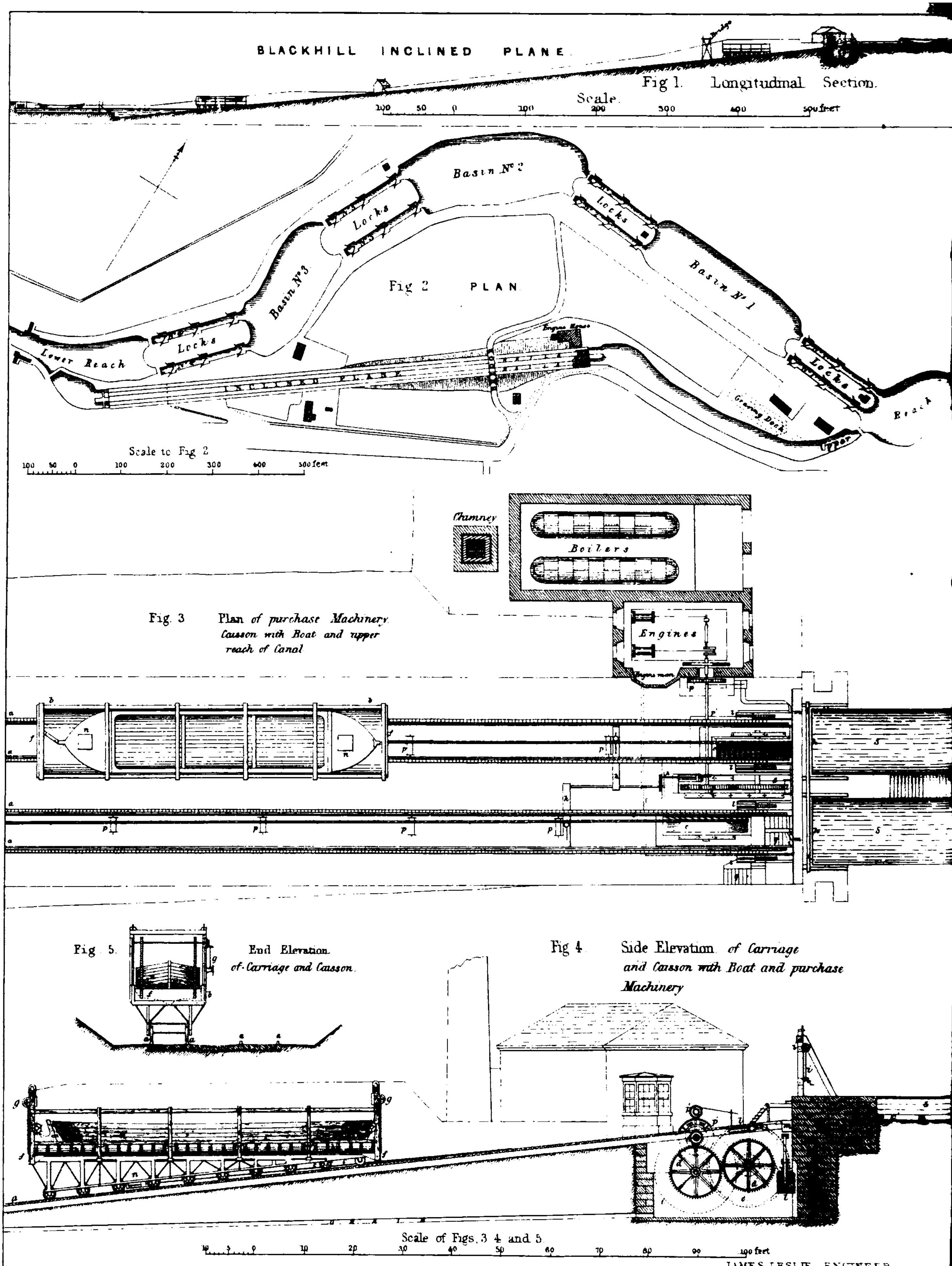

DETAILS
OF
PURCHASE GEARING.
M
C
N
M
L
O
Z
Z
Y
Scale of Feet.
0 1 2 3 4 5 10 15 20
J. R. Jobbins.

A. *Rails & R*
B. *Fly Wheel*
C. *Pinion*
D. *Spur Whee*
E. *Rope rolls*
F. *Spur & Fr*
G. *Pinion*
H. *Rope*
K. *Guides*
L. *Caisson*
M. *Sluice*
N. *Racks*

PLAN OF
PURCHASE MACHINERY.



J.R. Jobbins.


BLACKHILL INCLINED PLANE.
Fig 1. Longitudinal Section.
Scale.
100 50 0 100 200 300 400 500 feet
Basin No 2
Locks
Locks
Fig 2 PLAN
Basin No 3
Basin No 1
Locks
Lower Reach
Inclined Plane
Engine House
Graving Dock
Locks
Upper Reach
Scale to Fig 2
100 50 0 100 200 300 400 500 feet
Chimney
Boilers
Engines
Fig. 3 Plan of purchase Machinery Caisson with Boat and upper reach of Canal
Fig. 5. End Elevation of Carriage and Caisson.
Fig 4 Side Elevation of Carriage and Caisson with Boat and purchase Machinery
Scale of Figs. 3 4 and 5
10 5 0 10 20 30 40 50 60 70 80 90 100 feet
JAMES LESLIE ENGINEER

BLACKHILL CANAL INCLINED PLANE.

By James Leslie, C.E, Edinburgh.

(*With Three Engravings, Plates* XXIII. XXIV. *and* XXV.)

The application of the inclined plane to the purpose of conveying vessels from one line of a canal to another, is by no means new. It was, I believe, first made use of practically by Mr. William Reynolds, on the Ketly Canal in Shropshire, about the year 1789; it was afterwards adopted on the Shropshire Canal, and on the Duke of Bridgewater's Canal, on which last, however, it has since been laid aside. On the Shropshire canal incline, the weight of the boat, carriage, and load, is about 11 tons. More recently, it has been successfully employed, and on a larger scale, on the Morris Canal, United States. A description of the Morris Canal inclines, of which there are a great number, is given in Mr. D. Stevenson's book on the 'Engineering Works of North America,' and in Volume V. of the *Civil Engineer and Architect's Journal* (1842); but various modifications and improvements have been effected since these descriptions were given,—on at least one of these planes, particularly in running the carriage and vessel over a summit, and then down into the water of the upper reach, or in hauling them up out of the water of the upper reach over the summit, so as to be able to dispense with a lock at the top of the incline. On the Great Western Canal, boats are raised and lowered by means of a perpendicular lift, as described by the late Mr. Green, C.E., in 1838, in the Transactions of the Institution of Civil Engineers.

The inclined plane was first recommended for adoption on the Monkland Canal, for the purpose of taking up empty boats, in a report, dated January 1839, by the late Mr. Andrew Thomson, C.E., of Glasgow, who was then engaged in superintending the construction of new locks at Blackhill. The Monkland Canal has a depth of 5 feet, and is adapted for the passage of boats 70 feet in extreme length, including the rudder, 13¾ feet in width, drawing, when light, from 18 inches to 21 inches, when loaded, 4½ feet, and carrying a load of 60 tons. It is about 12 miles in length, and connects the rich mineral district of Monklands, abounding in valuable seams of coal and ironstone, with the Forth and Clyde Canal at Glasgow. As originally constructed in 1772, it extended from the Townhead Basin at St. Rollox, near Glasgow, a mile and-a-half to the foot of a steep ascent at Blackhill, where the first reach terminated; and from the top of that ascent it extended eastward to Sheepford, a distance of 8 miles, where it was stopped by another ascent. An inclined plane for railway wagons at Blackhill connected the two reaches of the canal. The coals were unloaded from the boats in the upper reach into the wagons, run down the inclined plane, and again loaded into boats in the lower reach, which was a tedious operation, and hurtful to the coals.

At one time, the canal was in such an unprosperous state that it was seriously contemplated to fill it up; and it is understood that the chief, if not the only reason why that intention was not carried out, was the want of pecuniary means. As matters have turned out, it is very fortunate that the company could not spare funds to fill up the canal, for the original 100*l.* shares, which were at one time down to 5*l.* or 7*l.*, afterwards rose to be worth about 3200*l.* This remarkable rise in the value of the canal stock may afford some encouragement to the shareholders in some of the many unremunerative undertakings of the present time. This prosperity was brought about mainly by the gradual development of the mineral riches of the district, aided materially, however, by the farther extension of the canal, and by other new works and improvements.

About the year 1788, a set of locks was constructed at Blackhill, enabling boats to pass from the one reach to the other. Two locks were constructed at Sheepford, and the canal was extended thence eastward two miles, to Woodhall, near Airdrie; and in 1790 the Forth and Clyde Canal Company formed the connection called the Cut of Junction, about one mile long, between the Monkland Basin at St. Rollox and the Forth and Clyde Canal Basin at Port Dundas, so that cargoes can now be conveyed from the further extremity of the Monkland Canal to Glasgow, or to the Forth and Clyde Ship Canal, without breaking bulk. The set of locks at Blackhill consists of four double locks 75 feet by 14 feet, having each two lifts of 12 feet, the whole height from reach to reach being generally 96 feet, but varying a few inches according to the supply of water and to the state of the winds.

In the year 1837 the two uppermost locks were so very much out of repair that it became necessary either to rebuild them or to construct two new ones. On being consulted then by the Monkland Canal Company as to what was best to be done, I recommended, in order to save stopping the trade during the time that the work was in progress, to build two new locks by the side of the old ones; and I advised, in order to save water, that, if sufficient space could be found for three chambers, each lock should be divided into three lifts of 8 feet each, instead of into two of 12 feet, assuming that the two lowermost locks should be rebuilt on that plan at some future time, or that two new ones should be constructed, and keeping in view that, ultimately, it might be necessary to have two sets of locks, which might allow the ascending trade to pass by the one, and the descending by the other. From the want of room, and from the additional expense that would have been incurred, the last recommendation was not adopted, but it was resolved to proceed immediately with the construction of two new double locks by the side of the old ones, which was done from plans furnished by me in 1838. By the time that the two new locks were finished, it had become evident, from the great increase in the trade, that either an entire second set of locks must be constructed, or some other means must be devised for passing a greater number of boats than could be accommodated by one set of locks. The trade in the canal, to the extent of about seven-eighths of the whole, is downward towards Glasgow, consisting almost entirely of coals and iron; the other eighth, passing upward, consists chiefly of ironstone, limestone, and manure; consequently nearly all the boats descend the locks loaded, and three-fourths of them return empty.

The plan proposed by Mr. Thomson for taking up the empty boats by means of an inclined plane seemed suitable for such a trade, and it was remitted to me by the committee of management to report on it. In that plan there was only one line of rails proposed for the boats, which were to be taken up afloat in a caisson placed on a carriage. The other line was to be occupied entirely by water-vessels, which were to form the counterbalance and the moving power, water being filled into them from the upper reach of the canal, and emptied out into the lower reach. A chain, having the one end attached to the carriage and caisson and the other to the water-vessels, was to pass over the upper rim of a large horizontal drum or pulley, at the top of the inclined plane, placed between the two lines of rails. According to this plan one pulley was quite sufficient, as no bite or friction was necessary, the load being at one end of the chain and the moving power being attached to the other. Mr. Thomson, however, suggested, in a postscript to his report, that it might be expedient to employ a steam-engine instead of the water-vessels as a moving power.

In a report, dated October 1839, I recommended that the plan of the inclined plane should be adopted with modifications; the first of which was, that there should be two lines of rails for the boats instead of one, so that the descending carriage should act as a counterbalance, but nothing more, to the ascending one, and that the motive-power should be a steam-engine acting on two vertical drums, each having a chain of its own, instead of there being only one chain passing over the upper rim of a horizontal pulley. I proposed two plans: first, one by which the vessels were to be brought up dry on a cradle, and launched over the summit of the incline into the upper reach of the canal, thereby not only losing no water at all in the upper reach, but actually gaining a quantity for every boat that was brought up equivalent to the displacement by the boat when immersed; and second, one having the boats taken up afloat in a water-tight caisson like that suggested by Mr. Thomson, having a gate or sluice at each end, and set level on a moving carriage. One caisson was to be run down full of water into the lower reach, its lower gate opened, the boat floated into it, the gate again shut, and the caisson and boat hauled up to the top of the incline, while the other caisson was descending on the opposite line of rails. When the caisson reached the top it was to be pressed hard, by means of a couple of screws, against the frame of the gate of the upper reach, so as to make a water-tight joint, by which means the caisson might be made to serve the purpose of a shallow lock, and no water would be wasted except the very small quantity contained between the gates of the canal and the upper gate of the caisson, which does not amount to 50 cubic feet. This plan admits of empty boats being sent down as well as taken up; but the cases of empty boats passing down, although they do occur occasionally, are but rare. The owners of boats objected to their being grounded on and launched from the cradle, from fear of injuring them; and so that plan was laid aside, but the other was considered feasible.

In 1840, Sir John Macneill was called on to report on the inclined plane. He also recommended its adoption, and proposed taking up the vessel lying dry on a carriage or cradle provided with small wheels running on level rails fixed on the principal carriage. The carriage was to be first run down into the lower reach, and the vessel floated on to it. When the carriage was hauled up to the top of the incline, the smaller carriage or cradle was to be moved forward off the main carriage into a shallow lock of masonry with rails in the bottom, the outer gates shut on it, and the water admitted from the canal, by which means the boat would be floated off the cradle and into the canal, after which the water in the lock was to be run down, and the upper carriage moved back to its place on the principal carriage. Sir John proposed that there should, in the first place, be only one boat-carriage and one lock, leaving the second ones until the increase in the trade required them. On another line of rails there was to be a counterbalance equal to one-half of the weight of the boat and carriage. The motive-power was recommended to be a high-pressure steam-engine, though one of the drawings which accompany the report shows a water-wheel. The engine, when not taking up boats, was to be employed in pumping back into the upper reach the water that had been run down out of the shallow lock, and which otherwise would have been wasted.

However, it was ultimately resolved, instead of carrying out any of the plans of the inclined planes, to rebuild the two old upper locks, and to build two new lower ones, so as to give an entire double set, which was done in 1841. The intermediate basins were enlarged; a graving-dock, entering from the lower reach, was removed, to make room for the new locks; a new graving-dock was built in the upper reach, and other improvements were effected. After this the trade was amply accommodated until July 1849, when the supply of water ran short, notwithstanding that storage is provided exceeding 300,000,000 cubic feet, and the canal was shut in consequence for six weeks. It then became evident that some effectual means must be adopted for preventing any such interruption in future.

The Monkland Canal had by this time become the property of the Forth and Clyde Canal Company, and in September 1849, I was called on to report, along with Mr. Bateman, that company's consulting engineer, as to the best means to be devised for securing the uninterrupted use of the canal, by providing an additional supply of water for lockage or otherwise. We considered the plan of providing an additional supply of water, by enlarging the store-reservoirs, or forming new ones, and by pumping water from the lower to the upper reach; and, finally, we turned our attention to the old scheme of the inclined plane, the designs for which had lain aside for ten or eleven years. After due consideration, we found that there was great difficulty in increasing the supply of water by additional storage, seeing that the existing reservoirs were already sufficiently capacious for the extent of gathering-ground, as sometimes they were not filled once in a year; and also, that there would be very great expense and loss of power in pumping up water from the lower to the upper reach, as there would be required, with the best of management, at least 12,600 cubic feet, or 350 tons, to be pumped up 96 feet for every boat passing the locks. After having considered and weighed all the difficulties and objections on both sides, we finally agreed in recommending the application of the inclined plane, having the boats taken up water-borne in a caisson, as being the most expeditious, the most economical, and, under all circumstances, the most eligible mode of passing the empty boats.

The committee of management adopted this recommendation, and resolved to proceed immediately with the construction of the inclined plane. About the end of October 1849, they instructed me to prepare the working plans and specifications, authorising me, at the same time, to communicate with Mr. Bateman, which I did occasionally, and had the benefit of his advice and suggestions. The earthwork was contracted for by the middle of November, and the buildings and machinery were contracted for in the middle of January 1850. The whole work was to have been completed by the middle of May 1850, but owing to various delays it was not ready for action until the end of July. The general arrangement is much the same as that proposed in 1839; but the caissons and carriages, instead of being formed of timber, as then proposed, are made of malleable iron; wire ropes have been substituted for the chains formerly intended, and various other improvements and modifications have been adopted. In arranging the details and working drawings, and also in superintending the execution of the work, I have had the benefit of the valuable assistance and co-operation of my friend Mr. Stirling, C.E., and I beg to acknowledge my great obligation to him.

I shall now proceed to describe the plan, as it has been actually carried into execution, and which is illustrated by the engravings, Plates XXIII. XXIV. and XXV.

The two caissons are constructed of boiler-plates ⅜-inch and $\frac{5}{16}$-inch thick, riveted together. They are each strengthened by thirty ribs of T-iron, and are set on a malleable iron carriage strongly framed and braced, and raised up at the lower end, so as to keep the caisson level. The caissons are 70 feet long, or just the extreme length of the boats, including the rudder, 13 ft. 4 in. wide, and 2 ft. 9 in. deep, exclusive of wash-boards to keep the water from splashing over.

The water is only meant, however, to be 2 feet deep, that being sufficient to float the deepest empty boat. The cross-section of the caisson is, as nearly as may be, taken from the mould of the boats, with a hollow space for the keel, so as to contain as little superfluous water as possible. Each caisson has ten pairs of wrought-iron flanged-wheels, similar to those of an ordinary railway-carriage, whereof eight pair are 3 feet diameter, one pair 2 ft. 3 in. diameter, and, in order to keep the caisson as low as possible above the rails, the uppermost pair is only 18 inches diameter. There are upright timber fenders at the sides of the caissons, for guiding the boats, and for fixing the sluice-gearing, framed and bound across the top, so as to give greater strength. The sluices are counterbalanced, and are worked each by two racks and pinions. The weight of the carriage, caisson, and water, or water and boat, varies from 70 to 80 tons.

The gauge of the railway is 7 feet, and the distance between the centres of the two lines of rails is 18 ft. 3 in. The gradient is 1 in 10; and the height from surface to surface of water being, as before stated, 96 feet, and the length of the carriage 70 feet, the whole length of the incline requires to be 1030 feet; but an additional length of 10 feet has been allowed as a provision for the case of the water being very low in the lower reach, and consequently the whole length of the incline is 1040 feet. The rails are 65 lb. to the yard, with flat soles, and are screwed down to longitudinal sleepers. These are of half-logs where the ground is solid, laid on continuous stone blocks with cross-ties 15 feet apart; but are of whole timbers, with cross-bearers, resting on piles 12 feet apart, where the ground is made up and soft. There is a cast-iron ratchet-plate along the outside of each rail, also screwed down to the longitudinal sleeper; and as a means of safety, in the event of any accident befalling the ropes or machinery, there are palls attached to the carriages, working constantly into the teeth of the ratchets while the caisson is ascending, and ready to drop into them when descending, the instant the tension is taken off the rope.

The motion is given by two coupled high-pressure steam-engines, of 25-horse power each, with horizontal cylinders. This is a much greater power than is needed during the greater part of the transit; but it is nearly all required at the time when the descending caisson is entering the water, and, so losing its gravity, ceases to act as a counterpoise, in consequence of which the engines have for a short distance to pull up nearly the whole weight of the ascending caisson, water, and boat. There is a double-friction drag on the fly-wheel, acted on by the piston-rod of a small steam-cylinder, by means of which the machinery may be speedily stopped and held on. A pinion on the crank-shaft outside of the engine-house, 2 ft. 4½ in. in diameter, drives a spur-wheel on the lying-shaft, of 7 ft. 9 in. diameter, having a friction-wheel in its interior, which, for the sake of safety and of preventing shocks, is made to slip when any unusual resistance is met with. The introduction of this friction-wheel, which is similar to that commonly used in dredging-machines, was suggested by Messrs. Yule and Wilkie, the contractors for the machinery, and is a decided improvement. A pinion, 2 ft. 10½ in., on the lying-shaft, drives a spur-wheel of 10 ft. 7 in. on the drum-shaft which is farthest down the incline, being on the left-hand line of rails in looking down, or the further side from the engine-house. This spur-wheel drives another similar wheel on the drum-shaft which is uppermost, and on the right-hand line of rails looking down, or the side nearest the engine-house. These shafts are all of malleable iron.

It is necessary to have the two drums on separate shafts, so as to move in opposite directions, in order that the one may coil and the other uncoil the rope at the same time, both by the upper side; otherwise another drum or pulley would have been required to bring up the rope from the lower side of one of the drums. The drums or rope-rolls are 16 feet in diameter, 4 feet broad, and make one turn nearly for every twelve strokes of the engines, so that while the engines are going at their usual speed of forty strokes (though they often go considerably faster), the caissons are travelling at the rate of about 2 miles an hour, and the time occupied in ascending or descending is between five and six minutes.

The rope-rolls are formed of wrought-iron arms, rings, and bracing, with a cleading of boiler-plate ½-inch thick. The ropes, which were manufactured at the Patent Wire Rope Works, Gateshead, are 2 inches in diameter. They are guided on to the drums by a screw and moving pulley apparatus, and are attached to the carriages by strong draught-springs placed in the frame under the caisson. The springs serve the purpose of saving jerks, and also are made the means of letting down the palls in the descending carriage, in the event of any accident befalling the rope or machinery, and thereby taking the tension off the spring. As originally constructed, when the caisson got to the top of the incline, two palls fell into clams formed on a lying-shaft extending across the top of both rails, and acted on by means of a lever and screw worked by hand, which turned round the shaft, and so pressed the caisson hard to the gates. This acted well enough, except that it gave too short a range for stopping the carriage in—viz., only about 4 inches, and consequently the caissons were sometimes brought with too much impetus against the gates, which tended to shake the building, and to strain unnecessarily the ropes, springs, and machinery.

Mr. Crichton, the manager of the Canal Company, devised an india-rubber buffer-joint, which is useful both for more perfect tightness and for lessening the jerk; but as a still more effectual precaution, a hydraulic apparatus has now been provided in addition, which, while the engines are working, slowly raises a heavy weight, and when the caisson is at the top of the incline, this weight is made, by turning a cock, to act by means of rams or pistons on two sliding ratchets, into which the palls drop as before, but which have a range of 3 feet; and as the engines can be stopped with ease quite within that range, the risk of striking the building is now altogether avoided. This apparatus, which was made by Messrs. A. More and Son, of Glasgow, is placed in the spur-wheel pit, between the two lines of rails, and is directed by a man stationed in the pier between the two gates, where he also opens and shuts the gates. The original screw apparatus is still, however, retained, and can be used in the event of anything being wrong with the hydraulic apparatus. A self-acting trigger has also been applied, by means of which the steam is first partially and then wholly shut off when the carriage gets to the proper place.

After the canal-gate has been shut, the caisson is slackened off from the framing, and the joint opened, so as to allow the water contained between the two gates, amounting, as before stated, to about 50 cubic feet, to escape by means of a transverse wrought-iron trough and a line of pipes into the uppermost basin of the canal-locks. Any water in the caisson which is above the ordinary or proper level, in consequence of the upper reach being over full, is also run-off in this way, so as not to overload the carriage; or, if required, the caisson may be entirely emptied. It will probably be found advisable, except in special cases, to bring up the boats not quite afloat, but slightly bearing on the bottom of the caisson, in which case the descending caisson would also require to be partly emptied, so as to give less strain on the ropes and machinery.

The original spur-wheels on the drum-shafts had either been made too slight, or there must have been a flaw in one of them, for shortly after the machinery had been set to work last August, one of the wheels broke in pieces. Luckily it was the second wheel that gave way, or that on the upper drum-shaft, which is driven by the one on the lower drum-shaft. Had it been the driving-wheel or that on the lower drum-shaft which gave way, both must have been stopped. As it was, instead of stopping the incline entirely, and so losing the benefit of it during the dry season, one of the carriages was worked all the rest of the autumn, until there was enough of water stored to insure the locks being kept going for the rest of the year. Of course the work was carried on at a very great disadvantage in this way, as the engines had a very great deal more work to do than they otherwise ought to have had, owing to the want of counterbalance, and at the same time were doing only half the effective work; but even with these drawbacks, there were taken up generally about 30 boats a-day, and in all 1124, including a few empty boats descending, were passed over the incline, up to the beginning of November, when it was stopped for the winter. This is equal to a saving of nine entire days' water in the ordinary working of the canal, which is reckoned at fully 60 boats down and as many up in one day.

The time taken by a boat to pass all the locks is from half-an-hour to forty minutes; but as there may be one boat in each of the four locks, that would admit of four passing during that time by each set of locks, or from 12 to 16 by both sets of locks in one hour, supposing no interruption to occur from boats going in opposite directions stopping each other, which, however, very frequently takes place, and on an average not more than nine boats can be reckoned on as passing up or down in an hour.

The whole time taken to ascend the inclined plane, allowing two minutes to enter the caisson, and two minutes to leave it, does not exceed ten minutes; but as one boat is entering while another is leaving, there is a boat passed upwards every eight minutes. Were there always empty boats both ascending and descending, one would be passed up and one down, both in ten minutes; but, as it has been before stated, cases of empty boats descending, although they do occur sometimes, are very rare.

Putting out of consideration the aggregate amount of traffic that can be passed, the time saved by the incline to each boat, considered by itself, is from two-thirds to three-fourths, as each takes only nine or ten minutes, instead of thirty or forty, to ascend; and there is also a very great economy in the wear and tear of the boats and gates, and in labour of men and horses, by using the incline instead of the locks. This seems now to be so well understood that there is a great feeling in favour of having the inclined plane worked constantly, instead of only during summer, as was originally intended; and there is little doubt that soon it will be found necessary to keep it going all the year round.

The working of the inclined plane, after it had been suspended for above four months during the winter, was resumed on 21st March, and it has been acting successfully and satisfactorily since then up to the present time, taking up generally about 13 boats in two hours.

From 20th March till 23rd August 1851, there were passed over the incline 5227 boats up, and 225 down, making a total of 5452. The longest day's work was ten hours, and the greatest number of boats passed in a day was 55. Rather a singular effect, and one which it may be worth noticing, is produced, in the frequently-occurring cases of the boats being taken up, for the sake of lightening the load, with rather less than the full depth of water in the caisson, which is due to the level of the canal, or when the upper reach of the canal is over-full. On the opening of the two gates or sluices, after the caisson has been pressed close to the mouth of the canal, a rush of water takes place from the canal into the caisson to level the surface, and this water being stopped by the after-end of the caisson, recoils, and forms a wave in the opposite direction, which, striking the stern of the boat, drives it with a considerable impetus out of the caisson into the canal, without any help being required from the horse. This result, which was quite unlooked for, considerably expedites the working of the incline.

The total cost of the incline, including land, amounted to about 13,500*l*.

In conclusion, I have to express my sense of very great obligation to Mr. Crichton, the superintendent of the Forth and Clyde Canal Company; Mr. M'Call, the overseer of masons; Mr. Wilson, the overseer of mechanics; and Mr. Thomson, the overseer of the Monkland Canal, for their zealous and efficient co-operation in their respective departments, in carrying into execution the plan of the works, and in devising means for giving increased facility and efficiency to the working of the inclined plane.

JAMES LESLIE, C.E.

Edinburgh, February 28th, 1852.

[*For Reference to Engravings see next page.*

Reference to Engravings of Blackhill Canal Inclined Plane, Plates XXIII. XXIV. *and* XXV.

a a, Lines of rails and ratchets laid on longitudinal timbers: gauge of rails 7 feet.
b b, Caisson and carriage of wrought-iron. Caisson 70 feet long, 13 ft. 4 in. wide, and 2 ft. 9 in. deep, with wooden framing to serve as fenders for guiding boat, which is shown in the caisson.
c c, Drums or rope-rolls, 16 feet diameter, and making about one turn for twelve strokes of the engine.
d d, Spur-wheels for driving rope-rolls.
e e, Pinion for driving spur-wheels.
f f, Vertical sluices at ends of caisson.
g g, Bevel gear for lifting sluices, with balance-weight.
h h, Vertical sluices at entrance to upper reach of canal.
i i, Gearing and portcullis for lifting sluices.
k k, Gearing for laying ropes on the rolls.
l l, Hydraulic apparatus and weight of 8 tons, lifted 4½ feet, for pressing caisson with a power of 12 tons, and a range of 3 feet, close up to the masonry of the canal, so as to tighten the joint.
m m, Trough for carrying the spilled water into the uppermost basin of the canal.
n n, Springs for taking jerks off the rope and for working the safety palls.
o o, Palls always working in the ratchets when the caisson is ascending, and also arranged so as to work when the caisson is descending, should anything go wrong with the rope.
p p, Rope sheave.
q q, Stair down to rope-roll chamber.
s s, The upper reach; *n' n'*, the canal boat; *o'*, bottom of canal; *p' p'*, pinion on end of crank-shaft, driving wheel with friction-centre, and lying-shaft carrying pinion; *e*, motive-power, two coupled engines of 25-horse power each. Average height from surface to surface of water, 96 feet; length of rails, 1040 feet; gradient, 1 in 10.
Weight of carriage, caisson, water, and boat, from 70 to 80 tons; weight of empty boat, about 22 tons.

ADMISSION OF DAYLIGHT INTO BUILDINGS.

By Robert Hesketh, Architect.

[*Paper read at the Royal Institute of British Architects, May 17th.*]

Light has been reckoned by philosophers as by no means amongst the least necessary of the substances or influences which nature has provided for the proper development of the functions of animals, especially of those endued with rational faculties. Every rudimentary treatise on chemistry, physiology, or other branch of natural philosophy which touches upon the subjects of light or of organic matter, whether in the animal or the vegetable kingdom, connects the perfect development of the one with the full influence of the other. Lavoisier, writing in the last century, states—"Thus much is certain; that plants which grow in darkness are altogether white, languid, and unhealthy, and that to make them acquire vigour, and recover their natural colours, the direct influence of light is absolutely necessary. Something similar takes place even in animals. Mankind degenerate to a certain degree when employed in sedentary manufactures, or living in crowded houses, or in the narrow lanes of large cities; whereas they improve in their nature and constitution in most of the country labours which are carried on in the open air." It is remarkable that this philosopher has placed light as an agent of health even before pure air, and the other sanitary requirements which are receiving most attention at the present day. But upon rational and moral beings there is doubtless a beneficial influence on the mind, *greater* and *more direct* than that upon the body, so that it may be safely alleged that habitual existence with deficiency of light, whilst it cannot improve the intellectual faculties, is unfavourable to cheerfulness of mind, high standard of morals, and health of body.

This preface, short as it is, I almost feel to be unnecessary, before offering to your attention some remarks and suggestions as to some of the means by which architects may carry into practice in their buildings, especially in narrow and confined parts of towns where most difficulties on this subject occur, a sure system of obtaining a sufficiency of daylight. The objects to which this paper is limited are—*first*, to demonstrate the methods by which light, admitted through openings, may be estimated *proportionably* as to quantity and effect; *secondly*, by reference to existing buildings, to endeavour to settle the numerical proportions obtained by such estimate into *definite* effects; and, *thirdly*, to suggest means, where the definite effect so ascertained is too little, of increasing that effect, and of ascertaining the increase.

Scarcely any rules on this important subject have been laid down by writers on architecture. Such as they are, they will be in most instances deceptive, and it will even be safer to trust to one's general idea of sufficiency than to such rules. Palladio, for instance, has said that the openings of windows should not exceed a fourth, nor be less than a fifth of the length of a side of a room, and should be in height two and one-sixth times the width. Mr. Gwilt has given the nearest approach to a definite rule that I have met with, which is to allow 1 foot of glass to 100 cubic feet of room. The subject, evidently, requires a more exact system of computation; and I trust, that whatever may be your opinion of the system now proposed, you will, at least, pardon the attempt. Some matters which come into a full consideration of the subject (it will be seen) are not ascertained with that precision which will result, I think, from experiment, conducted, except in one instance, on the basis of the system now to be defined. They do not, however, prevent a practical use being at once made of the system. One of these is of importance, and requires careful investigation—viz., the proportion of light which is absorbed in its passage through different kinds of glass at different angles of incidence. Crown, sheet, and polished plate glass, allow almost all the light to pass. Rough plate and ground glass, including rough plate ground either on the rough side or that which is fire-glazed, are as transparent in their substance as the others, and the only additional absorption of light which takes place is owing to irregularity in the refraction of rays at the surfaces, many of them being so refracted into the substance of the glass as to be partially or wholly absorbed. If, therefore, the respective action of the three surfaces — viz., rough, fire-glazed, and ground, on rays of light at different angles of incidence were determined, a very approximate proportion may be found, showing the relative obstruction by all these different kinds of glass. Fluted and embossed glass of various kinds may be added to the list, though, if the flutings and embossments are flat, probably they do not intercept the light more than the glass first above-mentioned.

In forming any estimate of the light to be derived in any place, variableness in the sources of light must not be taken into account, but provision must be made, especially in our climate, for sufficiency under ordinarily unfavourable circumstances. For this reason, a southern* aspect must be treated as a northern, and the zenith as a horizon, though in towns the former is often by far the purer source. The hemisphere of sky will therefore be considered as an equable source of light.

Methods of estimating the Proportions of Light passing through one or more Openings.

When a plane is exposed to a hemisphere of light, the incident light is equal in every part of it, and therefore every figure on that plane receives light in proportion to its area. We shall consider the case of rectangles, and from them (including squares) we shall obtain the proportion on the inscribed circles, ellipses, and other figures by direct proportion.

As we must examine the subject with reference to the obstructions to the incident light which ordinarily occur, we must therefore find a measure which will give us the quantity derived from every portion of that hemisphere. Now, *to* every point in a rectangle (so exposed to a hemisphere of light) a ray falls *from* every point in the hemisphere. Systematising those rays according to their parallel direction, they would form an infinite number of prisms of which the rectangle is the common base. The light, however, falling on the rectangle may be measured *proportionably* by estimating the proportion of rays falling on the vertical planes, passing through the middle of its length and width respectively. Mr. Hesketh then explained, by diagrams, how the proportional quantity of light may be determined when falling upon a rectangle exposed to a hemisphere of light, or when passing through a similar opening in an opaque plane without thickness—the formula being the same. He noticed also that, inasmuch as a horizontal skylight is exposed to a hemisphere, but an upright window to only a quadrisphere of light, the value of the former is exactly double that of the latter.

* A southerly aspect should be considered as desirable, not so much in respect of light as of warmth, and of the enjoyment we, in our dull latitudes, derive from an occasional gleam of brightness. The regulation of such light is more fitly effected by blinds and curtains than by structural provisions.

Mr. Hesketh next considered the proportionate diminution of light occasioned by the various obstructions which occur in practice, and first, that owing to the thickness of the wall or inclosure in which is the rectangular opening. This was demonstrated, first, with regard to openings with square sides; secondly, where part of the sides is splayed off; and thirdly, where the sides are altogether irregular. The same method was applied to all kinds of openings in succession, such as well-holes through several floors under a skylight, secondary or borrowed lights, and to shafts for admitting light. In the case of a succession of well-holes, it would be necessary to deduct from the light which passes through the first that which passes through the second, in ascertaining the available light between the respective floors. The method proposed can only be properly described when illustrated by the diagrams. It may be stated that the basis of the method is the consideration of the parallelograms of rays which would pass through an opening in that plane (through each of the middle lines of its length and breadth respectively) which is perpendicular to the plane of the window opening; commencing with one of the extreme rays which *can* pass through (where the width of the parallelogram is *nil*), and proceeding with the parallelograms in either such plane derived from the successive portions of the source of light; which parallelograms at first continuously increase in width, and then continuously decrease till they vanish again in the line of the other extreme ray. These would be measured at successive small intervals, say degrees, by the chords of the successive arcs of the semicircle, described on the line of one of the extreme rays between the angles limiting the successive parallelograms in width, and therefore by the sines of the half-arcs, which arcs correspond with the angle made with the side of the opening by the line (*diagonal*) of the extreme ray. The sums of the sines of all these arcs, multiplied by the radius (or half-diagonal), would give a proportional measure of the rays passing through the opening in the planes, both of its length or breadth; which results being multiplied together, would give a number measuring proportionably the whole light passing through the opening. A table of the sums of sines of angles from 0° to 90° is all that is required to make the estimate simple and short. Though circular, elliptical, and other openings do not always strictly follow the proportion of the circumscribing square or rectangle, yet they do so sufficiently for practical purposes. Examples of the application of the rules were given in the following cases of windows 6 feet by 3 feet: first, in an opaque plane without thickness; secondly, in an 18-inch wall, with square jambs and cill; and thirdly, in the same wall, with the inner 9 inches of the jambs splayed off to an angle of 45°, and with a recessed window-back 9 inches thick. The proportionate numerical values deduced were, in the first, 30,161; in the second, 16,324; and in the third, 19,647; those numbers, by comparison, showing the loss by thickness of wall, and, on the contrary, the gain by splaying the jambs and recessing the window-back.

The next class of obstructions to daylight consists of external objects. These are so various in their forms and characters, and often practically so difficult to measure that no very precise rules can be laid down. In towns they are chiefly buildings which may be generally classed as either parallel or perpendicular to the wall of the window, or nearly so. If the buildings are opposite to a window, and nearly parallel to the wall of the window, the angular height of the buildings, taken from the middle of the window, would give the proportion of obstructed light, and then the sums of the sines must be taken only to the angle made with the perpendicular by the line from the middle of the window to the top of the opposite buildings. This will give the direct light. The reflected light from the buildings would be found by applying the formula to the remaining angular height of the buildings, multiplied into such a fraction as would represent the ratio of the reflected light to that of the sky.

But in all cases of objects which are distant, it would be easy to form a judgment of the upper line of that which may be considered as the intercepted *lune* of light, two-thirds of the side obstructions, measured spherically, being allowed to one-third of the opposite ones in forming the average. In practice, I think this method will be found very easy of application. When the buildings are near and come within the scope of the architect's measurements, then the light will be accurately ascertained by reckoning the lines which form the outline of the unobscured portion of sky as the *outside* of the opening which admits light. Where there is a roof, as of a portico or verandah over the window, the outside lines of the soffit must be considered to be the outside of the opening. Generally, it may be remarked on this head that accessible obstructions may be estimated by supposing them as parts of the sides of the openings — inaccessible ones being more distant, it is of less importance to estimate accurately.

Method of estimating Effective Light passing into a Room.

We have as yet considered the proportions of light passing through openings; it remains to inquire into the effect of the light in a room.* The distance to which light passes into a room after admission, though it makes no difference as to *quantity* (because exactly as the intensity of light diminishes, so the area of surface lighted increases—viz., as the square of the distances from the opening to the parts where it falls), yet, in practice, a room is found to be much better lighted when the light passes far into a room than when only to a short distance. This effect is caused perhaps, first, by the eyes adapting themselves to particular lights by a slight alteration in their form; and thus, if a room be partially lighted, they adapt themselves to the stronger partial light, and the other parts appear more gloomy. The converse of this is shown by the effect of sun-light produced at dioramas, &c., by the direct light from the sky contrasted with the darkness of the remainder of the room. The second cause is, perhaps, the better adaptation of the whole room to use when all is sufficiently lighted than when part is lighter than necessary, and part too dark for comfort. There are probably no means of forming an exact estimate of the value of the distance traversed by light after admission before it falls on the surfaces of the room. The value certainly varies where the distance varies, but it also does not vary so rapidly as the distance. From this (and consideration of facts), I think the effect (though not the quantity) of light may be deemed to vary as the square root of the average distance through which it traverses a room. For ascertaining, then, the *effective* light, the numerical value of the proportionate *quantity* should be multiplied by the square root of the distance.

Little has been yet said with regard to the light reflected from external objects. These vary exceedingly, not only in the light or dark colours of the surfaces, but also in the quantity of light falling on the surfaces, both which circumstances greatly affect the quantity of light reflected from them. Where opposite buildings are very near to one another, they will be shadowed *by* one another; and therefore much less reflected light will result in such cases. Much may doubtless be done by having white or light-coloured surfaces, but perhaps no surface obtainable for a wall exposed to the open air can permanently reflect more than one-tenth of the light received upon it.

Method of ascertaining Definite Effects of Light.

A surer mode of lighting rooms in such places will be proposed below, and I will now pass to my second object, of endeavouring to settle the *numerical proportions* obtained by the above-mentioned processes into *definite effects*. Now the only means of coming to a result on this head is to show the numerical proportions which, on the basis of the forms of estimate before given, are found in different existing buildings. From our knowledge of the effect which we can perceive in such buildings, we may determine the number which should be assigned to rooms of different kinds for, say, every 100 cubic feet in the room. At a future time, I hope to collect more examples than I have as yet been able to do; and till then I shall not attempt to settle those numbers for fear of misleading, but will only give the results in a few buildings where the estimates have been made—viz.:—

Pantheon at Rome.†

Cubic contents	1,889,873 feet without side chapels.
Numerical value of light	9,003,507
Numerical value per 100 cubic feet ..	476

Rotunda, Bank of England.

Cubic contents	126,477 feet.
Numerical value of light	1,933,023
Numerical value per 100 cubic feet ..	1,500

* The difference occasioned by the manner in which a room is to be coloured or furnished cannot form the subject of any rule, but must be taken into account by estimating the effect of light in existing examples of various classes of rooms.

† Probably the Pantheon, which has been noted for its sufficiency of light, owes it to the brighter sky of Italy; for the proportion is small compared with buildings in England.

New Drawing Office, Bank of England.

Cubic contents	201,240 feet.
Numerical value of light	5,879,250
Numerical value per 100 cubic feet	2,922

Freemasons' Hall, Great Queen Street.

Cubic contents	98,192
Numerical value of light	2,136,922
Numerical value per 100 cubic feet	2,170

Great Hall, Euston Terminus.

Cubic contents	483,730
Numerical value of light	5,275,452
Numerical value per 100 cubic feet	1,090

Means of obtaining Additional Light where the Definite Effect is too little, and of ascertaining the Additional Effect.

This object, the third proposed, may be obtained by the use of reflectors. Very little use has hitherto been made of this expedient, and this is probably owing to the difficulty (often impossibility) of placing a reflector so that it will be, at the same time, in a proper position for reflecting the light to particular parts, and yet neither obstructive nor unsightly; and to the difficulty of regulating any such reflector, and of obtaining reflectors which will not be injured by the sun, the weather and the atmosphere of towns.

A single reflector may generally be placed on either the outside or inside of a window or skylight, so as to throw the light from the (perhaps small) portion of sky which remains unobscured over head to any part in which more light is required. But besides the objections already mentioned to a single reflector, there is also a considerable loss of side-light either by the reflector, if within the window, being partly obscured by the window-jambs, or, if without, by its reflecting part of the side-light against the outside of the wall, and not into the room. All these difficulties may be overcome in almost every case by, as it were, cutting up the single reflector into strips and arranging them one above the other, either in the reveal of the window, or in some other part where it will not interfere with ventilation or the action of the sashes. These combinations may be arranged horizontally, vertically, or obliquely, according to the positions of the centre of the unobscured portion of sky, and of the part into which the light is to be thrown, and according to the shape of the opening in which the combination is to be placed.

Mr. Hesketh then exhibited models of different methods of applying the principle. First, a model of a combination adapted for fixing in the reveals of windows. The reflectors would measure each 4 inches or 5 inches wide by the width of the opening, and be regulated instantaneously by a lever bar moveble from the inside of the window. They would be similar to the specimens exhibited, of glass coated in a brilliant manner with real silver chemically deposited, and therefore protected from the oxidising effects of the atmosphere. He stated that a combination had been fitted to a vault (at the Depôt Wharf in the Borough) 96 feet in depth from front to back. The area into which the window opens is a semicircle on plan, 2 ft. 4 in. projection by 4 ft. 10 in. wide, with a heavy iron grating over it, and the result is that small print can be easily read at the far end of the vault. The second model was a combination formed with glass tubes (manufactured by Messrs. Powell, of Blackfriars) of an equilateral triangular section silvered on the inside, and fixed in a light frame one above the other to form a dwarf window-blind, and the light from the exterior falling on the upper surfaces of the tubes is reflected into the room. The third was a combination, to be fixed as on the surface of a wall, under a skylight or within a window, from which combination the light is reflected in any desired direction.

In answer to Mr. Donaldson, Mr. Hesketh said that no streakiness whatever appeared in the light reflected because of the divergence of the reflected rays which therefore intermingle at a very short distance from the combination, and that in practice the effect was very uniform. The reflectors may be combined with ventilating glass louvres; or they may be made with wrought-iron backs, and thus form fireproof shutters closed at a moment's notice, which, inasmuch as their reflective use would be mostly required in cases where opposite buildings are near to a window, would be an important consideration. He then showed how an estimate may be easily made of the quantity and effect of the reflected light on the principles he had before defined, by considering that the light reflected from a reflecting surface is equal to that which would have passed through an opening equal to that surface, and in the place of the reflector, allowance being made for the light absorbed by the reflector. As an example, he supposed the case of a room 16 feet by 14 feet and 11 feet high, having a window 7 feet by 3 ft. 6 in., opening into an alley 10 feet wide, with the opposite houses 28 feet high. The direct light he estimated at 4090 numerical value, which would give 166 per 100 cubic feet. If three reflectors 4 inches wide were placed in the reveal, the top one would give 1409 of effective light; the second and third, 992 each; total 3393. These reflectors would scarcely intercept any rays but those which would have fallen on the window-cill and jambs, so that together the total effective light would be about 7483, or 303 per 100 cubic feet. Every additional reflector would give 40 additional per 100 cubic feet. In this estimate, an allowance has been made for the absorption of light by the reflectors; but this should not be made in ordinary cases, where the ceiling against which the reflected light is thrown, being far lighter than the floor, fully countervails that absorption.

Mr. Hesketh, in conclusion, stated that it was his intention to offer the Institute some suggestions on the admission of daylight into particular buildings, so as to obtain certain qualities as well as quantities of effect, including two classes which deserve much study—viz., picture galleries, and warehouses for the sale of Manchester fabrics, and other such goods.

Mr. Chapuis, the agent for Mr. Troupeau, exhibited and explained specimens of his Diurnal Reflectors, which were of copper, fluted and silvered, and protected, in some cases, by a sheet of transparent glass.

Mr. T. L. Donaldson, the Chairman, expressed his opinion, which he was sure was also that of the members generally, that the subject introduced by Mr. Hesketh was one of very great interest; and as that gentleman had promised to extend his observations on it at a future period, he thought it was desirable, in the meantime, that the members should take some opportunity of visiting the places where the invention described, as well as that of Mr. Troupeau, might be seen in actual use, so as to be enabled to enter upon a discussion of the subject more satisfactorily than they could on the present occasion.

NOTES ON CONSTRUCTION.

By Samuel Clegg, Jun., M. Inst. C.E., F.G.S.

*** These Notes, when completed, will be published in a separate form, as a Hand-Book for the use of the Students at the School of Construction.

Bricks and Brickwork.

In any country or district of a country where stone fit for building purposes is not found, bricks are substituted,* which are made from certain argillaceous earths, prepared by various processes suited to the original nature of the material, moulded into convenient shapes, and then burned. Mr. E. Dobson's work on the 'Art of Making Bricks and Tiles,'† may be consulted by those students desirous of becoming acquainted with it, and a few visits to brickfields after having perused the book will afford such an insight into the various processes as will be sufficient for their general guidance in practice.

By reason of a tax which was imposed upon bricks at the close of the last century, they have been made in a mould 10 inches long, 5 inches wide, and 3 inches deep; 150 cubical inches being the contents of a brick mould fixed by act of parliament. The duty upon bricks was last year happily repealed, still custom has hitherto provented much change being made in their size; but there is evidently a feeling with many of our architects that a change in form is desirable, and also that for the construction of house walls *hollow* bricks are preferable to the ordinary solid ones. Hollow bricks will certainly possess one very great advantage—viz., that of preventing the penetration of moisture through the wall, an object of vast importance in houses whose basements are perhaps beneath the surface of undrained ground. The best kind of hollow brickwork is that adopted by the Society for Improving the Condition of the Labouring Classes, from the design of Mr. Henry Roberts, F.S.A., honorary architect to the Society.

The dimensions of ordinary bricks produced from this mould (10 inches long, 5 inches wide, and 3 inches deep) vary according to the amount of contraction that takes place during the drying

* Except when economy is not the chief consideration, or when for ornament or for other reasons it is desirable to use stone. † Weale's Rudimentary Series.

and burning. The average size may be taken at 8¾ to 9 inches long, 4¼ to 4⅜ inches wide, and 2½ inches deep. The depth of a brick need not bear any definite proportion to its length and breadth, but the length must exceed twice the breadth by the thickness of a mortar joint—viz. about ¼-inch.

The necessary qualities of good bricks are, that they should be true in their shape, and ring when struck together; because the absence of the first prevents the possibility of good work being executed with them, and of the last that they have not been sufficiently burned. The colour of a brick is no index of its quality. Bricks of an uniform colour add to the good effect of work, and therefore should be chosen; but this uniformity may be of any shade. Truly-shaped and sound *stocks* are the most generally serviceable for engineering work; *place* bricks are those which have not been thoroughly burned, and are worthless.

When bricks are placed together, and united by mortar or cement, so as to form walls, piers, or any other erection, it is called *brickwork*. The strength of a mass of brickwork, in any form or situation, depends more upon the proper arrangement of the materials forming it than upon the strength of the materials themselves, if they are at all fit for the purpose of building—that is, if they will not crush with the weight of the mass above them, and will resist weather.

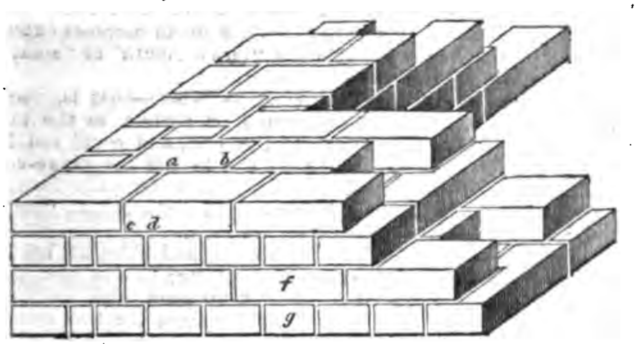


Fig. 1.

When two contiguous bricks have a third lying over or against them, so as to cover the joint between them, they form a certain dimension of overlap, and unite their strength, one brick being difficult to remove without the others; this is called *bond*, and the amount of overlap is the amount of bond; thus from *a* to *b* (fig. 1) is half-bond, the overlap being 4½ inches, or half the length of a brick; from *c* to *d* is quarter-bond, the overlap being one-quarter the length of a brick, or 2¼ inches. *Stretching* bond is when the longitudinal direction of the bricks is parallel to the face of the wall, and consequently presents the whole length of the bricks on the outside. Thus the course *f* is a stretching course, and the bricks of that row are called *stretchers*. *Heading* bond is when the longitudinal direction of the bricks makes a right angle with the face of the wall, and presents the *ends* of the bricks on the outside, as the course *g*, and the bricks in that course are called *headers*. The divisional lines of mortar between the bricks are called *joints*, and the rows of bricks between each horizontal joint are called *courses*; thus the upper and lower courses in fig. 1 are stretching courses, and the middle course is a heading course. The thickness of all brickwork, that is, its depth from face to back, is regulated by the dimensions of bricks; thus we have a half-brick wall, or one of 4½ inches; a one-brick wall, or one of 9 inches; a brick-and-a-half wall, or one of 13½ inches; and so on, advancing by half-bricks. The front of a wall is called the *face*, and the other side the *back*.

The *height* of a wall is also regulated by brick dimensions, and is often computed by the number of courses. One way of regulating the thickness of the joints (a matter of great importance) is to specify the number of inches that every four courses shall occupy; thus, supposing every brick to be exactly 2½ inches deep, and every joint to be ¼-inch thick, four courses would be contained in 11 inches; but unless the bricks be carefully picked, or rubbed to an uniform size, this nicety cannot be attained in ordinary erections,—but where it is, the work is called *gauged* work, because all the bricks are worked to a gauge of a certain dimension. In the ordnance works, and the fronts of good houses, four courses occupy 11½ inches in height; and in engineering works generally, except in some particular instances, four courses usually occupy 12 inches in height, *which height they ought never to exceed*; this is allowing 2⅝ inches for each brick, and ⅜-inch for each joint—dimensions amply sufficient to compensate for all defects, either in material or workmanship. In arranging any openings in brickwork, or when proposing to insert stone, the dimensions, particularly as to height, must be regulated by that of the courses, otherwise bricks will have to be cut.

There are two methods of bonding brickwork—viz., the English and the Flemish; but the latter method is so objectionable, that it ought never to be employed, for the reasons to be given presently.

English bond is the continuation of one kind of bond throughout the same course or horizontal layer, the courses being alternately all headers and all stretchers, as in fig. 1. The stretching courses bind the parts of the wall together in the direction of its *length*, and the heading courses bind them together in the direction of its *thickness*, or transversely. In plan, the bricks are seen in half-bond, and in elevation in quarter-bond. It is chiefly on this account that old English bond does not separate at the joints, but when a fracture occurs by the foundation yielding unequally, or from any other cause, it runs indiscriminately through bricks and joints, or breaks like any other solid body, such as stone of one piece would do. A wall constructed in this manner has, therefore, considerable strength, for the parts of a wall are less liable to separate the longer the bonds are. The bonds are greatest in the direction of the length of the bricks, for one brick overlaps its neighbour 4 inches, which is the length that must be removed before they can separate without breaking.

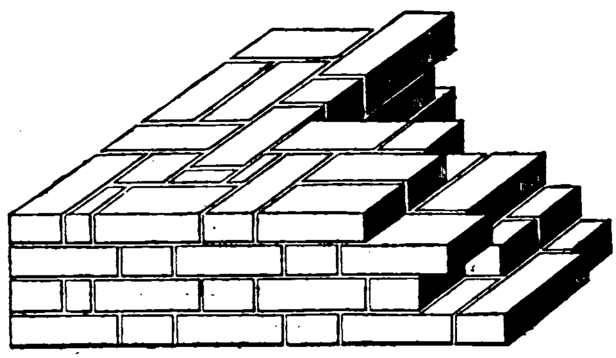


Fig. 2.

What is called *Flemish bond* consists in having alternately a header and a stretcher in the same course, as in fig. 2. This mode was introduced, together with other Dutch fashions, by King William III., as may be ascertained by observing brickwork prior and subsequent to that period, 1688. Strength was then sacrificed to a minute difference in the outside appearance, and bricks of two qualities were made for the purpose—a fine brick, often to be rubbed and laid in what is called a close putty joint, for the exterior, and an inferior coarse brick for interior substance of the wall. Architects of the present day very frequently specify for walls to be faced with *malms* or other fine brick, the backing to be of inferior kind, that they may obtain a good outside appearance: but this is obtained at the expense of strength in the wall. Malm bricks contract less in drying and burning than do common stock bricks, made from clay without the admixture of chalk; the consequence being, when these two qualities of bricks are thus used in the same wall, a thicker joint at the back than at the face. Mortar joints shrink by the pressure of the work upon them, especially if it be a slow-setting mortar, and the thicker the joint the more settlement: therefore, a wall with unequal joints at the front and back will be in danger of settling out of plumb.

Various schemes have been projected for obviating the defects in working with Flemish bond, which defects are—first, one or both faces bulging away from the interior substance; secondly, the separation of the wall into two thicknesses along the middle, called *splitting*, which is the great terror of bricklayers, and occurs more especially if the wall is very high or has to support great weights. To prevent these evils then: courses are at intervals in the height of the wall set in cement, or iron hooping is laid in the joints; or diagonal courses of bricks at certain heights are introduced—but this is a very doubtful cure, because the diagonal course is not continued to the outside, and the bricks are much mangled where strength is wanted. Others, again, lay all heading courses within the outside Flemish bond, as shown in fig. 3; and this is a practice in great repute, making the facework alternately of brick and half-brick in thickness. This, as far as relates to the *splitting* of the wall, is an effectual preventive; but in curing one evil another is increased, for there is no stretching bond to bind the work together longitudinally, the little that occurs in Flemish bond being too trifling to avail much.

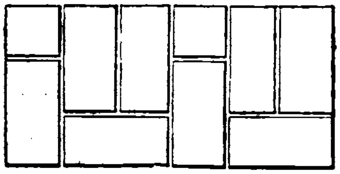


Fig. 3.

There is yet another practical reason why Flemish bond is objectionable. When the Flemish facings occur on both sides of the wall, they furnish no indication of the interior arrangement, they supply no guide to the workman as to the disposition of the vertical joints, for every course is similar on the outside. The interior of the top course is not seen, on account of being covered with mortar for the bed of the next course above it; and to recollect how every brick was laid beneath, is more than can be expected from men who are dispatching work. The work will, by inadvertance, produce continued joints that divide the wall into several thicknesses, when the separation or splitting usually takes place. In the old English bond, a workman cannot lose his way, for the outside of the last course shows him how the next is to be laid. It may be observed, that in the same course there cannot be *both* heading and stretching bond with complete effect throughout the line of wall, for wherever the stretching bond is crossed by the heading bond, the continuity and effect of stretching bond is destroyed; therefore the mixed position of the bricks will not answer, and it often produces a perpendicular joint in the middle of the thickness, dividing the length effectually into two or more walls. The outside appearance is all that the most strenuous advocates for Flemish bond can advance in its favour: of this, however, opinions are far from being in accord. Thus much has been said about Flemish bond that it may be avoided.

The directions for laying English bond to be given in specifications are—each course to be alternately all headers and all stretchers; *every brick in the same course is to be laid in the same parallel direction*, and in no case is a brick to be placed with its whole length alongside of another, but to be so situated that the end of one may reach to the middle of the others that lie contiguous to it, except in the outside of the heading courses, when *closer* bricks necessarily occur at the ends to prevent a continued upright joint in the face-work; quoins, or walls that cross at right angles, will have all the bricks of the same level course in the same parallel direction, which completely bonds the angles. These directions answer for walls of all thicknesses, all that is necessary being to repeat the courses until the proper thickness is attained.

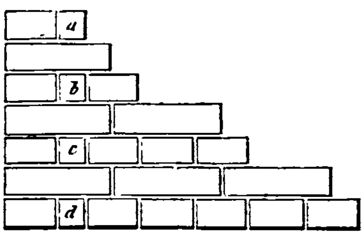


Fig. 4.

Bricks on the same course have half-bond with one another, while the bricks of the upper and lower courses have only quarter-bond with those above or below them; this is obtained by inserting *closer* bricks at the ends of each heading course, and these may be quarter bricks or threequarter bricks; the first are termed *queen*, and the second *king*, closers. Upon the nicety with which these closers are adjusted depends the bond of the entire work; and to make sure of the closers being thus properly adjusted, the best workmen only should be employed to raise the quoins, which consist of a certain number of courses racked back above the intermediate portion, as in fig. 4. The quoins give also *line* to the work. The closers *a*, *b*, *c*, *d*, are the bricks that give the longitudinal bond, by causing the second header of the course to lie half-way over the joint between the first and second stretcher, which it would not do if no closer were inserted. The angle or quoin of the wall is made perfectly vertical (or plumb) by a plumb-rule, and the courses are worked by a guage-rod, which is a rod marked into courses occupying the space specified—viz., 4 to 11, 11½, or 12 inches. These quoins are elevated at each end of the wall, or, if the wall be very long, at distances apart varying from 30 feet to 40 feet; a line is then stretched on the first horizontal joint between the two quoins, to which the bricklayers work, and make the line of each course perfectly horizontal.

The vertical range of closer bricks are technically called *perpends*, and in specifications it is frequently thought advisable to direct that "the perpends are to be truly kept;" for when they are not, the longitudinal bond cannot be perfect. With every care, it is always requisite to be watchful, for bricks are not exactly of the same length—they may overrun, or underrun their position in bond; the vertical joints may also vary a little in thickness, therefore a three-quarter or a cut brick has often to be inserted to gain anything that has been lost, or to keep back joints that have overrun. If the face and flank of a wall be not at right angles, the quoin becomes externally a "squint," and internally a "bird's mouth" or "splay," for both of which bricks have to be cut.

In building what is termed "compass" work—that is, work circular in plan, raised quoins would be useless, as the line would form a chord to the arc of the wall, and could not be worked to; therefore the workman has to use his gauge-rod constantly to get his courses, and a trammel or template for the sweep of the wall. For circular work of small radius, "compass" bricks, moulded to the curve, are used.

The mortar joints for the beds, ends, and sides of bricks should be laid on with the trowel carefully; to use technical language, "the work must be flushed-up solid with mortar." The general way of laying mortar is to spread the bed, scrape off with the trowel that which exudes from the face-joint when the brick is pressed into its place, and then wipe the trowel against the face-edge of the brick, leaving the remaining joints to be filled-in with the mortar that is spread for the next bed, or with *grout*, which is mortar made so thin as to run into the joints. I believe grouting to be utterly worthless, and that there is no substitute for flushing-up. When carrying up work, do not allow one portion to be raised above another more than 3 feet or 4 feet, as the weight upon the joints of any portion so raised will condense them more than those in the lower parts, which should be avoided;—not that the compression amounts to much in moderate work, but the principle should be carried out. If high chimney-shafts have to be built alongside of ordinary walls, they must not be bonded with the wall, but left to settle independently. If high buildings are bonded with lower ones, it is prudent to allow the work to settle for some days at one uniform height before carrying up the rest.

It is a common practice to leave toothings in the ends of walls, if it is the intention at any future time to erect walls in continuation of them, as will be observed in unfinished rows of houses. This is a bad practice, for the settlement of the green work will almost always break the bricks placed in the toothings of the old work. Junctions by indent should be substituted, which is a half-brick groove left in the end of the wall from top to bottom; the new work projected into this groove will settle without damage.

"Voids must be over voids"—that is, all openings in walls must be over one another, so that the piers which separate them may be carried up of an uniform width from the foundation; if this were not the case, the bases of the upper piers would be over voids, or partially so, causing certain inequality in the settlement of the work.

Beneath voids, or beneath thinner work between piers, inverted arches, or "inverts," should be turned, as in fig. 5, so that the pressure may be distributed equally over the foundation, and also that the settlement of the piers may be identical with that of the thinner work. It is a good custom to build these inverts in cement. The radius of curvature is usually equal to the width of the opening—*i. e.*, the chord and two radii forming an isosceles triangle, as in the figure.

In turning an arch between two piers, or over an opening above which weight is imposed, the skew-backs, or springing *a b*, fig. 5, should be formed by corbelling out the courses of brickwork from the line *c d*, so that the back of the arch may be disengaged from the internal upright of the wall. This is a custom not much followed, but it would be well if it were. The usual method is to spring the arch from *d*; but the pier above it has then a wedge-shaped base, which is not calculated to resist all the pressure due to the area of the work. When any stone, as at *d*, is bedded in a wall, the courses at the back should be set in cement, to prevent unequal settlement.

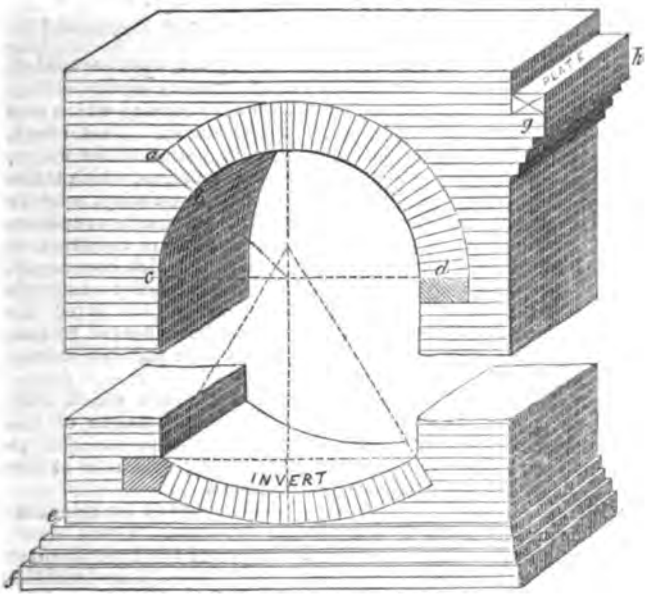
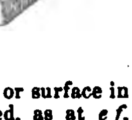


Fig. 5.

To give the bottom of a wall greater spread or surface in contact with its foundation, footings are provided, as at *e f*, figs. 5 and 6. The necessary projection of these footings will be given in the notes on "Foundations;" here it is simply necessary to state that each course should not project more than quarter-brick beyond that above it. The bases of all walls must be at right angles with their faces, and the joints carried up parallel to them. In "battering" walls, or those whose faces lean from the vertical, this must be carefully followed, to prevent any tendency in the joints to slide. The amount of batter in fig. 6 is one in ten, which means 1 foot horizontal to 10 feet vertical; but this ratio may vary according to circumstances. The strength of a wall to resist horizontal or inclined pressure depends upon its base, other dimensions being constant; if, therefore, counterforts or buttresses are built at intervals against a wall, as in fig. 6, great additional stability may be attained with comparatively little additional material. In the notes on "Retaining Walls," a practical rule will be given for the dimensions of battering walls and counterforts.

When a timber plate has to be bedded, it must never be placed within the substance of a wall, as by decaying it will cause the superincumbent brickwork to settle; but they should be laid on "salient courses," corbelled out to the proper projection, as in *g h*, fig. 5; these courses should be all headers in cement, the remaining thickness of the wall being also in cement. Two courses of bricks in cement, corbelled out 4½ inches, as in the sketch, will give way under a load of 24 cwt. per foot run; safe load stated to be 12 cwt. per foot run.* To give bond to work beyond that possible to be got by the mere overlapping of the bricks, hoop-iron along three or four courses should be laid in at intervals of from 10 feet to 15 feet in height; and if, in addition, these courses are set in cement, the "string" bond will be more perfect.



To span openings which require to have a straight soffit, as in house building, the flat arch is employed, as in fig. 7, which is a beam of brickwork formed with bricks radiating to a centre, so that it may contain an arch of 9-inch work. It is too often the practice to build false arches for this purpose, as in fig. 8, which, having no key, do not possess any of the properties of the arch, and are worthless; if they stand, their stability is due to the adhesion of the mortar.

Fig. 7.

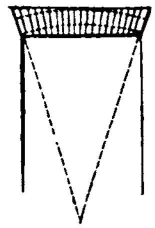
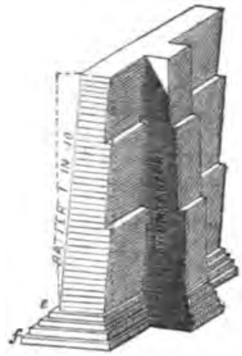


Fig. 6.



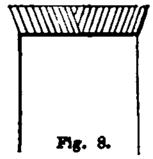


Fig. 8.

The pressure that *good* bricks will resist is very considerable; well-burnt stocks may be safely intrusted with 20 tons per foot super., but they must be *perfect* bricks. Place bricks will not stand probably more than 2 tons per foot super. I have remarked in a previous chapter that bricks should be *wet* when they are laid, otherwise they will absorb the moisture from the mortar, and prevent its proper induration.

As to the quantity of material and labour required for any brickwork. Brickwork of considerable superficial area, and of comparatively little thickness, as in house walls, is measured by the rod of 16½ feet square, making 272 feet super., the thickness being reduced to 1½ brick as a standard. The rod therefore contains 306 cubic feet. Find the area of wall in feet, multiply this by the factor of the thickness; the result, divided by 272, will be the number of rods. The factors are the constant ratios which the number of bricks in the thickness of a wall bear to 1½ brick, and are obtained by dividing that thickness in bricks by 1½. Thus, suppose a wall to be 4 bricks thick, $4 \div 1\frac{1}{2} = 2{\cdot}66$, which is the factor by which the area of the wall is multiplied to reduce it to the standard thickness.

Brickwork in mass, as in bridges, retaining walls, &c., is measured by the cubic yard. The heights, lengths, and thicknesses are taken in feet and inches; these dimensions multiplied together, and divided by 27, will give the contents in cubic yards. A rod of reduced brickwork is equal to 11⅓ cubic yards. A rod of brickwork laid to a 12-inch gauge—*i. e.*, four courses to 12 inches high, requires 4350 stock bricks. To a gauge of 11½ inches, 4550 stocks are required. But in buildings containing flues and bond timbers, which are not deducted in measuring, 4300 stocks are sufficient for 1 rod.

One rod of brickwork requires 71 cubic feet of mortar, or 1⅓ cube yard of chalk lime and 3 loads of sand; or 1 cubic yard of stone lime and 3⅓ loads of sand; or 36 bushels of cement and an equal quantity of sand. 27 cubic feet of mortar requires 9 bushels of lime and 1 load or 27 cubic feet of sand. One rod of brickwork weighs on an average 15 tons. These quantities divided by 11⅓ will give the quantities of material required for 1 cubic yard. A bricklayer, with the assistance of his labourer, will lay 1000 bricks in ten hours, in straightforward work.

EXPANSIVE ACTION OF STEAM.

Sir—With regard to Mr. Rankine's remarks in your last number, page 191, I am aware, with him, that steam does not expand according to Boyle's law unless it be maintained at a uniform temperature during expansion. This consideration, however, does not affect the comparison I had in view in the table quoted by him; for, so far as my experience of the action of steam in well-heated locomotive-cylinders goes, I have found it to expand sensibly according to the law of Boyle, which shows that, in fact, the steam really is in the favourable position required by him; and bears out substantially what I wanted to show—that in well-placed and well-conditioned locomotive-cylinders, the steam would work to much greater advantage than it now does, if every drawback were removed.

29, *Buccleuch-place, Edinburgh, June 16th*, 1852. D. K. Clark.

* 'Professional Papers Royal Engineers,' Vol. VI.

RULES FOR SOLID MENSURATION.*

By ELLWOOD MORRIS, C.E., Pittsburg, U. S.

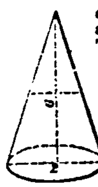
THE leading rules of solid mensuration laid down in the books, separate rules being given for each solid, are the following, every one of which may be superseded by the "prismoidal formula":—To find the solidity of, 1, a cube; 2, a parallelopipedon; 3, cylinders and prisms; 4, cones and pyramids; 5, a frustum of cone; 6, a frustum of pyramid; 7, a wedge; 8, a prismoid; 9, a sphere.

A number of other special rules are given for the solidity of spheroids, paraboloids, and other solids of revolution, their spindles and segments, to many of which our formula is also applicable; but for the purposes of this communication, it may be sufficient to show, by actual figures, working out examples of the most unpromising cases, the applicability of the "prismoidal formula" to compute the solidity of *a cone*, *a wedge*, *a sphere*, and *a hemisphere*. I may here mention that its accurate application to spheres and spheroids (solids of curved surface) has excited the surprise of many mathematicians, who were prepared to admit its fitness for the mensuration of right-lined or plane-bouuded solids.

BY SPECIAL RULES.

To find the Solidity of a Cone:—

RULE.—Multiply the area of the base by the height, and one-third of the product will be the solidity.



Given.—A cone having a diameter at the base of 2, and a height of 6. Query: The solidity?

2 × 2 × ·7854 = 3·1416
6
Mid. Diam. = 1· 3)18·8496
Solidity = 6·2837

BY PRISMOIDAL FORMULA.

To find the Solidity of a Cone:—

Add into one sum the areas of the two ends, and four times the middle section parallel to them; then this sum multiplied by one-sixth of the height will give the solidity

In the case of the cone opposite, the diameter of the base being 2, and of the mid-section 1, we have, by prismoidal formula,

Base . . 2 × 2 × ·7854 = 3·1416
4 times mid-sec. 1 × 1 × ·7854 × 4 = 3·1416
Top . . = 0·
$\frac{6}{6} = \frac{1}{6}$ ht. = 1· × 6·2832
Solidity = 6·2832

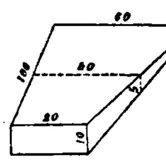
BY SPECIAL RULES.

To find the Solidity of a Wedge:—

RULE.—To the length of the edge add twice the length of the back; multiply this sum by the height of the wedge, and then by the breadth of the back: one-sixth of the product will be the solidity.

Given.—A wedge; length of edge 60, back length = 20, back breadth = 10, height 100. Query: The solidity?

Length of edge . . = 60·
Twice back . . 20 × 2 = 40·
100·
100
10,000
10
6)100,000



Solidity = 16,666⅔

BY PRISMOIDAL FORMULA.

To find the Solidity of a Wedge:—

Area of base . . 20 × 10 = 200
4 times mid-sec. . 40 × 5 × 4 = 800
Top . . . . = 0
$\frac{100}{6}$ = 16⅔ × 1,000
Solidity = 16,666⅔

We will now take the case of a sphere, to which nearly all mathematicians have at first sight denied the applicability of the "prismoidal formula."

BY SPECIAL RULES.

To find the Solidity of a Sphere:—

RULE.—Multiply the cube of the diameter by ·5236, the product will be the solidity.

Given—A sphere of a diameter or axis in length = 12. Query: The solidity?

Then—
12 × 12 × 12 × ·5236 = 904·7808 solidity.

BY PRISMOIDAL FORMULA.

To find the Solidity of a Sphere:—

Top . . = 0
4 times mid-sec.
12 × 12 × ·7854 × 4 = 452·3904
Base . = 0
452·3904
$\frac{1}{6}$ ht. = $\frac{12}{6}$ = 2
Solidity = 904·7808

BY SPECIAL RULES.

To find the Solidity of a Hemisphere:—

Take the same dimensions as in the sphere above, and we have—

2)904·78
Solidity = 452·39

BY PRISMOIDAL FORMULA.

To find the Solidity of a Hemisphere:—

Diameter of mid-section .. 10·392
Diameter of base . .. 12
Height or radius . .. 6
Then by Prismoidal Formula—
Area of base . . = 113·097
4 times mid-sec. .
10·392 × 10·392 × ·7854 × 4 = 339·272
Top . . . . = 0
452·369
$\frac{1}{6}$ ht. = $\frac{6}{1}$ 0
Solidity 452·369

The difference in the last decimals is owing to too few decimal places having been used in the computation.

* From the *Journal of the Franklin Institute.*

For the sake of illustration, it is not necessary to go any further. I think it will, on examination, be admitted that the "prismoidal formula" possesses some curious and useful properties; and that its adoption in the schools in teaching solid mensuration would alleviate very materially the tasks of the scholar.

A NEW MODE OF MEASURING HIGH TEMPERATURES.

By JOHN WILSON, of Bridgewater Works, St. Helen's.

[*Paper read at the Institution of Mechanical Engineers.*]

SEVERAL methods have been proposed for the measurement of temperatures beyond the range of the Mercurial Thermometer.

Wedgwood's Pyrometer was founded on the property which *clay* possesses of contracting at high temperatures. This effect, which in the first instance is due to the dissipation of the water, but afterwards to the partial vitrification occurring, which tends to bring the particles of clay into nearer proximity, may in some measure be regarded as an indication of the temperature which occasioned the contraction. The apparatus consisted of a metallic groove, 24 inches long, the sides of which converged, being ½-inch wide above and $\frac{3}{10}$-inch below. The clay was made up into little cylinders or truncated cones, which fitted the commencement of the groove after having been heated to redness; and their subsequent contraction by heat was determined by allowing them to slide from the top of the groove downwards till they arrived at a part of it through which they could not pass. Wedgwood divided the whole length of the groove into 240 degrees, each of which he supposed equal to 130° of Fahrenheit, and he fixed the *zero* of his scale at the 1077th degree of Fahrenheit's thermometer.

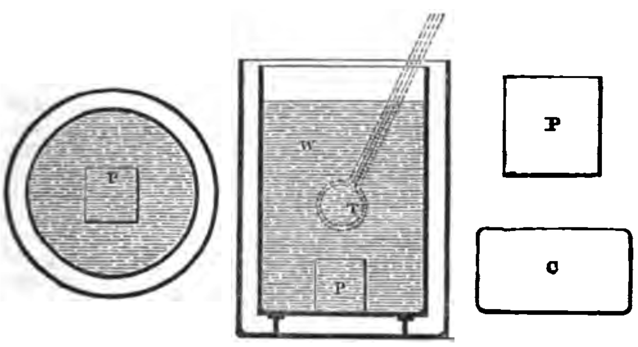
"Wedgwood's pyrometer is no longer employed by scientific men, because its indications cannot be relied on. Every observation requires a separate piece of clay, and the experimenter is never sure that the contraction of the second piece from the same heat will be exactly similar to that of the first, especially as it is difficult to procure specimens of the earth the composition of which is in every respect the same. Hence also the different results obtained by different observers; Guyton de Morveau making each degree to correspond to 62½° of Fahrenheit, instead of 130° as stated by Wedgwood."—*Turner's Chemistry.*

Daniell's Pyrometer.—In the pyrometer invented by the late Professor Daniell, the temperature is measured by the expansion of an *iron* bar inclosed in a case. This case consists of a bar of blacklead earthenware, in which is drilled a hole, $\frac{3}{10}$-inch in diameter, and 7½ inches deep. Into this hole a cylindrical bar of platinum or soft iron, of nearly the same diameter, and 6½ inches long, is introduced so as to rest against the solid end of the hole; and upon the outer or free end of the metallic bar rests a cylindrical piece of porcelain called the *index*, 1½ inch long, which is kept firmly fixed in its place by a strap of platinum and a little wedge of earthenware. The object of this arrangement is, that when the instrument is heated, the metal, expanding at each temperature more than the earthenware case, presses forward the index, which, in consequence of the strap and wedge, remains in the place to which it had been forced when the instrument is removed from the fire and cooled. There is a *scale*, afterwards attached, for measuring the precise extent to which the index has been pushed forward by the metallic bar; and it thus indicates the apparent elongation of the bar,—that is, the difference between its elongation and that of the blacklead case which contains it.

"For its indications to be correct (namely, that equal dilatations should indicate equal increments of heat)—it is necessary that the bar and the case should expand uniformly, or both vary at the same rate. But as regards the blacklead case, its total expansion is so very small that any want of uniformity at the intermediate points cannot be detected. As for the expansions of the metallic bar, these are not exactly uniform, but still they afford a good practical index of the relative intensity of different fires, and would prove an exact measure if the precise rate of expansion could be determined."—*Turner's Chemistry.*

Air Pyrometer.—In some cases the measurement of high temperatures has been attempted by means of a hollow sphere of platinum, fitted with an escape-tube; then the hotter the fire to which the platinum vessel is exposed the greater is the quantity of *air* driven out of it; and this is received over water and measured. In cases where this instrument can be conveniently applied, it is capable of yielding very accurate results. (See experiments of Pouillet, tome 1, p. 351, in *Elemens de Physique et de Météorologie.*)

New Pyrometer.—The following is the method employed by the author of the present paper to measure high temperatures. Take a given weight of *platinum*, and expose it for a few minutes to the fire, the temperature of which is to be measured, and then plunge it into a vessel containing *water* of a determined weight and temperature, and after the heat has been communicated to the water by heated platinum, mark the temperature which the water has attained: and from this is estimated the temperature to which the platinum had been subjected. Thus, if the piece of platinum employed be 1000 grains, and the water into which it is plunged be 2000 grains, and its temperature 60°, should the heated platinum when dropped into the water raise its temperature to 90°, then $90° - 60° = 30°$; which, multiplied by 2 (because the water is twice the weight of the platinum), gives 60°, that an equal weight of water would have been raised. Again, should the water in another case gain 40°, then $40° \times 2 = 80°$, denotes the temperature as measured by the pyrometer. To convert the degrees of this instrument into degrees of Fahrenheit, we must multiply by 31·25, or $31\frac{1}{4}$. Thus, $80° \times 31\frac{1}{4}$, would give 2500° of Fahrenheit. And $60° \times 31\frac{1}{4} = 1875°$. The multiplier 31·25 is the number expressing the *specific heat* of water as compared with that of platinum, the latter being regarded as 1.



W, WATER; P, PLATINUM; T, THERMOMETER; C, STOURBRIDGE CLAY.

In order to obtain very accurate results by this method, precautions similar to those required in determining the specific heat of bodies must be taken—that is, it is necessary to guard against the dissipation of heat by conduction and radiation. The apparatus used by the author is shown in the engravings, and consists of a polished tinned-iron vessel, of a cylindrical form, 3 inches deep and 2 inches in diameter; this is placed within a concentric cylinder, separated from the inclosed vessel about $\frac{1}{4}$-inch. By this means there is but little heat lost during the experiment, either by radiation or conduction. At the commencement of the experiments, the author imagined it would be necessary to employ a considerable proportion of water, and therefore took twenty-five times the weight of the platinum; but he found that the temperature gained by the water, even in cases of very high heats, did not exceed 4° or 5°, and an error of 1°, when converted into degrees of Fahrenheit, amounted to 400°. To obtain results within much narrower limits of error, it became obvious a much smaller proportion of water should be employed; and ultimately it was found that *double* the weight of water in proportion to the platinum was in all cases sufficient.

There is no appreciable loss of heat from the evaporation of steam when the hot platinum is plunged into water;—there is probably no actual contact with the water until the platinum is fairly at the bottom of the water. It is in fact the converse of dropping water on a plate of platinum or iron *strongly* heated, in which case the water, instead of being suddenly dissipated as steam, assumes the spheroidal form, and runs about over the plate without coming in contact with the heated surface. It is only when the temperature of the metal becomes much reduced that the water is rapidly converted into vapour. But whatever may be thought of this theory of contact, the fact is certain, that there is no necessity to increase the depth of the vessel of water to guard against the loss of heat by evaporation, or the escape of any bubbles of steam.

In ascertaining temperatures by this pyrometer, a correction has to be made for the portion of the total heat that is absorbed by—1st, the mercury of the thermometer in the water; 2nd, the glass bulb and stem of the thermometer; 3rd, the iron vessel containing the water; 4th, the heat retained by the piece of platinum. The portion of the total heat that is absorbed by these several bodies, compared to the portion received by the water, will be in proportion to their several weights, and the specific heat of each compared with water.

				Equivalent grains of water.
Mercury ..	200 grains	× $\frac{1}{30}$th	specific heat =	7
Glass......	35 ,,	× $\frac{1}{6}$th	,,	6
Iron	658 ,,	× $\frac{1}{9}$th	,,	73
Platinum ..	1000 ,,	× $\frac{1}{32}$nd	,,	31
			Total	117

Therefore the effect of these bodies is equivalent to the addition of 117 grains to the 2000 grains of water, or $\frac{1}{17}$th has to be added as a correction to all the temperatures obtained by this instrument; or in other words, the multiplier must be increased from $31\frac{1}{4}$ to 33 in this instrument, and in all similar ones where the weights of the mercury and glass of the thermometer, and of the iron vessel, are the same as stated above.

The following are some of the results obtained by this new pyrometer. In the experiments to which they refer, the melting points were ascertained by placing about 2 oz. of the metal in a cupel placed by the side of another cupel containing the piece of platinum;—the moment that the metal became fluid, the platinum was withdrawn, and the temperature measured as before described. It is necessary to avoid contact between the platinum and the melted body, for in some cases an alloy would be formed, and in others a portion of the melted substance would adhere to the platinum and affect the results; the closest proximity is requisite, but *contact* must be avoided. In lifting the piece of platinum, a pair of tongs is employed, *heated to redness*, to prevent any abstraction of heat during the momentary contact.

Temperatures of Melting Points in Degrees of Fahrenheit.

	WILSON. New Pyrometer.	POUILLET. Air Pyrometer.	DANIEL. Iron Pyrometer.
Silver . . .	1890°	1832°	1873°
Copper . . .	2220°	——	1996°
Grey cast-iron . .	2320°	2210°	2780°
Copper-smelting furnace	3128°	——	——
Crown glass . .	2244°	——	——
Flint glass . .	2145°	——	——
Copper slag . .	2046°	——	——

As the piece of *platinum* is the most expensive part of the apparatus, it is proposed that for practical purposes generally, a small piece of *baked Stourbridge clay* be substituted for the platinum; and the author has found by experiment, that a piece of Stourbridge clay, 200 grains in weight, when heated to the melting point of *silver*, and then plunged into the tinned vessel containing 2000 grains of water, raises the temperature of the water 41°. Now if 1890° Fahrenheit (the melting point of silver found before) be divided by 41, we obtain 46° as the number corresponding to 1° of this pyrometer; and 46 will therefore be the correct multiplier, and no corrections are required for any heat abstracted by the thermometer, the tinned vessel, or the piece of clay. The temperature of all sorts of furnaces and flues of steam-engines, &c., may be readily ascertained by means of the piece of Stourbridge clay. He had not had an opportunity at present of making experiments on the temperature of furnaces, &c., but hoped to do so shortly. He proposed to employ the pieces of Stourbridge clay for this purpose, and to carry the piece of clay in a small bowl or hollow at the end of an iron rod, which could be readily introduced into the flue through a small hole in the side, and after being left there as long as required to insure the full temperature being attained, the iron rod could be withdrawn and the piece of clay dropped instantly into the vessel of water, without being touched by any other body. He had not found any difficulty in using the pieces of clay, and had used the same piece as many as eight times without any change, and he expected it would do for a hundred times. It was only requisite to obtain ordinary pure clay, and to have the pieces well fired. The pieces should not exceed $\frac{1}{4}$-inch in thickness, to insure the clay being uniformly heated throughout, as it was so slow a conductor of heat.

The results obtained by this pyrometer could not be regarded as *absolutely* correct, the specific heat of platinum being assumed constant at all temperatures, which is not strictly true. Nevertheless, these results are quite as near approximation to perfect accuracy as those given by the mercurial thermometer, and all other instruments founded on the principle of expansion.

ON THE ADJUSTMENT OF THE TRANSIT CIRCLE AND EQUATORIAL.

By JOHN DREW, F.R.A.S., Ph. D. University of Bâle.

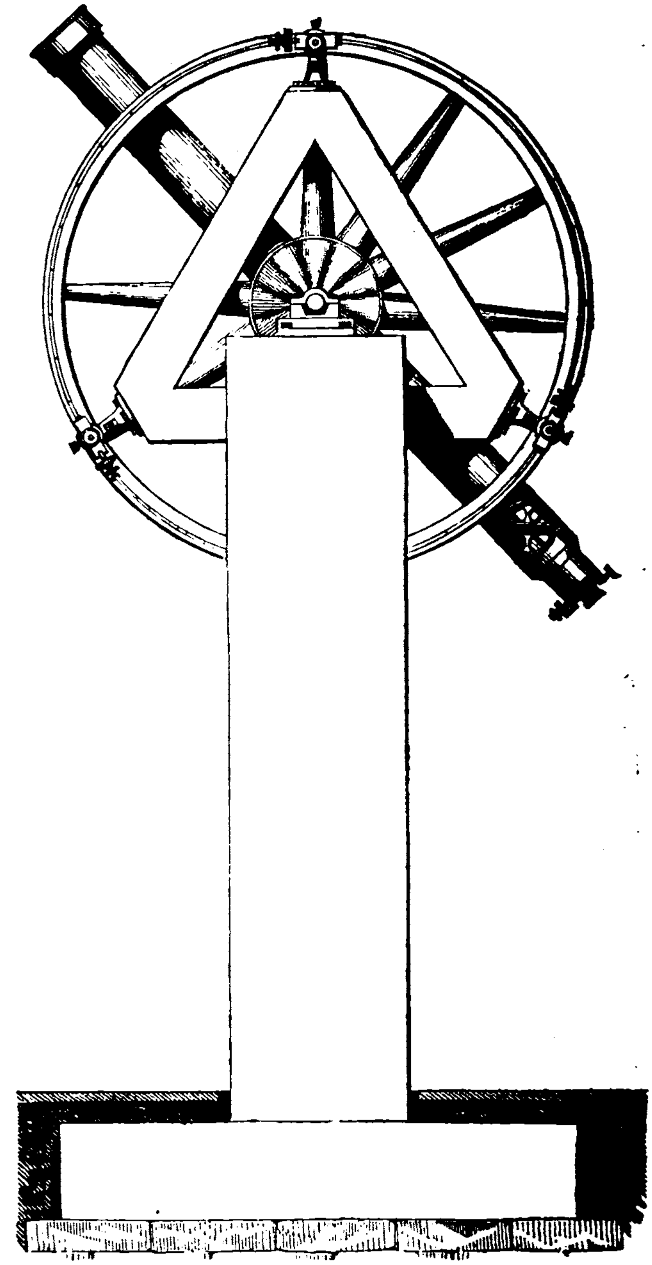
[*Read before the Royal Astronomical Society, December* 10*th*, 1851, *and published with the sanction of the Council.*]

THE following paper, on the Adjustment of the Transit Circle and Equatorial, has been published under the impression that a succinct explanation of the methods adopted might not be without its use to those who have no immediate opportunities of consulting others skilled in practical astronomy, or who have not at hand the "Greenwich Observations" or the volumes of the "Memoirs" of the Royal Astronomical Society; to which, in combination with the valuable papers of the Rev. R. Sheepshanks, and his readiness in obliging me with answers to my inquiries from time to time, I have been much indebted.

The transit circle in use at my observatory is a very fine one, by Jones, late of Charing-cross. The telescope has an object-glass of 3½ inches aperture, with a focal length of 3¼ feet, which will show the companion of Polaris on the unillumined field. As the weight of the instrument is very great, and the transit room small, and as, moreover, the mounting of the micrometer microscropes interferes, I have not been able to reverse it, but have adopted such methods in its rectification as have, I apprehend, answered every purpose of that cumbrous process. The pivots of the axis (which is 30 inches across) rest on agate bearings carefully protected from dust; their supports are based on stone piers, and the three micrometer microscopes are attached to the western pier on a triangle of stone, the base of which is hewn out of the solid block which forms the pier, and the two sides from another. Though the circle had been made fifteen years before it came into my possession, it had never been unpacked, and some contrivance was necessary before I could conveniently put the parts together. I apprehend, however, that this method of mounting the microscopes is superior to metal arms, which are subject to varying expansion from change of temperature. Two small circles, 3 inches in diameter, at the eye-end of the telescope serve for finding the object by its zenith distance. In the focus of the object-glass are one fixed horizontal wire and five vertical wires; parallel to the fixed wire another is carried by a micrometer-screw with a divided head. I have found the instrument preserve its adjustments steadily, and discharge its duties most faithfully, as the observations will show.

As, from the inclosed position of my observatory, I could not avail myself of any distant object of reference, I substituted a collimating telescope of 20 inches focal length, with an object glass of 1·6 inch in diameter, which I have mounted on a solid pier of brickwork, 2 ft. 3 in. by 1 ft. 3 in., laid in cement. It is built outside of the observatory to the north, and is carried down to the gravel four feet below the surface; being of such a height that, when the collimating telescope and that of the transit circle are both horizontal, their axes shall be in a straight line. It is protected from the weather by a moveable covering, in which are two small shutters opening north and south; when the south shutter is down, and the north (which opens downward) is depressed so as to form an angle of 45° with the horizon, the inside of it, being whitened, reflects sufficient light from the sky to render the cross wires of the collimator distinctly visible: at night they are easily illuminated.

I cannot say that the horizontal point ascertained by this collimator is trustworthy, although determined with a good level, 16 inches in length, to the amount of several seconds: the value of the collimator, however, as a point of reference is very great. The first use to which it was applied was in adjusting the central transit-wire to the vertical plane. To facilitate this adjustment the whole system of wires, including the eye-piece, has a small movement regulated by two antagonist screws on the exterior of the instrument. By making the central wire coincide with the cross of the collimator throughout the whole field of view, after the axis had been carefully levelled, this adjustment was completed.



DR. DREW'S TRANSIT CIRCLE.—SCALE 1 INCH TO 1 FOOT.

To determine the value of the run of the micrometer-screw carrying the moveable horizontal wire in the focus, the wire was brought on the cross of the collimator, and the arc of the circle read off by the three micrometer microscopes; the wire was then moved through 20 revolutions, and again brought upon the cross-wires by the slow movement of the transit circle, and the reading again recorded. Consistent results were obtained on several occasions.

Sept. 1850	... 20 revolutions = 938″	∴	1 rev. = 46″·9
"	... 20 revolutions = 933″	∴	1 rev. = 46″·65
Sept. 1851	... 20 revolutions = 936″	∴	1 rev. = 46″·8
"	... 19 revolutions = 890″	∴	1 rev. = 46″·84
	Mean of the whole		= 46″·8

To determine the distances of the wires, I make use of the wire-micrometer, att[illegible] to a 5-feet telescope. By bringing the axis of the tele[illegible]ch for that purpose must be dismounted—in a [illegible] the transit telescope, I have distinct view of the wires when the two object-glasses are directed towards each other: the value of the run of the micrometer being known, the distances are measured with ease and certainty. Thus: Oct. 1, 1851, calling the wires 1, 2, 3, 4, 5, advancing towards the illuminated end of the axis, or from west to east looking north, the following measures were taken—each revolution of the micrometer-screw being equal to 33″:—

From 1 to 3 = 578″·566 = 38s·5
From 2 to 3 = 289″·41 = 19s·29
From 3 to 4 = 289″·41 = 19s·29
From 3 to 5 = 578″·82 = 38s·58

By nine complete transits, and five incomplete, of δ Ursæ Minoris, the times of passing across the wires were,

1 to 2 = 324s·6; 2 to 3 = 325s·7; 3 to 4 = 326s·6; 4 to 5 = 326s·5,

which, multiplied by the cosine of the star's declination, give for the equatorial intervals of the wires,

1 to 2 = 19s·25; 2 to 3 = 19s·31; 3 to 4 = 19s·37; 4 to 5 = 19s·37.

To ascertain the reduction to the central wire of the mean derived from the transits over the five wires,—

By the Micrometer.		By δ Ursæ Minoris.	
−38·5	+19·29	−38·56	+19·37
−19·29	+39·58	−19·31	+38·74
−57·79	+57·87	−57·87	+58·11
	−57·79		−57·87
	$\frac{\cdot 08}{5}$ = 0s·016 = 0″·25		$\frac{\cdot 24}{5}$ = 0s·048 = 0″·72

As in neither case the difference amounts to a second of space, and as I put most confidence in the distances measured micrometrically, I have applied no correction to reduce the mean of all the wires to the central wire.

The telescope of the transit circle is provided with an eye-piece formed of a single lens; immediately underneath the lens is a perforated mirror, moving on an axis adjustable outside; an aperture at the side of the tube admits the light, which, being reflected down the axis of the telescope when in a vertical position, is again reflected from the surface of mercury: by this contrivance we see the direct image of the wires through the aperture in the mirror, and their reflected image in the mercury at the same time. A mirror outside of the tube is so adjusted as to reflect the light of the sky, which I much prefer to the lamp which the maker provided for the purpose of illumination. Now, on the supposition that the cross-level will indicate any deviation of the axis from horizontality, I have here the means of determining my collimation error without reversion. I first level carefully, so as to insure no deviation. I find, now that the foundation of the piers which were erected three years since is settled, that when once the axis is horizontal, it is not liable to derangement: thus, August 15th, 1851, the following level readings were taken:—

West readings.	East readings.
19	34 direct
35	18 reversed
19	34 direct
33	19 reversed
19	33 direct
33	19 reversed
158	157

Now, 158 − 157 ÷ 12, the number of readings, = $\frac{1}{12}$ of a division = 0″·2.

August 23rd, the readings showed no deviation:

35	21 direct
21	35 reversed

Nor did those of September 18th:

32·2	28 direct
28	32·2 reversed

Presuming now that the axis is horizontal, I have recourse to observation by reflection; and if the image of the central vertical wire does not coincide with the wire seen by direct vision, I move the wire by the collimating-screw, and bring the wire, seen directly, over its image seen by reflection: thus, I apprehend, the error of collimation is corrected. This was done August 23rd, 1851, and subsequent observations showed the correctness of the result.

I have endeavoured to determine the collimation error with two collimating telescopes, placed horizontally, one north and the other south of the transit telescope, in the following manner. If the circle could be raised (after having bisected the cross of one collimator) so as for the crosses of the two collimators to intersect each other, we should have two points exactly 180° distant from each other, measured on the plane of the horizon. On restoring the instrument to the Y's, there would be no error of collimation should the central wire bisect the northern cross, and also, when the instrument was turned half-way round, the southern. As I cannot conveniently displace my circle, I removed the object-glass and eye-piece, after producing coincidence with the vertical wire and the cross of the northern collimator; I then brought the crosses of the two collimators together, by adjusting the southern to the northern through the axis. Restoring the object-glass and eye-piece to their places, and bringing the central wire on the northern cross, I turned the instrument on the southern, and concluded that if it covered the bisection of the cross-wires, there would be no collimation error; and that if it did not, I must repeat the operation till this end was attained. In theory I believe I am right; but I apprehend my failure must have arisen from the southern collimator having moved in the interval, as it was insecurely mounted: the plan I believe to be worth a trial with both collimators mounted on stone piers.

Now, on the supposition that the collimation error has been eliminated (and the collimation adjustment is not liable to derangement), I can always rectify my level error by reflection, as is practised at Greenwich; for if the direct and reflected images of the central wire do not on any occasion coincide, they may be made to do so by the inclination-screw.

As, however, it is of consequence to be able to ascertain the inclination of the axis, for the application of the correction for that error should any be discovered after the completion of a series of observations, I have ascertained the value of the divisions of the cross-level, which, though professing to be seconds of arc, are not so in reality. For this purpose the level was strapped to the transit-circle, and the bubble moved through about forty divisions; the arc through which the circle had moved (noted by the cross-wires of the collimator) having been read off, supplied the proportion between those divisions and seconds of arc. Observations at various times have been consistent. The following were taken September 30th, 1851; temperature 56°.

38 divisions = 83″·66 ∴ 1 division = 2″·2
37 divisions = 80″·37 ∴ 1 division = 2″·17
42 divisions = 90″·71 ∴ 1 division = 2″·16

Now, suppose the level readings to be as they were June 5th, 1851—viz.:

West.	East.
45	18
17	46
40	22
20	42
122	128
	122

$$\frac{\text{Difference} \ldots \ldots = 6}{\text{No. of observations} = 8} = 0^{\text{div}}{\cdot}75 \times 2''{\cdot}2 = 1''{\cdot}65,$$

they would indicate that the east end was higher than the west by 1″·65, and all the transits of that day must be corrected by multiplying the factor of inclination by 1″·65, and applying the product with the sign − above the pole, + below, to the times of observation. The factor of inclination is found by the formula—

$$\frac{\textit{cos. zenith distance of star}}{\textit{15 sin. north polar distance}}$$

which, multiplied by the seconds of arc of inclination, will give the time at which the transit occurred over the true meridian, supposing the errors of collimation and azimuth to have been corrected.

The factors for collimation, inclination, and azimuth for the Greenwich stars, given in the "Greenwich Observations," are calculated for the latitude 51° 28′ north, but will serve for any latitude not differing greatly from that. In the correction for collimation, the error is supposed to be east; for level, the west end of the axis is considered the higher, therefore the deviation is east; and the azimuthal deviation is assumed to be east looking south: if either of these errors is in the contrary direction, the sign must be changed. To use the table: having found the deviation in seconds of arc, multiply the tabular factor by it, and apply the result to the observed time of transit with its proper sign. A full explanation of the principles on which these corrections are based will be found in my 'Manual of Astronomy,' of which a second edition will shortly appear.

The only correction at this stage of proceeding, on which no satisfactory determination has been arrived at, is the relative sizes of the pivots of the axis; the agreement of the observations will show whether an inequality exists to such an extent as to affect the results. It is true that this element may be determined, in the case of small instruments, by reversion; but I apprehend it admits of a question whether, after reversing an instrument weighing $1\frac{1}{4}$ cwt., it can be lowered into its place so gently as not to affect the inclination of the axis; yet, unless this important end can be completely insured, the same uncertainty will still exist.

The determination of the azimuthal variation now remains to be ascertained. If the clock has a fair rate, the transit of Polaris above, and again below the pole, will supply the requisite data.

On June 4th, 1851, at $8^h\ 30^m$ a.m., and in the evening of that day, the following transits were taken:—

Wire.	Polaris. h. m. s.		Wire.	Polaris sub Polo. h. m. s.	
1 ..	0 44 55		5 ..	12 44 55·5	
2 ..	0 57 23		4 ..	12 57 20·5	interpolated
3 ..	1 9 46	interpolated	3 ..	13 9 45	
4 ..	1 22 11	interpolated	2 ..	13 22 12	
5 ..	1 34 28		1 ..	13 24 24	
Mean	1 9 44·6		Mean	13 9 44	

Now, the right ascension of Polaris had increased $0^s{\cdot}37$ in the interval; the time, therefore, between the first and second transit should have been $12^h\ 0^m\ 0^s{\cdot}37$; and the gain of the clock was $0^s{\cdot}5$. The last transit, corrected for clock error, will therefore be—

	h. m. s.
	13 9 43·5
Subtract	1 9 44·6
Difference	11 59 58·9
Which should be	12 0 0·37
Error due to azimuthal deviation =	0 0 1·47

From this we observe that the western portion of the star's diurnal arc was too small, or that the supposed meridian was west of the true (looking north). Let $a =$ the amount in seconds of arc of the horizontal deviation; find the factors for azimuth of Polaris above and below the pole by the formula

$$\frac{\textit{sin. zenith distance}}{15\ \textit{sin. north polar distance}},$$

which, for Southampton, will be 1·564 and 1·668; then

$$a\,(1{\cdot}56 + 1{\cdot}67) = 1^s{\cdot}47, \text{ or } a = 0''{\cdot}45.$$

As Polaris, however, is not always to be thus conveniently taken, we must have recourse to other stars, such as δ Ursæ Minoris. Having eliminated the collimation error and levelled with care, on August 15th, 1851, the following transit of that star was taken with β Draconis and Capella sub polo.

Wire.	h. m. s.	β Draconis.		Capella s. p.
1..	18 9 12	25·5		9·2
2..	18 14 36	57		36·8
3..	18 20 2	28·5		4·6
4..	18 25 28	0·5		32·2
5..	18 30 52	31·2		59·4
Mean ..	18 20 2	17 26 28·54		17 4 4·44
Cor. for cl. err.	+37	17 27 5·53 n.a.	Az. 7″·9 × ·095	+·75
	18 20 39	−36·99		17 4 5·19
N. A.	18 20 33·8		N. A.	17 4 42·04
	+5·2 too late due to az. west of north.			−36·85

In this case the clock error is found from β Draconis. The azimuthal factor, from the above formula, for δ Ursæ Minoris is equal to ·656. Putting a for azimuthal deviation in seconds of arc ($\cdot 656\,a = 5{\cdot}2$, or $a = 7''{\cdot}9$): the azimuthal factor for Capella is ·095, and its transit corrected for this error brings out a tolerably fair and consistent result.

The surest method, however, of detecting the azimuthal error is to take the transit of δ Ursæ Minoris, and of 51 Cephei, one above and the other below the pole, which I am able to accomplish over all the wires by passing from one star to the other. The following observations of September 22nd, 1851, show that the instrument, as a transit simply, is not far from correct adjustment, and reward me for hours of labour extending through many months:—

Wire.	γ Draconis. h. m. s.	δ Ursæ Minoris. h. m. s.	Wire.	51 Cephei s. p. h. m. s.
1	13	10 33	5	16 53
2	44	15 57	4	23 39
3	15·1	21 23	3	30 23
4	46	26 46	2	37 2
5	17 2	32 18	1	43 46
Mean	17 54 15·06	18 21 23·4		18 30 20·6
True place ..	17 53 9·35	18 20 19		6 29 13
Clock error .	+1 5·71	+1 4·4		+1 7·6

Taking the clock error from γ Draconis, which is in the zenith, it appears that δ Ursæ Minoris came too soon by $1^s{\cdot}3$, and 51 Cephei too late by $1^s{\cdot}9$; in either case an azimuthal deviation of 2″ east of north is indicated. Applying this correction to the other transits taken the same evening, we have the following results:—

Let $a =$ azimuthal deviation in seconds of arc, then

For δ Ursæ Minoris $\cdot 646\,a = 1^s{\cdot}3$, or $a = 2''$

For 51 Cephei ...... $\cdot 92\,a = 1^s{\cdot}9$, or $a = 2''$

Wire.	β Lyræ. h. m. s.	ζ Aquilæ. h. m. s.	δ Aquilæ. h. m. s.	γ Aquilæ. h. m. s.	β Aquilæ. h. m. s.
1	55·5	1	27·8	38 7	28·8
2	18 7	20·8	47	58·5	47·5
3	41·6	40·5	6·2	18	7
4	4·8	0·5	25·2	57·4	26 5
5	28	20·5	44 8	57·4	46·2
Mean	18 45 41·72	18 59 40·66	19 18 6·20	19 40 18·	19 48 7·1
Azimuth correc.	+·05	+·08	+·10	+·09	+·1
Observed place	18 45 41·77	18 59 40·74	19 18 6·3	19 40 18·09	19 48 7·2
True place	18 44 36	18 58 35·10	19 17 0·68	19 39 12·20	19 47 1·35
Clock error	+ 1 5·77	+ 1 5·64	+ 1 5·62	+ 1 5·89	+ 1 5·85

Dividing the stars into two groups, one near the zenith and the other near the equator, we find the mean of the clock error from γ Draconis and β Lyræ $= 1^m\ 5^s{\cdot}76$; from the Aquiline stars $= 1^m\ 5^s{\cdot}67$, which differs so little from the other as to show that the adjustments of the instrument are not far from absolute correctness. Mean clock error of the whole series due to 19 hours sidereal time $+ 1^m\ 5^s{\cdot}71$; clock's rate $+ 2^s$ daily, or $1^s{\cdot}6$ in 19 hours; hence, clock error at $0^h\ 0^m\ 0^s$ sidereal time $= + 1^m\ 4^s{\cdot}11$.

For the adjustment of the micrometer microscopes, two things are necessary at first setting out—1, that they be at equal distances from the centre of the axis; 2, that they be at the three angles of an equilateral triangle inscribed in a circle concentric with the axis, whose circumference shall pass through the intersection of the cross-wires of each when at zero. To insure the first, I made a mark on a certain part of the arc at right angles to one of the divisions, and adjusted the cross-wires of each microscope to its intersection with the division; for the second, I brought the microscope marked A on 0, and made B read 120°; moving 0 to B, I made C read 120°; transferring 0 to C, I found 120° to extend beyond the zero 12″: this quantity, divided by 3, will give the difference between the distances of any two microscopes and that between 0° and 120°; and they were so adjusted that each microscope should be at 119° 59′ 56″ from the next on each side of it.

The nadir point of the circle was determined by producing coincidence between the direct and reflected images of the horizontal wire by daylight; and so accurately can this be done that several independent observations will give invariably the same result. The reading of the nadir point —180° gives the zenith point from which to reckon the series of zenith distances immediately following. I have so regulated the foci of the three microscopes that the mean of 5 revolutions of the micrometer-screw of each measures exactly one division on the arc, or 5′; and I find this to be one of the most permanent adjustments.

September 18th, 1851, on that part of the arc numbered 329°, the spaces passed over by 10 revolutions were—

At 329° A = 9′ 58″ B = 10′ 7″ C = 9′ 54″ Mean = 9′ 59″⅔

At 168° A = 10′ 5″ B = 10′ 0″ C = 9′ 54″ Mean = 9′ 59″⅔

OBSERVATIONS *to Determine the Latitude of* DR. DREW'S *Observatory, by Stars North and South of the Zenith, the Nadir Point having been Determined by Reflection, and the Zenith Point by Subtracting* 180° *from it, taken on two consecutive evenings.*

Date.	Object.	Degree.	Microscopes. A.	Microscopes. B.	Microscopes. C.	Additional Reading of Eye-piece Micrometer.	Concluded Circle Reading.	Zero, or Z. D. Point.	Barometer.	Thermometer.	Refraction.	Wt.	Latitude Deduced.
1851.		°	′ ″	′ ″	′ ″	″ ″	° ′ ″	° ′ ″			″		° ′ ″
Sept. 22.	β Draconis	147	59 52	59 59	59 34	+·7×46·8 or 32·7	148 0 21	149 29 51·8	30·040	55·5	1·5	10	50 54 33·7
"	γ Draconis	148	53 39	53 42	53 8		148 53 29·7				0	4	50 54 31·9
"	β Lyræ	167	12 11	12 28	11 58		167 12 12·8				18·4	10	50 54 33·9
"	51 Cephei	107	39 40	39 25	39 45	+·8×46·8 or 37·4	107 40 14				52	10	50 54 35·2
"	ζ Aquilæ	186	44 39	45 2	44 22		186 44 41				42 6	10	50 54 34·8
Sept. 23.	51 Cephei	107	40 52	40 16	40 48		107 40 38·7	149 30 16	30·115	57·3	52	10	50 54 35·2
"	γ Aquilæ	190	8 20	8 25	8 41		190 8 29				49·7	10	50 54 33·3
"	β Aquilæ	194	21 5	21 8	21 38		194 21 17				57 8	10	50 54 32·8
"	β Lyræ	167	12 28	12 35	12 50		167 12 21·7				18·4	6	50 54 34 6
								Mean of the Series=					50 54 34·4
								Latitude by the Trigonometrical Survey=					50 54 34

These observations are given not because they are considered sufficient to give an independent determination of the latitude, but to show the accuracy with which the nadir point, and from that the zenith point, may be determined by reflection. Their number could have been increased, and it might have been shown that the mean of ten or more observations gives the latitude 50° 54′ 34″ within a small fraction of a second, which is that of my observatory, as determined from the latitude of the Ordnance Map Office, Southampton.

THE ADJUSTMENT OF THE EQUATORIAL.

THE declination circle of the equatorial is read off by two verniers to minutes of space, and the hour circle by two verniers to 5 seconds of time. I am compelled, therefore, to consider the instrument in adjustment when the errors of observation fall within these limits. The instrument was established in its present position about four years ago. The following observations were lately taken to ascertain how much it had deviated by the settlement of the piers and the foundation, or from other causes, during that interval.

1. *For the Collimation Error.*—To ascertain the errors with precision, I insert the position-wire micrometer, and bring the fixed wire to correspond with the plane of a circle of declination, which is readily accomplished by bringing it on a star not far from the equator, and causing it to be bisected during the time of its transit across the field of view near the meridian. One of the moveable vertical wires is now brought as nearly as can be judged to the centre of the field. With the face of the declination circle *east*, I note by the clock the time a star (not far distant either from the equator or meridian) crosses the wire, and I read off the hour angle from the hour circle; turning the instrument half-way round, with the face of the declination circle *west*, I do the same. This star will be only affected by the error of collimation, and if the difference of the hour angles, read off from the hour circle, be equal to the difference of the times of observation, there is no collimation error; but if these be not equal an error exists, which must be corrected before other observations can be taken.

October 11, 1851.—α Aquilæ near the meridian.

	Clock times. h. m. s.	Hour angle. m. s.	
	19 50 50	+ 6 35	dec. circle east
	19 52 0	+ 7 40	dec. circle west
Difference	0 1 10	1 5	

As the difference between these is 5 seconds, the collimation error $= 2^{s}\cdot5$, which, if great accuracy is required, must be multiplied by the cosine of the star's declination; as this, however, would only alter $2^{s}\cdot5$ to $2^{s}\cdot3$, it may be neglected.

$$2^{s}\cdot5 \times 15'' = 37''\cdot5$$

Knowing the value of the run of the micrometer-screw, I advanced the wire through $37''\cdot5$ in such a direction that the transit (circle east) should occur sooner, and consequently the transit (circle west) later, and then took the following observation:—

	h. m. s.	m. s.	
Clock time	19 59 53	+ 15 32	hour angle circle east
"	20 1 25	+ 17 5	hour angle circle west
Difference	0 1 32	1 33	

These differences, falling within the limits of the readings of the hour circle, I now consider the collimation error compensated.

This observation enables me to ascertain whether or not the hour circle reads $0^{h}\ 0^{m}\ 0^{s}$ when a star is in the meridian.

	h. m. s.	h. m. s.
Clock times	19 59 53	20 1 25
Correction for clock error..	−39	−39
True sidereal time........	19 59 14	20 0 46
Right ascension of α Aquilæ	19 43 32	19 43 32
True hour angle..........	15 42	17 14
Instrumental hour angle ..	15 32	17 5
Difference	−10	−9

The star is west of the meridian, and its hour angle is less than the true by 9 or 10 seconds; hence the zero of the hour circle is west of the true meridian by that amount, which deviation was forthwith corrected.

2. *For the Latitude.*—To ascertain whether the angle formed by the polar axis with the horizon is equal to the latitude of the place, measure the polar distance of a star on the meridian with the declination circle east, and again with the circle west; the mean of these, corrected for refraction, should equal the polar distance of the star taken from the 'Nautical Almanack.' If a star in the zenith be employed, no correction for refraction is requisite.

September 26, 1851.	β Draconis.		γ Draconis.
Declination vernier A	52° 27′	circle east	51° 32′
" B	52 28		51 36
" A	52 15	circle west	51 20
" B	52 15		51 20
Mean declination	52 21 15″		51 27
Instrumental polar distance	37 38 45		38 33 0″
True polar distance	37 34 50		38 29 8
Difference......	+3 55		+3 52

As the instrumental polar distance is greater than the true, the pole of the instrument is too low, or the inclination is too small by 3′ 54″. Having elevated the pole, the following observations were subsequently taken:—

	α Aquilæ.		α Cygni.
Declination vernier A	8° 37′	circle east	44° 51′
" B	8 39		44 55
" A	8 21	circle west	44 35
" B	8 20		44 38
Mean declination........	8 29 15″		44 44 45″
Polar dist. = 90° − decl. =	81 30 45		45 15 15
Refraction	+52		+7
Instrumental polar distance	81 31 37		45 15 22
True polar distance	81 31 0		45 14 33
Difference......	37		49

These differences, falling within the limits of the divisions of the declination circle, indicate that the instrument is adjusted to the nearest minute of latitude.

3. *To ascertain whether the Declination Axis is at Right Angles to the Polar Axis.*—Having previously corrected the collimation error, take the hour angle of one of the Greenwich stars, whose declination is considerable, near the meridian, and compare it with its true hour angle, the error of the clock being known. Or its transit with the face of the declination circle east, and again with the circle west, being noted by the clock, may be compared with the hour angles read off from the hour circle. The effect of this error somewhat resembles that of the level error of the transit instrument, which is 0 at the horizon, and reaches its maximum at the zenith; so the effect of the inclination error in question is 0 at the equator, and reaches its maximum at the pole; varying, indeed, as the tangent of declination. And since tan. 45° = rad. or 1, it will be most convenient to select a star whose declination differs but little from 45°.

October 11th, 1851, the following observations of α Cygni were taken, the declination of the star being 44° 45′ 27″ north.

By the First Method.

	h. m. s.		h. m. s.	
Clock times	20 17 3	circle east	20 18 13	circle west
Correctn. for cl. error .	−39		−39	
Sidereal time	20 16 24		20 17 34	
R. A. of α Cygni	20 36 22		20 36 22	
True hour angle	−0 19 58		−0 18 48	
Instrumental hour ∠	−0 20 20		−0 18 30	
Difference	+0 0 22		−0 0 18	

By the Second Method.

	h. m. s.		m. s.	
Clock times	20 17 3	Hour ∠	− 20 20	circle east
	20 18 13		− 18 30	circle west
Difference	0 1 10		1 50	

An error of 40^s is here indicated, which is double that due to the inclination of the declination axis. With the declination circle east, the star arrived at the wire too late; and with the circle west, too soon. Now, $20^s \times$ tan. 45° (or 1) $\times 15'' = 300'' = 5'$, the difference between the inclination of the declination axis to the polar axis and 90°. Having elevated the western extremity of the declination axis one revolution of the adjusting-screw (the circle being east), I took the following observation:—

	h. m. s.		m. s.	
Clock times	20 30 10	Inst. hour ∠	−6 40	circle east
	20 31 30		−5 55	circle west
Difference	0 1 20		0 45	

The error now appears to be 35^s in the opposite direction. Having turned the screw back half a turn, the two following observations showed that the error was corrected; and, combined with the others, indicate that the value of one revolution of the adjusting-screw = 10′.

By the First Method.

	h. m. s.		h. m. s.	
Clock times	20 38 45	circle east	20 40 4	circle west
Correctn. for cl. error .	−39		−39	
Sidereal time	20 37 6		20 39 25	
R. A. of α Cygni	20 36 22		20 36 22	
True hour angle	+1 44		+3 3	
Instrumental hour ∠	+1 42		+3 0	
Difference	0 0 2		0 0 3	

By the Second Method.

	h. m. s.		m. s.	
Clock times	20 38 45	Inst. hour ∠	+1 42	circle east
	20 40 4		+3 0	circle west
Difference	0 1 19		1 18	

As the differences fall within the limits of the divisions of the hour circle, the inclination adjustment may now be considered completed.

4. *To ascertain the Azimuthal Deviation of the Polar Axis; the effect of which is to cause the Pole of the Equatorial to point East or West of the Pole of the Heavens.*—Measure the polar distance of a star 6 hours from the meridian, and compare it with the polar distance ascertained from the 'Nautical Almanack.' The difference, if any, will be the amount of deviation, east or west, after the observation has been corrected for the effect of refraction: east if the polar distance of a star west of the meridian be too great, west if it be too little.

Oct. 25, 1851.—β Ursæ Minoris, 5^h 20^m from the meridian.

	° ′ ″	
Declination vernier A	74 35	circle north
" B	74 38	
" A	74 52	circle south
" B	74 53	
Mean declination	74 44 30	
Polar dist. = 90° − decl. =	15 15 30	
Refraction	+0 0 26	
Instrumental polar distance	15 15 56	
True polar distance	15 14 8	
Difference	+1 48	deviation

As the star is west of the meridian, and the polar distance measured is too great, I advanced the north pole of the instrument towards the west by setting the verniers 2′ nearer the pole, and bringing the star on the wire by moving the adjusting-screw.

The following observations (October 27th) on β Ursæ Minoris 6 hours west of the meridian, and α Persei 6 hours east, show that the azimuthal error has been reduced within 1′—the extent to which the divisions of the declination circle are read:—

	β Ursæ Minoris. ° ′ ″		α Persei. ° ′ ″
Declination vernier A	74 36	circle north	49 14
" B	74 40		49 23
" A	74 53	circle south	49 28
" B	74 55		49 28
Mean declination	74 46 0		49 20 48
Polar dist. = 90° − decl. =	15 14 0		40 39 15
Refraction	+ 0 0 19		+ 0 0 50
Instrumental polar distance	15 14 19		40 40 5
True polar distance	15 14 10		40 40 21
Difference	−9		−16

To Investigate the Effect of Refraction in North Polar Distance, and the Hour Angle.

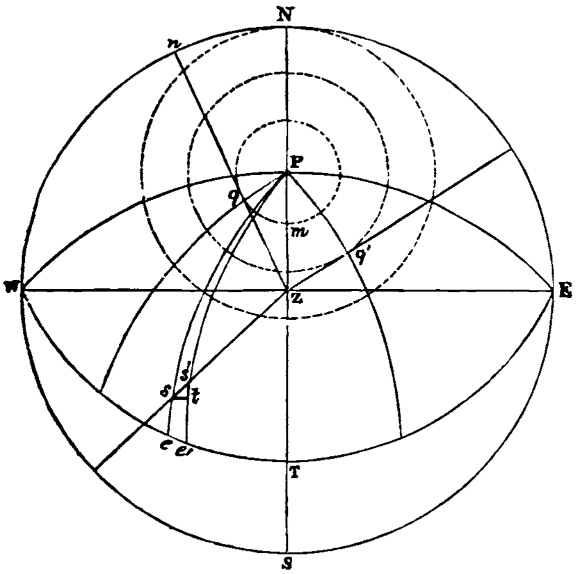
In the "projection of the sphere on the plane of the horizon" Z is the zenith; P the pole; W P e the six-hour circle; s the true place of a star, s' its apparent place; then P s is the true polar distance, P s' the apparent; s P T the true hour angle, s' P T the apparent; s' Z = apparent zenith distance; P Z = co-latitude; and $s s'$ = refraction in altitude; let fall $s t$ perpendicular to P s'. Now the angle $s s' t$ may be considered equal to P s' Z, which may be found in the spheric triangle P s' Z by the proportion sin. zenith dist. : cos. lat. : : sin. hour angle : sin. P s' Z. Hence $s s' \times$ cos. $s s' t$ (or P s' Z) = $s' t$ = correction in polar distance, and $s s' \times$ sin. $s s' t = s t$; which, divided by 15 sin. polar distance, will give the seconds of correction to be applied to the hour angle with the positive sign. The hour angle, anywhere out of the meridian, where the effect of refraction is 0, will always be lessened by refraction, reckoning from T (the point where the equator cuts the meridian) 12 hours east or west; hence the sign of the correction will be positive. Whether the correction in polar distance is positive or negative, may be determined by the following considerations:—

1. When the star is on the meridian, refraction will lessen polar distance by the whole amount between the south point of the horizon and the zenith; also between the north point and the pole; but will increase the polar distance between the pole and the zenith: hence, in the former positions, to the correction must be applied the sign +, and in the latter −.

2. Any star which culminates south of the zenith, or whose polar distance is greater than the co-latitude, will have its

polar distance diminished in every position; hence, for such stars, the correction will always have the positive sign.

3. Any star, whose polar distance is less than the co-latitude, will have its polar distance differently affected according to its position.



PROJECTION OF THE SPHERE ON THE PLANE OF THE HORIZON, ILLUSTRATING THE EFFECT OF REFRACTION IN NORTH POLAR DISTANCE AND THE HOUR ANGLE.

Let $Z\,q\,n$ be a vertical circle touching the parallel of declination of such star at the point q; at this point the correction for refraction in north polar distance will be 0. To find this point we have, in the spheric triangle, $P\,q\,Z$; the angle $P\,q\,Z = 90°$, $P\,q =$ polar distance, and $P\,Z$ the co-latitude; whence may be found the hour angle $Z\,P\,q$. Anywhere between q and m, and as far the other side of the meridian, the correction in polar distance will be negative; at the other portions of the diurnal arc it will be positive. This hour angle will be less as the polar distance is greater; thus $Z\,P\,q'$ is less than $Z\,P\,q$. It will never, however, be so great as 90°; hence, for 6 hours of distance from the meridian, the correction will always be positive.

From the same triangle, $Z\,q\,P$, may be found $Z\,q$, which is the zenith distance of the star; also, in any other part of the heavens, the zenith distance may be ascertained without an additional observation. Thus, in the spheric triangle $P\,s'\,Z$, we have $P\,Z =$ co-latitude, $P\,s' =$ observed polar distance, $Z\,P\,s' =$ the observed hour angle; whence may be found $Z\,s'$, the zenith distance of the star for which the refraction must be taken from the table.

PORTABLE LIFTING MACHINE.

THE object of this machine, which is the invention of Mr Long, hydrometer maker, London, is to obtain, in a portable and simple form, the means of multiplying the power of a man to a very great extent, for the purpose of lifting weights, &c., without the drawback of heavy friction and wear to which some lifting machines are liable, such as those in which an endless screw works into a toothed wheel. The construction is shown in the annexed engravings, figs 1 and 2. A, is a wheel on which eleven pins B H I, are fixed in the form of teeth, with a friction roller fitted upon each pin. The circular plate C C, is fixed at right angles to this wheel, upon the shaft of the winch D, to which the manual power is applied. On this plate is cast the spiral projecting piece E F G, which makes rather more than one turn upon the plate. This spiral is engaged with the pins B H, on the first wheel, and the difference in the amonnt of eccentricity of the two ends of the spiral is equal to the pitch or distance between the pins; so that when the plate C, and spiral are turned round one revolution by the handle, the wheel A, is driven round the distance of one pin or tooth.

The driving face of the spiral has a varying bevil, adjusted so as to bear fairly and uniformly upon each pin in succession throughout the entire revolution, as the pin varies its inclination from B to H; the next pin above, I, being then brought down into the position B. The thickness of the spiral, as shown at G, nearly fills the space between the two pins at all times, preventing any slip, and the upper pin is engaged a short distance before the lower one is released. The friction roller upon the pin turns round during the motion, rolling, with little friction, along the inner surface of the spiral, which forms an inclined plane, with an inclination of about 1 in 7.

Fig. 1.

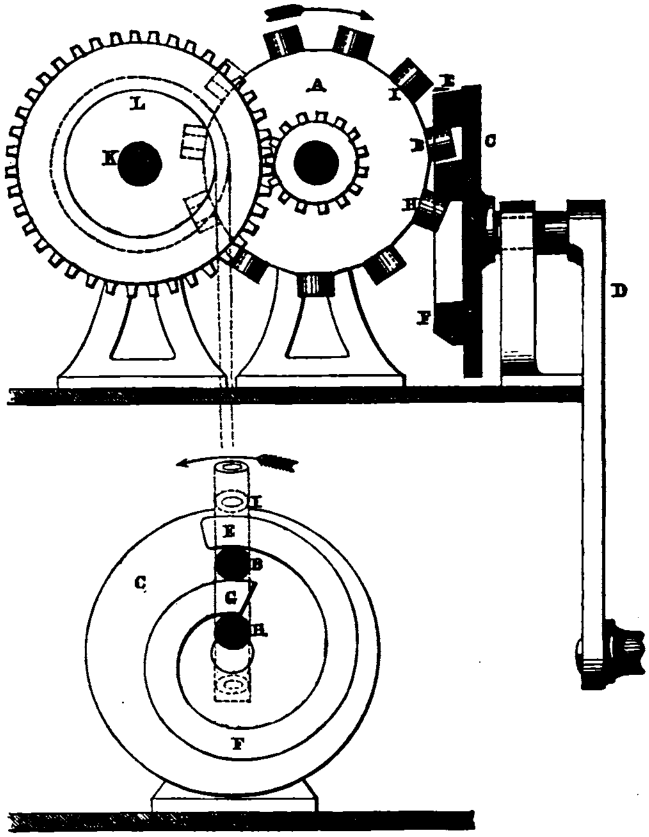


Fig. 2.

PORTABLE LIFTING MACHINE.—SCALE, ONE-FOURTH.

A pinion fixed on the wheel A, is geared into one of three times the diameter on the third shaft, K, upon which is fixed the drum L, for winding up the rope or chain attached to the weight to be lifted. The leverage of the spiral and first wheel being 11 to 1, and that of the spur gearing 3 to 11, makes a power of 33 to 1, and the radius of the winch-handle and of the drum being 6 to 1, the total increase of power obtained by the machine is 200 to 1 nearly; or one man exerting a power of ½-cwt. at the winch could lift five tons, including the friction.

This machine has the advantage of reducing the friction, in consequence of the rubbing action being confined to the revolving of the friction rollers upon their axles, instead of the inclined plane rubbing upon the pins, or the thread of an endless screw rubbing upon the teeth of a worm-wheel, which has only contact at little more than a line. This has a scraping action, tending constantly to remove the oil from the surface, but in the friction rollers there is a much larger surface in contact to bear the pressure, and this surface being always in contact never has the oil scraped off the surface, and can retain the oil for a much longer time.

Improvements in the London Docks.—Workmen are busily engaged in making extensive excavations near Old Gravel-lane-bridge of the London Docks, for the purpose of erecting several lofty warehouses and store-rooms for merchandise from foreign parts, and also to construct a new swing-bridge.

Leeds and Yorkshire Assurance Buildings Competition.—The premiums have been awarded as follows:—The first, of 50*l.*, to Mr. W. B. Gingell, of Bristol; the second, of 25*l.*, to Mr. Martineau; the third, of 25*l.*, to Mr. Dobson, of Leeds. Fifty-four designs were sent in.

ON THE USE OF METALS, ESPECIALLY OF COPPER AND IRON, BY THE ANCIENTS.

By Robert Ritchie, Assoc. Inst. C.E., Edinburgh.

[*Read at a Meeting of the Architectural Institute of Scotland.*]

The way in which metallurgy, or the art of working metals, first became known to mankind is involved in obscurity. It is more than probable that the processes of manufacturing the softer metals, as the ore of lead, led the way to the fusion and manufacture of the harder. Lead was much used in early times; in the era of the Roman Empire it was so much in use that even the cities were supplied with water by leaden pipes. The art of working in gold, silver, copper, and even iron, seems to have been known at a very early period of human history. Iron may have been accidentally discovered, it has been supposed, by the fusion of the ore in the making of charcoal, or by specimens of pure iron ore having been fashioned by fire into purposes of utility, for meteoric iron exists in a malleable state. Rude smelting-furnaces have been found even amongst tribes—as the Africans—among whom civilisation has made but little progress. Copper, and the alloys of tin, by which it became hardened, seem to have been very early known to the ancients.

Brass, so frequently mentioned in sacred and profane history, used for coins and other purposes, was synonymous with copper and bronze. The ancients well knew the process of casting bronze statues, and of mixing copper with tin to harden it. Some of the most valuable works of antiquity were made of mixed metal,—as the Colossus of Rhodes, of which no remains now exist, the weight of which has been estimated at 700,000 lb. of bronze.

Metallurgy, according to historians, had made great advancement 700 years before Christ. During the reign of Alexander the Great, 356 B.C., the celebrated sculptor Lysippus, originally a worker in brass, laboured so assiduously in moulding and melting metals and multiplying casts as to have left, it is said, 1500 groups of statuary, which Pliny the elder called the mob of Alexander. Amongst the best of his works were his statues of that monarch. It has been recorded by the Roman consul and historian Mucianus, who was the Premier of Vespasian, and who, as mentioned by his contemporary Pliny, in Hist. Nat., b. 39, c. 17, had been thrice consul, in A.D. 52, 70, and 75, that there existed in his time 3000 bronze statues at Rhodes, and that there were believed to be as many at Athens, Olympia, and Delphi.

That the art of working in iron and steel had made great progress in early times, it is the purport of this paper to show. It is known that the sword blades made in Damascus, a city of great antiquity, and mentioned in sacred writ as coëval with Babel and Nineveh, have had a far-spread reputation for their excellence of quality and workmanship and beautiful wave or water-mark. It is probable that long before the Christian era the Orientals, both in Hindostan and China, had also achieved great perfection in the manufacturing both of steel and iron, and in the inlaying of gold and silver. Of this there is very little doubt, from the specimens which have been preserved to modern times. The excellent sword blades of Toledo were early famed, the manufacture of which was introduced by the Moors into Spain, but is now nearly extinct. Although the ancients may not have acquired the same degree of skill in casting metals for general purposes in the mechanical arts as the moderns, they had attained great excellence in the working of malleable iron, copper, and bronze.

The importance of metals in coinage,* and especially the advantages of using iron for weapons of warfare, and in the construction of agricultural implements and various utensils, must have stimulated the faculties of the early tribes of mankind to their improvement. But the many useful properties which iron possessed could not have been at once discovered, and the knowledge of iron-making, and the application of iron to purposes of utility, must have been acquired by slow degrees. Although iron was known long before the Christian era, it has been doubted if it was in general use in the early ages of the world; but it is evident that mankind understood the art of working both iron and copper before the deluge, from the passage in Genesis,—"Tubal-Cain, an instructor of every artificer in brass and iron." It has been held that copper or bronze is the proper translation of the word rendered brass. The numerous notices of brass in early passages in the Bible must be inferred, in some instances, as meaning copper, and in others bronze. The same word is used in Hebrew for brass, copper, and bronze. In Latin, the word *æs*, which means brass or bronze, means also copper. In Greek, likewise, the word χαλκος, which means brass or bronze, means also copper.* In the passage (B.C. 1451), Deut. viii. 9, it is obvious that copper is meant, not brass—"A land whose stones are iron, and out of whose hills thou mayest dig brass."

One early commentator considers that the calamity of the deluge deprived the greater part of mankind of the knowledge of these as well as other arts, and that the use of iron was only revived at a much later period of the world's history. It has been recorded that the Egyptians gave the honour of the discovery of metals to their first sovereign Menes, who, according to Josephus, ascended the throne (2320 B.C.), and who reigned after the fabulous gods.

From sacred writ it is ascertained that metals were common in Egypt and in several countries in Asia. Egypt was distinguished in the very earliest records of the world not only for the richness of its soil, but for its valuable gold and silver mines, the annual produce of which is early mentioned in Egyptian history, and which were worked by captives taken in war. These mines have been ascertained by Benomi and Linant to lie in the Bisháree Desert, seventeen days' journey south-westward of Derow. The gold is found in quartz, and the excavations are 180 feet deep. Diodorus the Sicilian (Diodorus Siculus) lived 44 B.C.; but as he derived his information, sometimes without sufficient discrimination, from the writers who had preceded him, his statements are not always to be relied on. Still there is evidence that he visited many of the countries he describes. He mentions, in the first chapter of his Historical Library, "that in the confines of Egypt and neighbouring countries of Arabia and Ethiopia there is a place full of rich gold mines, out of which, with much art and pains of many labourers, gold is dug. The soil here naturally is black, but in the body of the earth run many white veins, shining with white marble, and glistening with all sorts of other bright metals, out of which laborious mines those appointed overseers cause the gold to be dug up by the labour of a vast multitude of people.......The earth which is hardest and full of gold they soften by putting fire under it, and then work it out with their hands." After the gold is washed the workmen take it away by weight and measure and then put it into earthen urns, "and according to the quantity of gold in every urn, they mix it with some lead, grains of salt, a little tin, and barley bran. Then covering every pot close, and carefully daubing them over with clay, they put them into a furnace, where they abide five days and nights." After they have stood some days to cool, "nothing is to be found in the pots but only pure refined gold a little diminished in weight." The whole description of Diodorus of the manner in which gold is obtained on the borders of Egypt is very interesting. He makes the remark, "that as gold is got with labour and toil, so it is kept with difficulty; creates everywhere the greatest cares; and the use of it is mixed with pleasure and sorrow." But he gives a very different description of the mines in Arabia, in which is found "pure gold, called gold without fire, for it is not extracted out of little pieces of drossy metal by melting in the fire, as in other places, but it is pure and refined at the first digging it out of the earth, every piece about the bigness of a chesnut, and so bright and glorious a colour that this gold adds an exceeding beauty and lustre to the most precious stones that are set in it." The same author, in his description of Egypt in early times, shows the resources of Egypt, which possessed valuable mines of copper, lead, iron, emeralds, and sulphur, which are said still to exist in the deserts of the Red Sea. His description of the abundance of gold and silver amongst early nations is corroborated by many passages in the Bible. One passage shows that the art of casting was early introduced, when Aaron, in the absence of Moses, made the golden calf. Ex. xxxii. 3 and 4,—"And all the people brake off the golden earrings which were in their ears, and brought them unto Aaron, and he received

* The coins chiefly used by the Jews, Greeks, and Romans, were of silver and brass, and a few of gold. Amongst the Romans the denarius victoriatus, sestertius, and sometimes the æs, were of silver, and the rest of bronze. The Roman gold coin was the aureus, in value, as stated by Pliny, 24s. 3½d. The Romans had coinage, except copper or bronze, till B.C. 269.

* ...ere appear to have been two kinds of brass known—one copper, or what was ...ve brass, also bronze or brass money, or money in general, and the word ...is a sword, spear, or axe—the other termed mountain brass.

them at their hand, and fashioned it with a graving tool, after he had made it a molten calf." In the building of Solomon's Temple gold and silver were much used.

It has been supposed that in those ages the working only of a few metals, such as gold, silver, and copper, was understood, and that iron, afterwards so common, was, if then known, little used. From the testimony of ancient authors it appears that long after the deluge, copper was, for many ages, employed for most of those purposes for which iron is now used, such as arms, tools of husbandry, and in the mechanical arts.

In the heathen mythology we find ascribed to Vulcan, the god of artificers, the making of the famous impenetrable armour of Achilles, whose shield is described by Homer, in the Iliad, Book xviii. 551 (B.C. 907). At the time of the Trojan war iron seems to have been little used, and copper supplied its place both for arms and all kinds of tools and utensils.

The Romans succeeding, and borrowing many of their customs from the Greeks, no doubt adopted in this respect their practices. It is somewhat singular that almost all the ancient arms and tools now extant are made of copper—a most convincing proof that the use of copper preceded that of iron, and that the ancients used brass in most of their religious ceremonies. This appears to have been a practice common not to the Greeks or Romans alone, but to all the nations of antiquity. According to Diodorus, the arms of the Egyptians* were commonly made of brass. Herodotus mentions that the Massagetae had their axes, pikes, quivers, hatchets, and horse trappings of brass.

In several passages of sacred writ the word translated brass occurs. The art of working in brass is distinctly mentioned in Ex. xxvii. 2,—"Overlay it with brass." The trade of a coppersmith is also mentioned in Scripture, Tim. iv. 14. In all the passages it may be inferred that copper or bronze was meant, and not brass as now used.

According to one writer, who has investigated the subject, it appears that in England, Switzerland, Germany, and in northern kingdoms, arms, rings, and other articles of brass or bronze are often found in tombs. In America also arms and tools have been found made of copper. Hatchets of this metal have been found in the ancient tombs of the Peruvians. It is said that in Japan, in modern times, articles which, in other countries, are commonly made of iron, are made of copper or brass. Indeed, every investigation seems to prove that no metal was so much used in ancient times as copper. It has been supposed that its general use arose from the circumstance that copper was found in great quantities in ancient times, and was easily wrought; and the ancients, as has been noticed, early found out the means of making it more useful by alloying it with tin, by which it was tempered and rendered so hard as to acquire in some measure the qualities which iron possessed; besides which, its non-liability to rust must have made it valued.

Although the metal, called brass both in sacred and profane history, was probably chiefly copper, there is undoubted evidence that the ancients—at least the Egyptians, Greeks, and Romans—understood the art of making various alloys with copper and tin. Bronze, so well known to the ancients, is merely a compound of copper with tin; and the brass of the ancients, there is little doubt, was an alloy of copper and tin—not copper and zinc. It has been supposed by some that although the practice of fusing copper into compounds, and zinc itself, were unknown in very ancient periods, yet the practice existed at a later period of forming the brass used for coins and other purposes, by combining the metals, brass being used before zinc was known in its metallic form, and the zinc may have been cemented with sheets of copper by charcoal, the zinc uniting with the copper without being visible. It is much more probable, however, that the compounds of the ancients were chiefly confined to the mixing of copper with gold, silver, and tin, and that zinc was not used, or unknown. It is improbable that the ancients knew the alloy of copper and zinc. Zinc is only found in the form of calamine, which consists of zinc, carbonic acid, and silica; and of blende, which is composed of zinc and sulphur. Both of these substances require sublimation to extract the metal; whereas by smelting or fusion they would pass away volatilised,—the former of these processes not very likely to be known by the ancients, although they may have been acquainted with that of cementation. The process of sublimation or distillation may have therefore been unknown to the ancients, while the process of smelting ores was familiar to them; hence they made use of the alloy of tin instead of zinc. The famed Corinthian brass shows clearly that the Greeks and Romans understood well the various alloys of copper. This brass was a mixture of gold, silver, and copper. At the destruction and burning of Corinth, 146 B.C., this metal was said to had been formed in quantities melted by the heat. This statement was made by the Roman writer J. Florus, and it is mentioned by Pliny, in Hist. Nat., b. 34, c. 3, only to be refuted as an anachronism, because the phrase "Corinthian brass" must have been familiar to and used by the ancients long before the destruction of Corinth by Mummius. *Æs Corinthium* denotes the alloy generally made use of at Corinth, and corresponds to *æs Deliacum* or *æs Æginaticum*, the bronzes and alloys most used at Delos and Ægina. The Corinthian alloys, according to Pliny, were mixed with the precious metals, and were of different colours. It has been held by some writers that the bronze called Corinthian, and sometimes Siracusan brass, was made of *stannum* (Agricola de re Metallica), the admixture of the precious metals with copper and tin, as the ancients gave the name of electrum to the mixture of gold and silver. It is mentioned by Suetonius that the Emperor Vitellus took away all the gold and silver from the temples, and substituted *orichalcum* and *stannum*.—Sue. Vit., vi., p. 192. As the term *orichalcum* was applied by the Romans to brass of great price, it may be supposed that the metal here used by Vitellus was Corinthian brass. The Romans applied the term *stannum* as well as *cassiteron*,* to tin; but in the sense in which the former word is here used, a mixed metal is implied.

That the Egyptians early knew the mode of compounding metals has been fully proved by the many articles which have been found in Egypt, especially at Thebes. The early history of the Phœnicians or Sidonians has thrown some light upon this subject. This country was in early times a great emporium of trade for the world. The purple of Tyre and glass of Sidon were early famed. The great progress these people had made in metallurgy is shown from their being employed by Solomon to decorate the Temple of Jerusalem under Hiram, king of Tyre. The advancement they had made in shipbuilding and navigation in early times would call for the application of metals for that purpose; and metals are mentioned by Diodorus as having been used for the prows of vessels and anchors. Even the plan of sheathing with metals is supposed to be of great antiquity. The same author, in his description of Britain, mentions that the Phœnicians undertook frequent voyages by sea in the way of traffic as merchants, and found out the coasts beyond the Pillars of Hercules, and that, driven by a storm, they arrived at Britain. This island he describes as very populous, and says that tin was dug and obtained there "with a great deal of care and labour. They dig it out of the earth, then melt and refine the metal, and beat it into four-square pieces like a die. The merchants transport the tin they buy into France, to the mouth of the river Rhone." Tin was largely exported by the Phœnicians from Britain into their own country, where it was used as the alloy of copper in the making of bronze. Speaking of the wealth of the Phœnicians, Diodorus remarks, they planted many colonies both in Africa and in the western parts of Europe. The Iberians sunk many large mines, whence they dug an infinite quantity of pure silver.

* From the collection of Mr. Salt, which has been preserved in the British Museum, several bronze weapons of warfare attest this fact. A portion of a blade of a battle-axe is in this collection 13½ inches long, and 2½ inches broad, inserted into a silver tube, fixed with nails of the same metal. The coat of armour or cuirass of the Egyptians has been described as consisting of about eleven horizontal rows of metal plates, secured by bronze pins. An Egyptian sword or dagger, which was excavated in the ruins at Thebes, also corroborates the general use of bronze in early times. "The blade was bronze, thicker in the middle than at the edges, and slightly grooved, and so exquisitely was the metal worked that some of those examined were found to have retained their pliability and spring after a period of several thousand years, and almost resembled steel in elasticity." Such is the dagger which has been discovered in a Theban tomb. Spear-heads, javelin-heads, of bronze-metal, have also been found and preserved in museums (the Berlin) which correspond to the description of Homer. It is probable that the Egyptians succeeded so well in hardening bronze that not only swords, knives, and warlike weapons and armour were made of it, but that the tools and chisels which were employed for carving and cutting hard stones, as granite, and also implements of husbandry, were made of it.

In the ruins of Nineveh (from Jonah, Nineveh, or Nimroud, existed 862 B.C.), Layard has as yet discovered few metallic remains. The articles found are of copper. The remains of metals found in Egypt, preserved in the British Museum, consist chiefly of articles in bronze and copper, such as vases, statues, agricultural implements, spear-heads, swords, daggers, tools, mirrors, knives, &c. In the Lycian collection, the few specimens of metals consist of articles in bronze and lead. In the same museum, the number of bronzes of the Greeks and Romans render it impossible to particularise them, such vases, statues, candelabra, helmets, swords, spear-heads, &c. In the Antiquarian Museum of Edinburgh there are various specimens of Roman articles in bronze found in Britain.

* *Stannum* may also have been very hard lead or pewter, Diodorus narrates "that above Lusitania (Portugal) there is much tin metal—that is, in the islands lying in the ocean over against Iberia, which are therefore called Cassiterides."

He gives a description of the rich mines of gold as well as of silver and brass in Iberia. He mentions that in many places of Spain, and in other places of the world then known, tin is found. From this abundance of metals known to the ancients long before the Christian era, one can be at no loss to know that they must have well understood the process of mixing copper and tin, and even silver.*

It has been held by some writers that the Romans were acquainted with the art of tinning or silvering copper vessels, but that vessels of tin have never been found, and silvered ones very rarely. The art of tinning plate-iron may be considered as a modern invention; while that of tinning copper was an ancient one. In corroboration of this, the vessels found at Herculaneum were chiefly of copper, or bronze, few of which were silvered, and none tinned; it has therefore been supposed that the art of tinning vessels was not practised. The art of soldering must have been known to the Romans, as Pliny mentions that lead cannot be soldered without tin, or tin without lead. In soldering, a mixture of both metals is required, either two parts or one of tin, and three parts or one of lead, respectively. As they do not appear to have been acquainted with the union of zinc and copper, it is unlikely that they used hard solder, which is a compound of these metals, zinc being in excess. Many of the bronzes of antiquity are found to be made of pieces of metal joined together. Several coins which bear a resemblance to brass have been found to be composed of copper and the precious metals. It has been held by some writers that there is no direct proof of the brass of the moderns —the union of copper and zinc, in the proportion of about four parts of copper and one part of zinc—being known to the ancients. Sometimes in the ancient bronzes a little silver has been found; but the proportions are almost uniform of 12 parts of tin to 100 parts of copper. It has been held by other writers, from a passage in Strabo, xiii., p. 619, that the ancients knew the common zinc ore calamine, although, perhaps, from the reasons previously assigned of the simpler application of tin as an alloy by fusion, they used it instead of zinc; at all events, few specimens of the mixture of copper and zinc have been discovered in the works of antiquity. It has been stated that an antique sword was found, which, from the analysis, showed the presence of a small portion of zinc.

Although copper was thus so generally used in very ancient times, it is not to be supposed from what has been stated that iron was not in use. A passage in Is. xlv. 1, shows the usage of both metals: "I will break in pieces the gates of brass, and cut asunder the bars of iron." That iron was known at an early period there is no reason to doubt; but, as it appears not to have been generally used, it has been considered that its common use is indicative of a more advanced state of civilisation than even that of gold and silver, although so much less intrinsically valuable.

Amongst ancient traditions there was one with the Egyptains that Vulcan taught them to forge arms of iron. The Phœnicians had also discovered iron, and the manner of working it. The Cretans, as Diodorus relates, placed the discovery of iron and the art of working it in the most remote period of their history. Iron is frequently noticed in his history of nations. Describing the Spaniards, he says: "They, the Celtiberians, make swords, warlike weapons, and darts in an admirable manner, for they bury plates of iron so long under ground till the rust has consumed the weaker part, so the rest becomes strong and firm. Of this they make their swords and other warlike weapons, and with these arms, thus tempered, they so cut through everything in their way, that neither shield, helmet, nor bone can withstand them." Plutarch also mentions this practice of making steel, which, it is said, still exists in Japan,† where the sword blades are famed. Describing the Arabians, Diodorus says that they exchanged gold with the merchants for the like weight in brass and iron.

Some authors ascribe the art of working iron to the Cyclops, and some to the Chalybes, described by Aristotle, a very ancient people, who inhabited part of Pontus, in Asia Minor, abounding in iron mines. Clemens Alexandrinus ascribes the art of rendering iron malleable to the Norches, a nation on the banks of the Danube. These traditions are hypothetical, and need not be investigated.

From the book of Deuteronomy it is plain that the use of iron was well known many generations after the flood (B.C. 1451); but no direct mention is made of iron tools or weapons until after the departure of the Israelites from Egypt. Several passages show that iron was known in Palestine; perhaps the mosaic prohibitions may have had an influence in the general use of copper instead of iron both in Egypt and in Palestine. The Jews appear to have been well acquainted, however, with two kinds of iron previous to the captivity in Babylon—the barzel iron, noticed in Genesis iv. 22, which was in common use, and the northern iron and steel. The difficulty which has been urged of the ancients knowing the practice of smelting the iron ore, and making it malleable, seems to have been early overcome. As it is rarely found of a perfect form ready for use, its application to the arts shows the ingenuity of early nations, and their possession of knowledge which we are often inclined to doubt. As early as the days of Moses an iron furnace is mentioned. It appears from the book of Job, which some commentators suppose to have been written by Moses, that the art of working in iron was known in some countries in the ages referred to.

Iron does not appear to have been made use of in the Tabernacle (B.C. 1490), and very little notice is taken of it in the construction of the Temple of Solomon five centuries later (B.C. 1012). That it was abundant, however, in the time of Solomon, and even used in the Temple, there is ample evidence, although copper is the metal chiefly referred to. In the First Book of Chronicles it is mentioned that, when David was preparing for the construction of the Temple (B.C. 1017), he "prepared iron in abundance for the nails for the doors of the gates, and for the joinings, &c.," and that he prepared "brass and iron without weight, for it is in abundance."

It appears, from the way iron is spoken of, that that metal must have been in use in Egypt long before the time of Moses. Its great hardness is alluded to in the words "I will make your heaven as iron, and your earth as brass." "A land whose stones are iron, and out of whose hills thou mayest dig brass." (Deut. viii. 9)—a passage from which may be clearly inferred the knowledge which in those days existed of the use of the ores both of iron and copper. We also read that "the bedstead of Og, the king of Bashan, was of iron." Mention is also made of an iron furnace, and of swords, knives, axes, and tools made of iron." The art of working in iron is distinctly shown in Isaiah.

According to the Arundelian marbles,* it has been held iron was known 1370 B.C.; but Hesiod, Plutarch, and others, limit its discovery to a much later period. Homer distinctly mentions its use. By the word "sideros," from a simile used in the Odyssey, derived from the quenching of metal in water, it may be supposed iron is meant. In the Homeric poems, and oldest writings, the word χαλκος is restricted to copper and its compounds. Although both in the Iliad and Odyssey of Homer more frequent reference is made to brass than iron, yet it is quite certain that in his age the use of iron was understood. That it was used, perhaps sparingly, for various purposes, such as swords, javelins, and spear-points, may be inferred from several passages.

Thus it is ascertained that the discovery of iron was very ancient, and that the art of working it, converting it into steel, and tempering it, was known at a very early period, probably first in Egypt, Palestine, and other parts of Asia; but it does not appear that its use was either general or much diffused.

Iron in very ancient times must have been regarded of much value, as it was presented in the temples of Greece amongst the most valuable offerings; and rings of iron, which had been worn as ornaments, have been found in the tombs of Egypt, showing the value of the metal. It has been justly supposed that one of the reasons why this metal came so slowly into use amongst the nations of antiquity, and why it was so rare in early times, was the difficulty of smelting it. It was this fact, it has been remarked, which made it to Job such a proof of the wisdom of man that he had invented the process of making iron, and separating it from the earthy particles in which it is found. It is more than probable that the liability of this metal to decay from its oxidation may be the reason why so few specimens of the iron workmanship of antiquity have been handed down to

* The Chinese gong metal is a mixture of 20 parts of tin to 80 of copper. The Chinese early knew the process of bronzing copper vessels. Speculum metal consists of 1 part of tin with 2 parts of copper.

† In Japan a sabre is described which will cut through a nail without injuring the edge, and cut off a man's head or cleave him asunder at one blow. Marvellous are the accounts of oriental weapons. The ancients say that with their swords they could cut through shields and helmets.

* Brought to this country by the Earl of Arundel, in 1624—hence the name. They contained the chronology of Greece from 1582 B.C. to A.D. 264.

the moderns in comparison with those of bronze and copper. Although it has been well established that at a later period of ancient history the use of iron became more common to the Greeks and Romans, it is probable that, from the facility with which it could be worked, they preferred to use copper.

In corroboration of the antiquity of the use of iron, a very interesting discovery was made some years ago by the traveller Belzoni, which throws some light upon this point. He found under a statue at Karnac, in Egypt, the blade of an iron sickle, 11 inches in diameter, not unlike a modern reaping-hook. It is preserved in the British Museum. It is fractured in three places, and completely oxidised throughout. Traces of the wooden handle into which it has been fitted are visible upon the end. Belzoni states that this sickle proves that iron was known to the Egyptians before the conquest of Egypt by the Persians under Cambyses, B.C. 525. The name of Darius appears on an inscription on the columns of the Temple of Osiris, and the names of Xerxes and Artaxerxes likewise appear in inscriptions in Egypt. The Persian empire fell by the conquest of Alexander, B.C. 332, and Egypt was reduced to a Roman province under Augustus, B.C. 31. The discovery of this sickle proves beyond doubt not only that iron was early used, but that the practice of reaping with it was of great antiquity. The elder Pliny says little regarding the manner in which the Romans discovered and prepared metals. He however mentions iron in his work.* In Grecian history the well-known fact is recorded, that Lycurgus, who lived B.C. 884, made the use of gold and silver of no value by ordering the Spartan coinage of iron, that there might be no temptation to covetousness, or perhaps its rarity at the period may have led to greater value being put upon it. In the British Museum are preserved several ancient Roman articles made of iron, as the stylus, strigiles, iron fetters, &c.

The Roman writers upon husbandry throw much light by their description of implements upon the progress the manufacture of metals had made about the commencement of the Christian era; but there is exceeding difficulty in ascertaining whether iron was chiefly used for their farm implements, or whether many of these were not made of the alloy of copper and tin. It is more than probable, however, from the construction of many of these implements, that they were made of iron. Virgil, who lived B.C. 19, has minutely described the aratrum or plough, of which there were several kinds. Cato mentions two —Romanicum and Campanicum. The first had probably an iron share, and the latter a piece of timber with a share or sock driven upon it. It may be supposed that the plough with which the Israelites fought against the Philistines (1 Sam. xiii. 19) was of metal, probably iron,—"The Israelites went down to the Philistines, to sharpen every man his share, and his coulter, and his axe, and his mattock." The Romans had ploughs with coulters and without them—ploughs with shares both broad and narrow pointed, ploughs with or without mould boards, and ploughs with or without wheels. Many other implements used in husbandry, in all probability made of iron, are mentioned by the Roman writers on husbandry, showing the general application and appreciation of metals. The following implements are mentioned beside the plough,—the irpex, crates, rastrum, bidens, capreolus, securis, ligo, pala, sarculum, marra. These were chiefly used, it is supposed, for digging, hoeing, or smoothing the surface of the ground. Beside those there were many others for reaping, beating out, and clearing the corn. The irpex, termed urpix by Cato, was a plank with several harrow-teeth, to pull roots out of the earth, drawn by oxen as a carriage. The rastrum was a rake used in manual labour like a common garden-rake. The sarculum was a common hand-hoe. The bidens was an instrument employed by the ancients in gardens and vineyards; it had two teeth, and was used like a hoe to open up hard and strong ground. The ligo was an instrument like a common spade. The pala is supposed to be a different name for the same instrument, and seems to have been made of timber, pointed with iron, and was probably used as a shovel. The securis and dolabra were sometimes joined in one—the securis on the one side, and the dolabra on the other—and they seem to have been tools like the common axe and adze. The marra is supposed to have been a kind of scraping instrument like a hand-hoe. The crates was an improvement upon the irpex; it was in the form of a harrow, and was drawn by oxen, as the irpex. One of the Roman writers on husbandry mentions that the crates* was used for smoothing the surface of the land, and breaking clods, and was drawn by cattle, as the harrow is now used.

Beside these implements, constructed wholly or partially of metal by the Romans, mention is made by their rural writers of the sickle, the scythe, the pecten, &c. In the reaping of grain much attention and care seem to have been manifested by the Romans. One may easily suppose that in barbarous ages, from the want of proper instruments, the practice must have been very rude. The Israelites, to whom manure was an object, cut the straw near the ground, and burned the stubble, while the Egyptians plucked off the ears or pulled up the corn by the roots. This is shown by the passage in Exodus, relative to the Israelites, from which it appears to have been the practice of the reapers to cut off the ears of corn with hooks, and to leave the stubble standing—a practice which the Romans, in some instances, seem to have followed. The sickle must be an implement of great antiquity, probably suggested by the idea of cutting several ears of corn at once. One commentator mentions that the sickle of Saturn is said to have taught the people to cultivate the earth. It is true that this supposes the working of metals, which, in those very ages, was known to very few nations. Various tribes of mankind might supply this want by different contrivances, but there is no doubt that in eastern countries, from very early ages, the ordinary way of cutting down corn was with hooks or sickles. The sickles used in ancient times were probably very much the same as those now in use. The sickle is mentioned in sacred writ—in Deut. xvi. 9 (B.C. 1451)—"As thou beginnest to put the sickle to the corn;" and in Joel iii. 13 (B.C. 800), "Put ye in the sickle, for the harvest is ripe." These passages corroborate the discovery of Belzoni as to the sickle found in Egypt. The Romans probably made use of the same kind of sickle as the Israelites and Egyptians. Besides cutting down the corn with the sickle they used a scythe, and sometimes they stripped off the ears of corn by means of an instrument called batillum or staff-hook, supposed to be a kind of iron saw, and the straw was afterwards cut down. Some commentators think the batillum was like a common scythe, or it may have resembled a pair of hedge-shears. Varro, in one passage, notices the batillum. He states —"They reap after another manner in Picenum, where they have a curved wooden batillum, upon the end of which there is a little iron saw; this, when it embraces a bunch of ears, cuts them, and leaves the straw standing in the field. There is another way, as in Umbria, where they cut the straw close to the ground with a hook." This was more probably a scythe.

Columella also mentions different instruments for cutting down grain. "Many," says he, "cut the stalks by the middle with vericulates, drag-hooks either beaked or toothed. Many gather the ears with mergæ, and others with combs." The merga is supposed to be like the pecten, a comb or a kind of rake, with a short handle, by which the ears were pulled from the stalk. The instrument first mentioned in this passage is called falx vericulata, from falx, a hook, and vericulum, a drag-net. A scythe of this kind may thus be called falx vericulata. This instrument was different from the batillum mentioned by Varro, for the batillum cut off only the ears, while the falx vericulata cut off part of the straw and ear. The antiquity of these different methods of cutting grain with instruments is placed beyond all manner of doubt, and clearly evinces the early application of metals to the purposes of the useful arts. Besides the methods noticed, the Romans likewise made use of machines for reaping and thrashing grain, evincing a still farther development of the same principles. Pliny (Hist. Nat. lib. xviii. cap. 30) gives an account of a kind of reaping machine used in the extensive plains of Gaul, from which we infer the great antiquity of this machine. Large hollow machines, with teeth fixed on the fore part, are pushed forward on two wheels, through the standing corn, by an ox yoked to the hinder part; the ears cut off fall into the hollow part of the machine. In other places we are informed the stalks are cut in the middle with hooks, and the ears are cut off between two mergites (ripples). There was a difference in the manner of reaping, according to circumstances. When long straw was

* "Ores of iron are found almost everywhere, and are also produced in the Island of Ilva (Elba) in Italy..... Of all metals the vein or ore of iron is found in the greatest quantity."—*Plin. Hist. Nat.*

* It is probable the harrow noticed in sacred writ, Job. xxxix. 10—"Will he harrow the valleys after thee"—may have been the crates of the Romans. The harrow is thus supposed to have been of great antiquity. It is mentioned by Columella and other writers. Crates was also the name given to all kinds of basket-work; there are different varieties noticed by the Roman writers, as *crates pastorales, crates stercorariæ*, woven with straw or rushes.

wanted, they cut high to keep the straw long; where there was a scarcity of hay, they cut low, that the straw might be added to the palea or chaff, or short straw. The Roman writers, in their description of these modes of beating out corn, notice the use of iron. Varro, describing the tribulum, says, "It is made of a board rough with stones or iron."—Lib. i., c. 52.

From these quotations and descriptions we see the great progress which mechanical inventions had made in ancient times, and the great extent to which iron was used amongst the Romans, especially in the later periods of the Empire.

All the descriptions here given are fully corroborated by the discoveries made in Herculaneum and Pompeii, as also by the remains of Roman antiquities which have been found in Europe. Iron cramps were found which had been used by the Romans in Britain for the fixing of their bricks in constructing their furnaces. Brazen vessels were in common use in the time of Vitruvius. Metal pipes were also in as common use in the time of Seneca. Whether the pipes referred to by the Roman writers (Trans. Arch. Inst. 1850-51, p. 229) were of copper or iron, it is not easy to ascertain. It is more than probable they were made of copper; but the vessel in which they were placed is distinctly described as made of lead, with a brazen bottom to resist the fire, proving beyond a doubt the advancement the Romans had made in the art of working in metals. The discoveries which have been made in Pompeii demonstrate the truth of the ancient Roman writers regarding the advancement they had made in applying metals to many purposes to which we now apply them. Lead seems to have been in common use as at present for conveying water in pipes, and was applied for distributing water from their aqueducts through their cities—for supplying fountains and jets d'eau. The description given by some of the Roman writers of the use of copper for supporting roofs and lattices of windows also proves that the Romans employed metals in the construction of their buildings.

It might be expected that the discoveries made in the ruins of Herculaneum and Pompeii would have thrown much light upon the use of metals amongst the ancients; but both these cities, being of the second order, were not likely to indicate the same progress in the arts as the capital. Herculaneum in Campania is supposed to have been founded about 1340 B.C., and was destroyed by the eruption of Vesuvius, 79 A.D. It thus partook, during the many centuries of its existence, of the character of the ancient Roman art. The ruins of Herculaneum are about 24 feet below the surface, and the ashes and lava which buried it now form a mass of dark grey stone, which is easily broken, and does not adhere, but rather incases the substance within, so that marbles and bronzes have been well preserved. The important relics excavated since its discovery in 1713 are highly interesting, as respects metals, coins, rings, and bronzes; tripods, lamps, looking-glasses of highly-polished metal; kitchen utensils, as copper pans lined with silver, kettles, cisterns for heating water, and other articles.

Pompeii was also destroyed by the eruption of Vesuvius, 23rd August 79 A.D. Its early history is but little known, although supposed of great antiquity. It was about ¾-mile in length, and ½-mile in breadth. The ruins are about from 12 to 14 feet below the surface. Its excavation commenced in 1775, although its ruins were known to exist in 1689. The ruins are so perfect that they convey an accurate idea of the buildings as they existed; hence they throw a clear light upon the state of the arts of the ancients. The streets are generally very narrow, and the houses low; but some of them are several stories in height. Others of them are insulated. In Pompeii fine specimens of metals have been found, showing beyond the possibility of mistake the progress which the art of metallurgy had made eighteen centuries ago. Bronze statues have been excavated in high preservation—as a bronze statue of Fame; many gold, silver, and copper coins; a great many utensils of all kinds—as chisels, saws, bells, springs, hinges, buckles, locks, inkstands; and articles in gold and silver—as earrings and spoons. The numerous lamps (1000 found in the baths), a candelabrum, an oval cauldron or boiler, cooking and kitchen utensils, scales, and steelyard, all indicate the progress of civilisation and of luxury. Numerous pieces of armour have also been found—as helmets in bronze, and greaves. Lead pipes, as well as other conduits, appear to have been employed for the conveyance and distribution of water; and iron and copper were then used for many of those purposes for which the moderns now employ them*—even to the making of shackles, within which human bones were found in the prison.

The frequent use of the arch in Roman architecture, instead of beams and joists as now practised, and the frequent use of bricks, may serve to explain why metal was not more required in their building and great engineering works, such as the celebrated stone bridge over the Rhone, built in the reign of the Emperor Trajan, consisting of twenty arches, and other great works. That timber, however, must have entered largely into the construction of their buildings is shown from the conflagrations of their cities. Cæsar's bridge over the Rhine, constructed when the Romans first invaded Germany, was made of timber; also the Pons Publicius at Rome.†

Although it is not easily ascertained from history to what extent iron was used in the construction of buildings by the Romans, and although, from its perishable nature, it could not be expected that many of its applications would reach these times, yet there is ample evidence, from what has been shown, that its utility was appreciated, and its use common. It has been said that the large stones of the aqueduct bridge at Nimes have been joined together without cement by ligaments of iron. In domestic buildings iron was used, according to the Roman authors, for many purposes similar to those to which it is now applied, such as the making of nails, bolts, locks, hinges, hooks, pillars, gates. For the last of these probably bronze was more frequently used, as the two gates of the Temple of Janus, which were opened in war and shut in peace, consisted, according to Livy, of brass. The brazen gate of the Pantheon is described to have been of great magnitude, and of fine workmanship. The progress made in the casting of statues in bronze has already been noticed, and when historians have recorded that there were 420 temples at Rome crowded with statues, one may easily conceive that bronze casts would be extensively used. Even brazen columns or pillars were constructed at Rome, as the Columna Æna. At the Columna Mænia, named after C. Mænius (A.C. 417) were placed the brazen beaks of captured ships.

The great skill displayed by the Romans in the manufacture of their brazen lamps is well known. These have been found in every variety of form and size. Many of those found at Herculaneum are preserved at the museum of Portici. Their braziers also displayed equal taste. In the construction of their carriages metals were employed, as with us, at least to the extent of the wheels, which were surrounded with iron or brass rings. Iron scythes were attached to their war-carriages. Regarding their weapons of warfare, we have the testimony of Diodorus, who lived at the period when the Temple of Janus was shut, when Cæsar had conquered the then known world. He was himself a native of Sicily, had opportunities of knowing the facts, and has stated of the celebrated mathematician Archimedes, also a native of Sicily, who flourished about 250 B.C., that such was his mechanical skill that by means of ropes and pulleys he drew towards him a galley which lay on the shore manned and loaded, and that by means of grappling-hooks placed at the extremity of levers he hoisted up vessels in the air and dashed them to pieces upon the rocks. His power in setting fire to the Roman ships at the siege of Syracuse with reflecting mirrors was long deemed fabulous, but modern discoveries have made this less doubtful. His knowledge of the power of the lever was great. It has reached posterity as one of his sayings—"Give me where I may stand, and I will move the world." Diodorus mentions that Egypt was indebted to him for the invention of the screw-pump, for drawing off water,‡ and of other useful machines; and Vitruvius mentions that he knew the doctrine of specific gravity. That he was well acquainted with the uses of iron and of other metals, and applied these, there is no doubt, from the fact of the powerful war-engines he contrived. The Roman battering-ram consisted of a beam 100 feet long, suspended by chains, and armed at one end with iron, in the form of a ram's head. Iron was also used in the later periods of the Roman history for many purposes of attack and defence, and for implements of warfare. There can be no doubt that, as their conquests extended throughout Eu-

* Diodorus corroborates this, for he mentions a bridge where, that the stones might be more firmly "join'd, they were bound together with hooks of iron, and the joints filled up with melted lead." What more could the moderns do?

† This bridge is said to have been so framed as to require neither iron bolts nor ties. No one reading the descriptions, however, of the colossal works of antiquity in Egypt and in Rome—of their bridges, aqueducts, and sewers—of their triumphal arches, forums, basilicas, temples, amphitheatres, and columns—but must be convinced that in the erection of these the use of metal was common.

‡ Diodorus remarks—"For this engine is so ingeniously contrived that a vast quantity of water is, strangely, with little labour, cast up..... The ingenuity of this artist is to be admired not only in these pumps, but justly in many far greater things."

rope, Africa, and Asia, they would participate in the knowledge of the minerals and metallurgy of the conquered countries.

In machinery there is little evidence that the Romans had made much progress; but it is not to be supposed that Hero of Alexandria (B.C. 120), to whom the invention of the steam-engine has been ascribed, did not well understand and appreciate the use of metals. His work on pneumatics, written in Greek, treated of his own inventions and of those who had preceded him.

In naval warfare the use of metals must likewise have gradually progressed with the ancients. The corvi, or crows, or iron hooks, and ferreæ manus, drags or grappling-irons, were used, and the nails and fastenings of the planks of their vessels were also made of metal.

It has thus been seen to what a variety of purposes the ancients applied metals at a period in history when it is often erroneously supposed the world was in an uncivilised state. One striking fact, proving the abundance of the precious metals, is recorded by Diodorus, who, when describing the Phœnician merchants in early times, says "that such was their covetousness, that when they had fully loaded their ships, and had much more silver to bring on board, they cut off the lead from their anchors, and made use of silver instead of lead." The ancient anchors were made of wood filled with lead, but the Romans afterwards used iron and bronze for anchors. Another striking proof of the progress of luxury is recorded by the Roman historians, who tell us that at the battle of Cannæ, in the second Punic war, when Hannibal defeated the Romans, he sent to Carthage three bushels of gold rings, taken from the fingers of the knights.

In a paper of this kind it is hardly possible to give more than a mere condensed view of a subject of such magnitude as that which I have considered; but enough has been said to show the great knowledge which mankind possessed from very early times of the use of metals. The very limited information which has been handed down to posterity of the mines of the ancients, does not serve to throw much light upon the subject. The historian Diodorus has given a few notices regarding these; and from his interesting work a few brief passages have been given, showing the vast resources of the ancients in gold, silver, and other minerals. With respect to iron, in his description of the Mediterranean Sea, he mentions an island, Æthalia, distant from Lipira nearly one hundred furlongs, which abounds with iron-stone, which the natives dug and cut out of the ground to melt, in order to make iron. Strabo (B.C. 25), who visited many countries, and upon whose geographical work much reliance is placed, mentions the abundance of gold, silver, copper, and iron, found at Turdetania, part of Spain.

According to some writers, such as Quintus Curtius, so plentiful was gold and silver, that even the soldiers of Alexander the Great made their armour of it. The Greeks and Athenians had mines, which they wrought, of silver, lead, zinc, copper, but not gold; but the gold mines of Thrace were known to the Phœnicians, who also knew and worked the copper mines at Cyprus. When they conquered Spain, they found immense supplies of gold, silver, and quicksilver. The value of the tin mines in Britain was early known to the ancients—a fact which serves to show that the natives of Britain, when the Phœnicians traded for tin with them, must have been farther advanced in civilisation than is supposed. At the Roman invasion of Britain, the minerals must have been great attraction to them to maintain their hold of the country. There is no doubt that the lead mines in Derbyshire were wrought by the Romans, as blocks with Roman inscriptions have been found, and preserved in the British Museum. As zinc has not been met with in a metallic state, although existing in other forms in several lead mines, it is improbable that it was used, as already noticed, though it may have been known to the Romans. It has been fully ascertained that gold mines were worked by the Roman soldiery in North Wales; and also that iron works were established by the Romans in the Forest of Dean, Gloucestershire. And it is more than probable that coal and other mines were worked by them in Britain. Various lead, copper, and iron mines situated in Germany, France, Spain, and other countries, there is no reason to doubt, were known to them. The rich iron mine of specular ore at Elba was known and wrought by the Romans in early times, proving beyond question that the art of making iron and its uses were well known. The metals used by the ancients appear to have been gold, silver, copper, tin, iron, lead, cadmia, antimony, and quicksilver.

Enough has been said to show the knowlege which the ancients had of minerals, and the great progress they had made in the art of metallurgy. It has been seen that in all ages and in all climes the power of reason has been given by Divine intelligence to mankind, and has enabled them to make even the crust of the earth to contribute to human benefit; while, by the gift of industry, the art of metallurgy has given employment to the people, and stimulated ingenuity, and advanced refinement. But when bringing an array of facts before this Institution bearing upon the knowledge of the ancients, we would fail in our object were there not something more to be deduced from them than what is fitted to gratify curiosity,—if the reflection were not awakened in the mind that all human things are perishable—that even the hardest metals will, like the rocks, decay,—and that the wonderful Providence which rules and governs the world, by whose decree kingdoms rise and fall, has so ordained, for the wisest and best of purposes, though these are inscrutable to us. When we look over the page of history we find nations pass before us in rapid succession. Many of them, "like the baseless fabric of a vision," have passed away and left "not a rack behind." And while we thus see the knowledge, genius, learning, and skill which many of the ancient nations possessed, and which it took centuries in their history to attain, now almost buried in the tomb of oblivion, they will not have lived in vain if we, profiting by what they have left behind, avoid the rocks upon which they were destroyed. Should not a spirit of thankfulness be inspired, that our lot is cast in better times, when opportunities of instruction, open almost to all, spread before us the wide fields of human knowledge.

MINING SCHOOLS.*

It is now some years ago since we had occasion to review the system of professional education, and the various schemes which were then proposed for its advancement. Among these was a College for Civil Engineers, and a School of Mining. To the former we objected that it proposed to substitute theoretical for practical instruction, the schoolroom for works and the workshop; the latter we advocated as promising to supply the mining engineer with the means of obtaining supplementary instruction. The College for Civil Engineers, as originally constituted, we looked upon as equally fatal to the education of the student and his professional advancement, by subverting unnecessarily the existing professional organisation. We foresaw that the parents and the students must be both disappointed, because the arrangements were constituted on an erroneous basis. Under the ordinary system the student becomes the articled pupil of a professional man, who not only affords him opportunities for practical instruction, but becomes a surety or voucher for his actual attainments, and has natural opportunities of affording employment. To a certain extent an undue advantage is hereby given to one man, simply on the ground of his employment, and not of his capacity; but that is incidental and inevitable. At all events the father, who puts his son with an unemployed engineer, has no one to blame but himself if opportunities for employment are found wanting. Between the engineer and his pupil a kind of relationship springs up, a social tie is formed; and if employment cannot be given by the former on his own works, his recommendation has some weight with other engineers.

The College, professing to give greater advantages, in reality gave less. It might be that the student went through a regular and systematic course of instruction, but not necessarily so, for the pupil of an engineer in London can attend the supplementary and theoretical classes at University and King's Colleges, and in other schools; and so in most of our great towns. Experience has proved that the students at Putney had not those opportunities for practical proficiency to be obtained in private establishments; and the examination and certificate, on which so much reliance was placed, did not produce any effect with the public. Even after great reforms and improvement had been made in the institution, and able practical men had been invested with the professorships, the original vices could not be overcome. By the nature of their avocations, the professors were precluded from full professional employment, and thereby from adequate opportunities of promoting the interests of the students. It must, further, be borne in mind, that though

* Museum of Practical Geology and Geological Survey—'Records of the School of Mines and of Science applied to the Arts': Vol. I. Part I. *Inaugural and Introductory Lectures to the Courses for the Session* 1851-2. London: Longmans. 1852.

a feeling of regard springs up between teacher and pupil, yet, there being several teachers for each pupil, and many pupils for each master, there was not the same intimate connection of interest as between the practitioner and his pupils.

All that ability could do to maintain the College for Civil Engineers was done, and many liberal individuals largely contributed to promote its objects; but although professional hostility had ceased, experience pronounced against it, and after lingering some time its labours were brought to a close.

The attempts to establish Mining Schools did not meet with the same measure of encouragement, although they have ultimately been brought to a successful issue; and, it is to be presumed, have obtained in the School of Mines a permanent foundation. It must always be regretted that the munificent effort of Sir Charles Lemon, to form a mining school in Cornwall, was not attended by correspondent exertion on the part of the mining interests, for thereby the opportunity was lost of giving an important example of the value of such institutions. The proper, and it may be said natural origin of mining schools is in the formation of establishments in mining districts, from which practical men may be obtained as teachers and students, who, without disturbance of their usual pursuits, may devote themselves to supplementary instruction. With a proper development of such local schools, a central, and perhaps, in preference, a metropolitan school acquires its true significance. In such central school the highest branches of instruction may be communicated, the local details of scientific and practical research be concentrated and compared, and a standard of emulation be created for the observance of the whole body of instructors and pupils. We are glad to see that Sir Henry De la Beche has directed his attention to the organisation of local institutions, extending even to the instruction of the common workmen in mines.

We think it right, too, to call the attention of our readers to the novel endeavour of the managers of the School of Mines, to open evening courses for the instruction of working men in the metropolis. Such arrangements are very much wanted, for though we ought scrupulously to avoid the technical schools of the continental commonwealths, as promoting theory in preference to practice, yet we do want for our workmen those opportunities of instruction in the accessory and higher branches of science which are liberally afforded to our competitors by foreign governments. Something has been done for education in design; but we want schools for mathematics, natural philosophy, mechanical drawing, and, above all, chemistry. To some extent the School of Mines will supply this deficiency, and the directors deserve great credit for making a beginning. We question, however, the propriety of making any charge to working men; for however inconsiderable it may be deemed by wealthier men, it constitutes a burthen which is strongly felt by those who pay it. A pound a-year, for instance, may be considered a small contribution for a mechanic; but the charge does not end here. There are books to be bought, and other expenses; and then, a young man has to save money to meet periods of distress and to provide for his marriage and establishment, while he has always benefit and club expenses. It is a mistaken notion of the middle classes that knowledge is only valued when it is paid for, and it may very safely be assumed that the student who only applies for instruction because he has to pay for it, cannot be worth much. In the organisation of schools of design, the mistake was made of levying large fees on the scholars, which had to be reduced; while we believe there are few schools which would not be filled, even if no charge whatever were to be levied. Not to speak of other institutions, the Royal Academy and British Museum are in no want of students, though not a halfpenny is paid by those resorting for instruction. We therefore advocate free instruction for mechanics, as on the continent.

Another measure wanted, to put us on a par with foreigners, is in the delivery of gratuitous public lectures on the higher branches of science and new discoveries, not coming within the ordinary curriculum of instruction. The lectures at the Royal Institution are, to a certain extent, of the requisite scientific standard, but do not possess the public character required. We are convinced that the delivery of a few such lectures by the professors, in the course of each year, would materially contribute to the reputation of the Institution.

The School of Mines and of Science applied to the Arts, now established in the Museum of Practical Geology, owes its rise, in a great degree, to Sir Henry De la Beche; and, as it presents no temptations to usurp the functions of practical men, promises to confer great public benefit. The volume of Inaugural discources, already published, is necessarily directed to the inculcation of the value of abstract science to practical men, because that is, as it were, the case to be made out at present; but it must not be thence assumed the nature of the instruction is wanting in a practical character. The volume before us is one we strongly recommend to our readers, because it well makes out the case for the establishment, and shows by apt illustration the real nature of the service to be obtained from the proper application of science in practical pursuits.

Many of these lectures have been already noticed in our pages, and they include the contributions of Sir Henry De la Beche, Dr. Forbes, Robert Hunt, Mr. Ramsay, Mr. Warrington Smyth, and Dr. Percy. We do not think it necessary to particularise these contributions, or to speak of their merits more than generally, because we feel that the book must have extended popularity.

HYDRAULIC ENGINEERING.*

We have often urged the importance of laying a sound basis for hydraulic engineering, by the publication of copious accounts of the history and examples of hydraulic works. The description of existing works alone is utterly useless for the instruction of the practical man, for no work, however complete it may seem to be, can be held satisfactory until it has stood the test of long experience; and even the value of such example is limited, because what will do for one locality is not suited for another,—although engineers think that a plan of a harbour, like that of a steam-engine, can be worked out anywhere, and that little is to be done beyond setting up well-built stone walls, providing backwater, and trusting to dredging-machines.

The great work of Sir John Rennie has, on these grounds, always seemed to us to require the greatest encouragement on the part of the profession, as the most important step towards the establishment of a great branch of engineering on a scientific and practical basis. Whether by the publication of Sir John Rennie's work, or urged to it by our observations in years past, the Harbour Department of the Admiralty have determined on contributing towards the accomplishment of the same object; and in the 'History of the Harbours of the United Kingdom' they promise a valuable series of professional memorials. Although the government has begun its task, Sir John Rennie's work loses none of its value or significance. It is, as yet, the most copious and the most practical, and is likely to be the first brought to a state of completion; not only on account of the extent of the scheme contemplated by the Harbour Department, but because government designs want the vigour and energy of private undertakings. Nevertheless, great credit is due to the present conductors of the Harbour Department for an enterprise which comes strictly within their duties, and will greatly promote the public interests. We look upon the expenditure, indeed, as a measure of economy, for by improving the state of hydraulic engineering, very large sums must be saved to the governments on works which are now, for a great part, unprofitably and ineffectively constructed.

We have so often had occasion to complain of the want of a sound basis for hydraulic engineering, that we might have been esteemed inveterate grumblers, had it not been that notorious examples of failure too truly vindicate the justice of our animadversions. The harbour engineer, besides the resources of physical science, requires the aid of the geologist, the seaman, and the merchant. He must have great local knowledge and long experience of the site to be operated upon, and wide acquaintance with the condition and history of harbours generally. We need scarcely say how few of the engineers employed, however high in other departments, possess these requirements. The hydraulic engineer has not, like the railway engineer, to operate on inert matter, but he has to contend with tides, currents, and winds, and the results of the great organic laws of nature, and the wondrous mechanism by which this globe of earth is maintained in action, or, it may almost be said, life.

The engineer coolly proposes to scoop out so much shingle, or to dredge so much silt, without bearing in mind that he is putting himself in antagonism with the great tides of the

* 'History of the Harbours of the United Kingdom; compiled by the Harbour Department of the Admiralty:—*Belfast*.' London: Eyre and Spottiswoode, Queen's Printers. 1852.

world, or it may be with an offshoot current of the gigantic gulf-stream, possessed of eternal action, and ready to resume the course of operations which the vain labours of a few days have suspended. Experience has the less effect in this branch of engineering, inasmuch as the results of experience are little known or attended to; and it is a sufficient indication of the present state of this branch of engineering that the practitioner rarely succeeds in gaining public confidence for his plans. The seaman, the pilot, or probably an old inhabitant, commonly criticises the design of the works, points out their practical deficiencies, and has too commonly the satisfaction of proving himself right by the course of events. There is, indeed, no branch of practical knowledge in such an unsound condition as this, where men are content to repeat the blunders of their predecessors, and to commit themselves to general propositions the fallacy of which has long since been demonstrated. The following remarks of Sir Henry De la Beche are very severe, and too true, as our readers know. Speaking of the value of the Geological surveys, Sir Henry says, "Our everyday's experience along coasts shows us how needful it is that the engineer should, as well as the geologist, study them. Let us, for example, consider this cove—there are hundreds such as it to be found on our coasts. The mode in which it is silted up is apparent to you; and yet many an artificial cove has been constructed, at great cost and loss, which was as certain to be filled up by silt and sand as this has been and must be." This is perfectly true; and "an artificial cove" or "shingle trap" is the true designation of many works styled by their constructors, and supposed to be, harbours and harbours of refuge—the right sense in which they are harbours being that of harbouring silt and sand.

Sir Henry goes on to say, "No doubt there are conditions where the silting up may be so small as to be comparatively unimportant; but the probability of these conditions requires the study pointed out. While on this subject let me also briefly call your attention to the silting up of estuaries. Those who are engaged on the Geological survey have often to consider it, both with reference to the mode of deposit of certain rocks, and to the changes effected by it at the present day. The plan before you shows an estuary, with the boundaries of high and low water; a spit of shingles, running in front of part of the estuary, separating it from the sea and the comparatively narrow entrance for the ingress and egress of the tide. The whole is the result of the balance of certain conditions by which the channel from the sea to the estuary is kept clear, and vessels of a certain class can enter and depart. The body of water entering and passing out is important; and yet, what do we often find done, and done too by act of parliament? The body of water entering, and consequently passing out, is diminished for the purpose of reclaiming, as it is termed, certain mud-banks, often extensive; thousands of tons of water are thus sometimes cut off from performing the work by which they aided in keeping the channel to the sea clear; the bottom of the channel rises, and the port is damaged. No doubt the mud-bank may be converted into fertile land, but at what loss! The natural causes for deteriorating estuary harbours are often bad enough, but why artificially try to injure them?"

The volume of the 'History of Harbours' now before us, relating to Belfast, is one highly useful, because it has a copious collection of the various plans and reports, bringing down the history of the harbour and the views of eminent men with regard to it to the latest time. The book does not, however, like Sir John Rennie's, contain drawings of the works, though these are of great importance, because unfortunately even the structure of walls and piers remains unsettled; and it is very desirable to get good examples of the forms of walls which under given conditions have proved effective. The book is very well drawn up, is cheap, and includes a number of details which will be found very useful. We hope to see the design fully carried out by the publication of complete records of the numerous and interesting harbour works around our coast.

Bilston.—Messrs. Ashpitel and Whichcord's design for the Baths and Washhouses, and Mr. Bidlake's, of Wolverhampton, for the Town Hall and Literary and Scientific Institution, have been accepted. The cost of each building will be about 2000*l.* and both are to be erected in the Italian style of architecture.

REVIEWS.

The Building erected in Hyde-Park for the Great Exhibition of the Works of Industry of all Nations, 1851. Plans, Elevations, and Details, by C. Downes, Architect; and Scientific Description by C. Cowper, C.E. London: Weale. 1852.

We have had brought before our notice a great many works on the Exhibition Building, but this is the one of most practical character—a necessary consequence of the advantages possessed by its editors in the access to the original working drawings. We believe nothing is omitted which is essential to a proper understanding of the whole structure, and the engravings are as numerous and as full of details as the most exacting could require. It must therefore be considered an accession to professional literature.

First Report of the Commissioners for the Exhibition of 1851. Presented to Parliament by command of Her Majesty.

This is called the first report of the Commissioners for the Great Exhibition, but it is a detailed account of the preliminary organisation and of the working of the Exhibition. It does not, however, take up the early history of the origination, beginning at a later date and showing very fully what the Executive Committee did.

Supplement to the Theory, Practice, and Architecture of Bridges. Part IV. '*Suspension Bridge across the River Danube.*' By W. Tierney Clark, F.R.S., C.E. London: Weale. 1852.

The additions made to Mr. Weale's work on Bridges are, we are glad to see, of a valuable character. The present part is devoted to the Pesth Bridge over the Danube—an example truly valuable, because referring to a work not only of great magnitude, but placed in a situation of natural difficulty, and requiring much ability and the exertion of great professional resources for its successful accomplishment. The engravings are an essential portion of a book of this class, and fully carry out its objects.

Elementary Practical Geometry for Schools and Workmen. London: Groombridge. 1852.

The author states that his object has been to provide a work of instruction for young workmen, and for the older pupils in schools where theoretical geometry is not taught. He seems to have carried out his plan and produced a very useful little book.

The Gold Seeker's Manual. By D. T. Ansted, M.A., F.R.S. London: J. Van Voorst. 1849.

Although this work—written in 1849, at the time when California occupied so considerable a share of the public attention—has no reference to the recent Australian discoveries, it will be found to be no disparagement. Its valuable information as to the general distribution of gold, as to its mineral characteristics, and the simple tests for ascertaining its specific gravity—tests of the highest practical importance—render it a useful book to the miner, while the chapters on the influence of California on the commercial value of gold render it worthy the attention of the economist. Mr. Ansted states that a remarkable mixture of native gold with silver, occasionally found in Siberia, and known under the name of electrum, is likewise to be found in California.

On Peruvian Guano; its History, Composition, and Fertilising Qualities; with the best mode of its application to the Soil. By J. C. Nesbit, F.G.S., F.C.S. London: Longman and Co. 1852.

This is the tenth edition of a small book in which Mr. Nesbit, the principal of an agricultural school, has very fully and practically illustrated the history and treatment of guano, so as to enable the agriculturist to buy it safely and apply it properly.

BOILERS OF THE U. S. STEAMSHIP "FULTON."*

By B. F. Isherwood, Chief Engineer.

The following is an account of the performance of the boilers of the *Fulton* on her trial trip under the ordinary circumstances of sea steaming, burning the fuel with natural draft, and without forcing the fires. The fuel used was soft anthracite, a mean between the Cumberland coal and the anthracite proper. The data is the average of 11 hours' continuous steaming.

Boilers.

Two double return drop flue iron boilers, circular from end to end, placed side by side	—
Length of each boiler	22 feet.
Diameter	10 ft. 6 in.
Contents of circumscribing parallelopipedon of each boiler, exclusive of steam chimney	2426·50 cubic ft.
Area of heating surface in the two boilers	2600·00 square ft.
Area of grate surface in the two boilers	112·00 "
Cross area of upper and middle row of flues, each, in the two boilers	16·75 "
Cross area of lower row of flues, in the two boilers	17·40 "
Cross area of chimney	21·65 "
Height of chimney above grate	43·00 feet.
Pressure of steam above atmosphere in boiler per sq. inch	24·00 lb.
Initial steam pressure above atmosphere in cylinder	22·30 lb.
Cutting off at, from commencement of stroke	3·00 feet.
Number of double strokes of piston per minute	16·
Consumption of anthracite coal per hour with natural draft	1342·00 lb
Capacity of steam room in boiler and steam-pipe	1210·00 cubic ft.

Proportions.

Proportion of heating to grate surface	23·214 to 1·000
Proportion of grate surface to cross area of upper and middle row of flues, each	6·687 "
Proportion of grate surface to lower row of flues	6·437 "
Proportion of grate surface to chimney	5·173 "
Proportion of heating surface to cross area of upper and middle row of flues, each	155·224 "
Proportion of heating surface to lower row of flues	149·425 "
Proportion of heating surface to chimney	120·092 "
Proportion of heating surface per cubic foot of space displacement of piston	18·453 square ft.
Proportion of heating surface per cubic foot per double stroke of piston per minute	1·153 "
Proportion of grate	0·050 "
Proportion of grate per cubic foot of space disp. of piston	0·795 "
Cubic feet of steam room per cubic foot of space displacement of piston	8·587 "
Consumption of anthracite coal with natural draft per square foot of grate surface, per hour	12·000 lb.
Consumption of heating surface, per hour	0·516 lb.
Sea water evaporated by 1 lb. of anthracite coal per hour	5·552 lb.
Sea water evaporated by 1 sq. ft. of heating surface per hour	2·365 lb.
Weight of boilers, exclusive of chimney and grates 111,356 lb.	
Weight of chimney, jacket, and chains 7,400 lb.	
Weight of grates 5,289 lb.	
	123,995 lb.
Weight of sea water in boilers	82,300 lb.
Total weight of boilers and water	206,295 lb.

In the above calculation of the amount of sea water evaporated per pound of coal, there is nothing allowed for blowing-off, as the density of the water is recorded from $\frac{1}{32}$ to $\frac{1\cdot14}{32}$ progressively. There being evaporated per hour 7112·67 lb. of sea water, there would be required over 11 hours' steaming to make the density $\frac{2}{32}$, supposing the density at starting to be $\frac{1}{32}$. There has, however, been included in the calculation the quantity of steam (3·094 cubic feet) required to fill the spaces between valves, in nozzles, and in clearance of cylinder.

By driving the blowers, the boilers can be made to fill the cylinder to half-stroke with steam of 30 lb. per square inch cylinder pressure above the atmosphere, giving the piston a proportionally increased number of strokes. When this is done, however, *foaming* or *priming* takes place.

It may be of advantage to compare the results obtained from the *Fulton's* boilers with those obtained from the experimental boiler at the Washington Navy Yard, of nearly the same proportions, used by Professor Walter R. Johnson, in his investigations on coals. The proportions compare as follows—viz.:—

	Johnson's Boiler.	Fulton's Boiler.
Proportion of heating to grate surface	26·000 to 1·000	23·214 to 1·000
Proportion of grate surface to least calorimeter	6·449 to 1·000	6·687 to 1·000
Height of chimney above grate	58·000 feet.	43·000 feet.
Pounds of anthracite coal burned per sq. foot of grate per hour with natural draft	6·430	12·030
Pounds of fresh water evaporated per hour per pound of anthracite, from a temperature of 100° Fahrenheit	8·900	5·713
Pounds of fresh water evaporated per hour per square foot of heating surface, from a temperature of 100° Fahrenheit	2·060	2·960

The above figures show pretty conclusively the advantages to be derived from a slow combustion, in giving time not only for the atmospheric air to become so well mixed with the constituents of the fuel as to completely oxidise them, but also in giving time for the caloric to enter the water, or be taken up by it.

In the above two boilers, we find that with nearly equal proportions of heating to grate surface, nearly double the quantity of fuel is burned per square foot of grate per hour in the *Fulton's* boiler, while the quantity of water evaporated per square foot of heating surface per hour is only 43·7 per cent. *more;* while the economical evaporation is 35·8 *less.* Now, inasmuch as in one case there is burned double the quantity of fuel per unit of grate per unit of time than in the other, it is obvious that if the two combustions were equally complete, double the amount of caloric would then be evolved in the one case over the other, and if it were proportionally absorbed by the heating surface, double the quantity of water per unit of heating surface per unit of time would be evaporated in the one case over the other; but we find this difference to be practically only 43·7 per cent. more, consequently the caloric, if evolved, could not have been taken up by the heating surface, but must have passed off up the chimney, and by this very passing off up the chimney, produced the increased draft necessary to burn a double amount of fuel.

The potential evaporation of the two boilers per same units may be compared as (6·43 × 8·9) 57·227 to (5·713 × 12) 68·556, or as 1·000 to 1·198; consequently if the grate and heating surfaces of the *Fulton's* boilers had been one-fifth greater, or 134·4 and 3120 square feet, instead of 112 and 2600 square feet, and half the quantity of fuel burned per unit of grate per unit of time, the same steam-power could have been obtained with 35·8 per cent. *less* fuel; making the chimneys of course of equal heights, the draft due to the greater height in Johnson's chimney being one-sixth more than in the *Fulton's.* It is not, however, always practicable in a steamship to obtain space for a larger boiler, and economy of fuel must frequently be sacrificed to other considerations. The economical evaporation of the *Fulton's* boilers is about equal to that of the general average of marine-boilers.

In making the comparison *absolutely,* it must be borne in mind that in the *Fulton's* boilers there were wastes by leakage of steam through the valves, and by foaming, *not included* in the calculation of their evaporation; while the calculation of the evaporation in Johnson's boilers was made from measurement of the actual amount of water put in them: of course, the calculation was *inclusive* of all losses.

* From the *Journal of the Franklin Institute.*

THE LATE JAMES SAVAGE, ARCHITECT.

Mr. James Savage was born at Hackney, Middlesex, April the 10th, 1779. After receiving his education at a private school, he was articled to Mr. Alexander, the architect of the London Docks, under whom he acted for several years as clerk of the works.

In 1798 he was admitted a student of the Royal Academy, and became subsequently a very constant contributor to their annual exhibition.

In the year 1800 his design for improving the city of Aberdeen obtained the second premium of 150*l.*, he being then under twenty-two years of age.

In 1805 he was the successful competitor among the numerous architects who submitted designs for rebuilding Ormond Bridge over the Liffey, Dublin; and in 1808 he furnished the design for Richmond Bridge, over the same river, which was carried into effect.

In 1806 he presented to the London Architectural Society, of which he was a member, an Essay on Bridge Building, which they published in the second volume of their 'Transactions.'

In 1815 his design sent in competition for a stone bridge of three arches over the Ouse at Temsford, in Bedfordshire, with the adjacent road and flood bridges, was selected by the magistrates of the county.

In 1819 his plans for building St. Luke's Church, Chelsea, were chosen from among above forty designs. This church is, in respect to construction and composition, an imitation of the Gothic churches of the fourteenth and fifteenth centuries, and is remarkable for the ceiling of the nave, which consists of a groined vault of solid stone, whose lateral pressure is resisted by flying buttresses, also of solid stone. In the original design for this church, the tower was terminated with an open spire, similar in principle to that of Sir Christopher Wren's church, St. Dunstan's-in-the-East; but the Board of Works considered it their duty not to sanction the construction of such a spire, and put their veto upon it accordingly.

In 1823 his design for the new London Bridge was submitted to a committee of the House of Commons, when, with the view of showing that his plan, although novel, was neither crude, hastily conceived, nor wholly without practical exemplification, he instanced, among other matters, that: "In proportioning the parts of the arches of Chelsea Church and their buttresses, and determining their lines, he had used the same means as in arranging the plan for the arches and piers of his design for rebuilding London Bridge. At Chelsea they had been employed with complete success, there not being the slightest settlement in any part of the building, nor even a thread opening in any of the joints of the courses to indicate any strain or inequality of pressure." His design for the bridge was highly approved, but the committee, by the casting vote of their chairman, decided in favour of the design of the late Mr. Rennie.

Among several others, he was one who made a plan (in 1825) for improving the river Thames, but while they selected the north bank for their operations, he chose the south; this scheme he named the Surrey Quay, which he proposed should extend from London-bridge to Bishop's-walk, Lambeth.

Much of his practice consisted in arbitration cases, and the investigation of architectural and engineering questions brought before the courts of law. Among these was the long protracted Custom House case of the Crown *v.* Peto, in which the defendant attributed his success mainly to the able and irrebuttable evidence of Mr. Savage.

In 1830 he succeeded the late Mr. Hakewell, as Architect to the Society of the Middle Temple. He erected the clock tower to their Hall, also Plowden-buildings in Middle Temple-lane, and other works.

About the year 1832 he was one of the active promoters of restoring and opening to public view that beautiful structure the Lady Chapel, St. Saviour's, Southwark, which, but for their timely interference, would have been shut out from view by the proposed new line of street forming the approach to new London-bridge.

In 1836 he published 'Observations on Style in Architecture, with suggestions on the best mode of procuring Designs for Public Buildings and promoting the improvement of Architecture; especially in reference to a recommendation in the Report of the Commissioners on the Designs for the New Houses of Parliament." This pamphlet obtained extensive circulation.

In 1840 he was commissioned by the Societies of the Inner and Middle Temple to prepare designs for the restoration of the Temple Church; and the works were fast progressing, apparently to the satisfaction of all parties concerned, when, as it would appear, the difficulty of pleasing in every particular the divided interests of both societies occasioned some trifling disagreement between them and Mr. Savage, which induced the Benchers to apply to other architects to carry on the works, which, after some delay, were, however, completed according to the original intentions of Mr. Savage, a few unimportant alterations having been introduced.

Among other buildings and works which he designed and executed, the following may be mentioned:—Trinity Church, Sloane-street; St. James' Church, Bermondsey; Trinity Church, Tottenham-green; St. Mary's Church, Ilford, Essex; St. Michael's Church, Burleigh-street, Strand; St. Thomas' the Martyr Church, Brentwood, Essex; St. Mary's Church, Speedhamland, near Newbury, Berks; St. Mary's Church, Addlestone, Chertsey, Surrey; two bridges on the road made through the Crown Lands at Reading, Berks; the new floor and bell-frame, and repairs to the Broad Tower of Lincoln Cathedral to receive "Great Tom," recast by Mr. Mears, of London, in 1836; repairs to the belfry-floor and bell-frame of St. Mary-le-Bow, Cheapside, London, so as to enable the peal of twelve bells therein to be rung with safety, which had not been rung out for very many years prior to the alteration; the Baptists' College, Stepney; Bromley and Tenterden Union Workhouses, &c. One of the last works upon which he was engaged till within a few months of his death, was altering and beautifying the Church of St. Mary-at-Hill, London; he had previously executed great alterations and repairs to this church in 1827-8, when it was in fact nearly rebuilt.

Mr. Savage was one of the oldest members of the Surveyors' Club, and, for a long period of his life, member and chairman of the Committee of Fine Arts, of the Society for the Promotion of Arts, Manufactures, and Commerce, in the Adelphi, London. He was a member of the Graphic Society from the time of its formation, a member of the Institution of Civil Engineers, a member of the Architectural Society, and, for a short time, a fellow of the Institute of British Architects, from which, difference of views upon some matters of regulation induced his early withdrawal.

With the exception of attacks of gout and rheumatism he enjoyed perfect health, till within six months of his death, which took place, after a fortnight's illness, on the 7th of May, in the seventy-fourth year of his age. His remains were interred on the 12th of the same month, at St. Luke's Church, Chelsea.

THE LATE JOHN HAVILAND, ARCHITECT.

We have to record the decease, on March 28th, at Philadelphia, of John Haviland, Esq., architect and engineer, M.R.I.B.A., aged 59. He was descended from the ancient Norman family of De Havilland, of Guernsey, one of whom, James De Havilland, settled in Dorsetshire early in the reign of Henry VII., in which county and in Somersetshire his descendants have ever since been among the landed gentry. The father of the deceased was James Haviland, Esq., of Taunton, the son of John Haviland, Esq., of Gundenham Manor, Somerset. He married Anne, the daughter of the Rev. Benjamin Cobley, Rector of Dodbrook, Devon. Mr. Haviland was consequently first cousin of Haydon, the celebrated historical painter. He studied his profession with Mr. Elmes, the well-known writer upon architecture and biographer of Sir Christopher Wren, who, appreciating the genius of his young pupil, confided to his care during a severe illness the erection of an important building—one of the new churches at Chichester—which displayed when completed such talent as to call forth not only the eulogy of his master, but the thanks of the corporation, in the substantial form of an extra pecuniary grant. In 1815 he went to Russia to enter the Imperial Corps of Engineers, by invitation from his uncle, Count Mordwinoff, then the Minister of Marine to the Emperor Alexander. Here, however, he met with the American Admiral and General Von Sonntag, then in the service of Russia, from whose representations he was induced in the following year to go to America. He went provided by Mr. Adams, then American minister at the imperial court, with every necessary introduction to the American government.

He was the first to introduce the radiating form in the construction of prisons, and he built the Pittsburgh Penitentiary upon this plan. Subsequently he built the Eastern Penitentiary at Cherry-hill, which is now the standard for all edifices of similar purposes. To Mr. Haviland is due the entire merit of having introduced this novel and complete style of prison architecture, which soon attracted the attention of all the civilised world; and the prisons built by Mr. Haviland were examined by commissioners sent for the purpose by the governments of England, France, Russia, and Prussia, and by all was his beautiful and original design extolled and adopted. In England we have the Model Prison at Pentonville.

Besides many others of lesser note, we may enumerate amongst his principal works the Hall of Justice at New York, which is considered "an honour not only to the city, but the American nation, being a perfectly original specimen, in its style, such as all Europe cannot produce;" the United States "Naval Asylum" at Norfolk; the New Jersey State Penitentiary; Missouri and Rhode Island State Penitentiary; the Alleghany, Lancaster, Berks, and many other jails; the Deaf and Dumb Asylum, Philadelphia; the State Insane Hospital, Harrisburgh; the United States Mint, Philadelphia; the county halls of Newark and York; and numerous churches and private mansions.

He married, July 2, 1819, Mary, only daughter of the late William Louis Von Sonntag, Captain in the French Army of Louis XVI., and sister of the Admiral and General Sir George Von Sonntag. He has left two sons, who are members of the bar. His body was interred on the 1st April in the family vault of St. Andrew's Church, Philadelphia, and was followed to the grave by the various societies of which he was a member.

CONCRETE HOUSES.

In our last Number we noticed a visit which we had made to East Cowes-park, in the Isle of Wight, adjoining Osborne, her Majesty's marine residence, and we expressed ourselves much pleased with the economy and stability displayed in the construction of two houses then building by Mr. Langley on that beautiful estate. We represented that on the estate most excellent gravel had been advantageously turned to account, by building a pair of cottage villas entirely of concrete, composed of one part of Francis' Medina Cement mixed with six parts of coarse gravel *and two of hoggin or coarse sand.* We further detailed the process adopted in the erection of the houses, which very forcibly struck us as being not only extremely economical, but having the great desideratum of having houses built by this process rendered perfectly free from damp, although the walls are not so thick as the ordinary method of building by bricks or stone, neither of those materials being used.

We have since been informed that we were in error in stating that the concrete was composed of one part of Francis' Medina Cement mixed with six parts of coarse gravel *and two of hoggin or coarse sand*, and now find that no hoggin or coarse sand was used in the composition, the whole being composed of one part of Francis' Cement and coarse gravel and grit, the gravel having been first carefully sifted clean and rendered perfectly free from sand and dirt; and if such had not been the case, the walls would not have been made so strong, nor have answered the intended purpose, as it is obvious that every particle of sand engages a proportion of cement, or, in other words, deprives the gravel of so much strength, and materially deteriorates the work; and we therefore feel ourselves much indebted to our correspondents for thus giving us an opportunity of more fully explaining and testing the works of Mr. Langley, which, although but little known, will no doubt be more generally adopted, as we have been well informed that many medical and scientific men witnessed the progress of the works, and expressed unanimous opinions that buildings so constructed would be more durable and impervious to wet than ordinary buildings. And we find that a building society is about to be formed, for the purpose of building many houses on this beautiful estate with similar materials; and feeling that extensive works at Dover, Alderney, Sandown Bay in the Isle of Wight, and many other important works, have been successfully carried out with similar materials, we cannot but anticipate satisfactory results from such a society.

THE STREET PAVING OF THE METROPOLIS.

By William Taylor, Assoc. Inst. C.E.

[Paper read at the Institution of Civil Engineers.]

The paving of the streets is next in importance to the sewage of the metropolis, and it is only by a good combination of the two that true sanitary measures can be rendered complete and permanent. The immense sums of money yearly expended in repairing paving prove that the subject has hitherto been much neglected; and the following observations, giving (it is true) only the practical results of hitherto limited operations, are made with the view of directing attention to the subject, and in the hope that the discussion may induce a more extended application of the system, if it be approved, and lend assistance to the consideration of a subject of such increasing magnitude.

The street paving of the metropolis has been for many years carried on under one general system. The method is to employ granite, in blocks of from 8 inches to 14 inches long, 6 inches to 9 inches wide, and 9 inches deep; these are merely laid in regular rows upon the subsoil, and after the usual process of grouting and ramming, the street is thrown open for the traffic which is expected to perform the last duty of the pavior, and to settle each stone upon its bed; for the large wooden rammer is altogether insufficient for this purpose, as may be observed from the irregular settlement of the blocks, caused by the rapid concussions from the carriage-wheels immediately after the traffic has been restored. The results produced are great noise as the carriages pass over, imperfect foot-hold for the horses, and risk to the axletrees and springs from the jolting.

The long continuation of this system of paving arises from two causes. First, the general opinion that great strength in the material employed is the only desideratum; consequently any attempt towards the improvement of the surface of pavements has been prevented, under the impression that depth or weight of stone alone constitutes strength. Secondly, the process of laying large blocks of stone has been found so easy, requiring so little care and anxiety for its results, that the pavior has felt satisfied to follow in the beaten track, so long as public opinion proved indifferent to a change. It will scarcely be credited that an act of parliament for Tottenham-court-road is in existence, which states that it shall only be paved with stones of not less than 9 inches in depth.

The "Macadamised" road is not only an advance upon the old system of gravelling roads, but it is also found to offer the most perfect surface for quietness and safety in travelling. The grinding action, however, of the carriage-wheels upon a material composed of small particles, reduces them rapidly to powder, and the expense of an annual supply of new stone to keep up the surface is such as to render it objectionable for the carriage-ways of streets where there is much traffic. The consideration of this difficulty caused an experiment to be made about twelve years ago, with paving-stones 4 inches in depth, adopting, in one particular, the principle which Macadam carried out—namely, a foundation possessing a certain amount of elasticity, but of sufficient strength to support the surface material, the difference being one stratum of solid granite, in lieu of broken ring-stone. The experiment was first tried at Birmingham, in the year 1838, at the crossing of a street where heavy wagon-loads were constantly passing over it; this pavement may now be seen in as perfect a condition as when it was first laid.

The success of this trial led to another of the same sort of pavement, about seven years ago, at the departure side of the Euston Station of the London and North-Western Railway, which has been found as perfect as that laid at Birmingham, and has been called the "Euston pavement," to distinguish it from others.

The manner in which this paving is laid may be simply thus described. The ground is first removed to the depth of 16 inches below the intended level of the pavement, the foundation being shaped to the convexity of the intended surface of the road; a layer of strong gravel, 4 inches thick, is then spread over the surface, and compressed, by being rammed equally throughout; after which, another layer of 4 inches of gravel, mixed with a small quantity of chalk, or hoggin, is laid on, for the purpose of giving elasticity to the bed, the ramming being continued as before. This is followed by the last layer, also 4 inches thick, of the same material, but of a finer quality, when the whole mass is compressed by the rammer into the smallest possible space. Thus the surface of the foundation is perfect, both in shape and solidity, in all its parts, and is ready to receive the pavement. The stones used are of Mount Sorrel granite, from 3 inches to 4 inches deep, 3 inches wide, and averaging 4 inches in length, neatly dressed and squared. These stones are laid in a bed of fine sand, 1 inch in depth, spread over the surface, and are carefully and closely jointed in the laying, so as not to allow any single stone to rock in its bed. The rammer is then applied over the whole, each stone receiving its blow in rotation; and this is repeated again and again, until no further impression can possibly be made upon it. It is by observing the action of the rammer at this stage of the work that the system is fully elucidated. The wooden rammer weighs 55 lb., and has an iron ring at its foot. It can only be used with effect by practised workmen; and such is the force of the blow that were it not for the resiliency from below, in the elastic quality of the foundation, the stone would necessarily break, or its edges be destroyed. It should, however, be remembered, that the same blow, if given to a stone of 9 inches, or of 12 inches deep, would produce but little effect, even though it were laid on a soft bed, the force of the blow being expended in the mass of stone, so that it would only be pressed to the bottom, in course of time, by the weight and action of the traffic; but such is the power exercised by this rammer on a small stone, that when the paving is finished, a weight of 10 tons, upon a pair of wheels, would be found to make no impression upon the surface. The operation of ramming having been completed, a small quantity of screened gravel is sprinkled over the surface, and the street is opened. The action of the first water upon it fills in the interstices at the corner joints of the stones, leaving the foundation impervious to wet, and thereby securing perfect cohesion.

The greatest care is required in fixing the levels for the workmen, so that a perfect line in the longitudinal inclination of the road may be insured, with thorough uniformity in the convexity of the carriage-way, the inclination from the centre to the side channels being only sufficient to drain off the surface water. The "Euston pavement" is distinguished by the extreme quiet it affords under busy traffic, by the numerous joints affording a very perfect foot-hold for the horse, and by the traction being less than on the best macadamised road; and from the nature of the Mount Sorrel stone, and the absence of those glassy qualities so observable in almost every other paving, there is none of that slipperiness so prevalent in the streets of London, whilst the appearance is admitted to be better than that of any other pavement now in use.

The cleansing of this pavement is also another important consideration. The arch of the road abutting upon the kerb-stone, on each side, enables "Whitworth's" sweeping-machines to brush off, effectually, every particle of dirt from kerb to kerb, thus insuring the cleanliness of the road at all seasons of the year; whereas in almost all the streets of the metropolis, the side channels are so constructed that this valuable machine is found comparatively useless beyond the centre part of the road.

With the view of proving the strength and durability of this pavement by the severest test that could be applied, an offer was made in 1844 to the Commissioners of Sewers at Guildhall, to pave any street in the City of London, and only to be paid for it, subject to their approval, at the end of twelve months. The offer was accepted, on condition of a small specimen being allowed to be laid by way of trial, in Watling-street, at the crossing of Bow-lane, it being the opinion of the board that this situation would afford the best trial for its merits. The pavement presenting the same surface at the end of twelve months, the amount stipulated was paid without any application for it, the testimony of the inhabitants at this particular spot being of the most flattering nature, from the quiet and comfort that marked the change from the former large pavement, and also from the safety it afforded to the horses, no accident having occurred since it had been laid down. The pavement, however, became mutilated from time to time by being opened for laying water and gas pipes; and the necessary repairs were so carelessly conducted that the city surveyor requested the whole to be again relaid in September, 1848, when it was found that such portion of the pavement as had remained undisturbed, was as perfect in surface as when it had been completed three-and-a-half years previously. It was at this period that an opportunity was afforded for comparing the relative advantages of the Mount Sorrel granite with those of the Aberdeen stone.

When this pavement was first laid in Watling-street, the channels consisted, in part, of large Aberdeen granite; and upon lifting this stone in September 1848, it was found to have lost fully 1 inch by wear within the previous three years and-a-half, although no perceptible wear could be observed in the Mount Sorrel stone—the impressions of the hammer, in the original dressing of the stone, being distinctly observed on the surface.

This stone is found to be perhaps the best that has hitherto been tried for paving, both on account of the toughness of its texture, and the dead surface it maintains under heavy wear. With a view to meet the predilection for large stones, a suggestion has been made to increase the depth of the Euston pavement to 5 inches; but when it is considered that every addition to the weight of the stone must necessarily increase the cost per superficial yard, and as the stability of this pavement depends chiefly upon the nature of the foundation, and the full complement of manual labour being bestowed upon it, 5 inches should be the maximum depth of the stones for streets having the heaviest traffic. It is frequently observed, in the streets of the metropolis, that when an old pavement is lifted, the stones are piled in heaps in the carriage-way for the purpose of being re-dressed, to restore again a flat surface to each stone. This expense and inconvenience would be obviated by the use of the small pavement, inasmuch as the joints or interstices are so numerous and insignificant that there is no possibility of the stone wearing round upon the surface; and after the lapse of years, this paving-stone would still be found available, without any redressing, for the numerous retired streets of small traffic. This arrangement would prove its own recommendation, both in economy of cost, and the quiet, comfort, and cleanliness that would mark the change; for it may be observed, when driving through these retired streets, the concussions are more violent than in the main thoroughfares, on account of the rounded and worn-out stones having been transferred to the second and third class streets.

An approach towards the improved system has been made in several streets in Marylebone parish, within the last three years, by the adoption of small stones of Mount Sorrel granite, 6 inches in depth; but the principle of the partially elastic foundation having been overlooked, and the workmanship being of so different a character to what is required for this description of pavement, it is evident that the trial could not be successful, and the consequences are manifest failures.

In making a comparison of the cost of the two systems of paving, the balance will be found to be in favour of the "Euston pavement." The usual practice in the old system has been for the contractor, in repaving a street, merely to lift the existing surface, and to substitute new stone in place of the old. The minimum cost of this replacing is 15*s*. per superficial yard, to which must be added 3*s*. per yard for the value of the old stone, claimed by the contractor, and which will make the clear cost of the large pavement 18*s*. per superficial yard. The maximum cost of the Euston pavement is 12*s*. per superficial yard, including the foundation; and after deducting 3*s*. per yard, the value of the old stone not claimed by the contractor, the nett cost will be 9*s*. per superficial yard, or about half the minimum cost of the large pavement.

It is difficult to find precise data, upon which a true estimate of the comparative expense of the annual repairs may be framed, on account of the very unequal duration of the pavement of the different metropolitan districts, much care being apparently bestowed on some streets, whilst in others the very opposite extreme, of neglect and indifference, is exhibited. The diversity of the nature of the traffic in the different quarters of the city, and in the different kinds of vehicles prevalent in certain thoroughfares, still further augment the difficulty.

It has been observed that a leading street in the city has been twice paved within one year; and many others, having a similar amount of traffic, have been also paved within the second or third year. Although it is possible these instance may be exceptions to the general rule, in first-class thoroughfares, yet they are the streets to be selected for comparison.

The average expense of the Euston pavement, including the first cost, would certainly not amount to more than 1*s*. 6*d*. per superficial yard per annum for ten years; indeed, arguing from examples in existence, it would be less, for the pavement in Watling-street was perfect in surface (where no disturbance had taken place for laying pipes, &c) after having been in wear for three years and-a-half, the surface of the stone at the same time remaining uninjured, so that it is fair to presume that a good travelling condition would have been maintained to the end of seven or ten years, without the necessity of repair.

These observations are not adduced from mere theoretical views, but are based on long practical experience. The principle of a partially elastic foundation belongs to Macadam; and the result of the author's experience, of more than twenty years, in the management of turnpike-roads and street paving, induces the conviction, that in any improvement yet to be made in carriage pavement this principle cannot be departed from.

The "Telford" system of paving, with deep blocks of stone imbedded in mortar, upon a concrete foundation, must be regarded only as so much masonry; and in practice it is found that the surface of the stone is soon destroyed under the action of the carriage-wheels, and the noise of the traffic is increased tenfold. Now, in order to provide for the constant action of the wheels upon a perishable material, it would appear self-evident that some partial elasticity must be permitted, and is, in fact, necessary, to protect the material of which the surface may be composed; it is on this principle that the railway-sleeper is laid on a bed of sand, and in the wood pavement the same principle is present, with this difference—that in the latter case the elasticity exists in the surface material, instead of in the foundation.

As a first step towards a general improvement, it is desirable that the different Paving Boards throughout the metropolis should make a trial, by experiment, in the retired streets of small traffic, by lifting the large stones, and "chopping" them into cubes, or rectangular pieces of 3 inches in depth, for the future pavement. The result would prove of the greatest comfort to the householders, by causing a cessation of the noise of the passing vehicles.

An experiment of this kind must, however, be conducted upon a system undeviating in its operations, both in the selection of proper materials for the substratum, and in the employment of a full complement of labour upon it. These quiet streets offer a good field for the practice of the paviors, to qualify them for the task of extending the system of the more important thoroughfares. The expense being for labour only will prove its own recommendation in point of economy, and when it is considered that stones of 9 inches in depth are cut down to 3 inches, a large surplus of stone will be accumulated for paving purposes, and the refuse will be valuable for "macadamising" the roads in the outskirts of the metropolis.

In conclusion, it is not intended to point out the Euston pavement as an example of an absolute remedy for all the evils attending the imperfect state of the thoroughfares; the object is widely different, being rather to invite attention to the magnitude of the question, which must be acknowledged by all to be a subject beset with serious difficulties. Its importance is continually felt in the metropolis and in all large towns; and amidst all the improvements and inventions by which the present era is distinguished, in the application of science and art to every known subject, the mode of paving the thoroughfares of towns has scarcely made any advance during the last century. The improvements in sub-drainage and the invention of cleansing-machines, can be regarded only as subsidiary to any general sanitary movement; the completion of the whole, in the production of a level and durable road surface, remains still a desideratum.

Discussion.—Mr. Haywood said the question of an elastic or a non-elastic foundation had been, he thought, finally determined many years ago, by Mr. Telford, and since then no further investigation had been made, or had been considered necessary. It had been stated that the usual mode of paving in the metropolis was to lay the stones upon the subsoil without preparation; such, however, was, he believed, not now the general practice, but rather the contrary, for it was the custom to make a good substratum of broken stone, varying from 9 inches to 12 inches in depth; and in some instances, in the principal streets of the city of London, he had laid a substratum full 15 inches in thickness. He thought there was an error in supposing Ludgate-hill to have been paved twice in one year; he believed the portion between the Old Bailey and Fleet-street had not been paved for six years; nor had the leading streets in the metropolis been so frequently paved as had been stated in the paper; at all events, such was not the case in those streets which were under his care. Fleet-street was paved three years and-a-half ago, and notwithstanding the enormous traffic it was subjected to, he thought the pavement would last for three years longer; the Poultry had not been paved for four years; Newgate-street, for three years and-a-half; nor Ludgate-street, between Old Bailey and St. Paul's, for two years and-a-half; Skinner-street was paved five years ago; and London-bridge eight years ago. Considering the large and the small streets together, the average duration of the pavement within the city of London, without being relaid, might be taken at eight years; this remark referred only to the streets of the city of London. A specimen of Euston paving was laid in Watling-street in 1845, and was relaid in 1848. It had been stated that there was no perceptible wear on that pavement, but that the channel stones, which were of Aberdeen granite, had lost 1 inch in thickness. Now, he had examined those stones very carefully, in order to see whether they had suffered any loss during the three years they had rested upon what was called an elastic foundation, and he found that they had suffered no more abrasion than the Mount Sorrel stone which formed the carriage-way. He thought it also very improbable that the channel stones had lost an inch in the three years, from the fact that two or three months after the Euston pavement was relaid in Watling-street, he had raised and examined very carefully an adjoining pavement formed of large stones of Aberdeen granite, 6 inches wide, which had lain for seventeen years in the same public thoroughfare, and he found they had only lost $1\frac{3}{32}$ inch in that time, or $\frac{1}{16}$-inch per annum; he thought, therefore, there was some error in the statement of the wearing away of the Aberdeen stone. In Great Tower-street he had found stones which, after having been down for nine years, had lost $1\frac{1}{4}$ inch; in Fleet-street they had lost 2 inches in fourteen years; in St. Paul's Churchyard, after having been down sixteen years, they had also lost 2 inches; and in Bishopsgate Without, they had lost $2\frac{1}{32}$ inches in twenty years. Mr. Haywood had examined the "Euston pavement" when it was taken up in Watling-street, and he found the stones had been originally so irregular in their depth when they were put down, that though he had gauged about seventy of them, he had not been able to arrive at any positive results; they did appear, however, to have suffered a certain amount of abrasion. He was of opinion that the more solid the substratum of the pavement was made, the longer the stone would last; and he considered London-bridge was a good illustration of that position, for nothing could be more solid than the substratum of its pavement, and yet it had not been relaid for eight years.

In answer to a question from Mr. C. May, as to whether paving-stones were capable of being measured with such accuracy as to determine the loss of $\frac{1}{32}$-inch, Mr. Haywood stated the stones were so irregular, even when they were first put down, that they could not be gauged with accuracy, although his own measurements generally were within $\frac{1}{16}$-inch. The more accurate measurements of abrasion were arrived at by averaging the loss in depth of a large number of stones, and distributing that loss over a number of years.

Mr. Brunel said that the method adopted for obtaining accuracy in the measurement of the loss by abrasion, was that which would be taken by all practical men, as an exact estimate could only be obtained by averaging a number of rough results; and although each of 10,000 paving-stones might be incapable of being measured within an inch, the average would still furnish sufficient accuracy for practical results.

Mr. Radford said Mr. Walker attached so much importance to obtaining a solid substratum, that Blackfriars-bridge was closed for some weeks, in order that the concrete foundation might have time to set and harden before the pavement was laid down; the narrow granite stones were laid with great accuracy, and the whole mass was bedded as if it was composed of bricks, and not in the ordinary rough way of laying pavement in the streets of London; the stones were bedded in, and the joints were well filled with good mortar; and in consequence of the careful workmanship and the narrow stones, the whole remained a good piece of work up to the present time. It was difficult to ascertain the wear of the stones, inasmuch as the steepness of the hill rendered the use of the skid necessary in descending, so that on the down-side of the bridge there was considerable wear, which was not observable on the up-side.

Mr. Holland thought the paper had scarcely been fairly treated in this discussion. It was no answer to the assertion, that the streets of the metropolis generally had pavements very inferior to that which was recommended, to instance in reply the good condition of the roadways of the city, and of the bridges, when the fact was, that those pavements were laid on a principle in many respects identical with that which was advocated in the paper, only that the latter was executed in what was considered a more perfect manner. In order to have a good substantial road, it was essential to give it a steady, firm, and sufficiently rigid foundation; great attention was paid to that point in the main streets of the city, and hence that great durability mentioned by Mr. Haywood. The excellence of the Euston pavement depended in a great measure upon the same circumstance; not as the paper stated, because the foundation was partially elastic, but because it was less elastic than the ordinary substratum. The perfection of a pavement consisted in its being sufficiently rigid, for if it yielded perceptibly, the effect would be as if the carriages were constantly travelling up-hill; the surface must be regular, so that there might be but little friction, and that the concussions should be as gentle as possible, and it must be as smooth as was compatible with affording a secure foothold for the horses. These conditions were fulfilled, to an unusual degree, by the Euston pavement; the small face of the stones was very advantageous, giving great additional security to the horses, though he thought it would be preferable to allow a greater depth, for the sake both of durability and steadiness. The careful laying greatly diminished the draught, by preventing the violent concussions always experienced in passing over an uneven pavement; these concussions were both dangerous and disagreeable, and also caused an unnecessary increase of toil for the horses. In considering the relative economy of roads, it was necessary to calculate the cost of repairs, and to assume it to be of far higher importance than the mere cheapness of first construction. But there was another point of equal importance—the economy in the use of paving; for instance, over many of the thoroughfares in London, upwards of five thousand vehicles passed per day; and it would be easily perceived, that if, in consequence of imperfect roadways, any perceptible increase was occasioned to the draught of each of that enormous number of carriages, the loss to the public must far exceed any possible cost of keeping the roads in the best condition. This view was frequently overlooked, and yet, that road must be acknowledged to be the cheapest, whatever its cost might be, which remained during the longest time in good repair, and which could be kept in the cleanest condition, so as to offer the least opposition to traction, and be the easiest and safest to travel on. It would, however, be vain to expect the best kind of management of the streets of London, so long as they remained under the control of such a number of different authorities. For instance, from Great George-street, Westminster, to Temple-bar, there were no less than five different districts, having five different authorities; and in the parish of St. Pancras there were fourteen or sixteen separate Paving Boards. If each large district were placed under one authority, that authority would recognise the necessity, and would deem it prudent, to appoint a competent and educated superintending engineer, who would be so paid as to enable him to devote to the subject all the time and attention required for a matter of such importance.

Professor Ansted said, he had seen the Mount Sorrel stone in use, and in the quarry, and from its constitution, he looked upon it as one of the most valuable of the mineral products of the country for roads; it was of a tough nature, and yet, having many natural joints, it could be dressed easily into cubes of the required size. He had a specimen in the King's College Museum, showing these natural joints, which added so much to the facility of working it. It was also very little liable to decomposition, nor did it easily suffer injury from abrasion by heavy traffic. It was a better material than either Aberdeen or Cornish granite, and was quite as tough as the basalt from some of the midland counties, such as that from near Nuneaton, where it was found in such great abundance, that a million of tons would not be missed. He did not feel competent to give any opinion as to the best mode of making the roads, but he would venture to say, that he thought no material would be found to answer well unless it was laid on a sound, solid, and somewhat rigid foundation.

Mr. P. W. Barlow said, that from a somewhat extended series of observations and experiments he had made on the laying and the wear of railway sleepers, he had arrived at the conviction, that a rigid foundation was indispensable on railways, and for the same reasons he was inclined to believe that a substratum possessing a considerable amount of rigidity, would be advantageous for street paving.

Mr. Dockray said that in 1837, or 1838, when the Birmingham Station was about to be opened for traffic, the pavement of the area in front of the booking-office, which was executed in the ordinary manner, with stones from 6 inches to 8 inches in depth, required to be extended, and Mr. Taylor then brought under his notice the pavement which had been described in the paper. His opinion however was, that the stones were too shallow, that they would turn on their axes, that the corners would project and form a surface like a very rough macadamised road, and that the system would not succeed. His attention was directed to several specimens in the town of Birmingham, which had been laid according to the proposed plan, and, finding that they remained firm, and that no movement did take place, he determined to give the pavement a trial. The remainder of the yard was accordingly so paved, and, up to the present time, it had never been disturbed. The traffic passing over it was not of a heavy description, consisting of omnibuses and other passenger vehicles, but the stones were subjected to a severe trial from all the carriages having to turn round upon it. After a trial of twelve years, no perceptible abrasion had taken place on the angles of the stones, nor did the surface present any appearance of wear; these were facts of the greatest importance, and he attributed them, in the first place, to the small size of the stones, and next, to the modified elasticity which was given to the foundation. At the Euston Station, where the pavement was originally executed in the most substantial manner, according to the old system, with stones 8 inches in depth, well grouted, and laid upon a substratum of concrete, the stones became so much rounded on the upper surface that, when it was necessary to remove the pavement, in consequence of the re-arrangement of the station in 1847, the directors, after mature consideration, and bearing in mind the excellent duration of the new kind of pavement in the Birmingham Station, resolved to pave the whole of their yards and roads, at the Euston Station, according to Mr. Taylor's plan. This work had been executed, and he had no doubt that it would prove an economical and useful pavement. It had a very handsome appearance, and attracted much attention, and, from the truth and uniformity of its surface, set off the surrounding buildings to great advantage. He attributed the success of this pavement to the partial elasticity which was given to it by the foundation, although this elasticity was confined within narrow limits. The foundation consisted of a number of thin layers of gravel and chalk, or cinders, each layer being well rammed down until a firm basis was obtained, great care being taken that the foundation, at its last course, should assume the exact form of the surface of the pavement when finished; upon the foundation a thin coating of sand was laid, in which the bases of the stones were buried. The stones were laid to a line stretched across the yard or road, being previously selected so that in each course they should be exactly of the same width. The ramming was then commenced; this was a peculiar operation, inasmuch as, instead of using a rammer of the ordinary description, as in London, which was a heavy implement which a man could scarcely lift, and was simply dropped upon the stones, acting only by its own weight, the new rammer was comparatively light, but was shod with an iron shoe of sufficient weight to bring the centre of gravity of the implement very low down, and thus the workmen were enabled, with comparatively little labour, to give a large amount of percussive force to the blow. In carrying on the work the men were arranged in a row across the pavement, passing regularly over the surface of the work, keeping exact time with their blows, and striking each stone in its turn. The first set of men was followed by another set, who continued exactly the same operation, and this was repeated over and over again, until the stones would not yield any further under the blows. The surface was then covered over with fine gravel-screenings, which was worked into the joints by the carriage-wheels, and so entirely fitted them, that when the surface was swept clean, it presented a very beautiful appearance, like a coarse mosaic. Any yielding in the foundation of this pavement simply caused a long crack in the surface, which, owing to the small size of the stones, did not occasion those violent shocks which were so painfully experienced in all the large-sized pavements. For the same reason (the smallness of the stones) they never became rounded on the upper surface by wear, as was the case in all the ordinary pavements, and which rendered it necessary to take the whole up after a few years' wear, to re-dress the individual stones. Another very important advantage arising from the use of this new pavement was, the facility with which any repair could be executed; and thus the laying of mains, and the repair or construction of sewers or culverts, was not a matter of much importance,—always presuming that the repairs were properly executed. From these remarks it would be evident, that it was on the perfection of the labour that no small amount of the usefulness and the beauty of this pavement depended. The foundation must be most carefully prepared, and particular attention must be paid to the form of its upper surface, which must, in all cases, be parallel with the intended surface of the finished pavement. He had seen several instances where, from want of attention to these matters, and from the employment of incompetent workmen, a rapid fracture has been the consequence, although, so far as the stones themselves were concerned, they were in all respects similar to those used by Mr. Taylor, and, in fact, supplied from the same quarries.

Messrs. Trelawney Saunders, Tennant, Haywood, and Legg, having made some observations,

Mr. Taylor observed, that notwithstanding the remarks which had fallen from the various speakers, he must still maintain his opinion, that the streets of London generally were paved in a very rough and careless manner; for however good the pavement of London and Blackfriars bridges might be, and that of those streets in the city of London which had been lately laid with blocks of stone 3 inches by 9 inches on the face, it must be remembered that these were only solitary instances, and formed but the very smallest fractional part of the total quantity. Moreover, in estimating the duration of the pavements at eight years for each relay, the question of their condition should not be altogether overlooked. He must repeat his assertion, that the pavement of London generally was not laid upon concrete, or on any other rigid foundation; indeed, the substratum was almost invariably formed of common material, such as sand, or hoggin. The concrete foundation, partially adopted many years ago, was now generally abandoned, owing to the difficulty of repairing the frequent openings made by the Water and Gas

Companies. As the term "partially elastic foundation" appeared to have been somewhat misunderstood, he must explain, that he did not mean a foundation that would rise and fall, but a firm, unyielding one, with a certain degree of elasticity imparted to the upper part of the substratum, by the admixture of a finer material, and which should be just sufficient to prevent any abrasion of the surface of the pavement, as would be the case if laid upon an arch of brickwork, or a mass of concrete. Mr. Taylor believed he might assume, that "macadamised roads" were now admitted to be unsuited for great thoroughfares in cities. He had arrived at that conclusion many years since, when he made a series of experiments, with a view to ascertain whether it was not possible to combine the advantages possessed both by the stone pavement and the macadamised road, and afford even a better foothold for the horses. For this purpose he had designed the pavement described in the paper, which he thought would be found to possess in itself the firmness of a stone pavement, with the elasticity of a macadamised road. It must also not be forgotten that economy both in first cost and in the subsequent repairs had been considered, and though in the paper, twelve shillings per superficial yard had been given as the maximum cost, this would doubtless be reduced to ten shillings, or even to eight shillings per superficial yard, if the system was extensively employed. The ornamental appearance of this pavement, resembling, in fact, a kind of mosaic, and especially when executed in large areas, was also another advantage, and rendered it peculiarly adapted for large court-yards, stable-floorings, &c. With regard to the specimen which had been laid down in Watling-street, he would observe, that at the time of its execution there was great difficulty in getting the stones dressed to a regular size, so that it was not possible to give to the substratum the evenness and regularity which was essential. It had been referred to, chiefly as proving the strength of the system, because as Watling-street was intersected at this point by Bow-lane, in turning round the corner, there was a constant strain of the carriage-wheels of the most trying nature for any pavement; and yet it had withstood that action without any perceptible effect. The appearance of the surface had been disfigured by the constant flow of water from the houses into the side channels, and by great neglect in the cleansing.—The proposed lifting of the old pavements in the retired streets, and reducing the stones to about 3 inches in depth, would be a vast improvement, as it would greatly diminish, if not altogether remove the noise of passing traffic; and the outlay for this would most probably be more than repaid by the accumulation of surplus stone. It must be evident, that however perfect any system of pavement might be, its permanent condition could never be secured until the Paving Boards were invested with some controlling power over the Gas and Water Companies, to prevent that carelessness with which the repairs were conducted, after the breaking up of the streets, an operation which required the very greatest possible care and attention. In connection with the subject of paving, it might not be out of place to direct attention to a stone which had been recently much used for flagging streets, and in other situations, and which he believed was the best material that could be employed. This material was brought from the quarries at Llangollen, North Wales; it could be procured in slabs of any dimensions, however large, and the quantity was unlimited. The stone partook somewhat of the nature of slate, but did not laminate in the same manner, although there was a natural cleavage, leaving the faces very free from nodules of pyrites. It was very easily planed, grooved, and polished, by machinery; and at the works at Llangollen, the finest qualities were worked up into baths, urinals, mangers, &c., whilst immense quantities were shipped with only one face planed for flagging streets, railways stations, kitchens, &c. The stone was stronger and cheaper than York paving, and was much more durable, inasmuch as all sandstones, when abraded, furnished a powder which served like particles of emery to rub further into the stones, whilst on even cutting into these slate flags, a fine powder was produced, which, whether wet or dry, rather protected the surface of the stone on which it was strewed. As good flagging was almost as essential as good paving, Mr. Taylor directed attention to the specimens of the stone which were exhibited.—In conclusion, he trusted that his observations might induce the scientific men of the present day to give their attention to the subject, and to use their power in the introduction of the best systems of paving and flagging, which would be of inestimable advantage to the streets of the metropolis.

ROYAL FREEMASONS' SCHOOL FOR FEMALE CHILDREN.

P. C. Hardwick, Esq., Architect.

(*With an Engraving, Plate* XXVI.)

This new building is erected on the Common at Wandsworth, close to the Clapham station of the South-Western Railway, and is intended to replace the old school situated in the Westminster-bridge-road, which is no longer fit for the purposes of so large an establishment. It was founded in the year 1788, by the Chevalier Ruspini, for the boarding, clothing, and educating sixty-five children, daughters of freemasons who have been in prosperous circumstances, but who have become so reduced as to require the aid of this charity.

As a site for a school, Wandsworth Common is, perhaps, the best position in the immediate neighbourhood of London; and the committee have taken care to secure a plot of ground large enough for all the purposes of the building, as well as playground for the children and a garden. The new building consists of an entrance hall in the centre, which is carried up above the other parts of the building so as to form a clock-tower. On one side of the entrance is the secretary's and board room, and on the other side rooms occupied by the porter. A large corridor, extending the whole length of the centre building, communicates at one extremity with the school-room, which is 38 feet long by 22 feet wide, out of which opens a class-room 22 feet long by 15 feet wide. At the other extremity of the corridor is the dining-hall, 38 feet long by 22 feet wide, and in the rear of this room are placed the offices, which include kitchen, scullery, laundry, washhouse, and all the usual requisites of a large establishment. The dormitories are over the hall and schoolroom, and some rooms for elder children over the centre part of the building. There is also an infirmary. Rooms for the matron and her assistant are provided in such positions that they are able to inspect the various parts of the establishment.

A large covered shed, attached to the building, will form a playground for the children in wet weather. The number of children in the school at present is about sixty, but the building is calculated to hold one hundred.

The material of the building is red brick and stone, from Prudholme on the Tyne, and is used here for the first time in a building of any importance in London. Travellers in the north will remember it, from the many beautiful buildings erected with stone of the sand formation in the country between Carlisle and Durham. The introduction of this stone into London will, it is hoped, afford facilities for a more extensive use of stone in preference to cement—a most desirable object with all those who are interested in the domestic architecture of London.

The contractors for the building are the Messrs. Piper, of Bishopsgate-street; the contract is about 7000*l*.

ON CERAMIC MANUFACTURES, PORCELAIN, AND POTTERY.

By L. Arnoux.

[*Abstract of an Exhibition Lecture delivered at the Society of Arts.*]

The art of pottery affords numerous resources for the gratification of our wants and taste. The progress of the ceramic art is intimately connected with that of the arts and sciences in general. From the decline of Greek art the ceramic art had laid dormant for twenty centuries, and it was only in the 15th and 16th centuries that attention was again directed towards the subject. England had been amongst the most backward of the nations in promoting the revival and advance of the art till 1760, when Wedgwood founded his first establishment, since which period she had outstripped all others in productions of this nature. In the present day the annual production of English pottery could not be estimated at less than 2,000,000*l*., no fewer than 185 factories being engaged in this important branch of national industry. Fifty-two were scattered over the country at Leeds, Stockton, Sunderland, Glasgow, Bristol, Swansea, and 133 in Staffordshire, where 60,000 persons were now employed in the manufacture of pottery. English pottery formed an important branch of her exports, no fewer than 82,000,000 pieces having been exported in the last year, the value of which was 1,122,000*l*. Nature provided England abundantly with clay, flint, felspar, and mineral fuel, which were

J R Jobbins

THE ROYAL FREEMASONS SCHOOL FOR FEMALE CHILDREN TO BE ERECTED AT WANDSWORTH.

P. Hardwick. R.A. G S.W Archt

necessary for the production of pottery. In France the cost of firing the same quantity of ware was not less than 30*l.* which in England only cost 8*l.* In machinery and the firing process, however, there was room for much improvement in England. Some specimens of bricks of great smoothness and angularity had been exhibited by Mr. Minton. There was a feeling against the use of enamelled bricks and terracotta for building purposes in England, but he thought they might be used with advantage for such a purpose in this country. Terracotta was used extensively in Vienna and Berlin, where the winters were certainly as rigorous as in London. Having glanced at the manufacture of tesseræ and encaustic tiles, and the various purposes of ornamentation to which they might be applied, Mr. Arnoux passed on to the most important article of English ceramic manufacture—namely, "earthenware"—which had arrived at such a point of perfection that this country had nothing to fear from foreign competition. They had only to follow the line traced by Wedgwood. The value of the English earthenware exported was 1,062,000*l.*; and so highly was it esteemed on the continent that many foreign manufacturers thought the best recommendation they could give their wares was to stamp them with the name of Wedgwood. France had only five or six first-rate establishments for the manufacture of earthenware, and that they might be benefitted, the whole French nation was prevented, by high protective duties, from getting English earthenware at a cheap rate. There were 3000 persons employed in the manufacture of earthenware in Prussia, and she exported 5000 tons. Austria was much behind both France and Prussia; but so superior was England to all these countries that purchasers frequently preferred her earthenware to hard porcelain. Mr. Arnoux then passed from the unvitrified to the vitrified manufactures, commencing with Parian or statuary-ware, as it was sometimes called. Parian-ware had been introduced only six or seven years, and the perfection to which it had been brought did great credit to our manufacturers. In the making of Parian figures the limbs were cut separately, and they were afterwards joined together. The figures contracted to the extent of one-fourth of the model, and great care was required that they were not spoiled in consequence. The firing, too, required great attention. These Parian figures took more transparency than the old French biscuit. They were manufactured with great skill by Messrs. Minton, Wedgwood, Copeland, Rose, and others, and they excited a great deal of admiration on the part of the foreign exhibitors. The manufacture of porcelain was known at a very early period. It was certainly known to the Egyptians. In the year 1518 the Portuguese introduced some specimens from China into Europe, and it was not till 200 years after this that the manufacture of soft porcelain was founded in France. There were 185 factories of soft porcelain in England, which employed 24,000 persons. The greatest part of the manufactured articles were purchased in the home market, the exports amounting to only 64,000*l.* Soft porcelain was not so good as the hard porcelain, and it only maintained its place by the artistic value which it was capable of receiving. The manufacture of hard porcelain had greatly extended in France of late years. The exports from France in 1846 amounted to 320,000*l.*; in 1850 they amounted to 670,000*l.*; and they were probably not less than 800,000*l.* last year. She exported these manufactures chiefly to America and the continental states, and having arrived at great perfection, she was more liberal in admitting other countries to compete with her in respect to those articles. But the specimens exhibited by Mr. Minton were superior to any produced on the continent. The Zollverein states had 40 factories of hard porcelain, in which 5000 men were employed, and they exported to the extent of 400 tons. Both earthenware and porcelain were derived from the east; they passed successively through Italy and France, and though England was the latest in receiving them, it was on her soil that they reached their greatest perfection. She would not lose the advantage she had acquired by her industry, her capital, and her skill, if she did not repose in her success; she had not improved so much for ten previous years in the ceramic art as she had since the year 1851. But she must advance in ornamentation and design, and for this purpose schools of design should be established as soon as possible, where the pupils might receive a special education in those branches of industry on which they were to be employed. Too much attention was paid in England to painting in flowers. Design in flowers was taught to the exclusion of almost everything else. This was not the case in the best period of art. They could not expect a tribunal such as existed in Greece for deciding upon the best ceramic productions; but he hoped it would not be destroyed by the mercantile spirit being carried to an extreme. They should cultivate art and taste, and they would find both profit and honour in so doing.

EXPLOSIONS IN COAL MINES.

REPORT *from the Select Committee of the House of Commons, appointed to inquire into the Causes of the frequency of Explosions in Coal Mines. (Ordered, by the House of Commons, to be printed June 22nd,* 1852.)*

THE Committee, considering the pressing emergency of the matter committed to their charge, how deeply the interests of humanity were involved (the deaths from explosions having latterly increased to the fearful number of about 1000 per annum), determined only to examine witnesses of the highest and most experienced character, in the hope that they might be able to derive sound information on which to recommend additional means for the prevention of such wide-spread calamities during the present session. The Committee are therefore of opinion—

That any system of ventilation depending on complicate machinery is unadvisable, since under any disarrangement or fracture of its parts, the ventilation is stopped or becomes less efficient.

That the two systems which alone can be considered as rival powers are the furnace and the steam-jet.

The *furnace* system, under favourable circumstances—*i. e.*, of area of the shafts being large and deep, the air-courses sufficient, the goaves (or old workings) well insulated, and the mine not very fiery, appears to be capable, with strict attention, of producing a current of air that will afford reasonable security from explosion; but when the workings are fiery and numerous, as well as remote, and the intensity of the furnace or furnaces requires to be raised in order to increase, on any particular emergency, the amount of ventilation, then the furnace not only refuses to answer the spur and to increase ventilation, but from a natural law (discovered by Mr. Gurney, and scientifically and practically confirmed before the Committee), there arises a dangerous stoppage to ventilation going on throughout the mine.

The quantity of heat generated by the furnace is directly as the quantity of fuel that can be consumed in a given time. The amount of rarefaction or power of the upcast will always be directly as the temperature of the column of air passing up in a given time, which temperature will vary in proportion to the quantity. The amount of heat of the furnace is a constant quantity, which will be spread over a more or less quantity of air. The power of the upcast rising in *an arithmetical ratio;* the friction or drag of a current of air through the workings of a coal mine, offering a resistance, equal to the *squares* of its velocity. Now it is manifest there will soon be a point where the resistance overtakes the power. The power being as an arithmetical ratio; while the resistance increases in a geometrical ratio, the "furnace limit" will be the point where these two powers balance each other. This limit commences in practice much earlier than would appear on calculation from these data, because there is another element to be taken into calculation that seems never to have been noticed. This element is the resistance offered to the air going through a mine by the *vena contracta.* It amounts to a serious quantity in the workings of an ordinary coal mine. This amount of extra resistance, added to the friction arising from the rate of current, adds considerably to the rate of increase of the drag. This important fact has never hitherto been noticed; nor was it referred to by any of the witnesses in the Committee of 1835, or that of the Lords in 1849.

The resistance, or drag of a current of air passing through the working of a coal mine is, as stated above, as the squares of its velocity. When this resistance is so great that the proper quantity of air cannot come through the galleries of a mine to fill the exhaustion produced at the bottom of the upcast-shaft, it will come down through the shaft itself, as the easiest channel. It will come down on one side, leaving room on the other for the hot air to ascend, the stationary particles of air be-

* We have thought it necessary at present to give only the leading features of this Report, but shall probably return to the subject when the Minutes of Evidence given before the Committee are made public.—ED.

tween the two moving currents forming an imaginary aerial plate. The plate has been called the "natural brattice."

The amount of resistance of currents of air coming through the workings increase as the *squares* of their velocity; the power of exhaustion by the upcast-shaft is *directly* as its temperature. If the quantity of air passing through a mine be reduced by increased friction or obstruction, that smaller quantity of air will be raised to a higher temperature by the furnace in the up-shaft, and the exhaustion arising from its increased temperature will produce a greater amount of *force*. The water-gauge is a measure of this force of exhaustion or power of the furnace. Under the above circumstances the water-gauge will rise and indicate a *greater power*, while the *amount* of ventilation is reduced. This is a seeming fallacy: it is not a fallacy; therefore, is called the "furnace paradox."

To the powers of the *steam jet*, on the other hand, there appears to be no practical limit; for although it acts, when placed (where recommended) at the bottom of the upcast as a rarefier to the extent of the steam used, and fire under the boiler, its principal or direct efficiency depends upon its power of propulsion. The heated air not only rises from rarefaction, but any amount of cold air can be bodily pushed up the upcast, the amount merely depending on the number and size of jets employed, and the pressure of steam. The Committee are unanimously of opinion that the steam jet is the most powerful, and at the same time, least expensive method for the ventilation of mines.

Previous to 1848, when Mr. Forster introduced the steam jet into the Seaton Delaval mine, the fire-damp was constantly seen playing around the face and edges of the goaves and other parts of the workings; since that period the mine is swept so clean that it is never observed, and all danger of explosion seems removed in a very fiery mine. The increase of ventilation is from 53,000 cubic feet per minute under the furnace system to 84,000 under the steam jet: and to double that quantity, which Mr. Forster considers sufficient, would, he says, only require the application of some extra jets. Mr. Forster states the original outlay for the steam jet to be less than for the furnace by 39*l.* 15*s.* 6*d.*; and the annual cost to be less by 50*l.* 12*s.* 1*d.*: while the power of ventilation is increased to nearly double.

Notwithstanding the increase of ventilation which Mr. N. Wood states he has obtained in one of his collieries, where the areas of the shafts are very large, and by the aid of three furnaces, it appeared in evidence that the explosion at the Killingworth Colliery last autumn, under Mr. N. Wood's management, took place under the furnace system of ventilation.

Although a few of the witnesses (two of the most intelligent of the government inspectors among the number,) seemed to have misunderstood the mode in which the steam jet operated as a ventilator, and professed themselves so far unacquainted with it as to be unable to form an accurate judgment on its merits, all the witnesses, with scarce an exception, coincided in the opinion that in a fiery mine, even where the furnace system was thought sufficient under ordinary circumstances, it would be a prudent and almost necessary precaution to have a steam jet apparatus at the top of the downcast connected with the boiler of the engine which worked the mine, in case a sudden and great increase of power was required, under pressing emergency.

It was stated in evidence that 70 per cent. of the deaths from explosions were occasioned not by the explosion of fire-damp, but by the "after-damp" which succeeds it. If the latter be inhaled in its pure state by the miner, it causes immediate death. But since, from the miners being subsequently discovered in various stages of prostration, it is apparently inhaled in various degrees of dilution, it seems clear that a power like the steam jet placed at the top of the downcast, out of reach (which the furnace at the bottom of the upcast occasionally is not) of the effects of the explosion, and capable of sweeping the galleries of the mine with an almost irresistible force immediately after the explosion, might be the means of saving a large proportion of the lives now lost for want of such a power. The furnace under such pressing emergency is inapplicable, and incapable of being used for the purpose.

The Committee, however, are unanimously of opinion that the primary object should be to prevent the explosions themselves; and that if human means (as far as known) can avail to prevent them, it is by the steam jet system as applied by Mr. Forster: although even in such case it might be prudent in a mine especially fiery to add an inexpensive steam jet apparatus at the top of the downcast, as a means in reserve in case of explosion from neglect or otherwise.

The proper condition of a mine, as regards its ventilation, the Committee consider is when the current of air through all the air courses, more particularly in the extreme workings, is from four to six feet per second in rate through an ordinary sized air-way, of (say) 50 feet sectional area; this, in the extreme workings, would command a rate of current to a much greater extent (and which would be necessary) through the less remote workings of the mine. Without a current of air at the rate of at least four feet per second, equal to about three miles per hour, in *every part* of a mine at all fiery, the miner cannot be considered safe from explosion. Such current would be the truest indication of the actual amount of fresh air circulating through the general workings of the mine. It seems immaterial by what mode this rate of current is produced, so that it be certainly produced, and a means be furnished to the inspector at each visit to ascertain that such rate of current has constantly existed during his absence.

The attention of the Committee has been directed to scientific and practical means of decomposing or neutralising the explosive gases as they exude from the coal and goaves; but it does not appear that science has discovered any practical means for producing this desirable effect. Mr. Blakemore, M.P., has offered, through the Royal College of Chemistry, a premium of 1000*l.* for the discovery of some simple practical means for the attainment of this important object.

The Committee would now refer to some more incidental means of security against explosion; first, stating their concurrence in the opinion expressed, directly or indirectly, by the Committees of 1835 and 1849, and also with that so strongly expressed by the South Shields Committee, that where a proper degree of ventilation does not exist in a mine, the Davy-lamp, or any modification of it, must be considered rather as a lure to danger than as a perfect security. Practically secure in a still atmosphere, it may be considered; and in the hands of a cautious over-man, an admirable instrument for exploring, or as an indicator of danger; but in a current, as admitted by its illustrious inventor himself, it is not a security; and in the hands of an ordinary workman, under circumstances of excitement, when danger is threatened, it is not improbably, far oftener than imagined, the very cause of the explosion which it is intended to prevent. The experiments of Dr. Bachhoffner, at the Polytechnic Institution, before the Committee, were very interesting on this point. Nevertheless, in a mine that is at all fiery, it it will be a prudent precaution to work with a lamp, until it can be proved that by means of ventilation a mine can be so far cleared of all explosive gases as to prevent any accumulation of them in the workings, goaves, or elsewhere. Some of the witnesses point to such a possibility; and if it were for the sake of the health of the miners alone, a current of fresh air passing through the mine which could produce this effect would render such a power one of the most valuable contributions of the age. One of the principal objections to the Davy-lamp, on the part of the workmen, has been the insufficient light which it affords. A lamp of greater reflecting power, which would, at the same time, admit of a double gauze protection, has been suggested. It is made of polished wire gauze, instead of black iron wire. The latter has an absorbing surface, the former has a reflecting one; the latter intercepts and obstructs more than half the light given out by the flame; the reflecting lamp reflects the light which falls on the meshes of the wire gauze, and sends the rays out on the opposite side, in a profitable direction.

In the furnace system of ventilation, the power depends on the difference of the temperature of the air going down the downcast shaft and that coming up the upcast; and when the temperature of the outer air is high, the power of the furnace is reduced. When the thermometer, therefore, exhibits a high rate of temperature, the ventilation is lessened. This may account for accidents being generally more frequent in spring and summer.

Under the ordinary pressure of the atmosphere, its weight operates in a fiery mine to keep back the escape of gas from the recesses of the mine. When the pressure is less, the explosive gases have greater power of escape. Whenever, therefore, there is a fall in the barometer, showing a diminished pressure of the atmosphere, danger is indicated, and an increased amount of ventilation required. In every mine, therefore, it should be imperative for a barometer to be kept. It should be placed near the ventilating power, properly connected with the external air, through the downcast, so as to take the pressure of the atmosphere. A "Differential Barometer" is much more sensitive than a common one, and should be used; and since it costs only a few shillings, there would be no excuse for not having one. The differential barometer, so called, is more delicate in its movement than an ordinary barometer: it may be made almost to any ratio of delicacy. It would show a change taking place in the weight of the atmosphere long before it could be seen in the ordinary barometer, and therefore be highly valuable in a coal pit. On the fall of the barometer fire-damp issues out of the goaves and recesses of the coal in larger quantities than usual, so that ventilation requires to be increased under such circumstances, and the fall in the barometer points it out before it can be otherwise seen. The barometer is said to be more useful in a coal-pit than in a ship. It indicates impending storms, or change of weather, and the more delicate it is the better. The index of the differential barometer can be made to range from 50 to 100 times through a greater space than the ordinary mercurial level; and therefore slight changes in the weight of the atmosphere can be read off by this instrument, which are invisible or inappreciable in the common barometer.

A Water Gauge should be placed at the bottom of the upcast, to indicate the power of the drag of the mine, where the furnace is used, so as to indicate the proximation of the furnace limit. The water gauge is a tube of glass bent in the form of the letter U, one end of which communicates with the upcast and the other with the downcast shafts by a pipe; it contains a little water at the bottom of the bend, and is an indicator of the *amount of power*; its extent of break of level in the two legs is a measure of the actual *force* which is necessary to overcome the "drag of a mine." When this force is known, its rise or fall indicates whether proper ventilation is going on in the extreme workings or not; thus if the air comes through the workings by a shorter passage than it ought to do, the water gauge will immediately fall. In a late explosion, occasioned by leaving a door open between the downcast and upcast shafts, the water gauge would have pointed it out. If the water gauge rises above its working point, it shows obstruction existing somewhere in the workings. If it stands at its working point, it shows that ventilation is going right. It is a most useful instrument; it is a measure of the actual power required for ventilation, and in the possession of a practical man, will tell him where and how ventilation is going on by simple inspection. In connection with the anemometer, this gauge is most valuable.

But an instrument of even greater importance than the above, especially in reference to the periodical visits of inspectors, is a self-registering Anemometer, by which the inspector would know at each visit the rate at which the current of air had been passing through the mine in his absence. The best instrument of this kind at present known, perhaps, is that of Mr. Biram. Three, at least, of these should be kept in every mine; one at the intake (bottom of downcast shaft), one at the return (bottom of upcast), and, especially, one or more in the extreme workings. By the anemometer the *actual quantity* of air passing may be known; and, at the same time, by the water gauge, the *absolute force or power* required to move or pass that quantity may be known; so that, by these two instruments the amount, power, and probable state of ventilation may be ascertained.

The goaves (old workings) in extensive mines are a principal source of danger. It has been suggested, if the water would permit, that the goaves might be as it were drained of the explosive gas by a bore-hole from the surface, acted on by a steam jet; that gas, being lighter than common air, would thus be drawn through the bore to the outer air.

For a similar purpose, a system of gas drifts along the *rise* of the coal deposit, intersecting its cleanages, banks, and interstices, and taken to the upcast shaft, might be, and in some cases has proved to be, a practical and scientific means for removing the light carburretted hydrogen gas from the coal, without permitting it to descend into the workings.

It was suggested by Mr. Gurney, also, that refuge stalls might be established at small expense, in places familiar to the miners, throughout the workings, to which, upon an explosion, they could at once fly from the fatal effects of the after-damp. At the ingoing end of the ordinary stalls, bays, or cul-de-sac recesses of the workings in a coalpit, boarding must be placed, so as to insulate it from the main air-courses, sufficiently strong to withstand the force of a moderate explosion at the spot; or of a violent one at a distance. In this stopping two openings are cut, one at the highest level, and the other as low as possible, so as to effect self-acting ventilation; by which means the bay will always be filled with good air. They also relieve the stopping from the force of explosion. On the inside two valves are suspended, so as to be always ready, in case of need, to close the openings from within. The upper opening is small, about four to six inches diameter; the under opening is sufficiently large for a man to pass through. In case of explosion, instead of the men running, as they now do, into the main air-courses, and consequently into the after-damp, they may go into these refuge stalls; close the openings, and remain there till the after-damp is removed. Taking into consideration the quantity of air required to support life for a given time, and the ordinary size of the stalls, it is clear that men may remain in them in safety for 24 hours, or longer, when properly constructed. During this period the after-damp ought to be withdrawn from the workings. These stalls are inexpensive, require no attendance, and may be made and left, or removed, at short distances, as the ordinary vorkings of a coal-mine proceed. They should be within a hundred yards of each other, so that one may be always at hand. A few pitmen only would be there and have occasion to go into the same refuge. The well-known laws of pneumatic disturbances show that, properly constructed, it would practically be sufficient to insulate and preserve the atmosphere of the refuge from danger of interchange with the after-damp for a long time together. In the midst, or *close to*, a violent explosion, the stoppings might be blown down; but not at a short distance. A violent explosion would produce death, by its force, in its immediate neighbourhood; but in such case the refuge stalls would under any circumstance be useless. They are intended only as a protection against loss of life from *after-damp*. It has been proposed to place large safety flaps or valves in the stoppings, to guard against the force of explosion, but this seems unnecessary.

It has been stated in the evidence, that boys are employed in mines to perform duties, the neglect of which in a single instance might be productive of great loss of life. They are employed, in particular, to attend to the opening and shutting of the doors or traps necessary to regulate the courses of air in every system of ventilation. It has further been stated, that even in the best disciplined pits, where the men are rarely, if ever, guilty of serious acts of neglect or carelessness, it has yet been found impossible to guard against similar negligence on the part of the boys; and accordingly it appears that in various instances fatal accidents have been traced to such negligence in the performance of the duties allotted to them. The Committee therefore are of opinion, that no responsible duties, the neglect of which would involve serious risk of life, ought in any mine to be intrusted to boys, or to any other class of inexperienced persons, but solely to persons in whose judgment and discretion full reliance can be placed.

Education is a point insisted on as a precautionary means both among the working colliers and their managers, as also that the qualification of inspectors should be rigidly tested previous to their appointment. In these views the Committee entirely concur. They not only trust to see education more rapidly spreading than heretofore among the working colliers, but schools of mines established, without certificates from which no overman, underlooker, or manager, shall be legally appointed to his office.

The qualification of inspectors for their office is a point of the first importance, and should be efficiently tested before a competent board, analogously with the tests exacted in various professions where the interests of life and health are involved. They should be acquainted generally with natural philosophy (especially pneumatics), chemistry, mechanics, also a competent knowledge of geology and mineralogy; and should also have had practical experience of colliery working.

Almost every witness, however, bore testimony to the total inadequacy of the present system of inspection. The numbers were too small, its powers too limited. Each of the inspectors summoned before the Committee had something like 400 mines in his district, the whole of which he would be unable to go through in less than four years. Many mines they had never visited. The Committee cannot therefore hesitate to recommend that the number of inspectors should be increased. They at present amount to six. That number probably should, at least, be doubled and two sub-inspectors to each chief inspector be added. In a letter of Sir H. de la Beche to the Committee it is indicated, and it appeared also in evidence, that the present salary of an inspector was too small, at least to induce a person really fitted for the office of inspector to remain in his situation.

The Committee, for their own part, feel disposed rather to trust to the appointment of an efficient and vigilant Board; to an increased number of well-qualified inspectors and sub-inspectors, who should practically have the power of enforcing such a rate of current of air through the various parts of the mine as, in their judgment, the safety of the miners required, together with the adoption in each mine of such scientific instruments as both preserved a register of the ventilation, and gave warning of danger; that these powers should extend to inflicting penalties for the non-possession of such instruments, and non-attention to the precautions recommended, and to stoppage of the mine until the right measures were taken. Such measures, together with the better education of the miners, and the establishment of schools of mines, and the circulation among the colliers of such rules and regulations as are adopted in the pits of Mr. Forster and Mr. Darlington, the Committee consider would go far to diminish, and ultimately almost entirely to prevent, the dreadful explosions to which their attention has been called.

VENTILATION OF COAL MINES.

NASMYTH'S "Direct-Action Steam Suction-Fan, for the better Ventilation of Coal-pits," was fully described at the last year's scientific meeting at Ipswich, and is now in most successful operation in one of Earl Fitzwilliam's mines. Its object and effect are to do away the *cause* of explosion, by withdrawing foul air from a mine more rapidly than it can be evolved. One grand feature of this apparatus is, that it is placed on the *surface of the ground, and in full daylight*, whereby its action and proper working condition are open to sight at all times, and the rate of ventilation in the mine is ascertainable at every moment by simply observing the rate at which the fan is working. A great point this, since facility of inspection is the only good security for a constant attention of persons charged with the management of preservative expedients. It is in this respect that the Davy lamp has failed to prevent the numerous dreadful explosions that have so frequently and fatally occurred in coal-pits; these lamps are necessarily intrusted to all miners—the reckless or the careful—too many of whom, from habit, are regardless of danger, and, spite of the most stringent orders, open their lamps in a vitiated atmosphere, thus hurling themselves with all around them into inevitable destruction.

Motion is given to Nasmyth's direct-action steam suction-fan by a steam-engine, which is in direct connection with the fan-spindle, the crank of the engine being fixed to the end of the fan-axle; by this, all intermediate agents for the transmission of the power of the engine to the fan are dispensed with, and thus the whole is rendered simple, compact, and highly efficient. The foul air is conveyed from the upcast-shaft to the fan by a tunnel, which divides into two side passages, one on each side of the fan, they terminating in a circular aperture equal in diameter to half that of the fan-wheel, or track of its blades. This action is so simple and self-evident as not to require further description. When the fan is set in motion—say 300 to 400 revolutions per minute, as may be required—it induces centrifugal action on the air within the fan-case, and causes this air to flow forth in nearly radial lines, while a partial vacuum is established about the central part of the fan. To supply this vacuum foul air from the mine rushes up by the side passages of the apparatus, in volume equal to that which the centrifugal action of the fan flings forth. The immense volume of air which may be thus drawn from a mine is almost incredible, amounting, when necessary, to a brisk gale within the pit; but at the same time, the apparatus is so completely under control, that the ventilation is at all times capable of instant regulation as to amount.

The security against explosion afforded by this fan seems to render superfluous any mention of a farther advantage of it consequent on its being *above* ground; yet, notwithstanding the little chance that, where it is employed, fire-damp should accumulate within the mine, it may be observed that were an explosion to occur, the fan affords means of an *immediate* renewal of ventilation throughout the mine, whereby, on the event of such a sad disaster, succour without delay could be afforded to the sufferers below, without danger to those disposed to give assistance.

M. S. B.

REGISTER OF NEW PATENTS.

PREPARING WOOD.

C. F. TACHET, of Paris, mathematical instrument maker, for *improvements in preparing wood to prevent its warping or shrinking.* Patent dated November 15, 1851.

Claims.—1. The application of an adhesive substance in a state of powder between the surfaces of sheets or pieces of wood to be united, and the softening and fusing the same by the application of transmitted heat through the thickness of the wood, for preserving the same from warping and shrinking. 2. The application of the apparatus for effecting the sprinkling and fusion of the adhesive matter. 3. The apparatus for filling the boxes or drawers with heated sand.

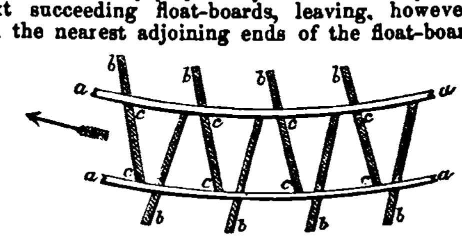
The ordinary method of preparing wood to prevent its warping or shrinking is to employ two or more thin pieces, which are united together by means of glue or liquid cement; but this mode only partially answers its intended purpose, as glue or cement applied in a liquid state is always liable to be affected by a moist atmosphere, and the expansion produced thereby, and the subsequent unequal contraction in drying, causes a certain amount of warping. The object of the patentee is so to unite pieces of wood together as to render them independent of any atmospheric influence, and the means he employs for this purpose are as follows:—A table having two surfaces formed by two iron boxes, connected by side-screws; between these surfaces the wood is placed, of as many thicknesses as are required. The different thicknesses, after having been respectively sprinkled with the cement employed, are then clamped together, including also the iron boxes, which are then filled with sand heated to about 300° centigrade; by these means the wood and the cement are both heated to the same degree of temperature and the cement fused. The sand is then removed from the iron boxes and the air admitted into them, for the purpose of cooling the wood and setting the cement. When quite cold the prepared wood is removed from the press, and may be applied to its intended purpose. The cement employed should be gum lac, either in combination with other materials or alone.

PADDLE-WHEELS.

J. L. STEVENS, of Kennington, Surrey, gentleman, for *certain improvements in propelling vessels on water.*—Patent dated November 27, 1851.

Claim.—The construction of paddle-wheels with diagonal float-boards, so fixed and arranged that the alternate float-boards overlap or project beyond the ends of the next float-boards on either side of the wheel, leaving spaces between the succeeding float-boards at either end thereof.

These improvements are effected by the construction of paddle-wheels in which the float-boards are placed diagonally in such manner that the ends of the float-boards on each side of the wheel shall alternately project beyond and overlap the ends of the next succeeding float-boards, leaving, however, spaces between the nearest adjoining ends of the float-boards. The



annexed diagram will explain this more fully. *a, a,* represents the frame of the wheel; *b, b,* are the float-boards, the ends of which overlap each other at their respective commencements *c, c.* The effect of this arrangement is the production of a double force by the paddle-wheel. The intention of the narrow spaces between the respective float-boards is the prevention of depression on the water entering, and of elevation on its leaving the wheel, and of any oscillating movement. The patentee prefers that the angle of divergence from parallelism with the axle of the wheel made by the float-boards, should be from 23° to 30°, and that the distance between the float-boards should be so regulated that the greater interval between the ends of the float-boards should be on one side of the wheel from three to four times as much as the lesser interval between the ends of the float-boards on the opposite side of the wheel.

BRICK-MAKING MACHINERY.

T. Burstall, of Lee-crescent, Edgbaston, civil engineer, for *certain improved machinery for manufacturing bricks and other articles from clay, alone or mixed with other materials.*—Patent dated December 1, 1851.

Claims.—1. The application of the direct action of steam-pressure for compressing clay, alone or mixed with other materials, into bricks, tiles, and other articles. 2. The direct action of steam in combination with the mechanical movement called a "toggle joint." 3. The direct action of steam in combination with a lever or levers, as may be suitable to produce the required effect.

The material or materials from which the bricks are intended to be formed are placed in the hoppers of a machine worked by steam power. This machine consists of a piston, working right and left. The hoppers being placed at the extremity of each plunger, and the material, falling from them into a cavity the intended size of the brick, is compressed by a stroke of the plunger into the required size. This being effected, the plunger on the other side of the piston, by its backward motion, operates in the same manner. The bricks are, by means of a slide, taken from the machine in a fit state for burning. The materials employed in their manufacture are clay, chalk, breeze, sand, and coal-dust, reduced to powder in a machine containing an internal roller acting on its surface. The machine has also gratings, through which the material passes when pulverised.

STEAM-ENGINES AND PROPELLING.

J. Macintosh, of Berners-street, Middlesex, civil engineer, for *improvements in steam-engines, in rigging and propelling vessels, and facilitating their progress through water.*—Patent dated December 4, 1851.

Claims.—1. The improvements in steam-engines described. 2. The improvements in rigging vessels. 3. The compositions described, and the application of the same to ships' bottoms.

1. The patentee describes an improved construction of rotary engine. The engine consists of a cylinder and a drum (furnished with two sliding plates, which act as pistons), placed eccentrically within it. In this particular it resembles others of the same class, with the exception that it has the end plates attached to and revolving with the internal drum. Between the end plates and the sides of the external drum a packing is introduced, in order to render the point where they come in contact steam tight. In order to produce a simultaneous motion of the sliding pistons in the internal drum, they are connected with each other by rods, to which springs are attached, which acting upon the packings of the pistons, serve to keep them constantly pressed outwards against the internal periphery of the external cylinder.

2. It is proposed by the patentee to construct the masts of vessels in such a manner that they may be inclined sideways, and thus to render the sails on them capable of lifting as well as propelling vessels. For this purpose the heel of the mast is furnished with a joint, allowing the mast to be inclined to an angle of 45°. A rope is fastened to the mast, and placed round a wheel, which, on being turned, takes in the rope on one side, and pays it out on the other, which brings the mast to the required degree of inclination. He also proposes to provide a yard for the foresail, and jib-shaped sails, to enable the sail to be brought to the wind without inclining the mast. For this purpose the block for the haulyards is furnished with a ring, which slides on a guiding iron attached to the yard.

3. In order to facilitate the progress of vessels through water, the patentee proposes to cover them with a composition produced by decomposing india-rubber in sweet oil by the application of heat—a composition found to adhere better, and from its glutinous nature allowing of an easier passage through the water. For sea-going vessels castor oil and copperas, or arsenic, or other poisonous materials, are added to the composition, to prevent the adherence of barnacles. The patentee is aware of poisonous materials having been previously used for a similar purpose, but asserts that they have always been of no effect, on account of their having dried or washed off. The present composition, however, never dries, but always continues glutinous as at the time of its application. Gutta-percha may be also added if desired, and is recommended by the patentee, both on account of its soluble and of its adhesive nature. The composition is to be applied in a warm state.

STEAM-ENGINES AND BOILERS.

J. Harrison, of Philadelphia, now of Oxford-square, Hyde-park-gardens, engineer, for *certain improvements in steam-engines and boilers.*—Patent dated December 8, 1851.

Claim.—The improvements claimed under this patent are capable of application to marine, locomotive, and stationary boilers.

First, as to marine boilers. The patentee proposes to advance the fire-box further into the boiler than is generally done, and also to surround the fire-box with a water-space. The boiler is traversed by pipes similar to those ordinarily used, but in addition to which are pipes open at the end leading to the steam-chamber only. The heated air generated in these additional pipes coming in contact with a series of vertical pipes passing through the steam-chamber, and connected with the steam-pipes, increases the temperature of the steam before it passes into the cylinder; and retiring through the ordinary pipes into the smoke-tube, in its passage heats the water in the boiler.

Second, as to locomotive engines. The same principle involved in the construction of the last mentioned engine directs that of the locomotive, with the addition of tubes passing across the fire-box and connecting the boiler with the water-space surrounding it.

Third, as to stationary engines. The patentee recommends that they should be erected of a circular upright form; he does not however confine himself to this shape, but simply recommends it on account of its greater strength, and also on account of its dispensing with the high chimney generally in use. The object of this arrangement is the consumption of the gases generated in the fire-box. This is effected by the ascension of the gases through a tube in the centre of the boiler to a space at the top, where they are mixed with pure air admitted through a small opening, and pass through another tube downwards to the fire-box, where they are consumed, after having assisted in increasing the temperature of the water in the boiler upon the principle before mentioned. The object desired by these arrangements being the obtaining of the largest possible amount of heating surface within a given space.

STEAM PROPULSION ON CANALS.

J. Lake, of Apsley, Herts, civil engineer, for *improvements in propelling on canals and rivers.*—Patent dated December 8, 1851.

Claims.—1. The employment in canal and river navigation of trackways between or on which boats can travel without the aid of steersmen, and be propelled by means of steam or other elementary power. [Upon trackways formed by a double row of piles, of the distance of 15 feet from each other, and placed upright in the canal, a top-rail is placed. Upon this top-rail is an iron rail, extending throughout its entire length; and on the inner side of the top-rail is another iron rail, having its upper surface racked. Between this double row of piles (and between which is a space of 9 feet) the barge is placed, the barge containing a steam-engine of the ordinary construction of steamboats, the axles of which are furnished with two driving-wheels on each side, the inner ones being toothed. The outer wheels working on the first-mentioned rail, and the inner toothed wheels gearing into the rack rail, impel the boat through the water. To this barge may be attached any number of barges the engine will sustain, and those at present in use may be altered to the necessary form at a very trifling expense.]

2. A mode of obtaining a sufficient "bite" or adhesion for the driving-wheels, by making use of a part of the weight of the boat and cargo in which the engine is placed for that purpose. [In the bottom of the boat is inserted a screw, and on to which a lever capable of being moved up and down, is fastened. This lever is attached to the axletree of the engine, and by being elevated or depressed at the screw end the required pressure upon the driving-wheels is obtained.]

3. A method of sustaining the weight of a boat and cargo while in the course of transit, partly on the rails of a trackway laid down as aforesaid, and partly by the water of the canal or river, as usual.

4. The employment in canal and river navigation of inclined planes for the passage of trains of boats from one level of the canal or river to another, constructed as described, and the working of the said planes by means of racks and pinions,

actuated by the same engine as is used for propelling on the level. [The object of this part of the patent is the doing away with the necessity for locks in canals. For this purpose the trackway is elevated, and the piles sustaining it are furnished with pinion-wheels at the level of the bottom of the barge. Up this inclined plane the boats pass, their ascent being rendered easier by means of their passing over the pinion-wheels. The patentee prefers the inclination of the plane being about 25°. In the case of the nature of the ground requiring a series of locks, he recommends that the inclined plane should be lengthened to the required extent.]

PIPES, SHAFTS, AND RAILWAY WHEELS.

P. G. Gardiner, of New York, civil engineer and machinist, for *improvements in the manufacture of malleable metals into pipes, hollow shafts, railway wheels, or other analogous forms, which are capable of being dressed, turned down, or polished in a lathe.*—Patent dated December 8, 1851.

Claims.—1. The manufacturing of malleable metals into pipes, hollow shafts, railway wheels, or other analogous forms, by the employment of a pair of suitably-shaped dies or swages, one or both of such dies or swages being made to revolve, and being gradually brought into closer proximity, whereby the mass of metal which is placed between them to be acted on is caused to assume the form of the article required to be made. 2. The arrangement and construction of machinery described for carrying out the principle upon which the invention is based.

In the manufacture of articles of a circular form, such as railway wheels, by means of pressure between dies, the metal is found not to possess a smooth surface, and in many parts to be defective. The object of the patentee is to remedy these defects; and this he effects by giving to each of the dies a rotary motion on its axis, the consequence of which is, that the metal becomes laid in concentric rings or in spirals, increasing the strength of the wheel, and producing also a smoothness and polish on its surface. For this purpose two bars are inserted in standards, each bar being furnished with a die, the one fitting into the other. These dies are capable of being shifted, in order that their places may be occupied by those of different forms as may be required. The heated metal is then placed in the hollow die, and the other die is then moved up to it by means of a screw in the interior of the bar; the two dies are then made to revolve swiftly in opposite directions, by means of drums attached to the bars, and turned by hand or otherwise. The metal, after being subjected to this process for some time, will be found to be of the shape required. It should be observed, that the swifter the dies are made to revolve the sooner will the desired effect be obtained; if the dies are moved slowly, the metal may probably require another heating.

Also in the manufacturing lead pipes by the hydraulic press, the grain of the metal being laid in a longitudinal direction, the pipes are consequently more liable to split under internal pressure or when bent. This is obviated by the patentee giving a revolving motion to the outer die, which causes the grain of the metal to be laid transversely, and produces a greater degree of strength than the ordinary method. The machine by which this is effected is upon the same principle as the one last mentioned; there is, however, a slight difference in its construction, which difference consists in one of the dies being furnished with a bore throughout the bar, and the other with a spindle. The metal being placed in a fused state in the hollow of one die, the spindle is pressed into the tube of the other a part of its length; further pressure being applied, the metal is exuded in a tubular form, and may be wound on to a coil provided for the purpose at the extremity of the machine.

ORNAMENTAL BRICKS AND TILES.

W. Pidding, of the Strand, London, gentleman, for *improvements in the treatment, manufacture, and application of materials or substances for building purposes.*—Patent dated December 8, 1851.

Claim.—The combination of certain materials for the manufacture of bricks, tiles, slabs, pipes, and other articles.

The invention consists, firstly, in a combination of broken stone, scoria, acetate and muriate of alumina, mineral earths, fluxes, wood, sawdust, papier-maché, coal, coke, naphtha, vegetable fibres, pitch, glue, and gutta-percha, which, in conjunction with a certain cement, is used for building purposes, and for purposes for which bricks have not been hitherto used.

Secondly, in veneering the brick formed of the above on one or more of its edges, with stone, marble, slate, or other material, a cement described being used for producing adhesion. This gives a handsome appearance to the bricks, and renders them more durable. The inventor also prepares a composition of pipeclay or porcelain clay, mixed with 20 per cent. of sulphate of soda or soda ash, and applies it to the bricks before or after burning, giving the bricks the appearance of porcelain blocks. Another method is also adopted for giving a fine appearance. The inventor takes sulphate of alumina, and deprives it of its water of crystallisation when in a semi-fluid state, produced by heat; this, with the combination of materials, is pressed into a mould. A solution of silicate of potassa is spread over it, and it is then submitted to a considerable heat. The inventor uses a composition of finely-ground or pulverised silica, mixed with one-fourth in quantity of potash or soda, for rendering the blocks or bricks impervious to water. The bricks, after being burnt, are coated with varnish, and then covered with a coating of the composition and re-burnt. Any colour may be given to the bricks by mixing minerals which produce the required colours with the potash or soda. To produce a slight glazing or colouring the sulphate of alumina before-mentioned is mixed with resin or other bituminous material; powdered glass, plain or coloured, is thrown into a tub; the brick being put into this, becomes covered with the particles of glass which adhere to the bituminous material or to the varnished surface; the brick is then baked, a fine glazed surface being produced. Coal reduced to coke, in combination with cinders, silica, or anthracite, mixed with pieces of coal the size of a pea, and united with any of the materials, such as vegetable fibre, mentioned in the first part of the invention, may be used to form light bricks, mantelpieces, &c.

CUTTING AND SHAPING METAL.

J. Frearson, of Birmingham, for *improvements in cutting, shaping, and pressing metal and other materials.*—Patent dated December 10, 1851.

Claims.—1. A mode of combining parts into a machine for cutting out, and for shaping several discs or blanks of sheet metal and other materials for the making of buttons and other articles. 2. Certain improvements in combining parts into machines for shaping and pressing metals and other materials in the processes of manufacturing them into various articles.

The first branch of the invention relates to a machine having two motions, one for feeding the material to the punchers for cutting, shaping, and pressing it, and the other for giving a reciprocating motion to the punchers, which are affixed to a vertical slide connected with an eccentric rod, turning on a vertical shaft, having the driving-pulleys and fly-wheel attached. The connecting-rod can be lengthened or shortened as the wear of the punchers require. The material is always kept between two pairs of rollers, revolving at the same speed, and kept close together at the nipping points by a spring. A bevel on the vertical shaft gears into a toothed wheel connected by gearing with the rollers. After the punchers have descended and ascended, the bevel moves the wheel one tooth forward, bringing a new surface of the material ready for punching.

The second branch of the invention relates to three arrangements of machinery: the first is arranged to feed, by pneumatic or other apparatus, sheet metal or blanks to certain machinery (punchers), for cutting, pressing, and shaping it; the second is intended for punching sheaves from short tubes of metal, which are supplied by a mechanical feeding action; the third is for punching tubes of metal out of discs or blanks of metal by machinery, for manufacturing eyelets for healds, and other uses. The patentee claims for the combination of known parts.

STEAM BOILER INDICATOR.

Sydney Smith, of Notingham, for *improvements in indicating the height of water in steam-boilers.*—Patent dated December 23, 1851.

Claim.—The application of a magnet, single or compound, combined with suitable apparatus, to give motion to a pointer or indicator in such a manner as to indicate the height of water in a steam-boiler.

A brass rod is inserted in a steam-tight tube passing into the boiler, on the outside end of which is placed a magnet. This brass rod is moved by a float in the boiler, operating upon a pulley at its extremity, which moves round the magnet, the poles of which, by their action upon a brass plate, cause a pointer or indicator to revolve round a dial, and thus effect the desired object. The same machine may be made to work perpendicularly by the employment of an upright arrangement of the magnet.

GOLD FIELDS OF AUSTRALIA.

By Mr. Shilling.

[*Abstract of a Paper read at the Society of Arts, June 16th.*]

After referring to the similarity in the geological formation of the Australian cordillera to that of the Sierra Nevada of California and Ural mountains of Russia, Mr. Shilling proceeded to describe the chief New South Wales diggings, and the geological character of each. He noticed especially Oakey Creek and the Braidwood diggings in the county of St. Vincent; Narrow Creek, in the county of Wellington; and the celebrated Louisa Creek. Having spoken of the Alexander diggings, near Bathurst, the lecturer glanced at the latest discoveries in Victoria, which, however, he had not personally inspected, and observed that there was no foundation for assuming that gold might anywhere be found concentrated in large quantities, and that it was almost hopeless to search after matrix gold. There were two kinds of diggings—river and dry diggings. The dry diggings had the advantage of never being flooded, but there was much more uncertainty in them than in those of the creek and river beds, where experience soon enabled a man to choose a place with some degree of certainty. The rocks about these creeks were schist and quartz. Where exposed to the weather, the schist was of a grey and red colour; but in the bed of the creek it was often blue and green, and had a polished appearance. The gold was generally found in surface earth, in black and red gravel; and under the gravel, in blue clay, which was the most promising, as it retained the gold; whereas the gravel, so easily disintegrated, allowed the heavy metal to fall through it; but the clay gave a great deal of trouble in the washing, being exceedingly difficult to get thoroughly away from the stones and pebbles that it clings to so tenaciously. The gold was deposited in certain places more plentifully than in others. Banks with a gentle slope from ridges covered with the detritus of the auriferous rocks, short sharp turns in the stream, and rocks in its bed lying with upturned edges, and crevices forming pockets for deposits, were pretty sure indications that gold in abundance was to be got there, and the greatest deposits were likely to be found at the turn of the stream on and near the projecting points; but, in the dry diggings, there was little to guide the digger; he had no idea what his fortune was likely to be until he had actually tried and dug a hole of the depth of from 5 to 20 feet to the underlying rock, which was composed for the most part of schistose, and reached after great labour. After working through to this bed rock the digger might be handsomely rewarded; and he might, on the other hand, have thrown all his labour away. Some such holes yield barely ¼-oz. a-day during washing, while others not half the depth may yield from 5 to 10 oz. It might at first excite surprise that gold had not been discovered before, but it must be remembered that it is so sparingly and minutely disseminated throughout the soil that it is only in the process of washing that it reveals itself. There is scarcely more appearance of it on the surface than on that of an ordinary field.

In noticing the locality where the celebrated hundredweight of gold was found, Mr. Shilling remarked on the great advantages of system, instancing a company who had thirty men working a half-acre claim there with great success.

At the close of the lecture several questions were put to Mr. Shilling, and a discussion arose, the general effect of which was—1st, that the class of emigrants wanted in Australia were strong able-bodied men, who could stand the fatigue of digging, and were accustomed to manual labour; 2ndly, that people who had in this country formed habits of life which unfitted them for employment as diggers or shepherds were not wanted, and would in all probability meet with little success; 3rdly, that the less emigrants took out with them beyond strong arms, a stout heart, and as much hard cash as they could collect for their enterprise, the better; 4thly, that concerted action in companies had been, and was likely to continue, on the whole, the most profitable at the mines; lastly, that as a preliminary training for the emigrant, who intended to try his fortune as a gold-seeker, he ought before starting to go down to Cornwall or Derbyshire, or any other of our mining districts, and acquire some insight there into the sort of life he would have to lead, and the knowledge he would acquire, by working for a few weeks as a common miner.

Mr. P. L. N. Foster moved, and Professor Tennant seconded, a vote of thanks to Mr. Shilling for his lecture, and in doing so the latter drew attention to the importance of the last mentioned point. He stated that a great variety of other mineral treasures, such as diamonds, emeralds, and topazes were always found associated with gold; and he drew the attention of the meeting to specimens illustrative of this fact, which were arranged on the table of the lecture-room, and will remain there for a day or two, to be inspected by members and ther friends.

The vote of thanks having been unanimously passed, Mr. Winkworth announced the close of the session, and congratulated the Society on its unprecedented success.

NOTES OF THE MONTH.

The Metropolitan Commission of Sewers.—At length this commission has been brought to a crisis, by the resignation of Sir William Cubitt, Mr. Robert Stephenson, Mr. Rendel, and Mr. Peto, thus leaving the responsibility upon the shoulders of the military engineers. We do not see how they could have done otherwise to avoid the bickerings that were constantly going on, besides the difficulties occasioned by the yearly postponement of an efficient act of parliament by which funds might be raised for carrying out the proposal of the late Mr. Forster, for effectually relieving the river Thames from the sewage of the metropolis.

The Metropolitan Water Bill.—After a battle of upwards of eighty days in committee in the House of Commons (fifty this session), an act of parliament has been obtained, by which the present water companies will, at the expiration of five years, be prevented from taking their supplies from the river Thames below Teddington Lock; that all reservoirs within five miles of St. Paul's are to be covered; that the water, if taken from any river, is to be effectually filtered; and that constant supply is to be given under certain conditions,—but the conditions are such, we fear, as will prevent a constant supply being given throughout the metropolis until competition comes to its aid. The old water companies commenced taking their supplies from the river Thames at London-bridge; they then travelled up the Thames, first to Southwark, then Lambeth, then Vauxhall, then Chelsea, then Hammersmith, then Brentford, and lastly, Thames Ditton—and there, after expending another half-million sterling, will remain until public taste will drive them from the Thames altogether. Some bold and decided measure ought to be adopted regardless of existing interests, whether that of mill-owners or water companies, so that a pure supply could be obtained. We feel convinced that, sooner or later, the public will compel the companies to take their supply from the deep springs, not only in the metropolis, but also in the provinces; care being taken that the situation is not too near the sea, or within the chance of the springs being polluted by the percolation of town sewage.

Provisional Committee-men.—The House of Lords, the judges in attendance, decided, on the 28th ult., in the case of Hutton *v.* Bright, that a provisional committee-man, who has had shares allotted to him and paid the deposits, but never authorised the incurring of any expenses, not having been present at any meetings, nor in any manner whatever become a party to any contract under which any expenses were incurred, was not liable beyond the amount of his deposits; at the same time reversing the order of the Master, which called upon the committee-man to contribute beyond the amount of his deposits.

Submarine Telegraph to Holland.—M. Ruyssenaers has obtained the concession from the Dutch government for laying down a telegraph between this country and Holland. This line will extend to Belgium, Prussia, and the north of Europe.

The Adriatic.—According to recent observations the alluvial soil on the Austrian coast of the Adriatic is increasing exceedingly, and it has been remarked that, since the beginning of this year, there has been a change on the shore of the west coast. Malghera, which at the time of the French invasion was an island, is now completely joined to the continent on one side.

Stephens' Propelling Pencils.—Nearly the whole length of the interior of these pencils contain lead, which is propelled to the point by turning the cap at the upper end; they are thus superior to the common kind of "ever-pointed" pencil, by having a greater length of lead in reserve, and do not require such frequent filling. They are made in wood or metal, of various lengths suitable for the pocket or desk.

The Marble Arch.—The following expenses were incurred in moving to and rebuilding the arch upon its present site, Cumberland-gate:—Taking down the arch, 626*l.*; moving and rebuilding, 2930*l.*; use of hoarding round the materials when deposited in the Green-park, 27*l.* 14*s.*; converting railing of the small archways into folding gates, 88*l.*; converting the rooms of the arch into living rooms, 150*l.*; Messrs. Burton and Nesfield for commission in respect of works designed by them, but which were not executed, (2½ per cent.), 482*l.* 2*s.*; removing and rebuilding lodge gate entrances, building drains, &c., at Cumberland-gate, 1518*l.*; alteration of the footways in Oxford-street, 45*l.* 7*s.* Total, 5868*l.* 6*s.*

Buckingham Palace.—The following are the items of expense incurred in the recent alterations:—Constructing the foundations and stone kerb for the iron railing, and piers to inclose the fore-court of the Palace, 1275*l.*; stone piers for the railing and gates, 1290*l.*; providing and fixing iron railing and gates, including candelabra and lanterns, 1864*l.*; other works, 449*l.* 6*s.*; joint commission of Messrs. Burton and Nesfield (5 per cent.), 294*l.* 9*s.*; setting back railing of Green-park and ornamental inclosure, 1010*l.*; levelling and forming approaches to fore-court and esplanade, and other ground works, 1830*l.* 5*s.* Total, 11,098*l.* 11*s.*—Under the Act 12 & 13 Vict., c. 102, intituled, "An Act to authorise the Sale of the Royal Pavilion at Brighton and the Grounds thereof, and to apply the Money arising from such Sale," a sum of 50,000*l.* is still applicable to the enlargement and improvement of Buckingham Palace; but no estimate is yet made of the expense of the proposed additions.

Great Western, and London and North Western Railways.—It appears from a comparison of the speed and fares of the express trains upon these railways that the speed of the fastest trains between London and Bristol on the Great Western is 43 miles per hour, and on the London and North-Western, between London and Birmingham, 40 miles per hour; the difference in favour of the former company being 3 miles per hour. The speed of all the mixed trains between London and Plymouth, and London and Liverpool, is 35¼ miles per hour on the Great Western, and 36¼ miles on the London and North-Western—being 1 mile per hour in favour of the latter. The average fares per mile on the Great Western are—for first-class, 3·068*d.*, and for second-class, 2·502*d.*; while on the London and North-Western the average is, for first-class, 2·676*d.*, and for second-class, 2·178*d.*—showing a difference in favour of a passenger travelling by the London and North-Western Railway of 0·392*d.* for first-class, and 0·324*d.* for second-class. A comparison of the time occupied and fare charged on a journey of 246¾ miles on both lines, shows a difference in time in favour of the London and North-Western of 34 minutes by a first-class train, and of 12 minutes by a mixed train; and also at the same time a saving of 8*s.* 1*d.* for that distance by the first-class, and of 6*s.* 8*d.* by the second-class, the fares on the Great Western Railway for first-class being 63*s.*, and for second-class 50*s.* 6*d.*; while on the London and North-Western the fare for the first-class is 54*s.* 11*d.*, and for the second-class 43*s.* 10*d.* By the mail trains the average speed per hour is 25 miles on the Great Western, and 28 miles per hour on the London and North-Western, the difference in favour of the latter being 3 miles per hour. The average fares per mile on the former railway amount to 2·724*d.* for first-class, and 1·867*d.* for second-class; while on the latter railway they amount to 2·419*d.* for first-class, and 1·775*d.* for second-class, showing a difference in favour of the latter of 0·315*d.* for first-class, and 0·092*d.* for second-class. A comparison of the time and fares calculated on a journey of 246¾ miles shows a saving in favour of the London and North-Western of 58 minutes, and of 6*s.* 8*d.* in first-class fares, and 1*s.* 10*d.* in second-class fares. By the ordinary trains the average speed per hour on the Great Western is 25 miles, and on the London and North-Western 26¼ miles, being 1¼ mile in favour of the latter. The saving in first-class fares being 0·583*d.*, and in second-class fares 0·291*d.* per mile also in favour of the latter company. A comparison of the time occupied on a journey of 246¾ miles shows a difference in favour of the London and North-Western of 21 minutes, the time occupied by the Great Western trains being 9h. 53m.; by the London and North-Western, 9h. 32m. The saving in the first-class fares is 12*s.* 4*d.*, and in the second-class fares, 6*s.* 1*d.* in favour of the latter company.

LIST OF NEW PATENTS

GRANTED IN ENGLAND FROM MAY 22, TO JUNE 24, 1852.

Six Months allowed for Enrolment unless otherwise expressed.

John Harcourt Brown, of Aberdeen, Scotland, and John Macintosh, of the same place, for improvements in the manufacture of paper and articles of paper.—May 22.

Louis Victor Buzé, manufacturer, of Gaillon, France, for certain improvements in the manufacture of hat-plush and other similar silk cloths.—May 22.

John James Russell, of Wednesbury, Stafford, patent tube manufacturer, for improvements in coating metal tubes.—May 22.

Edward Thomas Bainbridge, of St. Paul's Churchyard, for improvements in obtaining power when fluids are used.—May 22.

Samuel Cunliffe Lister, of Manningham, York, machine wool comber, for improvements in treating and preparing—before being spun—wool, cotton, and other fibrous materials.—May 22.

John Swarbrick, of Blackburn, Lancaster, fire-brick manufacturer, for certain improvements in the method of manufacturing retorts used for gas and other purposes, and in the apparatus connected therewith.—May 22.

Alfred Vincent Newton, of Chancery-lane, Middlesex, mechanical draughtsman, for certain improvements in winnowing machines. (A communication).—May 22.

Thomas Knott Parker, of London-wall, City, carpenter, for improvements in window sashes.—May 22.

Johann Stierba, of the firm of Messrs. Elsbrick and Co., of Prague, Bohemia, gentleman, for improvements in furnaces, and in treating and utilising certain products of combustion.—May 22.

John Mason, of Rochdale, Lancaster, machine-maker, and George Collier, of Halifax, York, manager, for certain improvements in preparing, spinning, twisting, doubling, and weaving cotton, wool, and other fibrous materials; also in tools or apparatus for constructing parts of machines used in such manufactures.—May 22.

Joseph Walker, jun., of Wolverhampton, Stafford, merchant, for certain improvements in vacuum-pans for the evaporation and crystallisation of saccharine or other solutions. (A communication.)—May 25.

Henry Webster, of Manthorpe, Lincoln, wheelwright, for improvements in regulating the draft in chimneys or flues.—May 25.

Adolphus Charles Von Herz, of Cecil-street, Middlesex, Esq., for improvements in treating, preparing, and preserving roots and plants, in extracting saccharine and other juices from roots and plants, in the treatment of such juices, and in the processes, machinery, and apparatus employed therein.—May 29.

Frederick Miller, of Fenchurch-street, London, gentleman, for improvements in apparatus for hatching eggs.—May 29.

Joseph Lees, the younger, of Manchester, calico printer, for an improved system of preparing, cutting, and engraving rollers to be used for printing woven and other fabrics, and improved machinery for printing and washing the same fabrics.—May 29.

Alexander Bain, of Beevor-lodge, Hammersmith, gentleman, for improvements in electric telegraphs and in electric clocks and time-keepers, and in apparatus connected therewith.—May 29.

William Septimus Losh, of Wreay Sykes, near Carlisle, gentleman, for improvements in the purification of coal gas.—May 29.

Richard Ford Sturges, of Birmingham, manufacturer, for certain new or improved ornamental fabrics.—May 29.

William Armand Gilbee, of South-street, Finsbury, Middlesex, for certain improvements in machinery for cutting corks.—June 1.

Alfred Vincent Newton, of Chancery-lane, Middlesex, mechanical draughtsman, for improvements in machinery for propelling vessels, and in apparatus to be used in connection therewith. (A communication.)—June 1.

William Henry Phillips, of Camberwell New-road, Surrey, engineer, for improvements in decorative illumination, and in applying light for other purposes.—June 1.

Thomas Willis, of Manchester, machine maker, for certain improvements in machinery or apparatus for winding yarns or threads, and also improvements in looms for weaving.—June 1.

Samuel Morris, of Stockport, for certain improvements in steam-boilers.—June 3.

William Haughton, of Manchester, for improvements in machinery for spinning cotton and other fibrous substances.—June 5.

Robert Hardman, of Bolton, for improvements in looms for weaving.—June 5.

Laurent Machabee, of Avignon, for an improved composition applicable to the coating of wood, metals, and other substances to be preserved from decay.—June 8.

Edme Augustin Chameroy, of Paris, manufacturer, for certain improvements in steam-engines.—June 8.

Enoch Townend, of Keighley, for certain improvements in the manufacture of textile fabrics.—June 8.

William Gratrix, of Salford, for certain improvements in the production of designs upon cotton and other fabrics.—June 8.

William Rettie, of Aberdeen, for certain improvements in lamps and burners, in apparatus for ventilating apartments, and in the mode of working signal lamps.—June 8.

Henry Houldsworth, of Manchester, for improvements in embroidering-machines, and in apparatus used in connection therewith.—June 10.

Thomas Wilks Lord, of Leeds, for improvements in machinery for spinning, preparing, and heckling of flax, tow, hemp, cotton, and other fibrous substances, and for the lubrication of the same and other machinery.—June 10.

William Beasley, of Kingswinford, for certain improvements in the manufacture of metal tubes and solid forms, and in apparatus and machinery to be employed therein.—June 10.

Michael Joseph John Donlan, of Rugely, Staffordshire, for improvements in treating the seeds of flax and hemp, and also in the treatment and preparation of flax and hemp for dressing.

Edwyn John Jeffery Dixon, of the Royal Slate Quarries, Bangor, and Arthur John Dodson, of the city of Bangor, gentleman, for improvements in machinery and apparatus used in quarrying slate and stone, and in cutting, dressing, planing, framing, and otherwise working and treating slate and stone, and in apparatus and wagons used for moving and conveying slate and stone, and improvements in joining, framing, and connecting slate and stone.—June 12.

William Reid, of University-street, electric telegraph engineer, and Thomas Watkins Benjamin Brett, of Hanover-square, gentleman, for improvements in electric telegraphs.—June 12.

Jean Ernest Beauvelet, of Paris, gentleman, for improvements in the manufacture of iron and steel. (A communication.)—June 12.

Joseph Brandeis, of Great Tower-street, Middlesex, for improvements in the manufacture of raw and refined sugar.—June 12.

George Pate Cooper, of Suffolk-street, Pall-Mall East, tailor, for certain improvements in fastenings for garments.—June 12.

Thomas Restell, of Kennington, Surrey, watch manufacturer, for certain improvements in the construction of lamps and burners.—June 17.

James Norton, of Ludgate-hill, merchant, for improvements in apparatus for ascertaining and measuring the mileage run by public vehicles during a given period; also the number of persons who have entered in or upon, or are travelling in public vehicles; part of which improvements is applicable to public buildings and other places where tolls are taken.—June 17.

William Cardwell M'Bride, of Alistragh, Armagh, farmer, for certain improvements in machinery for scutching or otherwise preparing flax and other like fibrous materials.—June 18.

Richard Archibald Brooman, of Fleet-street, London, patent agent, for improvements in the manufacture of wheels, tyres, and hoops. (A communication.)—June 18.

William Edward Newton, of Chancery-lane, civil engineer, for improvements in the construction of fences. (A communication.)—June 19.

William Burgess, of Newgate-street, gutta-percha merchant, for improvements in the manufacture of gutta-percha tubing.—June 21.

Jean Baptiste Georges Landes, of Paris, civil engineer, for certain improvements in locomotive-engines, part of which improvements are also applicable to other engines.—June 24.

Claude Arnoux, of Paris, gentleman, for certain improvements in the construction of railway-carriages.—June 24.

Alexander Johnston Warden, of Dundee, manufacturer, for improvements in the manufacture of certain descriptions of carpets.—June 24.

James Higgin of Manchester, manufacturing chemist, for certain improvements in bleaching and scouring woven and textile fabrics and yarns.—June 24.

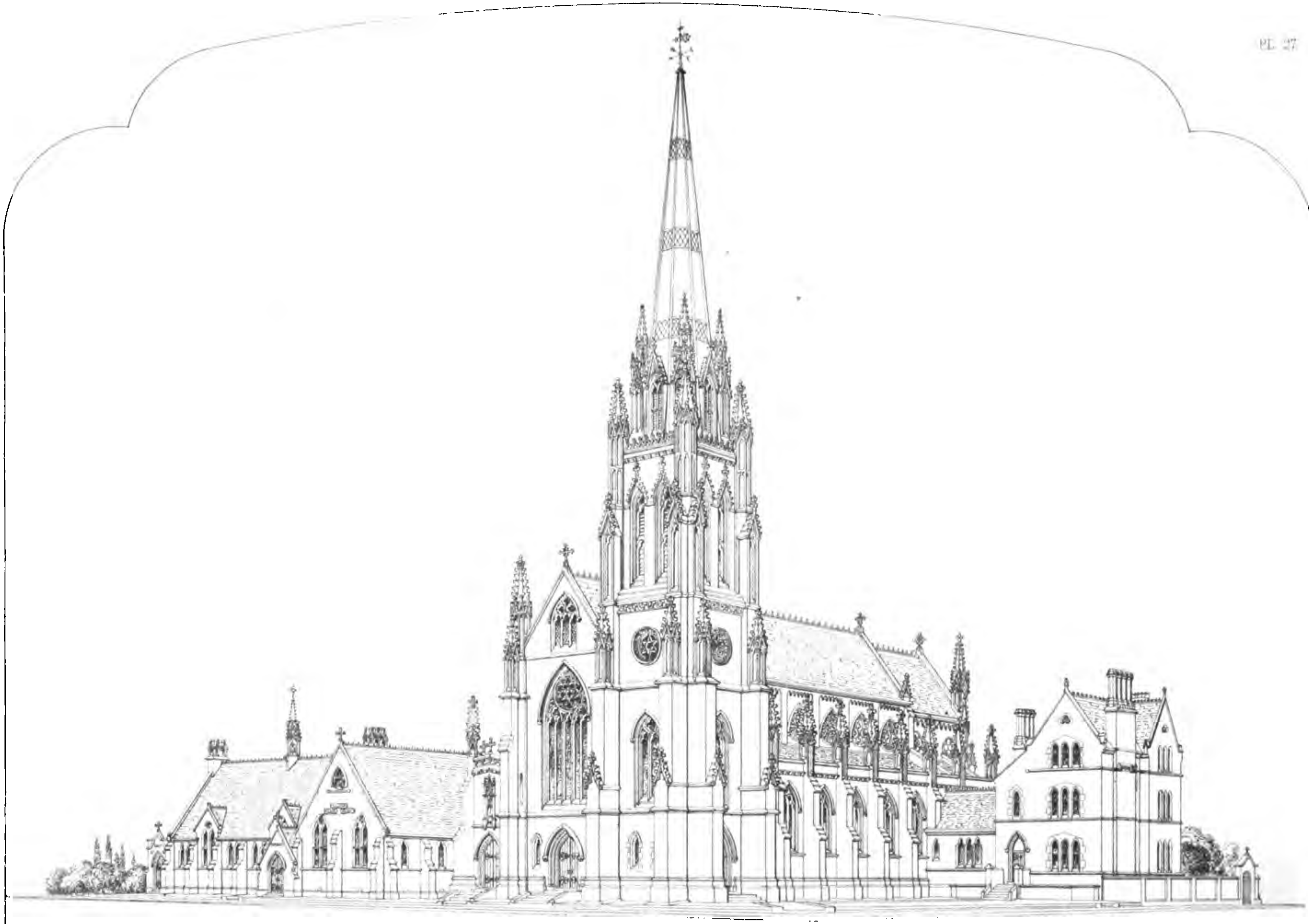
Joseph Swan, of Glasgow, North Britain, engineer, for improvements in the production of figured surfaces, and in printing, and in the machinery or apparatus used therein.—June 24.

George Pearson Renshaw, of the Park, Nottingham, civil engineer, for improvements in cutting and shaping.—June 24.

James Edward M'Connell, of Wolverton, Bucks, civil engineer, for improvements in steam-engines, in boilers, and other vessels for containing fluids, in railways, and in materials and apparatus employed therein or connected therewith.—June 24.

Joseph Hart Mortimer, of Hill-street, Peckham, for improvements in lamps.—June 24.

Erratum.—In the paper by Mr. Clayton, on the "Towers and Spires of the City Churches," *ante* p. 169, line 20 from bottom, *for* "tower" *read* "town."



ST. HELEN'S CHURCH AND SCHOOLS, PADDINGTON.

Thomas Meyer, Esqre. Architect.

J.R. Jobbins.

ST. HELEN'S CHURCH, PADDINGTON.

Thomas Meyer, Esq., Architect.

(*With an Engraving, Plate* XXVII.)

The Engraving shows a perspective view of St. Helen's church, free schools, and priest's house, in course of erection at Westbourne-grove North, Paddington, under the superintendence of Mr. Meyer, the architect, on two adjoining plots of freehold ground purchased at a cost of 2500*l.* A portion of the schools were commenced in May 1851, and were opened as a temporary chapel on the 2nd of December following, by Cardinal Wiseman. This portion of the schools has been erected upon the sole responsibility of Dr. Magee, at a cost of 1500*l.*, including boundary walls, gates, belfry, and necessary fittings, and accommodates about 200 persons. The principal front is faced with bricks from Beaulieu, Hampshire, and the stone for the dressings is the Box-ground Bath. The roof is open and stained, and the belfry constructed in timber, and covered with lead; the crockets to spire, gablets, and pinnacles are also in lead. The builders were Messrs. Smith and Appleford.

A second contract of 8131*l.* has also been entered into by the above-named builders for erecting the carcase of the church, the tower to be carried up to the underside of belfry, the sacristies finished, and the boundary inclosures. The walls are built to the height of the aisle parapets, and about 4000*l.* on the contract has already been expended. The external facings to the church and sacristies are in Kentish rag, with Box-ground Bath stone dressings. The steps are of Cragleith stone, and the nave pillars Portland stone. The floor of the church stands about 4 feet above the level of the road. There are three entrances at the west end of the church, and one at the east end for the acolytes; an organ gallery over the west end; two confessionals leading out of the north aisle, and one from between the south aisle and sub-sacristy. It is intended to have a side altar at the east end of each aisle. There is not to be any rood to the chancel. The whole of the church is to be groined, and will afford accommodation for 800 persons seated.

	ft.	in.
Length of nave	102	0
Length of chancel	25	6
Whole length, inside of walls	127	6
Length of north aisle	118	6
Length of south aisle	102	5
Side of tower, outside of walls	19	0
Width of nave, to centre of pillars	28	0
Width of aisles, to centre of pillars ... each	12	10
Whole width, inside of walls	48	8
Height of tower and spire	165	0
Height of nave and chancel, to apex of groining	43	9
Height of nave to ridge of roof, from floor line	60	0
Height of aisles, to apex of groining	22	3

ON A REVIVED MANUFACTURE OF COLOURED GLASS USED IN ANCIENT WINDOWS.

By Charles Winston.

[*Paper read at the Royal Institute of British Architects, June* 14*th.*]

The point to which I have to direct your attention is, "a revived manufacture of glass used in ancient windows;" but, in order that the importance of the subject may not be underrated, I wish to make some remarks, in the first place, on the harmony observable between the design and execution of glass paintings and the quality of the material of which they are composed—a harmony which, though more remarkable at some periods than at others, may yet be observed, in a greater or less degree, in all works having any pretension to originality. It is only when the perception of the artist has become blunted, and his invention paralysed by a habit of servile, unreflecting imitation, that *all* trace of this harmony is lost. I cannot better illustrate my meaning than by contrasting the glass paintings of the middle of the sixteenth century with those of the twelfth and thirteenth.

At this early period, when the richest, the most beautiful, and the deepest colouring in glass that we are acquainted with was employed, we always find that the picture was both designed and executed in the simplest manner. There are no complicated groups—no atmospheric effects—hardly any effect of light and shade,—and no high finish. If a group is represented, the figures all appear to be in the same plane, and to be cut out by a stiff background of deep blue, or red. A landscape is rarely attempted; when this is the case, it is symbolised rather than represented by trees, buildings, or other accessories, of most mediæval cut and conventional character, which always appear, by the positiveness of their colouring, to be in the same plane as the figures, and like them, are cut out by the aforesaid stiff background. The whole expression of the drawing is conveyed by means of strong black outlines, the effect of which is usually heightened by a simple wash of shadow in half-tint, the edges of which are left hard. In short, the artists of this early time seem to have aimed at producing little else than a rich mosaic, of the most vivid and harmonious hues. I say they *seem* to have done so,—for I am morally certain that they were really as ambitious of pictorial effect as any of their successors, and that their not having achieved it resulted rather from circumstances and want of skill than from any lack of intention. Had these men really adopted a flat style, on principle, they could hardly have failed to avoid those inconsistencies which are so obvious in their works. Such as representing a landscape at all—under such conditions—shading the figure and giving it greater relief than the canopy *under* which it is supposed to be placed, and regulating the depth of the shading rather by the size of the figure than the intended position of the painting in the church. Had they acted on a well-understood principle, we might have expected to find some attempt made to lessen, if not obviate, the indistinctness resulting from a flat treatment, by means of a proper arrangement of the colouring; but the instances where the *entire* colouring of a group is strongly contrasted with the hue of the background are so rare as to justify the supposition that they were accidental. I am, I confess, led by these and similar considerations irresistiby to the conclusion that the glass painters of the twelfth and thirteenth centuries, though great colourists, were not in other respects great artists; and that whatever we find good in their works is the rich legacy of antiquity. That as we undoubtedly owe to Pagan times the art of imparting these magnificent colours to glass,* so do we owe to the influence of Pagan art that style of low relief which, corrupted by the Byzantines, and misunderstood in "ye ages of feythe," is, nevertheless, so far as it is developed in the windows of the twelfth and thirteenth centuries, so truly admirable, because so excellently well adapted to the stiff and intense colours of the period—colours so intense and unvarying in depth as to preclude the possibility of their being made subservient to those pictorial effects which are indispensable to the satisfactory representation of a subject whose composition would rank above that of a bas-relief.

The contrast afforded by turning to a glass painting of the middle of the sixteenth century is very striking. We no longer behold a stiff mosaic depending for success almost exclusively on the richness of its colouring; but, on the contrary, a picture, brilliant it is true, but resting its claims quite as much on its composition and general treatment as on the vivacity of its hues. Here complicated foreground groups, as well as important architectural accessories are introduced; they are delineated correctly, and highly finished. The relative distances of the various objects are preserved by means of light and shade, and the landscape background, monotonous as it may appear in comparison with that of an oil or fresco painting, recedes and disengages itself from the figures and architecture, imparting to the picture an effect of atmosphere. The glass itself differs widely from that used in the twelfth and thirteenth centuries. In general it is thinner in substance—it is always weaker in tint,—and on that account, if regarded simply as a vehicle for colour, would be far inferior to the older material. Yet for the purpose to which it is applied it could not be more suitable. Its pellucidness and lightness of tint are admirably calculated to display the high finish of the painting—to favour atmospheric effect, and vivid contrasts of light and shade. Nor does the employment of a material comparatively so flimsy and weak impart a corresponding flimsiness or weakness to the picture. A good specimen of Cinque-cento work will be found as imposing in effect as a window of the twelfth or thirteenth century. Let any one endeavour to call to mind the glass at Chartres, and that filling the four windows of the Chapel of the Miraculous Sacrament, in Brussels Cathedral. I am sure

* The truth of this will sufficiently appear on comparing the coloured glass of the twelfth century with the specimens of Roman and Greek glass in the British Museum. So complete an identity of colour argues an identity of manufacture, which manufacture, there is good ground for believing, was handed down from Pagan times. The strong resemblance, which the most superficial observer must recognise, of the twelfth and early thirteenth century draperies and figures to those of the Greek school of art, raises a reasonable inference that the glass painters of those times, though, in all probability, natives of the countries in which they practised, derived their art from the Byzantines.

he will feel an impression that he has seen something at both places equally striking—something equally removed from flimsiness or poverty. The paradox is easily explained when we consider that in the mosaics of the twelfth and thirteenth centuries the effect of the glass is but little aided by contrast of colour, or by shading; whereas in the pictures of the Cinque-cento period, not only is the colour arranged in broader masses, which is of itself a great assistance to a poor material, but the strongest contrasts of colour and of light and shade are employed.

I have now compared the best exponent I have been able to find of a flat style of glass painting with what I believe to be a perfect exponent of the rotund or pictorial style of glass painting—and I have endeavoured to point out, that in each specimen the quality of the glass and mode of painting it are alike different—and further, that each kind of glass, and each mode of using it, are severally calculated to act and react upon one another, so as to set both off to the greatest advantage.

It will be useful to pursue the subject further, and show that during the whole interval which elapsed between the abandonment of the flat or mosaic style, at the end of the thirteenth or middle of the fourteenth century, and the adoption of the rotund or pictorial style, which it took two centuries to perfect in the Cinque-cento,—a certain harmony existed between the quality of the material and the mode of working it. It would be rather a matter of curiosity than of practical advantage to speculate on the causes which led to these changes in the quality of the material and the mode of working it. If I might hazard a conjecture, I should be inclined to say that it was a change in the manufacture which induced or necessitated a change in the painting, and not the reverse; because we know that from Pliny's time, downwards, the effort has always been to improve on the manufacture of glass—that is, to render the material more pure and pellucid, and better fitted for domestic purposes, without reference to its employment in painted windows. But however this may be, each change in the manufacture, and each change in the mode of painting were, in general, contemporaneous.

There was but little change in the quality of the glass between the end of the thirteenth century and the middle of the fourteenth, if perhaps we except the deterioration of some of the colours—the deep blue appears to have lost its sapphire-like hue, with the decline of Byzantine influences, soon after the middle of the thirteenth century. And, during the same period, the principles of the flat style were subjected to scarcely any greater violation than they had already if not always sustained. But in the second half of the fourteenth century, and as it would appear, in this country at least, about 1380, an important change in the manufacture of the material took place. The white glass became purer, and all the coloured glass lighter in tint. Simultaneously an equally important change in the mode of painting was effected. It is true that the colouring had become broader and less mosaic, and the designs somewhat more pictorial, previously to the change in the material in 1380; and this is particularly remarkable in the glass paintings of Germany, in which country I am strongly inclined to think that the alteration in the glass manufacture originated. But the change to which I would now particularly advert is in the execution of the painting.

Wykeham's glass, at New College Chapel, Oxford, which is one of the earliest specimens, may be referred to in illustration of it. The outlines became thinner, the shadows broader and softer, the painting altogether higher wrought and finished, and the treatment generally more pictorial. By the end of the fourteenth century, the new style of execution was established, as we see it in the east window of York Minster; but though rotund and pictorial in principle, it was not rotund or pictorial in effect till the end of the first quarter of the sixteenth century, when the bolder practice of the Cinque-cento artists broke out in all its vigour. Still, though we must regard the works of this long intermediate period as inferior alike to the painted glass of the thirteenth century and the Cinque-cento time, having neither the depth of colour of the one, nor the pictorial power of the other, it is impossible to examine them without perceiving that their authors must have felt that the more delicate material with which they were furnished, invited, if not demanded, a more delicate mode of execution.

Again, we may trace in all works executed since the middle of the sixteenth century down to the present time, except, indeed, the recent imitations of mediæval glass paintings, a certain degree of harmony between the quality of the material and the mode of working it. I do not intend to enter upon the comparative merits of the mode of execution adopted by the Cinque-cento artists, who used an enamel colour only for the purposes of shading; and of the mode of execution adopted subsequently, according to which enamel colours were used more or less in substitution of glass coloured in its manufacture; though I admit I entertain a strong opinion in favour of the former, because I know that the question is extensive enough, if gone into, to form the subject of a separate inquiry. But, apart from this consideration, we see in all the works of the Van Linges, the Prices, the Gervaises, and lastly in the modern Munich glass, a very delicate and finished style of painting, combined with the use of a material so delicate and pellucid as to appear extremely flimsy, were its thinness not disguised by the mode of painting it. In all glass paintings, therefore, of whatever period, with the single exception I have named, do we find the execution and design of the painting vary with the quality of the glass—being simple when the glass was rich in colour, and not over transparent; and proportionably more and more delicate and complicated as the glass became weaker in colour, more pellucid, and more thin in effect. And if any proof was wanting, either that these corresponding changes were intentional, or dictated by good taste and sound sense, it is amply afforded us by the modern copies of mediæval glass, and even by the devices resorted to in order to insure as much as possible the fidelity of the imitation; and, I am sorry to add, the enormous mendacity not unfrequently relied upon in support of a bad case. The works to which I allude are copies of glass paintings of the twelfth, thirteenth, fourteenth, and fifteenth centuries. Some persons roundly assert that there exists a positive identity of effect between these copies and the originals: others seek to excuse any apparent difference by the remark that age alone is wanting to complete the identity. In dealing with these assertions, I shall assume the possibility of making exact copies of the *design* and *manipulation* of ancient glass paintings, for though I have never met with an instance of such exactness in English work, I certainly have met with it repeatedly in French. I shall therefore found whatever I have to urge in disproof of this alleged identity, or would-be-identity, upon an examination of the nature and quality of the material of which these copies are composed.

I have discovered a simple mode of testing whether, on the one hand, glass is sufficiently opaque so as not to appear flimsy or watery when put up in a window, unassisted by shading, according to the practice of the flat style of glass painting; on the other, whether it is sufficiently clear to produce as brilliant an effect as the old does. As follows: If the glass when held at arm's length from the eye, and at the distance of *more* than a yard from an object, does not permit of that object being distinctly seen through it, the glass will be sufficiently opaque. And, if when held at the same distance from the eye, and at the distance of *not* more than a yard from the object, permits of its being distinctly seen through the glass, it will be sufficlear and transparent. I have found this to be the case with a great many pieces of glass of the twelfth, thirteenth, and fourteenth centuries, which had been rendered clear by polishing the surface, or which were already quite clear; for it is a great mistake to suppose that all old glass has been rendered dull on the surface by exposure to the atmosphere. I have seen a good deal of glass of the twelfth and thirteenth centuries that is as clear now as when it was first made, its surface not having been corroded in the least. But the glass of which these imitative works are made is either smooth on the surface and so pellucid or watery as, when held at arm's length, to permit of any object being perfectly seen through it which is at the distance of 100 or even 1000 yards, or more; or else is artificially roughened on the surface, a practice which reduces the condition of the glass nearly to that of ground glass, for when held at arm's length, it will not permit of any object being seen distinctly through it which is distant more than an inch from the glass.

The practice, not unfrequently resorted to by the imitators of old glass, of *antiquating* smooth-surfaced glass—that is, dulling it with the enamel colour used for painting the outlines, renders it, when held at arm's length, nearly if not quite as opaque as rough-surfaced glass; indeed, almost the only perceptible difference, in this respect, between rough-surfaced glass and smooth-surfaced glass that has been antiquated, is, that the former is free from the tint necessarily imparted to the latter by the enamel colour with which it is antiquated. Thus we find that imitations of glass of the twelfth, thirteenth, or fourteenth century, if executed in smooth-surfaced glass that has not been antiquated, are very poor and watery in comparison with original work of the period. And that if executed in glass that has been antiquated, or rough-surfaced glass, they are much too opaque. In the one case, to speak popularly, the vision passes too uninterruptedly through the glass; in the other, it is stopped at the surface of the glass, instead of passing about a yard through it, as in the case of ancient work.

I might show the non-identity of modern glass with ancient, even by a reference to the difference of its colouring. The old being invariably harmonious and rich, the modern almost as invariably raw, crude, and poor in tone—a circumstance arising partly from the use of colouring materials different from those formerly employed, partly from a difference in the make of the glass. But I am content to leave the case as it stands. I cannot, however, forbear the remark that it is most amusing to find many earnest admirers of mediæval imitations, who, though apparently ignorant of the practice of roughing the surface of glass, are aware of the pernicious effect of "smudging" or "antiquating" that which is smoothly surfaced, attributing to windows on which neither of these practices has been employed the effect of ancient ones, because, as they assert, "the glass then remains clear and pure as in ancient times." Was there ever so entire a misconception! Is flimsiness or wateriness a characteristic of ancient glass? Do we ever find the glass even of the sixteenth century, as flimsy and watery as that used in the works to which they allude, as exact imitations of glass paintings of the thirteenth? Of course we do not. I say of course, because recent analysis has discovered the presence of at least one constituent of old glass, which does not exist in the modern, and which, on being purposely introduced, produces the self-same effect of solidity and richness which we perceive and admire in the old.

It is now time to advert to the revived manufacture of glass, which constitutes the text of this paper. And in doing so, I must disclaim any merit which may attach to the discovery beyond having started the inquiry which led to it, and sometimes having given an opinion on the quality of the colours produced. The merit of the discovery is to be ascribed to the chemical science of my friend Mr. Medlock, of the Royal College of Chemistry, and the practical skill of Mr. Edward Green, of Messrs. Powell's glass-works in Whitefriars.

I was anxious in the autumn of 1849, to procure some blue glass like that of the twelfth century—that is to say, not a raw positive blue, such as we see in modern windows, but a soft, bright intense blue, or rather a sort of neutralised purple. And for this purpose I submitted some twelfth century blue glass to Mr. Medlock for analysis. He completed his analysis in Easter week, 1850, and thereby determined that the colouring matter was cobalt; thus putting an end to many ingenious speculations that had been previously formed on the subject: some, I am afraid, without much reflection. The lapis lazuli theory, which has been embraced by Mr. Hendrie in his translation of Theophilus, and Mrs. Merrifield in her 'Ancient Practice of Painting,' is indeed opposed to the testimony of Dr. Merret in the seventeenth century, in a note by him on the Treatise of Neri, where he declares that he had ascertained by experiment the impossibility of colouring glass blue with lapis lazuli, about which there can be no doubt. Mr. Medlock intends, I know, to prosecute inquiries on the subject of blue glass, and to analyse various specimens from the twelfth to the sixteenth century, when we know that cobalt was employed, so as to form a series which, when connected with the analyses of Roman and Greek glass made by Sir Henry De la Beche and others, will form a most valuable chain in the history of the manufacture. It would therefore be unbecoming in me to anticipate Mr. Medlock's Memoir, by giving a more detailed statement of this analysis. I may, however, add, that the discovery of the true colouring matter was but one of the beneficial results of this analysis, for in working it out practically, in which due attention was paid to the ancient recipes, the ancient art of making white and coloured glass was in effect revived. I say revived, for between the glass that has been already made and the old, I can discover no perceptible difference, though I have tested it in every way that I can conceive short of actually having a window made of it. I had hoped that it would have been subjected to this test ere now; but it will at all events be very shortly submitted to it, and as the blue in question, and indeed the rest of the new glass already made, is destined for some windows in the round part of the Temple Church, in which my friend the Rev. J. L. Petit and myself are interested, I need not say that you will all have an opportunity of judging for yourselves, whether or not the experiment is successful. It is, of course, never wise to halloo till you are out of the wood; and had I foreseen the unavoidable delays that have retarded the manufacture, I should have declined addressing you at present. However, as my name was actually put down, I did not think it right to cause fresh arrangements to be made, more particularly as I have reasonable grounds for believing in the success of the experiment.

I have to appeal to you, the professors of the noblest of arts, in favour of this unhappy art of glass painting. I call it an art, because it is impossible to look at the glass at Chartres, Angers, or Brussels, without feeling that glass painting was once practised by artists. I will ask you by whom it is *now* practised in this country? for abroad it is still artistical,—and further, whose fault is it that it continues in such bad hands? It cannot be for lack of pecuniary encouragement, for I doubt not but that if all the money that has been expended on painted windows, within the last twenty years, were added together, it would equal, if not exceed, the sums paid to Raphael or Michael Angelo. The fault lies in those who have imbibed the exaggerated and rather sentimental estimate of the middle ages which is so fashionable, who persist in regarding those ages at a distance, which, softening down deformities, keeps mean and debasing objects out of sight, and leaves only the more noble and lofty ones conspicuous,—who suffer their feelings to be so captivated by the pleasing phantom of their imagination as to admit neither beauty nor propriety in anything that does not remind them of the middle ages; and therefore prefer copies of mediæval work to anything the art of the nineteenth century can invent. To such persons I have long ceased to address myself; it is no use arguing against a man's feelings, however conclusive may be the facts adduced. I therefore appeal to you, who possess collectively so great an influence in these matters, whether it is enough to have improved in the manufacture of coloured glass? And here I would especially address myself to the Greeks, with whom I am connected by all my early associations, by my Pagan education. Is there any reason why painted glass should be banished from buildings in the classical style? For Palladian churches you have the Cinque-cento style made to your hands—a style susceptible of high artistical development, and which neither in its treatment, nor in its ornaments, is more severe than the architecture of the building. I advert to this circumstance, because in a neighbouring church (St. James's, Piccadilly) mediæval influences have so far triumphed as to cause the introduction of painted glass more severe in style than the church itself—glass which I have often heard made the theme of extravagant admiration. And for churches in the Greek style, surely it would not be difficult to form an artistically flat style; I say flat, because a flat style may be made more severe than a rotund style could be in painted glass, using the powerful and beautiful colours whose resuscitation I have proclaimed, and resorting to the pure models of antiquity for the forms. The researches of Mr. Penrose and others have exploded the idea that weak colours only are appropriate for the decoration of Greek architecture; why not then use deep colours in the windows, and shame the mediævals into some sort of improvement, by associating beautiful colouring with exquisite drawing.

In the course of the discussion which followed the paper, Mr. Wyatt wished to know if subjecting the paintings of ancient windows to any alkaline wash had the effect of cleaning them without rendering the colours crude, by removing the softening down of tone which time had produced. Mr. Winston replied that he had washed a good number of pieces, and found that it had the effect of making the colours purer. Some of the glass to which he had applied the test was as clean as it was the day it was put up, and the only reason he could assign for it was that it contained a greater quantity of silex than usual, in proportion to the alkali, and was therefore not so easily attacked by the atmosphere. It was capable of being toned down; and then certainly some of the colour must be lost. The glass in King's College Chapel, Cambridge, was of the same date and as light as that used in the Cathedral at Brussels, and he had cleaned some of it and found the same result, that old glass cleaned had a better effect than uncleaned glass of the same date; but compared with modern glass, old glass, cleaned or uncleaned, will always be found superior in tone and effect.

ST. PAUL'S CATHEDRAL, AND ITS APPROPRIATE DECORATIONS.

By Francis Cranmer Penrose, Architect.

[*Paper read at the Royal Institute of British Architects.*]

St. Paul's Cathedral at present, and for the last twenty years or so, has suffered some depreciation; but it must always maintain its dignity as it deserves, and whatever styles or forms of architecture may be in vogue, I feel satisfied that it will maintain its magnificent supremacy above all the buildings of its own age, and I believe of any later one. There are many things in St. Paul's which we cannot altogether admire, and which deserve even blame; but taking it on the main idea, I think we must admit that there is no building to be compared with it, excepting the magnificent Vatican. It has, however, always retained many admirers; and here, at any rate, where we meet to give an impartial consideration to matters of art, it must always have them, even among those who study Gothic architecture chiefly. I feel certain there is not one here who denies the magnificence of St. Paul's. It may be the fashion of some, who do not take the trouble to investigate the whole subject, to turn away their eyes from its beauties; but all who do properly study architecture, must be satisfied of its magnificence. The pleasure given by the contemplation of such a building is the surest test of its great excellence; and there can be no doubt that the combination of such magnificent science, both theoretical and constructive, in its architect, and his very great love of the beautiful, and (considering the time) his great freedom from the errors which were then fashionable, are most remarkable; because, if we compare his vagaries with those of Borromini, who was almost his contemporary, we shall find that he is perfect purity itself. He was indeed most lovely in his life; during which, as in his death, he was scarcely divided from his building. He lived to the age of 91 years, for fifty of which he was the Surveyor-General, not being dismissed from that office till late in life, in the beginning of the reign of George I. About the year 1660, Wren seems to have bestowed very great attention on architecture. He built several buildings at Oxford and Cambridge, and appears, in fact, to have spent altogether upwards of sixty years in the practice of architecture, with such energy and activity as probably has never been paralleled. We should look with affection at the memorials that such a man has left; and what could be a more delightful object than to see completed, according to his ideas, the magnificent building which gives the greatest lustre to his name!

The exterior of St. Paul's is tolerably well completed. There are some points which Sir C. Wren intended, and it would be well if they had been completed; but it is not attention to the exterior that is so much wanted,—it is to the interior, which is in a lamentably deficient state, not only from the greater part of the decorations that were intended by him having been left undone, but because there has never been, since the building was concluded, a proper feeling of public spirit to maintain it in the state in which it should be kept. The Dean and Chapter have done a great deal; they have kept the building, in all essentials, in a sound and firm condition; the estates belonging to such a building are not large, indeed they are only sufficient just to keep the fabric in ordinary repair. That has been done, and the question now is one of decoration, which does not properly fall to them to manage, nor can they be expected to do so.

There has never, for the last 140 years, been so hopeful a time for bringing this subject forward as the present. The authorities, generally, of St. Paul's, have hitherto discouraged any attempt at moving in the matter; but now they are very desirous—most, if not all of them—that something should be done to put the building in a more satisfactory state as regards decoration: the Dean, especially, appears to have the well-being of the church more at heart than any of his predecessors since the time of Sancroft, who was Dean in Wren's time. The present Dean of St. Paul's has kindly encouraged this attempt to bring the present subject before your notice. The main object to consider is, what decorations are suitable to the building; and, in determining this, the views of Wren, so far as they are known, should be considered first, and should carry more weight than any others. I will therefore read several extracts which I have made from the 'Parentalia,' and I shall be obliged to appeal to your indulgence if they are longer than they should be in an original paper; but the 'Parentalia' is a work, composed mainly by Wren's son, from his own documents, and finally published by his grandson; and therefore, though it is written of Wren, it is almost always Wren's own words that are used. In page 262, Wren writes a letter from France, which shows how much he felt concerned in the interests of the arts and manufactures: "I shall bring you almost all France on paper, which I found by some or other ready designed to my hand, in which I have spent both labour and some money. Bernini's design of the Louvre I would have given my skin for, but the old reserved Italian gave me but a few minutes view; it was five little designs on paper, for which he hath received as many thousand pistoles; I had only time to copy it in my fancy and memory; I shall be able, by discourse, and a crayon, to give you a tolerable account of it. I have purchased a great deal of Taille-douce, that I might give our countrymen examples of ornaments and groteska, in which the Italians themselves confess the French to excel. I hope I shall give you a very good account of all the best artists of France; my business now is to pry into trades and arts. I put myself into all shapes to humour them; 'tis a comedy to me, and though sometimes expenceful, I am loth yet to leave it." This was in 1665, before the Great Fire of London. As soon as he returned, the subject of repairing Old St. Paul's, which had been long in an unsatisfactory state, was mooted. Inigo Jones had made some repairs to the building, which (excepting the portico) were not very good it seems, even so far as construction was concerned; and they had come to ruin in Wren's time—that is, in 1665.

Wren proposed, in his repairs to Old St. Paul's, to build a cupola round the old tower, using the latter for fixing the scaffolding, so that he might first finish his dome and then take away the tower. Then he says, with a good deal of knowledge of what people would like, and what would encourage them to proceed: "As the portico built by Inigo Jones, being an entire and excellent piece, gave great reputation to the work in the first repairs, and occasioned fair contributions, so to begin now with the *dome* may probably prove the best advice, being an absolute piece of itself, and what will most likely be finished in our time; will make by far the most splendid appearance; may be of present use for the auditory, will make up all the outward repairs perfect, and become an ornament to his Majesty's most excellent reign, to the Church of England, and to this great city, which it is a pity, in the opinion of our neighbours, should longer continue the most unadorned of her bigness in the world." With regard to his wishing so much for a dome, it is plain that he had that in his mind for a very long time. I have here two or three instances of the motives which seem to have led him to the dome of St. Paul's. *There* (referring to the ground plans) is, I suppose, the earliest example—Sienna Cathedral; and *that* is Ely, drawn to the same scale; *that* is Florence; and *there* is a model of the plan of St. Paul's. Of all these it would appear that Ely must have given him the most complete hints for the result which he arrived at in the present St. Paul's. The main feature at Ely is the extraordinary and happy arrangement of the vistas through the aisles, and through the great arches of the cupola, uninterruptedly. That he did not hint at in the model first proposed, but that is one of the great beauties of St. Paul's. Wren's uncle was Bishop of Ely, and it is very likely that Wren was called there very often, and picked up many hints from that cathedral. He seems to have thought that a cupola was a great feature in a Protestant church, and he always had in view the advantage of it to an auditory; and, unless I am mistaken, some attempt will be made to make his ideas useful in the present day.

After the fire, it became necessary to proceed to some real and thorough repair, if not re-edification of St. Paul's. The Dean and Chapter had endeavoured to patch up the old building, but had met with nothing but mishaps, and it was falling into a state of utter ruin. Wren had advised them from the beginning that it must be pulled down, but they thought they could avoid that alternative. At last, however, Dean Sancroft was desired to write to Wren, and invite him to help them in making a new design. He had offered to make a design just suitable for a temporary purpose; but the Dean very happily thought something more might be done, and, in fact, he helped Wren in every way to forward the complete work as it is. The Dean thus wrote to him: "I am therefore commanded to give you an invitation hither, in his Grace's (*i. e.*, of Canterbury) name, and the rest of the commissioners with all speed. The only part of your letter we demur to, is the method you propound of declaring first what money we would bestow, and then designing something just of that expense; for quite otherwise, the way their lordships resolve upon, is to frame a design handsome and noble, and suitable to all the ends of it, and to the reputation of the city and the nation, and to take it for granted that the money will be had to accomplish it."

A little further on in the 'Parentalia,' we find a kind of apology for the use of coupled columns. The magnificent effect of coupled columns in the Louvre, and their equally fine effect in the entrance to St. Paul's, render such an apology unnecessary; but Wren's words are always worth hearing: "As the ancients shifted the columns of the portico for the better approach to one door, so at St. Paul's for the same reason, where there are three doors (the two side doors for daily use, and the middle for solemnities) the columns are widened to make a more open and commodious access to each. Those who duly examine by measure the best remains of the Greek or Roman structures, whether temples, pillars, arches, or theatres, will soon discern that even among these there is no certain general agreement; for it is manifest the ancient architects took great liberties in their capitals and members of cornices to show their own inventions, even where the design did not oblige them; but where it did oblige them to a rational variation, still keeping a good symmetry, they are surely to be commended, and in like cases to be followed." He proceeded zealously to make the present structure as magnificent as the design permitted. And he makes the following observations upon it:—"The surveyor followed the Templum Pacis, as near as our measures would admit, having but three arcades in each of the bodies east and west, as there; but where there are no arcades, and next the dome, he has continued the whole entablature.

Again—"This temple, being an example of a three-aisled fabric, is certainly the best and most authentic pattern of a Cathedral Church, which must have three aisles, according to custom, and be vaulted: though it may not be always necessary to vault with diagonal cross-vaults, as the Templum Pacis, and halls of the Roman baths are. The Romans used hemispherical vaultings also in some places; the surveyor chose those as being demonstrably much lighter than the other [two-thirds]. So the vault of St. Paul's consists of twenty-four cupolas cut off semicircular with segments to join to the great arches one way, and which are cut cross the other way with elliptical cylinders to let in the upper lights of the nave. But in the aisles the lesser cupolas are both ways cut in semicircular sections, and altogether make a graceful geometrical form, distinguished by circular wreaths, which is the horizontal section of the cupola, for the hemisphere may be cut all manner of ways into circular sections; and the arches and wreaths being of stone carved, the spandrels between are of sound brick invested with stucco of cockle-shell lime, which becomes hard as Portland stone, and which, having large planes between the stone ribs, are capable of further ornaments of painting if required. Besides these twenty-four cupolas, there is a half-cupola at the east, and the great cupola of 112 feet diameter in the middle of the crossing of the great aisles. In this the surveyor has imitated the Pantheon, or Rotondo in Rome....... The Pantheon is no higher within than its diameter; St. Peter's is two diameters. This shows too high, the other too low. The surveyor at St. Paul's took a mean proportion [1·414 : 1], which shows its concave every way; and is very lightsome by the windows of the upper order, which strike down the light through the great colonnade which incircles the dome without, and serves for the butment of the dome, which is brick of two bricks thick, but as it rises every 5 feet high, has a course of excellent brick of 18 inches long, banding through the whole thickness. The concave was turned upon a centre, which was judged necessary to keep the work even and true, though a cupola might be built without a centre; but this is observable that the centre was laid without any standards from below to support it; and as it was both centering and scaffolding, it remained for the use of the painter. Every story of this scaffolding being circular, and the ends of all the ledgers meeting as so many rings, and truly wrought, it supported itself. This machine was an original of its kind, and will be a useful project for the like work hereafter.......It was necessary to give a greater height than the cupola would gracefully allow within, though it is considerably above the roof of the church; yet the old church having had before a very lofty spire of timber and lead, the world expected that the new work should not in this respect fall short of the old (though that was but a spit and this a mountain). He was therefore obliged to comply with the humour of the age, and to raise another structure over the first cupola, and this was a cone of brick, so built as to support a stone lantern of an elegant figure, and ending in ornaments of copper gilt: the cone being covered and hid out of sight with another cupola of oak timber and lead, and between this and the cone are easy stairs that ascend to the lantern."

"He took no care to make little luthern windows in the leaden cupola, as are done out of St. Peter's, because he had otherwise provided for light enough to the stairs from the lantern above, and around the pedestal of the same, which are not seen below. So he only ribbed the outward cupola, which he thought less Gothic than to stick it full of such little lights in three stories one above the other (as is executed in the cupola of St. Peter's at Rome), which could not without difficulty be mended, and if neglected would soon damage the timbers. The inside of the whole cupola is painted and richly decorated by an eminent English artist, Sir James Thornhill, containining in eight compartments, the Histories of St. Paul. In the crown of the vault, as in the Pantheon, is a circular opening, by which not only the lantern transmits light, but the inside ornaments of the painted and gilded cone display a new and agreeable scene."*

The first stone was laid in the year 1675. The walls of the choir and side aisles were finished, 1685. The highest stone on the top of the lantern was laid in 1710, by the hands of Christopher Wren, the son of the surveyor, by him deputed to it; Sir Christopher being in his 78th year.—So much for the extracts from the 'Parentalia.'

It is well known that Wren was averse to a balustrade above the main cornice; and in Elmes's 'Life of Wren,' there is an amusing letter from him, deprecating its introduction, dated October 1717, just before his dismissal, which occurred in 1718. In certain points of view, as from some of the narrow streets adjoining, the pierced work of the balustrade was a happy effect; but Wren always looked at St. Paul's as a work that might be seen from suitable points of view, and the cornice, with the magnificent line of trusses which he provided for its support, required no balustrade. Another point shown by these designs is, that two statues were to have been placed at *this* point [exterior, west front], and no doubt they were required and intended; they are shown in all the old engravings, and would be of great advantage. Of course, we should not think of now putting statues on the outside, because they could not be made to conform in appearance with the rest of the exterior. Interior decoration is a different matter, because the whole may have an uniform tone given to it if required.

The church was carried on with every attempt to make it as rich and perfect as the funds would possibly allow, in the time of the Stuarts. At the accession of William III., both he and queen Mary were well disposed to carry on the building; but they seemed to wish to get over it quickly; they did not, like the Stuarts, treat it as a work of love, but as a piece of business. Still they were great friends to Wren; and the queen, herself a Stuart, was his great patron after the deposition of James II. After her death, in 1695, his enemies began to get the better of him; and in 1696, in an act of the 9th William III., "for completing and adorning the Cathedral Church of St. Paul, London," a clause was inserted to suspend a moiety of the surveyor's salary till the church should be finished, "thereby the better to encourage him to finish it." When we consider that his salary was only 200*l.* a-year, and that he received no other advantage besides that, we see that he was rather in bad case towards the end of William's reign. The king was not inimical to Wren, and seems to have been pleased with what he did at Hampton Court; but he was immersed in politics to an extent beyond that which other kings have been before or since. In queen Anne's reign the church was still carried on, but more or less with the same wish to get it over, and to that fact we may ascribe what is said in the 'Parentalia' as to the mosaics. These Wren certainly intended, and they were no doubt prac-

* "The judgment of the surveyor was originally, instead of painting in the manner it is now performed, to have beautified the inside of the cupola with the more durable ornament of mosaic-work, as is nobly executed in the cupola of St. Peter's at Rome. For this purpose he had projected to have procured from Italy four of the most eminent artists in that profession; but as this art was a great novelty in England and not generally apprehended, it did not receive the encouragement it deserved, it was imagined, also, the expense would prove too great and the time very long in the execution; but though these and all objections were fully answered, yet this excellent design was no further pursued. The painting and gilding of the architecture of the east end of the church over the Communion Table, was intended only to serve the present occasion, till such time as materials could have been procured for a magnificent design of an Altar, consisting of four pillars wreathed of the richest Greek marbles supporting a canopy, hemispherical, with proper decorations of architecture and sculpture, for which the respective drawings and a model were prepared."

ticable. In this reign, however, Sir James Thornhill obtained the commission to decorate the church, and there can be little doubt, from *these* prints (and from the model), that Wren intended a coffered ceiling, and, generally, a thoroughly architectural design. There is still a good deal of architectural device in the present cupola, and we cannot much blame that. So that, for the first years of Sir James Thornhill's commission (till about the year 1712), they must have worked pretty well together; but afterwards—if any faith be placed in *this* print by Wale and Gwyn—the paintings were to be sprawled about over the architecture, much as they are in the late Borrominesque churches. Therefore, it must be supposed that as Wren's hold relaxed, Thornhill's became firmer, and the painter got the start of the architect; so that it is in some degree fortunate that these lower parts of Thornhill's design were not executed. They would have interfered with the architectural character of the building; but if we can eliminate from them the ideas of Wren, we may do much to form a consistent scheme of decoration. In a print engraved by Wren's permission and authority, figures are shown in the spandrels of the dome, somewhat as in the pendentives of St. Peter's, but much smaller; in the small cupolas of the nave there are coffers, with figures in the spandrels, in due subordination to the architecture. Here is a passage in which Wren complains of the painting being taken out of his hands. He had applied for the moiety of his salary, but was told the building was not done. He replies:—"Nothing can be said to be unperfected but the iron fence round the church, and painting the cupola, the directing of which has been taken out of my hands; and therefore I hope I am neither answerable for them, nor that the said suspending clause can, or ought to, affect me any further on that account." This was undoubtedly very different treatment from that which such a man deserved. Moreover, we have seen that the surveyor's salary was only 200*l*. per annum.

By the accession of George I., all the old intention of carrying on the building as it should be was lost sight of. The puritanic zeal of the time seems to have entirely put a stop to the decoration of the church; and the same feeling was strongly developed in the case of the window of St. Margaret's Church, which was objected to as superstitious, although it is simply a very beautiful picture of the Crucifixion. That discussion led to the production of an exceedingly valuable publication, by Dr. Wilson, which was published in 1761. I will read a few extracts from that work, which I think furnish an excellent apology for the introduction of historical figures into St. Paul's, or any other church; of course, always observing that nothing should be introduced which could in any way offend persons who might conscientiously take offence. Dr. Wilson says:—

"It is impossible for any one who has made the least observation on mankind not to have discovered the vast influence which grandeur and magnificence have on our minds. The splendour of the palace begets the most respectful ideas of the prince who inhabits it; and the courts of justice would lose a great share of their dignity were the judges divested of their robes.

"It may, perhaps, be said that objects of this nature affect only the vulgar, whilst men of sense look farther, and bestow their reverence on those real and internal qualities which alone deserve it. If this be true, it is, I believe, certain that all mankind are the vulgar in this respect, since there does not, probably, a human creature exist who is not in some degree influenced by appearances.... and contempt is the concomitant of meanness—and reverence of splendour.

"I have sometimes thought that men may have considered this as a kind of mechanical method of exciting devotion, and have, perhaps, objected to it as if it derogated from the dignity of true religion. It would, in my opinion, be equally reasonable to object to the use of a lever, because the application of it was a reproach to our natural strength.

"It was undoubtedly with the religious hope of doing something acceptable to God, that men were led to adorn his temples, and not from any reflections, *a priori*, that ornaments were capable of raising devotion. But since experience convinces us that this is true, we have now an additional motive for embellishing the structure in which we pay our adoration to the God of all."

With regard to the subjects that may be proposed for decorations of churches, he cites the following highly important passage from Archbishop Wake (then reputed of the Low Church party), in his 'Exposition of the Doctrine of the Church of England:'—

"When the pictures of God the Father and of the Holy Ghost—so directly contrary to the Second Commandment, and to St. Paul's doctrine—shall be taken away, and those of our Saviour and the blessed saints be by all necessary cautions rendered truly the books not snares of the ignorant, then will we respect the images of our Saviour and of the blessed Virgin. And as some of us now bow down towards the altar, and all of us are enjoined to do so at the name of the Lord Jesus, so will we not fail to testify all due respect to his representation."

"As ornament and instruction are all we contend for, I should prefer large historical paintings to single figures; and this the more readily, because adoration has at no time nor in any place been paid to them. Indeed, it is scarcely possible to conceive, when a number of objects are placed before the eye in one picture, that a particular one can be selected for this purpose; and yet it must be done, unless we can suppose men ridiculous enough to adore the thieves that were crucified with our Saviour and the guards who attended."

Now, we find in St. Paul's some magnificent spaces adapted for paintings. The various cupolas of the nave and aisles, the spandrels of the roof, and part of the drum of the dome, are all open to the painter; and if so decorated, of course under due restrictions, and in accordance with the Protestant authorities of those times, I think St. Paul's Cathedral might be made worthy of its position, as the head church of this country. But before that is done there is one very important consideration. The paintings by Thornhill in the cupola are in a very deplorable state. They are painted in oil, and are now about 130 or 140 years old; and, owing in all probability to the settlement of damp in the church, a great part of them has perished. Means have been taken which will render the settlement of damp less likely in future, so that if there were any chance of restoring those paintings, they would be more permanent than they have been. Such opportunities and chances have been brought before us. *Here* we have a model of the cupola of St. Paul's prepared by Mr. Parris, whose most able and courageous plan for restoring these works has before been mentioned; at any rate, his proposition should be mentioned now, as one of the noblest offers that have ever been made, more especially as I believe I am justified in announcing that Mr. Parris is now as willing as he was thirty years ago to undertake the restoration of the cupola. [Mr. Penrose described the action of Mr. Parris's scaffold in the model, and observed that if the work were now to be undertaken, some improvement upon it would probably be introduced.]

Mr. Penrose then read the following extracts from Mr. Cockerell's address, in 1849, to the Archbishop of Canterbury, the Bishop of London, and the Lord Mayor, and said that they would fitly follow up the views of Sir Christopher Wren, as no one could have so thoroughly embued himself with the spirit of St. Paul's as one who himself fully competent to lead, had yet for thirty years so modestly followed the footsteps of that great architect:—

"I beg permission, as an old and attached servant to this glorious fabric, to address your lordships upon the propriety of considering such means as may possibly be devised of carrying out those adornments of the interior which were originally designed by the Rev. and Hon^ble^ the Commissioners of the Fabric; and which are so important to the dignity of public worship, and to the character of the Metropolitan Cathedral Church of the wealthiest and most powerful city of the world.

"In the fabric of St. Paul's Cathedral, ranking third amongst the European Christian Temples, as respects magnitude and architectural magnificence, it was clearly intended, but for the political troubles of the time, that 'beauty as well as strength should be found in the sanctuary of the Lord.' The shortcomings in this respect, arising from political and other causes, have ever been with foreigners, as well as our own people, a subject of national reproach and estrangement, as unworthy of a religious and wealthy people, and of an endowed clergy; and have been the fertile occasion of those almost daily attacks, and scandal issued by the press, against the administration of the Cathedral Church and its pious ministers. Meanwhile, the Very Rev. the Dean and Chapter have annually expended money in adornments to the extent of their means; especially in 1821, when a very large sum was defrayed by them in the choir and communion end, as well as other parts of the church, under my superintendence; and I think it would not be difficult to show that more has been done in these respects within the last thirty years, by that venerable body, than had been previously accomplished since the completion of the fabric.

"The intentions of the Right Rev. and Hon^ble^ the Commissioners of the Fabric, and of their architect, Sir C. Wren, respecting the decorations of this noble pile, are recorded,* and portions, as of the communion end and the ornaments of the dome, are still before us; the latter, at present and for some years past, has been in a ruinous and discreditable state. It is also plain, from the very mean quality of the glazings, that it was the intention subsequently to have used painted or other

* *Parentalia, page* 291.—"The twenty-four cupolas of St. Paul's are formed of brick with stone wreaths, the brick invested *with cockle-shell lime*, which becomes as hard as Portland stone, and which, having large planes between the stone ribs, are capable of further ornaments of painting if required." *Parentalia, page* 292.—"The judgment of the surveyor was originally, instead of painting in the manner it is now performed, to have beautified the inside of the cupola with the more durable ornament *of mosaic work*, as is nobly executed in St. Peter's at Rome, which strikes the eye of the beholder with the most magnificent and splendid appearance, and which, without the least decay of colours, is as lasting as marble, or the building itself," &c. *Parentalia, page* 292.—"The painting and gilding of the architecture of the east end of the church over the communion table was intended only to serve the present occasion, till such time as materials could have been procured for a magnificent altar-piece, consisting of four pillars, wreathed of the richest Greek marbles, &c., for which the respective drawings and a model were prepared. Information and particular descriptions of certain blocks of marble were once sent to the Right Rev. Dr. Compton, Bishop of London, from a Levantine merchant in Holland, and communicated to the surveyor, but unluckily the colours and scantlings did not answer his purpose. So it rested in expectance of a fitter opportunity, else probably this curious and stately design had been finished at the same time with the main fabric."

glazings, suited to the dignity and style of the more substantial decorations of the building.

"The accomplishment of these becoming objects may not be wholly within the power of the present age, but the subject should not be lost sight of, and I humbly presume that the extensive influence of your lordships, seconded by the spirit of the actual times, would effect a commencement of this good work, which would silence complaint, and tend manifestly to the glory of our worship, and promote no less the growing attachment to our church.

"It is very remarkable that recently, while the clergy of this country, by its pious efforts, has found the means of erecting and endowing the unprecedented numer of 1400 new churches within the last thirty years —viz., up to A.D. 1849, and while the public has responded with promptness and liberality to extraordinary demands for the supply of the spiritual necessities of the people, that demands for the restoration of the old Cathedral and other churches have been no less liberally met by the public, the Diocesans, and the Dean and Chapters, under circumstances of diminished revenues from the Church, not only have those substantial repairs and completions (which will secure their endurance to future centuries) been effected during these thirty years, but also very extensive decorations in the style and spirit of the original design. Witness Canterbury, York, Westminster Abbey, Ely, Winchester, Wells, Temple Church (in which seven churches not less than 175,000*l.* must have been expended) and many others—to which almost alone the Metropolitan Cathedral Church of St. Paul, situate in the greatest capital of the Christian world, and singularly blessed by Almighty God during a long series of years, with prosperity, commerce, power, wealth, and dominion, beyond any nation of the earth, forms a rare exception.

"It is remarkable that elsewhere the spirit of zeal and devotion on this subject has grown with its exercise, and that a better understanding of religious duty in similar good works has happily been established of late, in this as well as other countries. The literary taste, and archæological tendencies of the day, display abundantly the reflection of these better sentiments, which both wisdom and duty enjoin, by every means in our power; and it is certain that propositions such as I now presume to submit to the notice of your lordships, formerly treated, to say the least, with neglect, are now met with respect, and often with ready zeal, especially when recommended on high authority.

"In all parts of the continent great efforts have been made in this direction; in Paris alone, within the last thirty years, there cannot have been less than 100,000*l.* expended in the restoration of decoration of the ancient churches alone, with solidity, and with unexampled splendour; and though the number of their new churches bears no comparison with our own, the style and dignity of those which have been raised by the piety of the monarchs of France during this period, very far exceed anything attempted in England. In Germany the same spirit prevails, and not less than 70,000*l.* have been expended, it is said, alone in the Cathedral Church of Cologne, the windows of which, presented by the king of Bavaria, cost about 1300*l.* each.

"On these grounds—namely, the universality of public opinion in favour of these laudable undertakings, and in the midst of those strenuous exertions so well known to employ the zeal and means of your lordships, the clergy generally, and the public, to supply the spiritual necessities of our capital, it is presumed that a well-devised scheme for the proper and becoming decoration of the Cathedral Church of St. Paul would not only be respected, but hailed by the good wishes and subscriptions of a large portion of a public, so manifestly favoured by Providence during a long course of years.

"The actual state of the Fine Arts is no less propitious to the undertaking, the extraordinary sumptuousness of the Houses of Parliament and of our royal and other palaces, and the liberal views and encouragement of government as regards the higher walks of historical and monumental painting and decoration, have already disciplined a school abounding in talent and capacity for such operations. The professors of Fine Art have never been backward in zeal towards such noble objects, and in the proffer of their services to carry out the well known scheme of Sir C. Wren and the Commissioners of the Fabric.

"Sir J. Thornhill painted the dome, now so decayed by time, for 2*l.* per square yard (about the year 1720), a price scarcely defraying his disbursements; Sir J. Reynolds and the Academicians, in 1773, made a gratuitous offer of their services for the decoration of the interior; and very recently the eminent painter, Mr. Parris, proposed to restore the paintings of the dome by a very bold and economical process. Nor are our actual professors less animated now than formerly with the ability, zeal, and piety, necessary to such enterprises.

"The practical mode in which, as your surveyor, I should venture to recommend the application of such funds as could be raised, would be:—*First.* To restore the painting and gilding of the dome, and parts adjacent thereto, as part and parcel of that magnificence, designed and directed by Sir C. Wren himself; as, however different in style from that at present approved, it is highly decorative and appropriate to the architecture, and is too far removed from the eye to challenge minute criticism. *Secondly.* To carry out the gilding and painting of the symbols and ornaments of the choir, as already commenced at the communion end, together with all the becoming ornaments to the gates, the pulpit, the stalls, the organ, the communion rail and table, &c. *Thirdly.* To reglaze the whole of the twenty-three lower windows on the floor of the Cathedral with Scripture subjects in coloured glass,—offering, as this occasion would, the first grand opportunity, since the Reformation, of illustrating the unadulterated word of God in spirit and in truth, and uncontaminated by the apocryphal and superstitious representations which occupied this noble art under the Papistic doctrines and direction.

"Such a mode of decoration is at once the most conformable to Christian and ancient associations, and the most economical that could be devised, at the same time that it is the most splendid; since, as the vehicle of light, it transmits all that effect and lustre to the interior which mural decoration fails to effect in the same degree, and which in fact it supersedes."

After reading this report, Mr. Penrose said there was one circumstance which required to be dwelt on particularly, and in which he was sure they would all agree, that it was of the very greatest importance to the subject under contemplation that it should have the active concurrence of Mr. Cockerell. For not only had he (Mr. C.) most judiciously condusted the repairs of the fabric for about thirty years, during which the hand of decay had been arrested, and even turned backwards, so that the building is now in a far more satisfactory state than it was at the beginning of the century; but he had been, at the same time, so scrupulously observant of the intentions of Sir Christopher Wren, that everything in the slightest degree out of harmony with the general plan had always met with his decided opposition. We might then feel great courage in proceeding under such a leader. It was very little that he had to advance on the subject—for he came there rather to solicit the views of the gentlemen he saw around him than to state his own, which he was free to confess were not yet formed into the detailed state, for which much time and consideration would be necessary; but if we could interest many in the pursuit of this important question, we should have all the better chance of falling on the right scent. But the first thing which he had to inform them was, that the restoration of Sir James Thornhill's cupola had taken a very definite shape. He was authorised to state that it was become a practical question with the Dean and Chapter, and no pains would be spared on their part to get the whole of the cupola and the drum effectually restored. Mr. Penrose stated, in continuation, that the restoration of the cupola in chiaro-scuro, with a very large amount of gilding, must be taken as the starting point for other decorations of the cathedral. He thought, therefore, that surface painting in colours would be out of place, with the exception of the windows, which should be of stained glass. Where the walls of a building and the windows were alike highly coloured, there was a want of harmony. In the most highly coloured Italian buildings not much light was admitted, and that almost always through comparatively pure glass. Where coloured glass was employed, natural colours, or natural materials were used on the walls, so that they never had the glaring or prominent effect of surface colouring. Mr. Penrose referred to a rough sketch of the choir of St. Paul's, in illustration of his views of the mode of decorating it. The apse was already ornamented with a sufficient or satisfactory amount of gilding; but a certain amount of chiaro-scuro decoration was wanted (as in the cupola) to bear out that gilding. He pointed out the architectural features of the vaulting, consisting of three small cupolas with their spandrels, separated by a magnificent guilloche. If the depths of the latter were increased by a little chiaro-scuro, and a great deal of gilding, that, he thought, would be sufficient for it. The spandrels were evidently intended by Wren for some coloured decorations, and they furnished admirable situations for the introduction of single figures or small groups. In the small cupolas, however, figures would be objectionable, and therefore those surfaces would be better ornamented architecturally with painted coffers, slightly differing in shape from the actual coffers to the eastward, but brought into harmony with them. The spandrels of the main arches of the choir were admirably adapted for painting in monochrome. It might be fitting to insert coloured porphyries or marbles into the panels beneath the windows, or even to paint them, as the pilasters in the apse were already most effectively painted in imitation of lapis lazuli. He had not yet considered the decoration of the aisles, his object being merely, by these observations, to elicit the opinions of members.

Discussion.—Mr. Cockerell said it had been his own peculiar happiness to have the care of St. Paul's Cathedral for very many years, and the contemplation of that building had been a constant source of delight and reflection to him. The whole scheme of the work—the structure, the beauty of proportion, and the admirable contrivance of every part—were perfect. It was like a work of nature,—every exigency of the building, and everything belonging to climate and circumstances had been so carefully and skilfully considered, that it was the very exemplar of all that Vitruvius had said of the great elements of architecture—economy, structure, proportion, and beauty of detail. He dissented from one expression employed by Mr. Penrose—namely, that some parts of St. Paul's were even blameable. He would challenge any gentleman present to point out anything that could be truly called blameable in that building; and he would challenge a comparison of St. Paul's with any other building in Europe, of any age, in respect to all the essential qualities of architecture. It was remarkable that the plan of St. Paul's would be found to agree with the three masonic rules, with respect to its length, width, and columnar distribution; and also in the section, which was formed upon the lines of an equilateral triangle. For a long time he had been at a loss to conceive what principle had determined the height of the nave of St. Paul's; but at length he discovered that it had been determined by the masonic rule. This was the more interesting as Wren was the Grand Master of the Antique Masonic Lodge, which was not dissolved till 1717, since which time freemasonry had been only a mask for political societies. Wren, in fact, lectured to the masons, and it was to be deplored that so great a philosopher had left so few of his writings to posterity; he would have revealed many things that could now only be gathered incidentally from his works. In his two or three admirable papers in the 'Parentalia,' Wren spoke like a great master, and those papers could not be too attentively studied. With regard to St. Paul's, they must all admire that "irritable genius" which seized, as he had done, the beauties of Sienna, and after of Ely, with its wonderful octagonal lantern; and the skill with which he had avoided that constant intersection of nave and transept which limited the perspective in so painful a manner, but which had been so eternally adopted, even from the Roman times. After seeing a great number of cathedrals, that monotony of plan became really shocking, and led to the idea that men were merely imitative animals. The quickness and capacity which led Wren to seize and introduce in St. Paul's the beautiful contrivance of Adam Walsingham at Ely deserved the highest admiration. The plan of St. Paul's was unfortunately influenced by James II., who desired to restore the Roman Catholic worship; and above all things, to retain the old cathedral fashion, and to preserve the aisles as well as the nave, to the injury of the novelty and beautiful of the original, or "coloss" plan of Sir C. Wren, which could never be sufficiently commended. That plan, as the model of it showed, was adapted to the Anglican form of worship, and for a large congregation. Its beautiful perspectives had been well described by Mr. Penrose, and he could not but consider it as the earliest and the most truly Protestant cathedral church that had ever been designed. He hoped the day would come when Wren, and the style he adopted, would be duly estimated. As architects, they were all more or less the victims of fashion, ephemeral education, and early prejudices — their notions were cramped before they knew how to think or originate. At one time they were told that Greek was the only architecture to be practised; at another time Italian or Palladian; and at another time Gothic. It was deplorable that they should imbibe prejudices of this kind for particular styles; but it appeared to be a necessity of their birth, education, and position. Great things might be accomplished if they could lift themselves above such prejudices; and he looked to an institution like this for such fruits; and they could not be more effectually produced than by discussing, in connection with a subject like the present, the great principles of the art. The principle of economy was most admirably displayed in St. Paul's. Mighty as it is, it was executed in thirty years, and at a cost of only 750,000*l.* (A.D. 1710), whereas Waterloo Bridge cost 1,100,000*l.* (A.D. 1816). It was raised by a very small tax upon coals, which caused no inconvenience to the public; and he was quite sure a competent jury of Europe would pronounce it to be the most perfect of all the family of domes; and in its general design, and all its parts, the most admirable building in Europe. Wren, like every one else who followed his time, adapted the Gothic as the principle of his structure. St. Paul's was Gothic in plan, in section, and in construction; but he clothed the skeleton with a coat of the style which was most admired in his day. Bernini was then triumphant, and gave the fashion to Europe. Wren visited him at Paris, but his own works were much less exaggerated; he was, in fact, Bernini, purified in the fire of reason and logical judgment. The western towers of St. Paul's were copies on a smaller scale of those designed by Bernini for St. Peter's at Rome; but the latter (inasmuch as the Italian architects were rather painters and sculptors) soon began to fail, and were taken down, and no attempt was made to rebuild them. Although, as stated in his Report, 1400—(now 1500)—churches had been erected in England since the year 1818, the restoration of St. Paul's Cathedral had been neglected; and whilst the most lavish expenditure was bestowed on Houses of Parliament, Museums, and upon all temporal objects, he regretted to say that what had been done to the honour of God had been niggardly and paltry beyond measure. This was derogatory to the honour of the country, and contrasted most unfavourably with the liberality displayed on such objects in France. At Westminster Abbey a great deal had been done, with the very best effect, in restoring and improving the fabric, and chiefly through the zeal and taste of the Rev. Mr. Milman, now Dean of St. Paul's, from whom similar results might be expected for the metropolitan cathedral. The Venerable Archdeacon Hale, who was present, had displayed the greatest interest in the subject under discussion, and with the aid and influence of the Institute, he had no doubt the object might be accomplished. He knew many individuals who were willing to subscribe, as soon as operations were commenced. He had, in his enthusiastic admiration of St. Paul's, thrown out a challenge to maintain its beauties against all questions or objections; but the subject was so extensive that he should desire further time for the purpose; and on a future occasion he should hope to have the honour of offering some remarks on the wisdom, the beauty, the delicacy, and the sentiment of the design and execution of the masterpiece of that great architect—Sir C. Wren.

Mr. Billings could not acquiesce in all that had fallen from Mr. Cockerell. What was useless, could not be very good. Sir C. Wren might have shown greater talent if he had made a feature of his flying buttresses. As a matter of construction, the upper order of St. Paul's, on the exterior, though magnificent in its effect, was altogether useless internally. Again, though not a fault of form or of design, but a fault of fact, the outer dome was a perishable one, which it should not be in such a building. For the funds for restoring the Cathedral they need not look again to a tax on *coals*, but rather to a circumstance which must eventually happen. The future revenues of the bishopric, which had increased, and were still enormously increasing, had been so apportioned that, on the next election to the see, there would be from 40,000*l.* to 50,000*l.* a-year applicable to some purpose; and it would therefore be as well to petition the Ecclesiastical Commissioners to apply that sum to putting St. Paul's in order. As to Mr. Parris's ingenious scaffolding, a much more simple contrivance might be seen in daily use in Durham Cathedral, which he believed had been employed ever since the cathedral had been built. He should much like to see St. Paul's *decorated*, but not *painted;* for he regarded it more as a building of form than of colour. Sculpture, of course, would be admissible, but not painting; for it was clear that Wren was opposed to the painting adopted by Sir James Thornhill.

Mr. Parris said that his proposal for renovating the dome of St. Paul's had been occasioned by a statement that the paintings could not be restored on account of the expense of raising a scaffolding from the floor of the Cathedral. He accordingly, in the year 1822, contrived the scaffolding or apparatus which had been referred to, and made a model, which had received the approbation of Professor Cockerell, Mr. Brunel, Mr. Clarke, and others. From want of funds, however, the matter dropped. Without going further into details, he might state that in 1825, he had used his contrivance in painting the interior of the dome of the Colosseum in the Regent's-park, where most convincing proofs had been given of the safety attending the use of it.

Mr. Jennings called attention to the position of the organ screen of St. Paul's, as diminishing the importance of the choir; he would be glad to know if Wren had not intended it to be placed further westward.

Mr. Penrose said that, with reference to the position of the organ screen, the economy and arrangement of the ritual required a direct passage across the choir, west of the organ screen; and a much greater distance must be traversed from aisle to aisle, if the screen were removed further westward.

Mr. D. Mocatta, suggested that the discussion should be confined to the interior decoration of the cathedral; and it struck him, as a guiding point in that discussion, that it was most important to remember that the decoration of the dome was now for the first time stated to be a positively settled point; and, as artists, they were bound to bear that in mind, in considering the other directions, so as to bring them into harmony with it. No doubt many of the gentlemen present had considered the subject, and formed different views as to the decoration of the cathedral by sculpture, by polychromy, or in other ways; but he felt bound to direct their attention to the settled point which he had mentioned, as being of the greatest importance.

Mr. Jennings was disposed to object to the use of stained glass at all in St. Paul's Cathedral. As a general principle, colour had a tendency to decrease the effect of size in a building. Possibly, however, by the introduction of paintings in the panels, which, by the distance at which they were seen, would give an apparent increase of size, the decreased effect of size necessarily caused by the use of colour might be remedied. If colour were at all introduced, stained glass could not be effectively employed. As he had before observed, he thought the removal of the organ and organ screen further westward was essential. He objected to the dark colour of the pilasters at the east end of the choir. Perhaps the effect of size would be greater if all the pilasters throughout were to be of white or veined marble.

Archdeacon Hale said his own connection with St. Paul's Cathedral had existed nearly as long as that of Professor Cockerell, and they had each in that period risen in their respective professions. In no respect however had their course of life been more parallel than in the continual affection they had both shown towards the cathedral church of the metropolis. Confining himself to the internal decoration of the church, he would commence with the dome, the restoration of which there was now every prospect of being accomplished. He believed, until that should be done, no person would be thoroughly able to judge what ought to be done to the rest of the building. Many years ago Mr. Cockerell had lent him an old book, in which that dome, now so dirty and dingy, was described as so splendid in appearance, from the quantity of gold that shone upon its walls, that it was compared with the aurora borealis in splendour and brilliancy. When, therefore, the restoration of the dome had taken place, those who undertook the remainder of the edifice, instead of having to contend with a dark and gloomy recess, would find that part of the building come forward with the greatest brilliancy, and it would be necessary to decorate the rest of the edifice very highly to accord with it. He was sorry to say he differed, *toto cœlo*, from Mr. Cockerell and Mr. Penrose on the question of painted glass. On that subject he had had some experience, having worked with Mr. Winston, and devoted much consideration to the effects produced by that branch of art, and to its present condition. One of his objections to that mode of decoration was, that he believed we had yet to see the art of staining glass fall into hands much higher in the scale of art than any that had yet exercised it. When the pigment which the ancients possessed should be discovered, and when the artist could work his colours on glass with the same facility as oil and water colours now flowed from his pencil, so that the highest artists would not consider it beneath them to practice it,—then, and not till then, would be the time to introduce stained glass in the windows of such a cathedral as St. Paul's. Moreover, he was of opinion that when stained glass was employed, it became the whole and absorbing point, and attracted people from picture to picture in the windows, to the disregard of the architectural beauties and the form and majesty of the building. From a set of four designs by Sir James Thornhill, preserved in the Cathedral (representing the four Evangelists), it was evident that he had intended the building to be adorned with figures. The whole of the church was panelled, and apparently expressly for paintings. He had no doubt it was Wren's intention that every part of the church should be painted; some parts, at a distance, with pictures which might exercise the skill of a subordinate class of artists, and others, close to the eye, with beautiful cabinet pictures, the minute beauty and perfection of which might be contemplated at leisure. He had long desired, and expressed a desire to have that design carried out; and he had been laughed at for the notion. To the late Bishop of Llandaff and the Rev. Canon Tyler he had expressed the conviction that he should live to see St. Paul's painted from one end to the other; but they had laughed him to scorn. He had even sketched the general design of such an undertaking. He was thankful that the project of Sir Joshua Reynolds and his friends had not been accepted, for he believed it contemplated a series of paintings of more incidents in the life of St. Paul; and, much as he venerated that apostle, he did not desire to see more representations of his acts and labours than there were already on the inside and outside of the cathedral. He had even gone so far as to define the principle on which the paintings he contemplated should be introduced. He would have in every panel a picture of the highest class of art which could be produced, and so treated as to give no offence to the feelings of those who feared lest superstition should creep into the church by the mere use of pictures. He had thought that the Cathedral might, in fact, be made a great pictorial bible. Near the entrance should be delineated the early parts of Scripture history; at the transepts the middle portion; and in the choir and aisles subjects from the New Testament. Before the admission fee had been got rid of he had said, "Paint the Cathedral so, and Joseph Hume shall have his way, and people shall come in from morning till night, to read and study these beautiful pictures." He would fill the church with pure historical Scripture subjects, with the texts they illustrated in letters of gold beneath them. The beautiful cupola at the west end of the nave was admirably adapted for a painting of the Deluge; typifying the church itself as the ark in which God inclosed his flock, and the prophetic types of the events shown in pictures in the choir might be represented in corresponding pictures from the Old Testament in the nave. With the effect of the Cathedral painted in this way, he thought the light transmitted through painted glass would seriously interfere. The decoration of the architectural members and details of the building he must leave to the artist. Descending to the floor, he expressed what might be thought a heterodox opinion—namely, that the floor could never be rightly decorated till the monuments of sculpture now placed in the Cathedral were removed. He admired them as works of art, but heroes and heathen subjects (with thanks to man for conquest, without in one instance any acknowledgment to God for victory) were unsuited to a Christian temple. They well suited the taste of the last century, but he hoped the day would come when they might be removed to a Walhalla, where the country might more appropriately do honour to its heroes. He was not very fond of the Rev. the Cardinal Wiseman; but there was one part of the writings of that individual—his criticism on the heathenism of the statues in St. Paul's—which ought to be written in letters of gold, as a lesson to us in the decoration of our Cathedral. In the boldness of his views on this subject, he (Archdeacon Hale) had asserted that for 20,000*l.* *down*, the whole decoration of St. Paul's, in the manner he had proposed, might be accomplished. It would be remembered that there were eighteen compartments to decorate, which, to be done with due care and consideration, so as not to involve subsequent regret, would occupy something more than eighteen years. At the time he made that assertion, 20,000*l.* consols would have produced 600*l.* a-year. For 600*l.* the scaffolding to enable an artist to paint one compartment could be made. Artists should be solicited to submit cartoons and suggestions for the decorations of the parts, and if 600*l.* were given to them in prizes, that 600*l.* might be received again, and remain in hand, from the exhibition of those cartoons. Having that 600*l.*, he conceived there were many artists who would be willing to draw lots for the commission to paint the first compartment for that sum. The first successful effort would excite the public zeal; subscriptions would flow in; a duke, or a distinguished lady, or the Dean and Chapter would defray the cost of other compartments, and they would soon be so much pressed with the means of carrying out the work, that the only care requisite would be not to go on with it too rapidly or carelessly.

Mr. G. Foggo rejoiced to hear the great difficulty overcome of illustrating our great Protestant Cathedral by pictorial representations. The plan suggested by Archdeacon Hale was both rational, religious, and practical. He (Mr. Foggo) was glad that Mr. Parris had been consulted, and was likely to be considered in this great work, for which his profound knowledge of perspective especially fitted him. If the magnificent idea of Archdeacon Hale were carried out, it would be essential that the monuments in the Cathedral should be removed; but he feared it might take some time to reconcile the public mind to such a measure. Mr. Foggo concluded by some remarks intended to correct an error in the statement that Wren had derived his architectural knowledge, in some degree, from the ancient Freemasons, and that that body continued in existence in his time. He stated that, even so early as the reign of Henry VI., an ineffectual effort had been made by that monarch to trace the origin and history of the craft, which, of course, must have been still more obscure in the days of Wren.

Mr. Garling, jun., thought the curved surface of the dome was not well adapted for historical paintings, especially at such a distance from the eye, where the figures must be of such a size (if they were to be visible at all) as very much to reduce the apparent size of the building. The human figure was the scale by which the size of other objects was most readily estimated, and nothing tended more to diminish them than any exaggeration in the proportions of the human form. Nothing could be more beautiful, more artistic, or more poetical, than the idea thrown out by the Archdeacon; but it was essential to consider the varied surfaces to which the paintings were to be applied. From what Mr. Penrose had said, it appeared that he considered the small domes should be painted in coffers in chiaro-scuro; but he considered that a very inappropriate mode of decoration, if only because it was a deception.

Mr. Twining thought nothing could be more beautiful or appropriate than the effect of stained glass, which need not detract from the effect of the painted decorations, if the latter were judiciously applied. He highly eulogised the idea thrown out by Archdeacon Hale. Unless the whole of the Cathedral were decorated simultaneously, he thought the choir should be done first, and separately from the other parts.

Mr. J. W. Papworth considered that the first duty of an artist, when such an immense mass of building came under his hands for decoration, was to decide what was the general effect to be produced; and he therefore wished to ask whether anything had yet suggested itself to Mr. Penrose as to the general effect, or the general key of colour, in this instance. The effect might be either splendour, immensity, or majesty; and this would depend upon the general key of colour to be adopted; which in its turn would at once regulate all the minor details of the decoration.

Mr. Penrose said that the general key of colour would unquestionably be given by the cupola.

Mr. Papworth hoped he might further be allowed to ask what that key would be. Was it to be chiaro-scuro? [Mr. Penrose.—Yes, chiaro-scuro.] Then, in that case, he (Mr. Papworth) thought there was nothing to prevent the building being as gloomy and miserable as at present. No amount of gilding could possibly relieve the general brown tints so produced. In settling the general key of colour it was necessary to decide whether the idea of vastness, or grandeur, or majesty, should predominate, those being the only three sentiments to be considered in such a building; and in following the question out, it should be considered whether historical pictures (not decorative painting) and stained glass would accord with those ideas. Many gentlemen would probably agree with him that a temple, such as St. Paul's Cathedral, should not be a mere exhibition gallery of pictures. He thought the whole question turned upon whether the decoration of the dome really was a fixed matter, because if so the opinion of the members of the Institute was quite unnecessary, that point involving both the key of colour and the question of the introduction of historical decorative pictures.

Archdeacon Hale said it was in reference to the effect of the dome as governing the other decorations that he had referred to the historical evidence of an old writer. He believed that that effect would really be one of the utmost radiance and splendour; and then, the whole of the cornices and capitals, and every horizontal, carved, or moulded line, being also richly gilt, he thought (with much deference) that in the lower part of the building the decorations might gradually assume a greater amount of colour, even to the extent of the historical pictures he had suggested. These would be subordinate to the architectural forms, distinctly marked as the latter would be by gilding.

Mr. E. T. Parris agreed with Mr. Papworth that a monotonous tone of colour throughout would produce a very melancholy and dismal effect; but as in a piece of music, though set in a given key, a discord was occasionally allowed, so it might be in painting. He thought Wren's idea must have been white and gold; and that the general idea in his mind was that of form and line—outline combining form throughout—not internally alone, but externally. There was not a line in the building, internally or externally, which was not artistically beautiful. Everything was strongly marked by a bold outline. Of course, there could be no idea of converting St. Paul's into a picture gallery, even if it were filled with pictures and stained glass. In considering the restoration of the dome, it was necessary to have regard to the views of Sir James Thornhill, and to his other works. The ceiling of Whitehall Chapel was executed about the year 1630, and was imitated by French artists at the Louvre, Versailles, &c. Le Brun and his pupils became immensely popular, and Verrio, Laguerre, and Delafosse, executed many painted ceilings in England. Wren, who was familiar with these works, might possibly have been so far biassed by the prevailing fashion as to have even contemplated the small cupolas at St. Paul's being painted in that style. Thornhill imitated Delafosse and Verrio in all his other works, and in the dome of St. Paul's he was probably only restrained by the architect. The chiaro-scuro there employed was not a mere imitation of bas-relief, but was far more effective. A great deal of it might be called architectural ornamentation, intended to assist the architecture by a cheap painted imitation. This part of the work was admirably executed. Because Thornhill was restricted from the use of colours in the dome, it did not follow that they were equally to be excluded in other parts. Many passages in the 'Parentalia' showed that Wren intended to employ colour, but of course he would not use it in the dome, where it could not be seen to advantage. Thornhill's predilections would have led him to use colour in imitation of the domes abroad. With respect to stained glass, he (Mr. Parris) thought Sir C. Wren fully intended to have stained glass in the windows—not painted glass, but pot-metal—the effect of which in the dome would be exceedingly beautiful. Whilst it would not obstruct the light it would obscure it a little, and lower the cutting rays which now strike across the dome, and interfere with the effect of the paintings. In the lower part of the building colour was certainly contemplated originally. A mosaic pavement was proposed, and no architect would use such a pavement without stained glass in the windows. The art of painting on glass he thought would not succeed in this or any other country—not for want of talent, or of peculiar pigments (for our knowledge of the effects of juxtaposition of colours was most complete), but from the mistaken notion of producing a picture as on canvas. The works of West and Jarvis were total failures; but in the ancient stained glass the effect was produced by figures in the most brilliant and positive colours, cut out with a hard outline in lead, on the same principle as the paintings on the Etruscan vases. He thought an excellent effect might be produced by the use of pot-metals. Alluding to the offer by Sir Joshua Reynolds and other artists to decorate St. Paul's gratuitously, Mr. Parris explained that that was not (as was often supposed) an offer to paint out the work of Sir James Thornhill—which had only been executed about thirty-five years—but to introduce pictures in other parts of the building. Considering, however, that Cipriani and Angelica Kauffman were among the artists proposing it, he agreed with Archdeacon Hale that it was fortunate the offer had been declined. The Dean of that day, however, rejected it because, as he said, "he would never give way to popery." Thus taken out of the hands of the painters, St. Paul's fell into those of the sculptors; and he (Mr. Parris) remembered the first statues—those of Howard and Dr. Johnson—being placed in the building. These were less open to the Archdeacon's objection; but the monuments of the *heroes* rapidly followed, and upwards of 100,000*l.* had been expended upon them. It was time now that the painters should have their turn. He thought the general key of colour should be that of the stone, with a quantity of gold; because gilding never interfered with colour. There was no fear now of paintings being injured by damp. Archdeacon Hale and Professor Cockerell had jointly effected an immense improvement in that respect. When he (Mr. Parris) first proposed to restore the dome, the only thing he feared was the cold and damp to which he should be exposed; but that danger was now entirely removed. Mr. Parris went into some details of the state of art in the time of Wren and Thornhill, and the prices "per yard" paid to Rubens, Delafosse, Verrio, and Thornhill; and stated that an attempt was actually made by the Commissioners for St. Paul's to supersede Thornhill and employ Laguerre. He noticed, in conclusion, the existing prejudice against painting in churches, especially if assuming a mediæval character—a prejudice which it would take fifty years more to obliterate. His own ambition led him only to a comparatively insignificant portion of the decoration of St. Paul's—namely, the mere restoration of the dome as an antiquary; the remainder of the works he wished to see accomplished by the very best artists in the kingdom.

Mr. D. Mocatta said, that as the leading question in his mind was still as to the general tone of the building, he would venture to ask Mr. Parris whether, supposing he were left free to carry out his own view of that general key being white and gold, he would allow chiaro-scuro to pervade the whole building as in the dome, or whether he would introduce colour?

Mr. Parris said he would carry out every part of the building at all remote from the eye structurally and architecturally, and only in form, and light and shade; but in the panels nearer the ground, and wherever the parts approached nearer the eye, he would have colour, because those parts could be looked at separately; and he would also have stained glass.

Mr. Mocatta further inquired whether, in Mr. Parris's opinion, it was desirable that the dome should remain in chiaro-scuro, or partake of colour?

Mr. Parris thought if colour were admitted in the dome it would entirely destroy its effect. St. Paul's was totally different from St. Peter's. The latter was prepared to be cut up into a number of splendid parts, which, notwithstanding their real magnitude, appeared actually small; and in that building there was a balance of colour and enrichment throughout. The large and ponderous masses of St. Paul's were not prepared for colour, and if it were to be employed in the dome, it would render it an isolated canopy, and the harmony of the whole building would be destroyed.

Mr. G. G. Scott observed that a question seemed to be raised as to whether coloured decorations and stained glass should be admitted in the same building; and he was strongly impressed with the fact that they did not militate against each other, even when richly painted glass was used. He had found in practice that richly decorated interiors, without stained glass windows, were crude and almost offensive to the eye; and as by degrees the light was toned down by filling the windows with stained glass, the decorations on the wall became first sufferable, then pleasing, and, when the last window was filled in, delightful. He was inclined to think the case would not be very different where the decorations consisted of pictures. The chapel of Giotto at Padua now appeared crude in its colouring, the windows being of plain glass; but it was evident on examining the cuspings at the top that there had been originally stained glass of a very rich description. In the church of Sta. Croce at Florence, every part of the wall was covered with the finest frescoes of the school of Giotto's followers; all the windows were filled with stained glass, of the richest and deepest colours; but he had not the slightest recollection of any one of the subjects of the frescoes being obscured in any degree, from their being so lighted. The great artists of those works could not therefore have supposed that coloured glass would spoil the effect of them. The greater intensity of light in Italy would be met by larger and more numerous windows in this country. In objecting to painted glass, he presumed Mr. Parris and Archdeacon Hale to mean enamelled painted glass. He did not think glass was at all a material on which an artist should desire to paint as freely or in the same manner as he could on canvas. Enamel glass painting, therefore, however adapted to a drawing-room, would be quite out of place in a church or other large building, where it would probably injure the effect of frescoes or pictures; but the ordinary system of glass painting, as practised from the twelfth to the sixteenth centuries (pot-metal glass with a moderate amount of black shading), would not be at all open to that objection. In Mr. Winston's recent paper on coloured glass, the windows of the Church of St. Gudule at Brussels had been mentioned. They were certainly wonderfully beautiful, but the windows of St. Paul's should be founded upon the earlier specimens of the art. He should not think of introducing a direct imitation of mediæval glass into a Palladian building, but it was not necessary to resort to an inferior principle because it happened to be coincident with the period of the structure. What he should like to see would be stained glass of the best principle (that of the earlier or middle period of the range he had referred to), with the very finest art, and the best drawing in the figures, and with such ornaments as should coincide with the general character of the building. In saying that the finest art should be displayed in the windows of St. Paul's, he did not mean that our best painters should execute them as if they were working on an easel picture, because the first principle in such works was that of outline with very little shading. Conceding that the restoration of the dome was the point from which to work, it did not follow that all the decorations should be in monochrome, as that was. The result in that case would be dull and heavy. On the other hand, the rich colours of the late Italian works would neither suit the feelings nor the climate of this country; but a considerable amount of colour might be fairly introduced. He thought the practice of representing by colour forms which might have been produced in masonry, was highly objectionable, and therefore differed from Mr. Penrose as to the propriety of painting the small domes in coffers. If Wren had wished them coffered he would have coffered them; and to paint them so now would be an attempt to supply a deficiency in his architecture. In painting the different surfaces, the modes adopted should vary according to the duties each part had to perform constructively; as the lower panels, the vaulted ceilings, and the pendentives. In the cupolas any representation of figures should be almost entirely in line, so as not to disturb the natural form of the dome, as was the case in St. Mark's at Venice. If the money could be obtained for it, mosaic was certainly the proper material both for the domes and pendentives. [Mr. Penrose.—Certainly. No question of it.] Wren meant to have mosaics; and it should be done now if possible. The conception of Archdeacon Hale was the finest that could be imagined, and ought to be the key note of everything that was done; but it did not militate against the use of stained glass, with which, on the contrary, it might be brought in perfect unison.

The Chairman (Mr. Mocatta), in conclusion, said it was not surprising that they might not be able to come to a satisfactory conclusion at once. Probably Mr. Cockerell would kindly bring the Cathedral under their notice on a future occasion, when, after further consideration, they would be better prepared to do so. For himself, he had merely wished, by his questions to Mr. Parris, to elicit his views on what Mr. Papworth had happily called the general key of colour, as the most important point; and he entirely concurred in the opinion of Mr. Parris as to the dome, that no injury would be done by following in the steps of Sir James Thornhill, and that, at so great a distance from the eye, the dulness of the monochrome painting there would be sufficiently relieved by the gilding.

TOPOGRAPHY OF THE ROMAN FORUM AND THE CLIVUS CAPITOLINUS.

By the Rev. Richard Burgess, B.D.

[*Paper read at the Royal Institute of British Architects, June 28.*]

At a meeting of this Institute on the 31st May last, some extracts were read from a letter* addressed to one of the Vice-Presidents, in which it was stated that a good deal was going on at Rome to interest the architect and the archæologist. The author of that letter, Mr. Tite, has been surveying with the

* *Extracts from a Letter from* Mr. W. Tite *to* T. L. Donaldson, V.P.

"At Rome there is a good deal going on to interest the architect and the archæologist. Your introduction, and that of other friends, to our distinguished foreign associate, the Comandante Canina, gave me the best opportunities of informing myself of these researches and discoveries, and his great kindness, afforded me facilities not enjoyed by others. The excavations in the Forum at Rome still continue, though slowly. The Republic pulled down some houses that stood much in the way both of the antiquities and the view, but unluckily they cut down the trees which used to mark the line of the Via Sacra, and thus they spoiled one of the most picturesque features of that interesting site. The foundations of the Basilica Julia are cleared out; the ascent of the Via Sacra to the Capitol is quite distinct; the Arch of Titus is thoroughly repaired; and they are now excavating in and around the Basilica of Constantine—that great ruin, formerly familiar to us under another name. The result of all these excavations certainly tends to confirm the suggestions of Chevalier Bunsen, and the German archæologists; and the Forum *of the Emperors* is now cleared of difficulty and confusion; and the *vexatæ questiones* connected with it are at an end. It is not possible in the compass of a letter to give you much account of this; but, if health be spared me, on some future occasion I hope to occupy our friends at the Institute, and yourself, with the results of these investigations. At the Coliseum much is doing in the way of necessary repairs, and certainly just in time, for if eye of a man of taste that interesting "field in which a thousand years of silenced factions sleep"—*The Roman Forum;* he has given us a sketch of the indiscriminate slaughter made by the *Republic* of 1848, on that sacred ground, which equally exerted its short-lived energy in pulling down the houses which obstructed the view, and uprooting the trees which graced the classical landscape. The only satisfaction we have is, that, as on the Boulevards of Paris, so along the margin of the Via Sacra, the trees may grow again before the next revolution, while the houses which obstructed the view and concealed the ancient topography are gone for ever. Upon the whole, therefore, the future student and antiquary may be indebted to the Republic for a better view of the Palatine Hill, where despotism had its seat, and clearer conceptions of the limits of the Forum, where liberty luxuriated into license. Our learned friend observes that the foundations of the Basilica Julia are cleared out, and the ascent of the Via Sacra to the Capitol is quite distinct. He adds, that the result of all these excavations certainly tends to clear away all doubts and difficulties as to the Forum of the Emperors—the Forum as it was from the time of Julius Cæsar. These observations of our learned colleague have induced me to take up a subject which some may consider to be worn out, "The Topography of the Roman Forum," but I flatter myself that at an Institute of Architects, anything that tends to illustrate that classical ground, and the models of architecture which once stood upon it, and whose remains still exist, can never be unacceptable. The object I have in view in this paper, is to assign to what Mr. Tite calls the Forum of the Emperors its proper limits and dimensions, which have so long been a matter of antiquarian controversy—not that I presume to set that controversy at rest, but I mean to offer such proofs, from the present state of the ground and ancient authorities and other monuments, as appear to me to assign the proper limits: you will still have to judge for yourselves whether those proofs be satisfactory or not. For the sake of perspicuity, and rendering the subject more accessible to your attention, I lay down the order in which I propose to treat this question: I shall first glance at the various opinions of antiquaries, and the commonly received opinions up to the period of the modern excavations as to the limits of the Forum; but, inasmuch as the question of limits is materially affected by the adjacent places, and especially by the Clivus Capitolinus, I shall have to examine the names and positions of the three temples whose remains still exist upon it, and then bring the argument to bear upon the limits of the Forum with special reference to the discovered basement of the Basilica Julia.

I do not mean, by referring you to the various opinions of antiquaries, to bring up those opinions for the sake of refuting them, but simply to state what they are for the purpose of showing the few points in which they agree, for this will be so much gained towards the object I have in view. They all agree, for instance, from Camucci in 1500 to Professors Fea and Nibby in 1840, that one angle of the Roman Forum was at the Mamertine Prison, which now exists beneath the Church of St. Joseph near the Arch of Septimus Severus. Marliano, one of the earliest of antiquarian writers who deserves attention, considered the Forum to be 100 paces in length, extending from the Arch of Severus to the Temple of Antoninus and Faustina, and he took the width of 50 paces across to the north angle of the Palatine Hill, including the three celebrated columns now standing; he even prolonged it, but by another name, as far as the Arch of Titus; Donatus the Jesuit showed this to be an error from the authorities of Dionysius and Livy, who describe the Forum as occupying the space between the Palatine and Capitoline Hills, and so completely has this portion of the argument prevailed, that a second angle of the Forum, with the consent of all, has been fixed near the Temple of Antoninus, in a line with the Arch of Septimus Severus, and where

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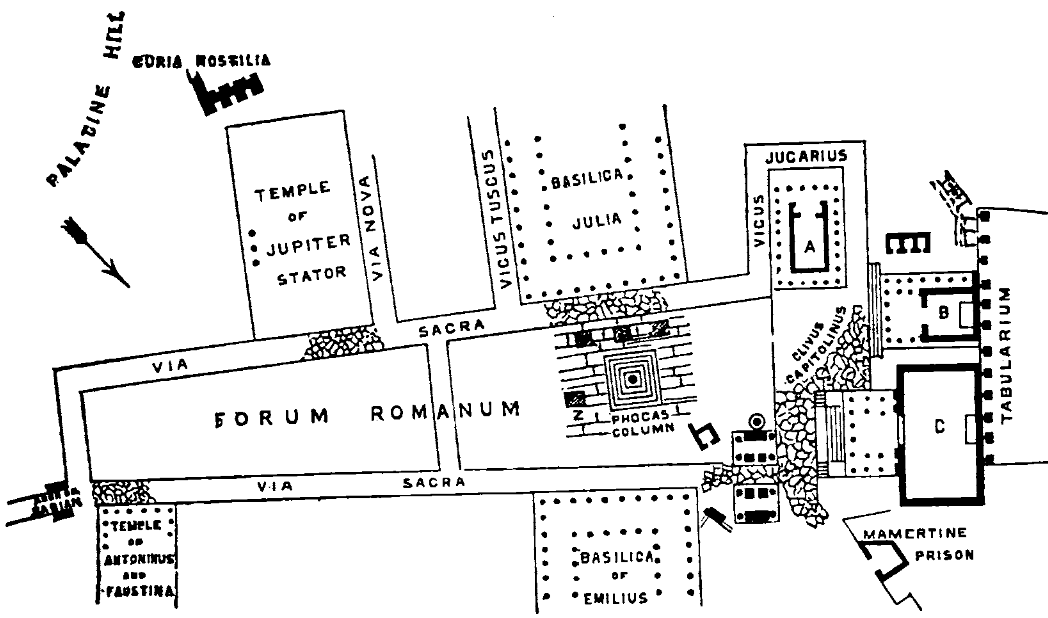
they had been delayed much longer, the upper story must have fallen. These works are really very extensive; and when complete, they will not only rescue this magnificent ruin from destruction, but in part will show what the interior once was. I mean that the intention is to place the fragments of the upper range of internal columns in their places, to restore the divisions, and to reinstate some of the seats, so as to give an idea of what the whole of this mighty edifice might have been. The same care is now extended to most of the principal ruins, and the excavations formerly made are well preserved. I perceive in the papers some notice of the excavations and researches on the old Appian way. That account is in the main correct; but, perhaps, a somewhat more extensive notice may be acceptable. You will recollect that the old Appian way descended the hill from Albano, and went straight across the Campagna to the gate of S. Sebastian, formerly the Porta Appia, immediately within which is the Arch of Drusus. Of this ancient way, the Nuova Appia only really occupied so much as served to descend the hill at Albano; it then turned aside to the east, and by a good but somewhat crooked road entered Rome by the Porta San Giovanni, and the Great Basilica of St. John Lateran. The old road was therefore abandoned, except about three miles at the furthest end. At the Roman extremity, however, it was still kept up by the road passing the ancient Basilica of S. Sebastian, and up the hill to the tomb of Cecilia Metella: soon after this it entered the Campagna, first as a road, then as a track, and finally it was entirely lost in the turf. Its course, however, was to be seen by the ruins of a line of tombs, in some cases of enormous dimensions. Canina suggested the excavating round these ruins, and though not intending to re-establish the ancient road, still to trace out its course, and to make it carriageable throughout its whole length. He obliged me by allowing me to accompany him on one of his visits of inspection, and by giving me, at the various points of interest, his views and opinions. At that time, the last day in March, he had 220 men at work under a most intelligent staff. The men were paid 2½ pauls per diem, almost a shilling English, and they seemed to work with great spirit and care. Soon after passing the tomb of Cecilia Metella these excavations had begun, and the result, in many cases, was a complete street of tombs, almost as close as houses, with here and there some remarkable monument. The course directed by Canina is this—first, to excavate in and round each mass, whether large or small; every fragment is numbered, and left *in situ*, the earth only being removed into the adjoining fields. These fragments are then carefully examined and matched, and so far as possible built up into the ancient forms; and the inscriptions, bas-reliefs, or sculpture, are replaced and secured by substantial walls. In this way many tombs, of very curious workmanship, and a host of curious inscriptions, have been developed; and in some parts the restorations are so perfect as to give the road a good deal the character of the street of tombs at Pompeii. The material is very often marble, and there is much exquisite detail at times; but the sculpture at present found is not very remarkable, though three or four statues of good workmanship have been sent to the Vatican. At a distance of about four miles from Rome, Canina has restored two or three of those curious tombs which consist in a circular podium, or retaining wall, with a conical mound of earth, planted with cypresses. Strabo thus describes the ancient appearance of the mausoleum of Augustus, in the Campus Martius; and here this character of restoration is not only *vraisemblable*, but most agreeable in the landscape. Just beyond that great mass of ruins in the Campagna, called Roma Vecchia, is that immense circular building, known familiarly as the Casa Rotonda. It was an enormous mass of brickwork and tufa; on the top is a moderate-sized farm-house, and an olive garden, to which a way had been made from the ground raised by the ruins, at the back through the monument. On clearing out the earth round this ruin, nearly all the marble casing has been discovered, and the Comandante means to restore it. There is a rich marble base moulding; the face was cased with marble to some height, probably rusticated; then came a magnificent marble entablature, decorated with shields in the frieze, with a highly-decorated cornice of immense blocks of marble, resting on modillions; above this was an attic of small Corinthian pilasters. There was an inscription, and it is somewhat curious that the only fragment remaining gives the name of the founder of the tomb 'COTTA,' on a large block of marble, beautifully cut, with the letters at least 18 inches high. The general features of this tomb therefore resemble those of Cecilia Metella, but greatly increased in dimensions and magnificence, particularly of material, as her tomb is cased with travertino, this with marble. Soon after leaving this tomb, all trace of the road is lost, and the ruins stood 'mid the deep silence of the pathless wild.' By excavating, however, it is easily followed, as the enormous kerbs of the footpaths generally remain, though the paving is usually broken up and carried away. The excavations are carried on to the eighth mile-stone from Rome, and here the Itineraries speak of a temple to Hercules; and in the turf some shafts of small dimensions were seen still erect. This ruin was somewhat cleared out when we were there, and it disclosed six ancient columns, and part of the wall of the cell *in situ*. They are not very large, perhaps 2 ft. 6 in. in diameter, but in a very good Greek style and Doric. They are of peperino, and much wasted. The capitals had been found, but no traces of the entablature; perhaps the architrave had been wood, for Canina was quite of opinion that this temple was of the earliest time of the Republic. I could not trace any necking, nor did there appear to have been any very evident entasis as in the columns at Pæstum. Beyond this point all at present is the turf of the Campagna, though in the distance the line of the road climbing the hill to Albano is distinctly seen. The works, I believe, are now suspended, because the labourers are wanted for the operations of the farmers; but they will be resumed in the winter. Canina will give the results of the most important of these excavations in a work he is about to publish, to be entitled 'Gli Edifizj di Roma antica e di sua Campagna.'"



PLAN OF THE ROMAN FORUM AND CLIVUS CAPITOLINUS.

the Arch of Fabius, who conquered the Allobroges, once stood; the question of limits was then reduced to this—whether did these two angular points, upon which all were agreed, define the length or the width of the Forum. Until Nardini came, all unanimously said the length; since the time of Nardini, by far the majority of antiquaries have said the width; but within the last quarter of a century, the German antiquaries and architects, led on by the great name of Niebuhr, and followed up by the learned diligence of Bunsen, have unanimously returned to the opinion of the old antiquaries.

Vitruvius informs us that the Greeks made their fora square, with wide and double porticoes; but in the cities of Italy, he adds, they were of a different form, on account of the gladiatorial shows which custom had introduced into them. They ought not to be made, he says, too large, so that a crowd would appear lost in them, nor too small for the population; and the length should be in proportion to the width as three to two;* this proportion, however, was not always observed, for the Forum of Pompeii is only one-third of its length in width, but still we may infer that if the Roman Forum had differed from those proportions laid down by Vitruvius, he would at least have remarked the circumstance; it is therefore fair to conclude that the Roman Forum was a rectangular space in the Vitruvian proportions. Now, to apply them to the ground, it should be observed that between the Arch of Severus and the supposed site of that of Fabian, is a distance of about 400 feet; if this be taken for the length of the Forum, then 270 feet across for the width will bring us near the large brick fabric supposed to be the Curia, and the rectangle completed will join the Clivus Capitolinus just behind the Temple of the eight columns. If on the other hand 400 feet be the width, then the Forum will be laid out according to the doctrine of Nardini—that is to say, it will be a rectangular space about a diagonal drawn from the Arch of Septimus Severus to the Church of St. Teodoro. I have already said that the first is now the favourite theory of the Germans. The Italian antiquaries have not yet relinquished the second; but Canina (whose plan is now before you), an architect but not an archæologist, appears to agree mainly with the Germans. The numerous passages cited by all parties from ancient authors have of course been applied according to every one's theory; it is not my intention to trouble you with many of these, but rather to see how the modern excavations may be cited to bear evidence upon the subject. The important discovery of the Basilica Julia will throw great light upon the limits of the Forum, but this object must be taken in connection with the adjacent Clivus Capitolinus; and therefore I proposed, as the next step in our argument, to call your attention to the three temples whose remains will be familiar to every one who has visited Rome. Those temples are marked A, B, C, is the Temple of Concord, about which there is no longer any dispute. There were found in 1817 several inscriptions amongst its ruins with the word Concordia, and happy it is that the temple of such a goddess should afford no matter of discord, even "where her altars are no more divine." The other two have, however, frequently changed their appellations, and are yet destined to undergo more changes. A, with the eight granite columns, still standing, had usurped the name of Concord ever since the year 1431, when Poggio Bracciolini saw it nearly perfect in the last days of Pope Eugenius. That learned Florentine ascended the Capitoline Hill with a friend, and sitting down on the ruins of the Tarpeian Citadel, he moralised on the vicissitudes of all human things, and has left his reflections in a book entitled 'De Varietate Fortunæ.' "The Forum of the Roman People," he says, "where they assembled to enact their laws and elect their magistrates, is now inclosed for the cultivation of pot herbs, or thrown open for the reception of swine and buffaloes. The public and private edifices that were founded for eternity lie prostrate, naked, and broken, like the limbs of a mighty giant; and the ruin is the more visible from the stupendous relics that have survived the injuries of time and fortune." The description which the learned Tuscan then gives of the ruins shows that a moralist and an antiquary are not always combined in the same person, and among other rash conjectures upon the names of the ruins he saw, he fixed that of *Concord* upon the eight columns on the Clivus, the site of the Temple of Concord being however discovered as I have already intimated. His own goddess, Fortune, succeeded to the honours by common consent of the Roman Ciceroni. Fortune however has her day, and what could this goddess expect but vicissitudes, who had herself brought vicissitudes on so many of her votaries. She has of late years been obliged to yield up her honours again to Vespasian; but Vespasian must yield again, according the German theory, if Canina is right, to a god no less venerable than old Saturn himself. The three columns which remain of the Temple marked B, have long been invested with the title of Jupiter Tonans.

The origin of the thundering Jove is this. Augustus, during his expedition in Spain, was travelling one stormy night, when the litter in which he was conveyed was struck by lightning, and the slave carrying the torch before him was killed on the spot. The Emperor, grateful for his narrow escape, vowed a temple to the master of the thunderbolt; it was built, according to the expression of Suetonius, on the Capitol, *in Capitolio*. Dion Cassius describes it as occurring in the ascent to the Capitol. Pliny, who often mentions it, says it was on the Capitol. Publius Victor, in the fifth century, says it was on the Clivus. It is exhibited on a medal extant with six columns in front, and the statue of the god, which was a *chef d'œuvre* of Leocras, is represented standing in the midst. As soon as the temple was erected, the worship of Jupiter Tonans, out of compliment to

* Latitudo autem ita finiatur, uti longitudo in tres partes quum divisa fuerit, ex his duæ partes ei dentur. Lib. V., c. I.

the Emperor, became very popular, so much so as to cause inconvenience about the passage; it was considered desirable to turn the tide in another direction. For this purpose Augustus had a dream, Jupiter Capitolinus appeared to the Emperor asleep, and complained that he had taken away all his worshippers by setting up a rival Jupiter; the Emperor consoled the Optimus Maximus Jove, by assuring him that he intended Tonans to be nothing more than a porter's lodge to his Capitoline Majesty, and shortly after he put bells upon the pediment to show that it was a mere entrance. Now all this would appear to take Jupiter Tonans higher up the hill than the three angular columns, and I conceive we are at liberty to make some changes among these imperial deities. I shall this evening have to remove the Thunderer from the place he has usurped, and put Vespasian in possession of his honours. You will now very naturally require that I should produce my reasons. It is the custom among the Roman antiquaries, before they proceed to deliver their own opinions, and give their proofs and reasons for them, to summon up one by one the opinions of antagonists, and dispose of them as mere dreams, or as the baseless fabric of a vision. I should not have time, nor you patience, to allow of proceeding after that manner, but I shall be content with stating why I think the three columns called Jupiter Tonans, ought to be called the Temple of Vepasian, and the eight columns commonly called the Temple of Fortune, should belong to the Temple of Saturn.

Mabillon found a MS. in the Convent of Einsiedlen in Switzerland, which has turned out to be one of the most valuable documents to the Roman antiquary of any that time has spared. It bears no name, but appears to have been the faithful record of the pilgrimage of a pious German or Swiss who visited Rome in the eighth century. To perform his devotions according to the prescribed canons of those days, he visited all the seven Basilicas, and in going from one to the other registered every building and inscription that came in his way. This curious document is published by Mabillon, in the fourth volume of his Analecta Vetera; but Niebuhr made a journey to Einsiedlen on purpose to seek out the MS. again. He found it, and I was permitted by his successor at Rome to copy from the fac-simile the portion I now design to use. The anonymous pilgrim arriving at the Capitoline Hill, copies the inscriptions which he read on three temples, but all those inscriptions are written in the MS. without any more marked divisions of the words and lines than that which the context points out. They read thus: "Senatus Populusque Romanus incendio consumptum restituit. Divo Vespasiano Augusto S. P. Q. R., Impp. Cæss. Severus et Antoninus pii. felic. aug. restituerunt." I need not insert the rest, which relates to the Temple of Concord. Now upon the entablature which rests upon the eight granite columns we still read the words which 'Anonymous' read in the eighth century—"Senatus populusque romanus incendio consumptum restituit;" and we read nothing more. The German antiquaries say we ought to go on, and add the three following words of 'Anonymous.' "Divo Vespasiano Augusto," and then the portico of the eight columns would be the Temple of Vespasian. But it is triumphantly asked, where is the space for the additional words; the frieze is filled up, and whoever saw an inscription upon an architrave or a cornice? Oh, but they say, "Divo Vespasiano" was inscribed on the other elevation which is now demolished, and so we should have to send 'Anonymous' to the other end of the temple to discover the three additional words before he proceeded with the other inscriptions which were before his eyes; besides, whoever saw the name of an Emperor to whom a temple was dedicated inscribed on the back elevation? or if it be alleged that the demolished part was the front elevation, then it may still be asked, whoever saw the Senate and the Roman people, the awful S. P. Q. R. put behind a temple? We therefore take the three words for the beginning of the second inscription, and then it reads, "Divo Vespasiano Augusto S. P. Q. R., Impp. Cæss. Severus et Antoninus pii felic. aug. restituerunt." This inscription belongs to the three angular columns supporting a beautiful piece of entablature, on which is read "ESTITVER," being part of the word "restituerunt"; from all which it appears that Septimus Severus and his son Caracalla repaired that temple to the honour of Vespasian the Emperor. I think this a sufficient proof, but I shall have occasion to add another when I take you down into the Forum. To return now to the portico of eight columns. It is true we learn neither from 'Anonymous,' nor from the inscription as it exists, to what divinity this temple belonged, for that inscription never said any more than it now says, that the Senate and Roman people repaired the temple after it had been destroyed by fire—we must therefore have recourse to some other mode of proof. I could cite passages from various ancient writers to show that the Temple of Saturn was situated at the entrance of the Clivus, or, as Varro's expression is, "in faucibus Clivi." Servius describes it as being "ante Clivum juxta Concordiæ templum." It was also very near the Milliarum Aureum. There was a difficulty in applying these descriptive passages to the eight columns before the excavations were made, because the portico appeared to be standing on a basement considerably elevated above the level of the Forum, and consequently some way up the Clivus, but now that the ground has been cleared, we see that basement magnificently constructed of peperine and travertine stone, rising from the very bottom of the Clivus, where the ascent began, and there is now no longer any difficulty in saying that the temple marked in the plan A stands in "faucibus Clivi," or "infimo Clivo; nor is there any where space to be found where another temple could have stood. I am therefore inclined to believe that the temple which has so long been called the Temple of Fortune is really the Temple of Saturn, and that commonly called Jupiter Tonans is the Temple of Vespasian. I may not conceal the fact that I am here in conflict with all the German school of antiquaries, who insist upon the temple B as being the Temple of Saturn, and they rely upon the words, "juxta ædem Concordiæ;" and upon a votive altar, found in the narrow space between the temples B and C, on which were the words, "AB. AER. SAT." This celebrated fane of Saturn, wherever it was, contained the public treasure of the Romans, and a præfect was appointed to the care of it. Ancient rescripts or registers of contracts were also preserved in the Temple of Saturn, and the reason why all these valuable articles were placed under his care was because, in the golden age of that old god, there was no such crime as theft, and in those primitive times avarice and bad faith were unknown; but besides this treasury, which was considered as the public exchequer, there was also attached to Saturn's Temple a "sanctius ærarium," and the wealth stowed up here was not to be touched except in the greatest emergency. The Germans say they can discover vestiges of a door or opening which led from their Temple of Saturn into this reserve treasury. I recollect using every faculty of sight I could command, but never could I find the traces spoken of; and, for reasons I shall shortly give, I must turn Saturn in another direction. However important and decisive may be thought the discoveries made by excavations, they must be adjusted with the passages descriptive of buildings and places which we find in the ancient writers. The poet Statius, contemporary with Domitian, has given us a general view of the Forum as it was in his time. When he describes the famous equestrian statue of Domitian, he names five monuments, which respectively stood in front, in the rear, and on the flanks of this colossal statue, and he turns the horse's head towards the Palatium. The Temple of Julius Cæsar in front he thus describes:

> "Hinc obvia limina pandit,
> Qui, fessus bellis, adscitæ munere prolis,
> Primus iter nostris ostendit in æthera divis."

The two Basilicas on each flank, and the two temples of Concord and Vespasian behind the horse, are comprised in the three following verses:

> At laterum gressus hinc *Julia tecta* tuentur.
> *Illinc belligeri* sublimis *regia Pauli.*
> Terga *Pater*, blandoque videt *Concordia* vultu.

The rest of the passage describes the objects which the Emperor was supposed to see from his seat on the horse, and amongst those objects the *nova Palatia*, which Domitian himself had made, and the Temple of Vesta, are mentioned. In the present state of the Roman Forum this has become one of the most valuable passages which the records of antiquity have preserved; we have nothing to do but place Domitian's horse in some central place between the Palatine and Capitoline Hills, and then take our general survey. The Temple of Julius Cæsar is gone; no one pretends to exhibit a vestige of it—no, not even a Roman architect; but the two temples which saw the horse's tail are remaining on the Clivus Capitolinus. Of the one, Concord, there is no dispute; the temple whose ruin consists in the three angular columns, Jupiter Tonans, has alone the same aspect. The expression "terga Pater" (Vespasianus) and Concordia *videt*" alludes to the statues looking out of their respective cellas upon the horse's tail; but unless the cellas had been turned in that direction, this description would not merely have been unpoetical, but false. Now the temple with the portico of eight columns has its flank behind the statue, and therefore cannot answer to the words "Terga Pater videt;" but the temple called Jupiter Tonans does answer, and I take this authority to be enough to complete the proof that the temple marked B is rightly named the Temple of Vespasian. It may however be still asked where is the equestrian statue to be placed. This question is answered by the excavations, and is shown thus: On each side of the equestrian statue of Domitian was a Basilica. In laying the foundation of the church of S. Adriano, in 1665, a mutilated inscription on a marble pedestal was discovered, in which mention was made of a Basilica, and this is generally allowed to point out the site of the "regia Pauli," mentioned by Statius, synonymous with the Basilica Emilia. Taking Statius for our guide, we look at once in the opposite side of the Forum for the Julia tecta; and just in the direction where we ought to look, the steps leading into the supposed Basilica Julia have been discovered in the late excavations; the ground which has been the most effectually laid open is about the Column of Phocas. The spectator of the ruins of the Forum, when standing on its present level, is elevated about 20 feet from the base of that honorary column, and he descends by the Clivus and passes under an archway (now made for convenience) to arrive at the ancient level of the Forum. At the width of about 15 feet from the enclosure of Phocas' Column have been discovered the steps just described; and although it might be shown from the authority of classical writers that the Basilica Julia was at least on this side of the Forum now in question, yet there is one stronger proof than all the rest to be adduced. In the Spring of 1835, when the first step of the supposed Basilica Julia was brought to light, a fragment of an honorary basement just appeared, and as if it would refuse to give any evidence on a disputed point, fell into the "cloaca" which runs under the steps, and so disappeared. Professor Emeliano Sarti, who kept a constant watch over those excavations, was the only person who observed the fragment with the eye of an antiquary. He communicated the secret to Kellermann, an intelligent antiquary, who immediately aroused the Cavaliere Bunsen to go with diplomatic authority and fetch up the precious relic from the cloaca. It was taken up and scraped and washed, for, like a piece of buttered bread, it had fallen with the inscription side downwards, and when it was set to the light Kellermann read these letters:—

A
ASILICA
ER. REPARATAE
SET. ADIECIT.

Any one but a determined antiquary might have asked, and what then? But in the Corpus Inscriptionum of Gruter there had been read, for more than two centuries, the following copy of an inscription said to have been found or seen in the Forum; it runs thus—"Gabinius Vettius Probianus. V.C. Præf. urb. statuam quæ Basilicæ Juliæ a se noviter reparatæ ornamento esset adjecit;" and by comparing the odd letters with the full Gruterian inscription, there was no doubt remaining of the proper way to fill up the lacunæ of the cloaca fragment; this was either the inscription which Gruter had seen and copied in its entire form, or it was a duplicate, for being on a basement, and making mention of a Præfect, who in the year 307 restored the Basilica Julia, it is most probable it would be more than once repeated; however that may be, the inscription, from the position in which it was found, leaves no rational doubt that the Basilica Julia is found, and it speaks much for the ingenuity of Canina that he marked the place, as in No. XVIII. of his plan, before the inscription, which confirmed his conjecture, was brought to light. The Basilica Julia being then found, and the Basilica Emilia being acknowledged to be near the Church of S. Adriano, on the east side of the Forum, the equestrian statue of Domitian must be placed between them. But having found those vestiges of the steps, and nothing else, it will very naturally be asked how is the plan of the whole Basilica known? To answer this question we must have recourse to the fragments of a marble plan of Rome, made in the time of Severus and Caracalla, and found in the sixteenth century broken to pieces, in the Church of S. S. Damiano e Cosma. It is now encrusted into the wall of the staircase leading to the Capitoline Museum, and must be well known to all architects who have been to Rome, and to all who have not it will be familiar by the illustrations of Piranesi, under the title of Pianta Capitolina. One of those fragments, although broken, exhibits a ground plan of a building of immense proportions, on which we read "Julia," and on a corresponding piece the letter "B." I need not presume to describe to you the form, parts, and uses of an ancient Basilica, but I may remark upon the Basilica Julia, that according to the ichnography of the Pianta Capitolina it had five naves, divided by four rows of pilasters; the wall which inclosed it was also decorated externally with pilasters, and between them were windows; in other words, it may be described as formed of three peristyles one within the other; the outward one had twelve pilasters in front, and twenty-three on the flanks; the middle one eight in front, and fifteen on the side; the innermost six in front, and eleven on the sides; it must have been a most splendid edifice, for according to Pliny the younger it afforded accommodation for four tribunals of forty-five judges each. Caligula made his bridge to pass over it, to go from his Palatine residence to the Temple of J. O. M., and when he got on the top, "fastigium Basilicæ," he used to throw pieces of money down among the people. When, therefore, we have made sufficient space for the Basilica, according to the ichnography and the site which these arguments now alleged will assign, it takes us about 350 feet from the column of Phocas in the direction of the Velabrum.

But we have yet to deal with another fragment of the Pianta Capitolina, showing the ichnography of this north-west angle of the Forum. It is usually adjusted with that fragment we have already considered as marking the three peristyles of the Basilica Julia; it exhibits an open space with the letters "URNI," which no one doubts is the left limb of "SATURNI:" an open space of this description was called an area, and such areas before the porticoes of temples were not unusual. If the Basilica Julia has its length from north to south, and consequently its flank along the west side of the Forum, this fragment comes in to fill up the space through which the Vicus Jugarius ran, and actually brings us up to the eight columns. This may be taken as a kind of reflective evidence of the eight columns belonging to the Temple of Saturn; and I must say, that, putting aside all envy and jealousy, I shall be glad to learn from our learned traveller, Mr. Tite, when he comes to give us the result of his observations, whether this said Basilica had its elevation towards the Forum or its flank; if the former, then our fragment "URNI" will fail us, and we must still rest the claims of Saturn upon the other arguments. But we have another remarkable passage of the 'Monumentum Ancyranum,' which says, "Forum Julium et Basilicam quæ fuit inter ædem Castoris et ædem Saturni." The Temple of Castor and Pollux, and the Temple of Saturn were, according to this monumental inscription, divided by the Basilica; now the Temple of Castor was that which Caligula turned into a portico for his Augustan House, which all agree overlooked the south side of the Forum, and which must have been very near, if not identified, with the large square brick building usually called the Curia. A line drawn across the Forum would come to the eight columns, and cut the Basilica Julia longitudinally, and answer exactly to the Ancyra inscription; and thus we should obtain a third fixed angle of the Forum beneath the Tarpeian rock, and behind the present Church of Madonna della Consolazione, and gain another particle of evidence for driving Fortune away, and bringing back Saturn to his own again. Now if we adhere to the Vitruvian precepts, which teach that Basilicas are to be placed near, that is, on the sides of the open area of the Forum, we may now walk round the Campo Vaccino (the name applied to the sacred ground ever since Poggio's buffaloes), and adjust the limits. On the east side, measuring from the arch of Septimus Severus to the site of the Fabian arch, there are 400 feet. The Basilica Emilia, and another Basilica of the same name, used by the Roman municipia as a guard-house, have long had peaceable possession of the east side of the Forum, and we are here denied the pleasure of disputing. Proceeding from the south-east angle we pass along the south side, under the Palatine Hill, until we have measured from the supposed site of the Fabian arch 500 feet, which will bring us to the west side of the square brick building called the Domus Caligulæ; fixing our south-west angle there, and completing the parallelogram, we are brought to the Madonna della Consolazione, where I should very much like to leave you all, as some sort of recompence for our weary chase.

Perhaps there is no portion of ground in the world which has been put to such ingenious torture by the skill of restoring architects as the space I have gone over. I believe it will be allowed that architects in all countries build more castles in the air than on solid ground; but in Rome, since the Apostolic coffers have been emptied by a variety of vicissitudes, and the Popes who patronised the arts have ceased to exist, the architects have nowhere to build but in the air; and hence the pleasure they take in putting inflexible and tasteless antiquaries to the torture by filling up a space, which authors say was clear, and driving into a corner a most classical monument because it was not of the right dimensions for completing a general plan. I may just add that I agree with the direction Canina has given to the three viæ which led into the Forum from the Velabrum—the Via Nova under the Palatine Hill, the Vicus Jugarius under the Capitol, and the Vicus Tuscus in the middle.

I may not proceed to make any further experiments upon your patience, by passing to any other objects in and around the Forum than those I have already treated of. Every inch of that classic ground must ever be interesting to the Institute of British Architects; but every inch must be contended for by the topographer and the antiquary: such discussions are for the most part tedious to all but antiquaries. The architect has the pleasing task of laying out his plan from the discovered angle of a wall, and rearing his edifice in due proportion; from the section of a column he can erect his portico, and fill up his tympanum with Niobe and her children, and crown the angles of his pediment with statues of gods and heroes, for which a medal will give him authority. The poor office of the antiquary is to put the inscription on the frieze, which few will care to read when enraptured with the indescribable harmony which reigns in architectural proportion. I cannot, however, omit this opportunity, as a humble labourer in that field, to solicit your votes and interest in favour of Vespasian and old Saturn, against the next general election of those temples on the Clivus, to serve in a representation of the ruins of Rome; and in doing this, I am running the risk of being charged with deserting my former constituents, for in my 'Antiquities of Rome,' although I had the prudence to leave the question somewhat open, I did incline for Jupiter Tonans and Fortune. Nay more, by a reference to my chapter on the Roman Forum, it will be seen that I split my vote between Vespasian and Jupiter, and showed the greatest anxiety to find space for Saturn; but antiquaries, like all other responsible advisers, must be allowed to alter their opinions when fresh proofs are excavated, new diggings opened, and circumstances are changed. Some of the Italian professors, whose theories will never be able to stand against the evidence of the discovered Basilica, have not yet brought themselves to acknowledge that it *is* the Basilica; and they wait in hopes it may lead to some building of the middle ages, and so maintain the theory of Nardini's Forum. I confess, although the discovery interferes somewhat with my preconceived, and what is worse, my published notions, I think it prudent to yield in time. It is long before we give up conservative principles; and an old opinion is often retained for the sake of consistency long after we have ceased to think it infallible. It is an admirable provision in our moral constitution, that men should be attached to the traditions of their fathers, for this often prevents rash innovations, not only in the names of temples, but of churches and constitutions; at the same time, we have long learned to reject the maxim that what is is best, for by this we might go on sanctioning error which had become hoary by time; and looking upon all reform and improvements as elements of destruction, we might have refused to entertain the notion of a Crystal Palace because Vitruvius spoke of nothing but peperine stone and marble; and if, as professors of civil architecture, we had kept to the narrow streets and gable ends of olden time, we might still have had a six-bedded room and a back kitchen for a model lodging house. It is evident that both in the material and intellectual departments we are to innovate,—but innovate with all the advantages of what has gone before; to know well the discoveries and works of genius which others have produced before us, and starting from the platform which others have erected, rear our Pantheon in air, which was before on the ground.

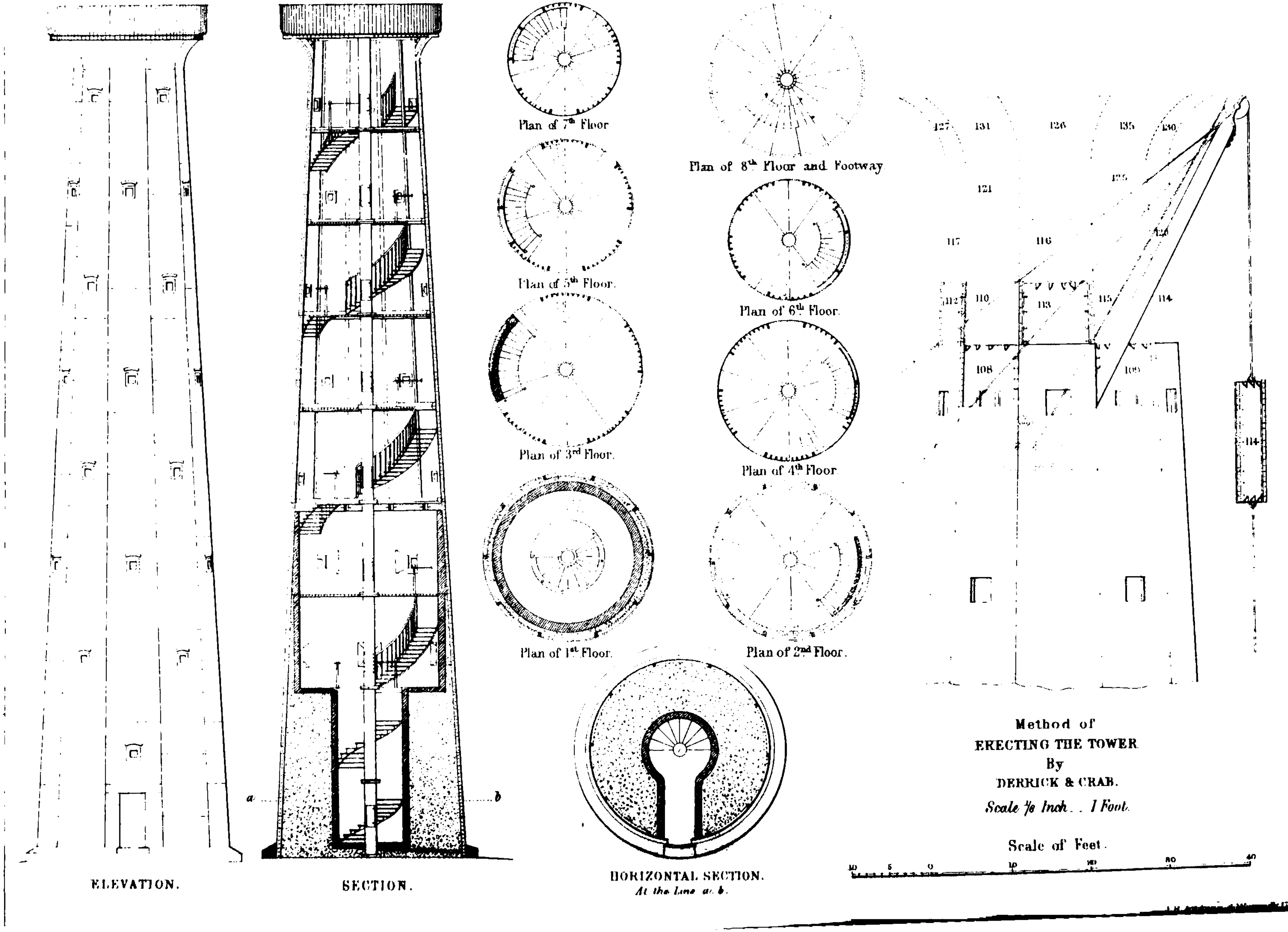
I am aware that this paper is more of a topographical than an architectural description, but the very names of the Forum and the Capitol are always a passport; for whether it be the Temple of Jupiter or of Saturn, whether it be the Basilica Julia or the Temple of Concord, it is still Vitruvius—that perpetual President of an Architectural Society. Whatever may be the diversity of tastes and pursuits, if they be refined they must all meet in the Roman Forum: there the painter loves to use his pencil, under the deep blue sky by which the time-worn ruins are arched; there the sculptor loves to linger over the exquisite fragments which time has spared to excite his admiration and his envy; there the disciple of Palladio, and the ardent admirer of Michael Angelo's bold genius, grows into the proportions of the things around him; whilst the classical scholar, whose youthful imagination has led him to form ideas of the Forum as colossal as the deeds with which its fame is emblazoned, stands astonished at the narrow limits within which such scenes were acted; and what neither painter, nor sculptor, nor architect supplies to his fancy, the poet sings to the balmy breeze standing on the Capitol—

> "Did the conquerors heap
> Their spoils here? Yes: and in yon field below
> A thousand years of silenced factious sleep.—
> The Forum, where the immortal accents glow,
> And still the eloquent air breathes—burns with—Cicero."

Mr. Tite said he was most happy that his hasty letter had produced such an elaborate and valuable paper from Mr. Burgess. He was further glad to find that that gentleman's heresies were all abandoned, and that they were now entirely agreed upon every point which he had referred to. The only one matter of discussion now between the Italians and the Germans, was as to the identity of the temples of Vespasian and Saturn; and he entirely agreed with his friend that Vespasian had the best claim to the ruins generally known as the Temple of Jupiter Tonans. Canina was of the same opinion, and therefore it did seem to him that all question was at an end, and that Mr. Burgess, the learned commentator on the antiquities of Rome, having recanted his errors, there were no more to be recanted; and there could be no more discussion on the subject. He had certainly thought of trying to trace the history of the Roman Forum at an earlier period; but as far as regarded the Forum of the Emperors, the conclusions to which Mr. Burgess had arrived must be those to which every man's mind must be brought on a full consideration of the subject. He had forwarded in illustration of Mr. Burgess's paper, a series of photographs of the remains in the Forum as they at present exist; and to these he called the particular attention of the meeting. Referring to the plan exhibited by Mr. Burgess, he explained the certainty now arrived at, that the length of the Forum was in the direction of north and south, instead of east to west; and observed that the original pavement of the time of the Emperors, along which the processions passed from the Arch of Titus through the Forum and up the steep ascent of the Clivus Capitolinus to the Temple of the Capitoline Jove, might still be traced throughout the greater part of its length. The only question, he repeated, was which of the two temples referred to was that of Vespasian, and which that of Saturn. He agreed with Mr. Burgess on that point; and very much for the same reasons. The base of the great statue of Domitian in the centre of the Forum had also been discovered, clearly proving the accuracy of the position assigned to it by Mr. Burgess. As to the Basilica Julia, his impression was that its face was towards the Forum, but Canina was of opinion that that edifice had been completely cleared out and stripped, and that scarcely a fragment of it remained. The ruins commonly called the Baths of Diocletian were now being cleared out, under the superintendence of Canina, whose intention it was to clear out the bases of everything that could be found; and after that, not to fill them up again, but to wall them round, so that the whole might be traced. In a learned assembly like that, there could be no need of an apology for the discussion of where and what the "Forum Romanum" was. Some trifling points might still remain unsettled for archæologists and antiquaries to lecture about; but all the main points were set at rest; and therefore he should be spared the necessity of dealing with a subject which Mr. Burgess had now explained with so much more ability and elegance than he could have devoted to it.

Mansion House.—The citizens of London are about to patronise the introduction of sculpture. The Common Council have it in contemplation to fill the sixteen niches of the Egyptian Hall, at the Mansion House, with sculptured groups or figures. Mr. Bunning, the City Architect, reports that the cost will be about 700*l.* per niche; and recommends, in order that all the niches may be at once filled, that sculptors should be invited to send in plaster casts, and that they should be annually replaced by one or more statues, to be executed in marble by the sculptor who may have contributed the cast.

CAST IRON LIGHTHOUSE TOWER,
ON GIBB'S HILL BERMUDA.



GORDON'S CAST-IRON LIGHTHOUSE TOWER, GIBB'S HILL, BERMUDA.

By PETER PATERSON, C.E.

[*Paper read at the Institution of Civil Engineers.*]

(*With Engravings, Plate* XXVIII.)

SINCE the discovery of these islands by Juan Bermuda, in 1522, the want of a good sea light has been severely felt, the approach being both difficult and dangerous, and although the expeditions under Sir George Somers, in 1609 and in 1613, suffered from shipwreck, and the islands have been in the possession of the British for 230 years, yet, until lately, nothing was done to remedy so serious a defect. To other nations the Bermudas would be of little or no value; but to Great Britain they are important as a naval depôt, and as affording a stronghold and efficient place of refit and rendezvous for the fleets cruising in those latitudes, for the protection of our possessions on the continent of North America and in the West Indies.

A few years since the home government decided upon erecting a lighthouse, and in the expectation that the tower might be built of stone found on the islands, a lantern, and one of Fresnel's dioptric apparatus of the first order, were prepared by the Trinity Corporation; but after some progress had been made in quarrying and dressing the stone for a lofty tower on which to place the light, it was ascertained to be of too friable a character for the purpose; therefore, in 1842, the home government directed Mr. Alexander Gordon, M. Inst. C.E., to design a cast-iron tower, of a similar construction to that which he had previously erected at Morant Point, Jamaica, in the year 1841, and which had proved so successful. The site chosen by the naval and colonial authorities was the top of Gibb's Hill, on the southern part of the Bermudas, in latitude 32° 14′ N., and longitude 64° 50′ W. of Greenwich. This site was determined on, because Bermuda is always approached with the greatest safety from the southward.

The form of the lighthouse, the base of which is 245 feet above the level of the sea, is that of a strong conoidal figure, 105 ft. 9 in. in height, terminated at the top by an inverted conoidal figure 4 feet high, instead of a capital. The external shell of the tower is constructed of 135 concentric cast-iron plates, including those for the doorway. These plates vary in thickness, from 1 inch at the base to about ¾-inch at the top; they have cast-iron flanges on the inside, 4 inches broad (including the thickness of the plate), and are further strengthened, at intervals of 12 inches, by angular feathers ½-inch thick; holes are drilled in all the vertical and horizontal flanges, 6 inches apart, and the plates are united to form the tower, by square-headed screw-bolts ¾-inch in diameter, with nuts and washers.

In the centre of the tower there is a column of cast-iron, 18 inches in diameter in the inside, the thickness of the metal being ¾-inch, for supporting the optical arrangement of Mr. Fresnel, and in which the weight of the revolving apparatus descends. This column was cast in nine lengths, each terminating with circular flanges, to which the floor-plates are bolted. At a height of 2 feet above each floor there is a man-hole, or opening into this hollow column, 26 inches high and 15 inches wide, to which wooden doors are fitted; it is thus enabled to be used during the daytime for passing stores up and down, and it likewise contains the waste-water pipe.

About 20 feet of the lower part of the tower is filled in with concrete, leaving a well in the middle, about 8 feet in diameter, faced with brickwork. There are seven floors, exclusive of the lantern floor, or gallery, each 12 feet in height. The first and second floors are cased with brickwork, and serve as oil and store rooms; the five upper floors are lined with sheet-iron, No. 16 gage, disposed in panels, with oak pilasters, cornices, and skirtings. On the first-floor there is a cast-iron kerb, 10 inches wide and 1 inch thick, on which a cast-iron floor-plate ⅝-inch thick, is fixed by bolts ⅜-inch in diameter. The inner edges of this, and of all the other floor-plates in the tower, are bolted between the flanges of the corresponding parts of the hollow column, by ¾-inch bolts, nuts, and washers. The second-floor consists of ten radiating cast-iron plates, ⅝-inch thick, extending from the brickwork to the hollow column: these plates have flanges on their underside, and are held together by ⅜-inch bolts, at intervals of 6 inches. The third, fourth, fifth, sixth, and seventh floors, are similarly constructed; but the outer edges rest on the upper flanges of the carcase, corresponding with the position of the floors, being bolted to it by the same bolts which connect together the flanges of the carcase. The eighth-floor, and also the floorway, consist of sixteen radiating cast-iron plates, ¾-inch thick, connected together in the same manner as the above, but with ½-inch bolts. All these plates are so arranged as to leave the necessary headway for the staircase on each floor. There are five windows on each floor, one in the centre of every alternate plate in the circle: these windows are 18 inches square, and are fitted with strong wooden ports, opening outwards, in which a plate of polished plate-glass, 9½ inches square, is fixed, for giving light when the port is shut. There is also a window of the same dimensions in the circular well, for admitting light to the staircase; making thirty-six windows in all.

The staircase consists of two wrought-iron stringings, 1⅝ inch square, the risers and supports being ⅝-inch thick, with oak treads 1½ inch thick. To each step there is an iron balluster, ⅞-inch in diameter, on the top of which is fitted a wrought-iron hand-rail, 1⅜ inch wide and ⅝-inch thick. From the level of the bottom of the doorway, to the landing on the first-floor, the staircase rises spirally round the hollow column, the ballusters and rail being on the outer edge of the steps, whilst from the first-floor to the eighth-floor the staircase runs spirally round the respective rooms, the ballusters and rail being on the inner edge of the steps. There are standards and rails round the headways of all the floors; the standards are of wrought-iron, 3 ft. 6 in. in height, and 2 inches in diameter at the bottom, tapering to 1½ inch at the top; there are five of these standards on the first-floor, and three on each of the other floors.

A wrought-iron ring, in four pieces, 5 inches wide and ⅝-inch thick, is attached to the underside of the eighth-floor, by screw-bolts, ½-inch in diameter, to which the lantern and light room are bolted. The gallery railing consists of wrought-iron ballusters, 1¼ inch in diameter, fixed at intervals of 6 inches, and fitted with a rail at the top, 2½ inches wide by ¾-inch thick. The height from the gallery to the centre of the light is 11 feet, and from the centre of the light to the top of the vane is 17 feet, making the total height of the lighthouse 378 ft. 9 in. above the level of high water.

It has been calculated that the light could be seen from the deck of a vessel at the distance of 26 or 27 miles, though, under certain conditions of the atmosphere, it would be visible at a still greater distance, and this at all points of the compass, excepting where obscured by the high land to the north and east, between Gibb's Hill and Castle Harbour.

Much unnecessary delay was occasioned in the erection of this lighthouse, in consequence of the Board of Ordnance appointing a new commanding officer of Royal Engineers stationed at Bermuda, and as the work had to be erected under his directions, and he had to come from head-quarters to his post, to approve of the site selected and of the work as it progressed, under the immediate superintendence of Mr. Grove (Mr. Gordon's assistant), such delays occurred from this government system, that three years were required to do work that might have been accomplished in twelve months. The first parts of the lighthouse were landed in Bermuda about the end of November 1844, and no time being then lost, the first plate was erected on Gibb's Hill on the 19th of December, 1844, and the last plate of the tower on the 9th of October, 1845.

By a parliamentary return, the following is shown to have been the cost of this lofty lighthouse, constructed in so short a time, and in so tempestuous a locality:—

Sums paid to the Trinity Board for the optical apparatus, to Messrs. Wilkins for the lantern, and to Messrs. Cottam and Hallen for the iron-work of the tower in England (where the whole was first erected), including all tools, materials, and freight	£5,436 16 6
Total cost in Bermuda for materials, labour, resident engineer, &c.	2,252 5 10
	£7,689 2 6

The annual expense of maintaining this lighthouse is estimated to be about 450*l.*; the consumption of oil is 18 pints per night.

Besides the immediate benefits conferred by this lighthouse on all shipping approaching the Bermudas, it has also been the means of effecting a beneficial change in the habits and morals of the inhabitants. Owing to the numerous and very dangerous rocks and shoals with which the Bermudas are surrounded, shipwrecks were so frequent, previous to the erection of the lighthouse, that the inhabitants gained their livelihood almost entirely by wrecking; whilst agriculture was wholly neglected, although the soil is naturally very rich and fertile. Since the light has been exhibited, there has not been a single shipwreck, and consequently the inhabitants, finding their former occupation at an end, have been compelled to return to the cultivation of the land, as a means of subsistence; so that the islands now produce oranges and other fruits of the finest description, and in great abundance, as well as contributing some of the best productions for the Pharmacopœia.

Discussion.—Mr. Alexander Gordon said, that owing to the difficulties of the situation, the frequent recurrence of storms in the Bermudas, and the scantiness of the pecuniary means, it was necessary that the lighthouse should be expeditiously executed, and at a small cost; but yet that it should be capable of resisting the destructive force of the hurricanes. Though the lighthouse in question was one of the loftiest which had ever been constructed, and exhibited a light of the most powerful kind, its entire cost, including the trial erection in England, the freight to Bermuda, and the re-erection on Gibb's Hill, was less than 8000*l.* This amount was very small; indeed, he was not aware of any great sea-light having been erected in any part of the world at so moderate a cost. Cast-iron lighthouses were, he believed, first proposed by Captain Sir Samuel Brown, R.N.; but the small light tower on the town pier at Gravesend, constructed by Mr. Tierney Clark, was the first absolutely erected, though Mr. Walker had previously introduced iron lanterns for lighthouses. The first great sea-light, on an iron tower, was that erected by Mr. Gordon, on Morant Point, Jamaica, at the extremity of the low swamps which formed the eastern end of that island; this position was very difficult of access, and was also extremely unhealthy for European workmen. The frequent shocks of earthquakes, in that island, having hitherto prevented the erection of any structure exceeding two stories in height, it occurred to him, that a lighthouse for such a site should be self-supporting, and should therefore be treated as a very large lamp-post; and that the engineer, instead of attempting to build a monument for himself, should design and execute the work with an especial view to economy. It had been recorded in the 'Jamaica Almanack' for 1844, that this lighthouse had several times withstood the shocks of earthquakes and violent storms of lightning, which were, of course, rendered perfectly harmless by the conducting power of so large a surface of metal. He had employed this system of building lighthouses, with a core of masonry or concrete, in the inside, for some height upwards from the base, in several other instances, notwithstanding the objections of Mr. Alan Stevenson, who thought that there would be an expansion and contraction of the metal, and a change going on at the base of the structure which would destroy its stability. Mr. Gordon, however, considered that opinion erroneous, because the metallic shell, or case, insured a perfect bond, which, with the weight of the core, would securely retain the lighthouse on its site. He was so convinced of the correctness of this principle, that he had recommended it for the consideration of the home government, for a lighthouse on a half-tide rock at Simon's Bay, in South Africa. He objected to building a lighthouse in such a situation on piles, or on an open frame-work, similar to those at Fleetwood and on the Maplin Sands, because if the piles or open frame-work were of wood, the worm, or the rot would be liable to cause the destruction of the erection; and if the piles were of cast-iron, they would be exposed to the effect of the chemical action of the salt water, as well as to the heavy blows of the waves, which, being given to the respective supports at different times, would cause great irregularity in their vibrations. It was, in his opinion, to this cause that the destruction of the beautiful structure erected on the Bishop Rock, at the entrance of the British Channel, must be attributed. One of its cast-iron limbs had, doubtless, been struck by a heavy sea, thereby putting it into a state of vibration, differing in amplitude and intensity from that in the other limbs, which would just bring it into the most favourable condition for breaking cast-iron. In answer to observations from Mr. Saunders as to the advantages of the use of wrought-iron in the columnar supports of lighthouses, such as the Maplin Sand, Mr. Gordon said there was no necessity for giving any opinion on the subject of Mitchell's screw-piles, nor did that excellent system require him to do so. It, as well as Dr. Potts's system of sinking a foundation, had both been tried to a considerable extent, by the Corporation of the Trinity House; but as neither of those systems were referred to in the paper before the meeting, he had merely intended his observations to allude to the difficulty of founding a metallic lighthouse of wrought or cast iron, or gun-metal, upon rocks above or under water, and exposed to the action of the sea. Although he had erected several iron lighthouses, they had hitherto been founded on granite, coral, hard sandstone, or slate rocks, and he would not build with cast-iron under high-water mark, unless the core was of such a hard and durable character as to stand alone, in case of the exterior shell being changed into carburet of iron. He hoped soon to be able to communicate to the Institution the results of founding a lighthouse, several feet under water, upon compact limestone; at present he had not determined whether the external shell of the base of the tower should be formed of gun-metal plates, or of lead slabs; but in either case he wished to obtain great inertia, as well as a strong and tight outer bond to resist the action of the sea. He knew little on the subject of the preservation or expenditure of stores in any of these lighthouses. In one lighthouse constructed under his directions the stores and attendance cost as much as 1600*l.* a-year, whilst in that referred to in the paper, it was only about 400*l.* per annum, although the latter consumed more oil; yet he supposed them both to be managed according to his own recommendations. These, and many similar discrepancies, showed that the whole subject of the erection and maintenance of the colonial lights required great and prompt attention from the home government; for although Great Britain had 147 colonial lighthouses, there was, he believed, no regular system of management, and no collection of statistical facts connected with them, nor was there any department of the public service where such necessary information was collected, tabulated, and registered, and from whence any person might obtain information with respect to such lighthouses.

Sir John Rennie believed that a cast-iron structure had been originally proposed by Captain Brodie for the Bell Rock Lighthouse, and it had been favourably reported on by Mr. R. Stevenson.

Mr. Borthwick said Sir S. Brown proposed the first tower entirely of cast-iron; the lighthouse designed by Captain Brodie and Mr. Stevenson was intended to have been an open structure on piles. The pamphlet published by Sir S. Brown, describing his proposed lighthouse, contained a valuable opinion by Dr. Faraday as to the chemical action of salt water on cast-iron.

Mr. Gordon said it was to be regretted that so little was now known of Rudyerd's lighthouse built on the Edystone Rock in the year 1708, which was about 48 years before Smeaton commenced building the present lighthouse: it was constructed entirely of wood, loaded for some height upwards from the base with stone, and fastened down by strong iron dovetailties leaded into the rock: it stood well for 47 years, subject to the action of the sea in that exposed situation, and was ultimately destroyed by fire.

Mr. Walker said, that before replying to Mr. Gordon's observations on the columns for the intended lighthouse upon the Bishop Rock, he would direct attention to a remarkable wooden lighthouse, erected in 1778, and now standing on the Small's Rock, off St. David's Head, and which was in a more exposed position than even the Edystone. The height was 56 feet from the top of the rock, and it consisted of nine oak piles, secured to the rock in a nearly vertical position with four raking shores against the easterly pillars, forming the main support of the building during the westerly storms. Although it was exposed to the whole force of the Atlantic, it had stood for upwards of 60 years, and indeed the wooden standards were affected so little, that the erection was now quite as secure as it had been for some years past. Considering the violence of the sea, it was a wonder the building had stood so well, as from the size of the piles, and their closeness to each other, the resistance to the sea is considerable. During a violent storm in the spring of 1831, a great part of the flooring of the dwelling was forced up, and the stove in the living-room squeezed flat, between which and the side of the dwelling one of the keepers, named Lewis, was jammed, and so much injured that he had to be superannuated, but he died two years afterwards. Two sides of the octagon living-room were also forced in, so that the victuals had to be cooked by the flame of the lamps for eight days, which was the period that elapsed between the commencement of the storm and the time when a landing could be effected on the rock. With regard to the Bishop Rock Lighthouse, it must be remembered that the structure was in a very incomplete state when the workmen left it to stand through a winter, so that it was not at all prepared to resist so violent a storm as that of the 5th and 6th of February, 1850, by which it had been destroyed. At present there was no correct account of the state in which the storm had left it, as no one had since been able to land on the rock; there was, however, no doubt that, at least, the upper part of the columns had been carried away. He wished Mr. Gordon had exercised a little more patience, and had not brought the subject forward in Mr. Walker's absence, nor until it had been possible to ascertain its actual condition, in order that the Institution might have been more accurately informed of the extent and nature of damage the structure had received. Immediately after the accident had been announced, the Trinity House, at Mr. Walker's request, had sent down Mr. Douglas, who erected the building; but no communication had yet been received from him.* Mr. Walker would, however, be happy to give any information in his power to the Institution, because he thought it was perhaps more important that the profession should be acquainted with those attempts which had failed, rather than with those which were successful. With respect to the resistance of the action of the sea, it was proper to observe that in consequence of the approach of bad weather, the central column, which was 3ft. 6in. in diameter, had not been filled up, as had been intended. The first operation in the ensuing spring would have been to have inserted the inner pipe, which was to form a tank for water, and also to strengthen the lower part of the building. The space between the inner and the outer pipe was also intended to have been filled up with concrete, so as to form a solid mass for 20 feet above the surface of the rock; if these and some other alterations had been effected, it was not improbable that the building would have been enabled to withstand the storm, even in its unfinished state, and the experiment would have terminated more satisfactorily. Economy had been one of the main objects of the Trinity Board, for the cost would not have been more than from one-sixth to one-tenth part of that of a stone building. As Engineer to the Trinity Board, he proposed a building entirely of granite or of stone up to a height of 20 feet or 30 feet above high-water mark, with a superstructure of cast-iron; but the corporation preferred one entirely of cast-iron, and determined to try the experiment. The arrangement was to allow the cast-iron columns to stand during the winter, in order to test their strength; and it was to be lamented that there was not time to complete the centre column, for even in its unfinished state it had resisted the storms up to the 6th of February. A few weeks before that period, the rock had been visited, at his desire, when the piles were found standing as perfect as when they were left at the end of the previous summer—a proof that nothing less than a very severe storm could damage the columns, even in their unfinished state. The work had been well put together by Messrs. Robinson and Son, of Pimlico. Inside each column there was a wrought-iron bolt, 4 inches in diameter, with its dovetailed end sunk into the rock, to a depth of 15 inches below the bottom of the columns; this bolt gradually diminished to 3 inches at the top, where it terminated with a nut and screw, and the space between the bolt and the column was filled in solid with iron cement, so that each was firmly tied down to the rock. Although he thought any discussion was premature, in the present state of information, as to the actual condition of the structure, he was desirous of imparting to the Institution even the imperfect information he had been enabled to collect. The original drawing of the building had been altered and strengthened when it was sent to Mr. Walker by the Trinity House; and although he did not design the structure, and should have preferred a stone building, still he would not have been connected with it at all, unless he had expected the iron lighthouse would have succeeded. The Maplin and the Point of Ayr lighthouses were both columnar structures. The former was erected in the year 1838-9, on a sand-bank, and was supported on Mitchell's screw-piles, with wrought-iron standards, which formed the best foundation in such localities. The Point of Ayr lighthouse was a modification of that system, which had been adopted because an agreement could not be effected with the then proprietor of the patent; both lighthouses had stood perfectly well, and under similar circumstances he should always adopt the system of screw-piles.

Mr. Scott Russell inquired whether the great danger to a construction on submerged rocks was not so much from the force or pressure of the waves as from the chance of a wreck being driven against it. The destruction of the temporary barrack on the Skerryvore Rock was attributed by Mr. Alan Stevenson to such an occurrence; and it could be well imagined how formidable a blow would be given by the hull of a ship, cast with the impulse of the waves against the base of such a structure, as had been described. He suggested the propriety of considering the possibility of guarding against such an accident, which would be fatal to any kind of structure of considerable height, standing on a base of limited dimensions.

Mr. Walker said there was not any account of a wreck having struck the building; in fact, nothing was as yet known respecting it. He did not think any iron building would be so suitable to the site as the columnar kind of erection, which had been attempted. A mere casing of iron filled in with concrete, unless it had been so fixed as to form a portion of the rock, as at the Edystone, would have been upset by the waves of the Atlantic. It would certainly have been very desirable to have had a larger base, but the size of the rock would not admit of a greater extension for the base than 30 feet between the columns.

General Pasley observed that the external surface of cast-iron, continually immersed for a considerable length of time in salt water, became soft, and the metal would in time give way; but that no perceptible action could be perceived either on lead, brass, or copper, under similar circumstances.

* Mr. Douglas succeeded in reaching the rock on Sunday the 24th of February, 1850, when he found all the cast-iron columns and the internal wrought-iron rods had been broken off at different heights, varying from 1 foot to 6 feet from the surface of the rock; but that all the points of attachment remained uninjured, and the rock itself was not torn up.—*Sec. Inst. C.E.*

ON THE MANUFACTURE OF MALLEABLE IRON, AND RAILWAY AXLES.

By George Benjamin Thorneycroft, Assoc. Inst. C.E.

[*Paper read at the Institution of Civil Engineers.*]

Malleable iron may be divided into two distinct classes—"Red-short" and "Cold-short," the former being generally produced from the rich ores, and the latter from the poorer, or leaner ores.

The pig-iron made from the rich ores (under the cold blast process only) is not so fluid as that from the lean ores; when, however, it has been converted into malleable iron, it is tough and fibrous when cold, but is troublesome and difficult to be worked by the smiths at less than a white heat; this want of ductility has caused it to be denominated "Red-short."

The pig-iron produced from the lean ores possesses, on the contrary, more fluidity, and it is thence well adapted for small castings; but when it is manufactured into malleable iron, although in the hands of the smith it is ductile and is easily worked, even at a dark red heat, it becomes, when cold, weak and unfitted to support sudden shocks, or continued strains, and is hence called "Cold-short."

It is obvious, that to obtain qualities of iron suitable for the various purposes to which it is now applied, a judicious mixture of these two kinds must be made; but even this will not suffice, unless the pig-iron, forming the basis, be of a proper quality. It may be received as an axiom, that good malleable iron can only be made from good dark, and bright grey pig-iron, smelted from iron ore alone, or with a very small admixture of any extraneous substance. Iron made from white pig-iron alone is never ductile, although it may be cold-short, whilst it differs materially from the red-short iron, made from rich ores; in fact, it possesses no good quality either hot or cold, and may be termed "Rotten-short."

The quality of the fuel used in the smelting-furnace and in the subsequent processes is very important, for the produce of the best ores may be rendered utterly worthless by the use of inferior fuel; on the other hand, iron made from rich ores, and having great strength when cold, but which cracks in working at a red heat, if smelted with very pure coal, or charcoal, retains all its strength; whilst it becomes much more ductile than if an inferior quality of fuel had been used. Hence, when a strong ductile iron is required, the best fuel must be employed in its manufacture.

The introduction of hot-blast for smelting iron rendered necessary a careful investigation into the comparative use of hot and of cold blast pig-iron in the manufacture of bars; the result of this would appear to indicate that if the same quality of materials be used in both cases, equally good bar-iron will be produced; but it is more difficult to convert the hot-blast pig-iron into "number one" bars, and the waste is greater, than when cold-blast iron is used.

It is certain, that whilst good grey pig-iron can only be produced, by cold-blast, from the best materials, iron of apparently excellent quality can be produced, by hot-blast, from the most sulphureous ore and fuel; indeed, to this alone must be attributed the bad reputation of hot-blast iron for certain purposes. Castings for the forge and mill, such as rolls, housings, hammers, anvils, &c., which require great strength, as being subjected to considerable strain, or to sudden concussion, should not be made of hot-blast iron. Wherever strength and durability are required, a mixture of qualities of iron is essential, in order to produce metal having a bright grey fracture, slightly mottled, which is the best quality. Any nearer approach to grey renders the casting weaker, as the more highly carbonised cast-iron becomes (whether hot-blast, or cold-blast), the softer and weaker it becomes, and it can only have strength imparted to it by a due admixture in re-melting. This mixture is generally the result of the experience of the workman, as no definite system has been laid down, nor have a sufficient number of experiments been made to establish any certainty on the subject.

The same kind of distinction takes place in the texture as in the character of malleable iron—that is, the red-short quality is most inclined to possess a fibrous texture, and the cold-short to present a crystalline or granular fracture, though these characteristics can be materially modified, or altogether changed, by judicious mixture and by re-working, and even fibrous iron can be made very ductile; this quality, however, will become granular when a number of bars, all of the best quality, are bound together, and subjected, in the process of faggotting, to a sufficient degree of heat to weld them into a homogeneous mass; but if that mass be worked down again with a moderate heat into bars of the same size as those from which it was originally made, the fibrous texture will have been recovered. Such iron, whilst in the granular state, will bear impact better than if it had been made of bars whose texture was originally granular.

Malleable iron becomes granular from two causes: first, in consequence of being made from naturally cold-short pig-iron; and secondly, from a peculiar manipulation during the process of "puddling." If the iron be made up into balls as soon as the granulated particles will stick together, or as the workmen term it "put together young, before it has got into nature," the texture will be fine, and close-grained, and the fracture will present a bright granular appearance; such iron will not, however, bear sudden impact, nor will it become fibrous in texture by working until it is reduced into very small bars, or into plate-iron. All granular iron is much harder when cold, and will endure longer than fibrous iron, although it is not so well adapted for general purposes.

It is easy to give a fibrous fracture to iron, by welding the "pile" or "faggot" at a low heat, so that the interior does not become thoroughly solid; but if a pile be subjected to a sufficient degree of heat to make it perfectly sound, and the iron presents a fibrous fracture throughout, when reduced to 1¼ inch square or round bars, the quality must be very good.

It has often been asserted that the peculiar quality of some of the Yorkshire iron ores caused the fine granular texture by which the malleable iron of that country is distinguished; the author has, however, uniformly dissented from this opinion, and in order to test the fact, some pig-iron was converted into bars in Yorkshire, and a portion of the same metal was sent to the Shrubbery Ironworks, Wolverhampton, where it was worked up into bars of the same size; the result of this experiment completely verified the author's opinion, as bars of the finest granular fracture, and of the strongest fibrous texture, were produced from the same quality of Yorkshire pig-iron.

Identical results were obtained from Staffordshire pig-iron when subjected to different kinds of manipulation.

Swedish iron often presents, in the same bar, both a fibrous and granular appearance. This arises from the method of manufacture, which is very simple:—One end of a long pig of iron is placed in a charcoal refinery, and as much metal is melted off as will make a bloom; but the workman commences working it as soon as it begins to melt, and continues to do so until the quantity required for the bloom is melted off into the fire; and when the mass will adhere together, the bloom is brought out and hammered into a bar. It must be evident that by such a process the first portion will have been subjected to a much greater amount of manipulation than the latter, and thus two qualities of iron, or degrees of malleability, are produced in the same bar.

Independently of the alterations of texture which arise from peculiarities in the process of manufacturing iron, great changes are induced by certain actions upon it when cold. Compression, or impact upon the end of a bar of iron, will alter its texture from a fibrous to a granular character. This is well exemplified by two tools used by forgemen. The first is the "gag," which is a short bar of iron, of about 2 inches diameter, employed for holding up the end of the large helve during the intervals of working; it is subjected to impact endways whenever the lower end is placed on the anvil, and the other receives a vertical blow from the helve falling about an inch upon it. However fibrous may be the quality of iron used for making the "gag," it soon becomes brittle, and literally falls to pieces, as if it were made of cast-iron.

The second instance is that of the tool employed in puddling, one end of which is constantly subject to blows from a small hammer, in order to detach the metal which adheres to the other extremity; after being some time in use, it frequently breaks at a slight blow, exhibiting a perfectly granular fracture.

If a bar of fibrous iron be bent down at a short angle, the fibres of one side are compressed, and those of the other side elongated; and after being bent back again, the fracture on the compressed side will exhibit a granular appearance, having evidently lost the fibre and been broken off short.

A bar of iron reduced in the centre and used as the connecting-rod of a steam-engine, by being subjected to constant vibration, or bending, will soon break at the middle, and the fracture will be perfectly granular, although it may have been originally made of the best quality of iron. The connecting-rod for working the large shears in rolling-mills, and the rods of deep pumps, when they are so small as to bend or vibrate at each stroke, are further examples of this action.

Iron-shafting in mills working horizontally being generally too strong to bend, or to vibrate, apparently retains its fibrous quality, even when twisted asunder by a sudden action; but if it be so deficient in strength as to bend and vibrate whilst at work, it soon loses its fibrous nature and is destroyed.

Railway-axles should be made parallel from journal to journal, and of sufficient strength to prevent any vibration in rotating. If this general rule were adopted there would not be any change in texture, and consequently a less number of fractures would occur. If it be considered necessary to reduce the substance of the middle of an axle, it would be safer to use good granular iron at first, as it is naturally much stiffer and less liable to bend and vibrate than fibrous iron, and would probably not change its form so soon, or receive injury whilst working under ordinary circumstances. It is, however, the author's opinion that axles should be perfectly rigid, so as not to bend or vibrate, even if that should have to be accomplished by making them somewhat larger in the centre, like the connecting-rod of an engine.

Many other causes of change could be adduced, but enough has been stated to prove that the compression of iron, when cold, is certain to change fibrous into granular iron, and that vibration or bending, even to a slight extent, if continued for any length of time, has the effect of compressing all the particles consecutively.

A series of experiments was carefully made for the purpose of ascertaining, practically, the best form for railway-axles, so as to obtain the greatest strength with a given weight of material. From these experiments it would appear that the forms generally adopted are very erroneous, especially in reducing the substance of the middle of the axles, and in turning rectangular shoulders near to the journals; and they proved, that by simply moving the face of the wheel back from the neck of the journal, the strength to resist impact was increased in the ratio of 100 to 30; that the relative strengths to resist impact where there is no shoulder, and where there is one, is in the ratio of 155 to 55; that the strength of a parallel axle compared with one which has been reduced in the middle, is in the proportion of 5 inches to 1½ inch. Again, it is well known that the strength of round bars to resist transverse strain is as the cubes of their diameters, which would give the parallel axle an advantage over the reduced axle in the proportion of

83·74 to 58·18; and as the same law obtains in reference to torsion, if the velocity is the same, the strength to resist torsion will be in a like proportion.

Mr. Thorneycroft said, that though many discussions had taken place, at different times, on the subject of the crystallisation or granulation of axle-bars, no decision had yet been arrived at on the subject. He was prepared to concur with Mr. Stephenson in the opinion that if the iron was fibrous when worked into an axle, no subsequent jarring motion would alter its character. The granulation of iron might arise from various causes, but nothing so surely affected it as when a bar of iron was gradually bent, so that the fibres on the inner side would be compressed, whilst those on the outer side were extended; and as this process was continued, so the granulation progressed. He did not think that nicking the iron would materially influence the appearance of its fracture, nor would a blow, which merely caused a jar, destroy the fibrous character of the iron. This was well exemplified by two pieces of iron exhibited, which had been used as liners for a tilt hammer. That portion of each which had been compressed by blows, was granular in its fracture, whilst that which had been subjected to constant vibration remained very fibrous.

With regard to the forms of railway-axles, it appeared to him, from the experiments, that the nave of the wheel should not be placed close to, but at some little distance (say ¾-inch) from the neck of the journal; also, that the shoulder behind the wheel should be entirely done away with; and instead of reducing the diameter of the axle in the middle, it would be advisable rather to increase its bulk at that point, like the connecting-rod of an engine. He had never heard of a single case in which the texture of a fractured parallel axle had been changed from a fibrous to a granular character, although a certain amount of granulation had been repeatedly observed with axles which had been reduced in the middle, and had then been broken in course of regular working. It appeared in all such cases as if there had been a progressive and alternate action of compression and extension of the outer fibres, from the bending of the axle whilst it was rotating; and that thus the granular fracture had been produced.

Discussion.—Mr. Gibson said he did not consider it a fair test of the strength and utility of an axle to subject it to hammering, but that it would be preferable to deduce results only from practice. He had found that those axles which were parallel throughout did not bend in the centre, but at a distance of from 7 inches to 24 inches from the nave of the wheel; whereas axles which were reduced in diameter in the middle, almost invariably bent in the centre. He thought the shoulder behind the wheel was advantageous when of a curved form, but not when it was square to the body of the axle. The shoulder merely served as a gauge for keying the wheels accurately on to the axle.

Mr. Beattie thought the quality of the iron used in the manufacture of railway-axles was so important, that he had always advocated the use of the very best material; and to that precaution might in a great measure be attributed the comparative freedom from broken axles on the South-Western Railway. With regard to the form of axles, he preferred those without shoulders, and which were uniform in section between the wheels, because any vibration produced by sudden or violent blows, from the flange of the wheels coming in contact with the rails, or passing through points, or crossings, would then be more equally distributed; whereas, if the axle was diminished in the centre, the vibration and strain would terminate there, so that the texture and cohesive quality of the iron would, in time, be completely destroyed. It was certainly very disadvantageous to place the nave of the wheel close to the neck of the journal, and shoulders were injurious both to the strength and durability of the axle; and in fact were, in many instances, the cause of their breaking; if, however, it was thought desirable to have shoulders, as gauges for keying the wheels up, they should certainly never exceed $\frac{1}{16}$-inch in projection.

Mr. Joseph Freeman said, as a proof of the importance of the best material and of good workmanship being united in the manufacture of railway-axles, he might mention that there was not an instance of an axle made by the Low Moor Iron Company having ever been broken in work; this must be attributed to these combined causes. Much had been argued as to the particular form of the axle, and so far the Low Moor Iron Company agreed with Mr. Thorneycroft that the parallel axle was the preferable form; but he must contend that good material and sound workmanship were the main points.

Mr. Thorneycroft said that the whole series of experiments he had tried strongly confirmed his previous opinions. He had lately examined fifteen engines in iron-works in Staffordshire, including ten engines in his own works, and had found in all of them that the crank-pin was placed in a line with the neck of the journal, thereby receiving the strain in the weakest place, and causing constant accidents; now, if the crank-pin had been made ¾-inch, or even 1 inch longer beyond the face of the crank, leaving a space between it and the spear-rod, the liability of accident would have been much reduced, by the strain being thrown on a part of the pin less liable to commence fracture. If a shoulder was left on an axle, it should be curved, for, if it was left square, it would induce fracture at that part. It would appear that there was a constant progressive tendency to fracture, wherever opportunity was afforded for commencing. Now a parallel axle did not afford any spot for the commencement of fracture; on the contrary, the fibres extended unbroken throughout the length of the bar; and, unless from the undue weakness of the axle, a constantly recurring bending action occurred, by which the whole external fibres were compressed *seriâtim* as the axle rotated, there could be no tendency to break it; it was therefore important not to weaken an axle by diminishing the centre of it. In conclusion, though an axle reduced in diameter in the centre might never have been broken, yet it was much more liable to be bent than a parallel axle, and as bending could not take place without compression, which he had shown completely destroyed the fibres of the iron and subjected the parts to sudden fracture, care should be taken to avoid bending in the least degree.

NETHERLANDS LAND INCLOSURE.

The interest which this remarkable work excites has induced us to bring together a few facts relative to it for the benefit of our readers. The kingdom of Holland, as well as a large proportion of the Lowlands adjacent to it, is undoubtedly formed by the depositions of alluvial matter which are brought down from the upper countries of Germany and France by the Rhine, Meuse, and Scheldt rivers, and which, being repelled back by the pressure of the winds and tides from the German ocean, have formed the numerous sandbanks at their embouchures. The immense deposit of the Dogger Bank, exceeding 1100 square miles in extent, is supposed to have been formed by the meeting or confluence of the tides from the German and Atlantic Oceans in that vicinity. These sandbanks are gradually elevated by the deposition of argillaceous and vegetable matter, until being covered with grass they are embanked from the sea, and are then termed *schorres* or *polders* in Holland and Belgium. These polders are generally bounded by sandy plains or slight elevations of land, beyond which the tide rarely rises, and there the first embankments are generally supposed to have been commenced. The polders, therefore, are lands which have been acquired from the sea or rivers by embankments sufficiently high to keep out the highest tides. Previous to the embankment the Lowlands were intersected by creeks and inlets, some of them of great extent and depth, and which formed the ports of Ostend, Nieuport, and Damme, which were formerly of greater depth than at present. To these different causes of natural destruction the hand of man has contributed not a little. The period when the first inclosures were made is uncertain. The earliest embankments are attributed to the Danes and Normans in 836, during their invasion of Zealand. The ancient chronicles of Zealand affirm that the Islands of Walcheren and Schowen were not only recovered from the sea previous to 833, but were covered by numerous villages and houses. But the islands of Duveland, North and South Beveland, Wolfersdyke, and Tholen were not completely recovered until after 850. But the embankments were not always successful, and the disastrous inundations which have occurred at different periods, over the lands which border the lower Scheldt, from the year 820 would form a painful history of destruction as well by the hand of man as of nature.

The alluvial lands which are now proposed to be embanked are situated in the channel which communicates between the East and West Scheldt, and which separates the eastern end of the island of South Beveland from the western of North Brabant. The whole extent of alluvium exposed at low water of spring tides is not less than 40,000 English acres, so that at this period of the tide the depth of water in the channel is scarcely two feet, and it will very shortly be entirely silted up at low water. This vast deposition of alluvium is gradually rising on both sides of the channel, and it only requires to close the communication between, by means of a dam, to occasion the whole to be rapidly silted up.

In the year 1846 a project was brought forward, and a concession obtained, by an enterprising gentleman of Middleburgh, in the Island of Walcheren, M. Dick Dronken, for making a canal and railway from Flushing, through Middleburgh, across the channel of the Sloe, which separates the island of Walcheren from North and South Beveland, by means of an embankment across the Sloe of nearly one and a half mile in length, 40 feet in width, and 13 feet above high water. The line of railway was to have been carried through the whole length of the island of South Beveland, and thence across the East Scheldt channel, by means of a similar embankment five miles in length, and thus join the main land near the village of Woendrecht, leaving an opening in the line of the channel for the passage of vessels. It was in 1846 that Mr. G. Rennie was called upon to report his opinion, when, having surveyed the whole line, he reported the project was not only feasible but that it presented besides the advantages of the direct communication of the railway and canal between the continent and England; it would "cause vast accumulations of alluvial land in the estuaries of the Sloe and Scheldt, passages which, if stopped up as he proposed, would not only benefit the Western Scheldt, and assist in clearing away many of the sandbanks which now obtrude the entrance to its mouth, but be the means of calling into existence large tracts of valuable land equal in extent (to 40,000 or 50,000 English acres) to pay the whole cost of the railway." He further proposed to continue the Middleburgh Canal across the Sloe and passages, so as to open a more direct communication between Flushing and Rotterdam, by which the intricacies and dangers of the present communication between Rotterdam and the sea would be avoided. These projects were checked for the time by the disasters which befel the railway market; but the advantages which they presented were not lost sight of, and they were brought before the King of Holland and his government, and the favourable report of M. Greve, a Dutch engineer of eminence, of the Waterstadt, in confirmation of the report of M. Theimmens, the engineer who made the surveys in addition to those of M. Greve and Mr. Rennie, led to the formation of the present scheme, which is part of the original, by an Anglo-Dutch and Belgian Company.

The object of the present concession is to inclose 14,000 French hectares of alluvium, or 34,580 English acres, from the intermediate channel of the West and East Scheldt by means of an embankment thrown across it upwards of 4 miles in length and 4 mètres (13·16 feet) above high-water spring tide, with a width at the top of 6 mètres, or 19¾ feet, with slopes on either side of three horizontal to one perpendicular. The situation of the embankment will be between and near the Fort Bath on the Island of South Beveland, and the village of Woensduct on the main land. But it is enacted, by the terms of the concession, that the embankment shall not be made until a canal of large dimensions be made across the Island of South Beveland, with sluices of suitable dimensions, capable of passing the largest vessels which now pass the old navigation. The site chosen for the canal commences at a small hamlet and creek, called Hanswert, which is directed in nearly a straight line by the villages of Schorre-de-Vlake and Wemeldinge to the channel of the East Scheldt, for a distance of 10,000 mètres, or about 6 English miles. The width of the canal will be 10 mètres, or 32·47 feet wide at the bottom, with slopes on both sides of 2½ to 1, while the depth will be 8 mètres, or 25¼ feet deep at high water. There will also be provided at each end locks of large dimensions, and harbours of entrance outside the locks, well protected by jetty heads.

Three years are allowed for the completion of the canal, and six years for the embankment across the East Scheldt branch. It being considered essential by the government that the old passage should be kept open until the completion of the canal, permission, however, is given to inclose a portion of the conceded lands, amounting to 5568 hectares, or 13,752 English acres, without interfering with the navigation of the channel of the East Scheldt; and it is upon these works that the engineers, Sir John Rennie and M. Muller are engaged. The land now being embanked is higher by 6 feet than the land in the interior of the Island of South Beveland, and opposite the present embankments the land near the shore is 12¾ feet above low water; and so rich is the deposits that it is calculated that it may be sown and cropped for upwards of twenty-two years without manure; and the crops in coleseed, barley, wheat, beans, flax, &c., are worth from at least 600 to 1000 francs per acre; and these examples are confirmed by the produce of other lands in the neighbourhood. The crops on the neighbouring lands are most extraordinary; and M. Greve, an eminent Dutch engineer of the first class, states, that 5568 hectares, or 13752 English acres, are ready for embankment at present; that 10,000 hectares, or 24,777 acres, in three years, and the remainder in nine years, and taking the land at 50*l.* per acre, which we are assured is too little, the total value of the land which will be derived from the present concession will be not far short of 2,000,000*l.* sterling; and if we deduct 20*l.* per acre as the cost of reclaiming the land, there will remain to the shareholders a disposable fund of nearly one million of money.

REGISTER OF NEW PATENTS.

HYDRAULIC MACHINERY.

(*With Engravings, Plates* XXIX. *and* XXX.)

Richard Roberts, of Manchester, engineer, for *improvements in machinery or apparatus for regulating and measuring the flow of fluids; also for pumping, forcing, agitating, and evaporating fluids, and for obtaining motive power from fluids.*—Patent dated October 17, 1851.

These inventions consist—

1. In rendering the force of the fluid to be regulated available as a power for opening and closing the valve or other apparatus used for that purpose.

2. In constructing rotary meters for measuring the flow of fluids, with spiral passages in the external casing to impart rotary motion to the fluid to be measured.

3. In constructing the measuring wheel of rotary meters with straight, instead of spiral or curved, vanes.

4. In tapering the vanes of rotary meters at their lower edges so as to cause them to describe the frustrum of an inverted cone, revolving in a corresponding cone at the delivering end of the spiral passages herein secondly before-mentioned.

5. In making the delivering end of the casing of rotary meters slightly conical, and the extremities of the vanes of the wheel taper to correspond with it; the object of which provision is to allow foreign matters to pass, without, as nearly as practicable, impeding the action of the meter.

6. In the application of an oscillating cylinder or chamber, furnished with a piston or plate, to meters for measuring the flow of fluids, and in certain machinery or apparatus connected therewith.

7. In certain improved applications of yielding substances to meters for measuring the flow of fluids, whereby the pressure on the outgoing fluid during the reversal of the ports is maintained nearly equal to that on the incoming fluid.

8. In the application of suitable apparatus for allowing the escape of air from fluid meters.

9. In constructing pumps having spiral or curve vaned wheels in such wise that the wheel and its shaft shall act as a counterbalance to the rising column of fluid; also in the application of a floater in the upper end of the delivering pipe, in connection with a valve, to prevent the return of the fluid.

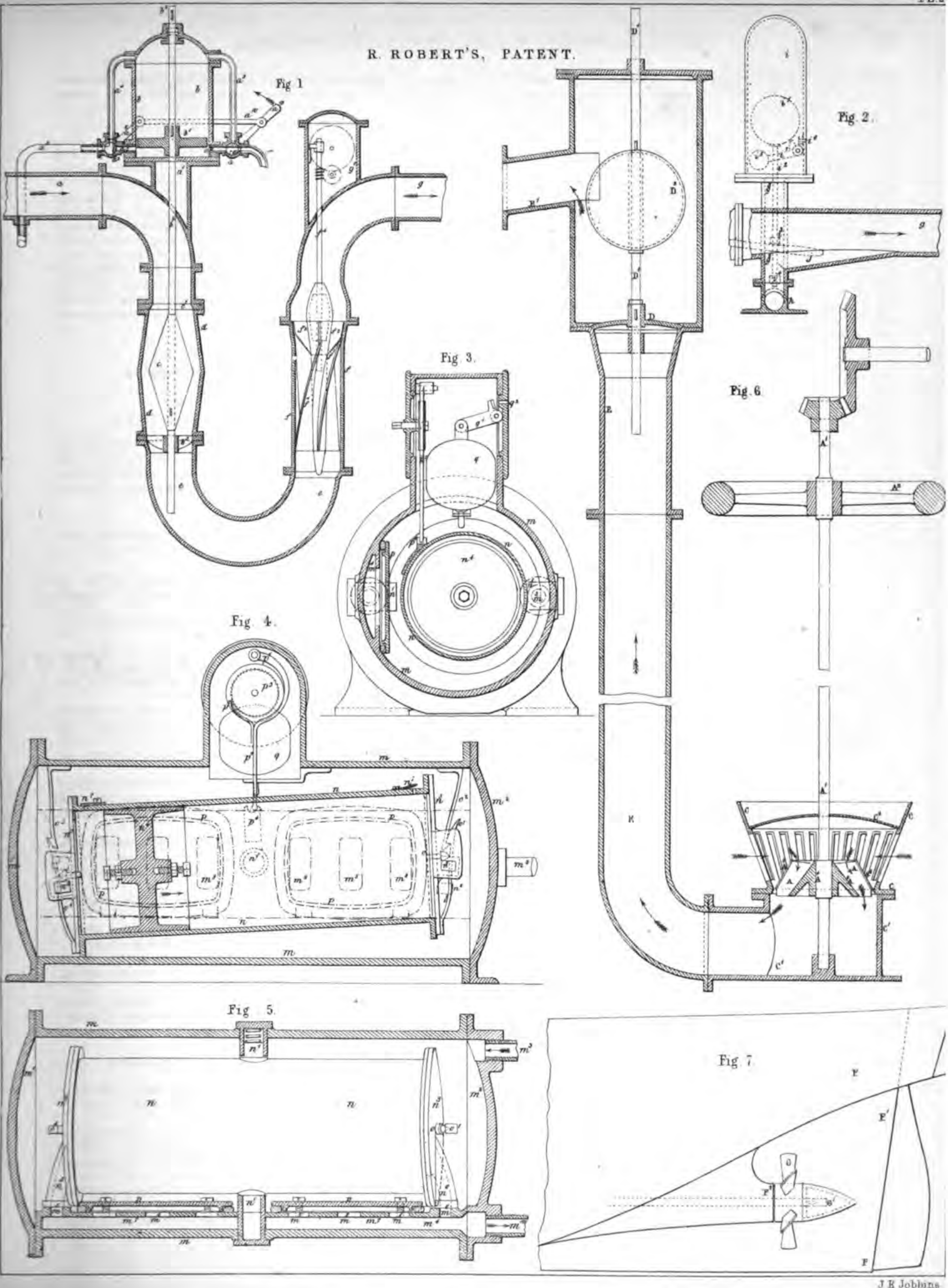
10. In certain improvements in machinery for forcing fluids, whereby motion may be given to vessels with greater economy of power than can be given by the forcing machinery now in use.

11. In a new combination of machinery for agitating fluids, more particularly applicable to churning.

12. In suspending the drums of centrifugal-action machines from their vertical driving-shaft by means of cords, chains, or links.

13. In increasing the evaporation of fluids by inclosing or partly inclosing the same, and conducting the vapour arising therefrom to a flue or chimney in which rarefaction is produced by the heat employed to evaporate the fluid.

14. In evaporating the moisture contained in warps or piece goods by causing the same to pass through an inclosed heated chamber connected with a flue or chimney in which rarefaction is produced by the heat from the chamber.



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15. In employing a current or a jet of steam to increase the draught for carrying off the vapour in chimneys used in connection with apparatus for evaporating fluids.

16. In evaporating fluids by causing the rarefaction of the air in the chimney connected with the pan to produce a current of air through tubes having their inner end immersed in the fluid in the said pan.

17. In obtaining motive power from fluids in their passage from a higher to a lower level, by conveying the fluid down what is called the longer leg of an inverted syphon, and up the shorter leg, which is furnished with curved or inclined divisions to give the requisite direction to the water, in order that it may act effectively upon a spiral wheel or a turbine through which the motive power is transmitted.

18. In employing two spiral wheels or turbines placed one above the other over the short leg of the syphon, which in this case may be furnished with curved, inclined, or straight divisions.

19. In applying the power of a column of water acting upon a piston to the opening and closing of lock and dock gates, swing bridges, and other machinery of the like nature.

20. In the direct application of the pressure of steam or water for compressing or packing goods, for hooping barrels and casks, and for the like purposes.

Regulation of the Flow of Fluids.

Fig. 1 is a sectional elevation of one of the improvements in machinery for regulating the flow of fluids, to which is connected an improved rotary meter. a, is the supply-pipe from which rises the branch a^1; to the flange of this branch is bolted the cylinder b, with a piston fixed on a rod, the upper end of which passes through a stuffing-box in the cover of the cylinder, for the convenience of closing the valve when the pressure in the pipe a, is insufficient; the lower end of the rod is guided by a cross-piece. a^2 is a two-way cock connected by the branch pipe a^3 to the main-pipe a, and by the pipes a^4 and a^5 to the cylinder b; a^6 is a lever attached to the plug of the tap a^2; a^7 is another double-way cock connected to the cylinder by the pipes a^8 and a^9; the levers a^6 and a^{16} on the plugs of the cocks are connected together by the link a^{10}: the object of these will be explained hereafter. To the rod is fixed a plug or valve c, which is inclosed by the enlarged pipe d, the area of the space between the greatest diameter of the plug or valve c, and the greatest diameter of the pipe d, being equal to the area of the supply-pipe a. The ring c^1 serves as the seating for the valve c. e, is a bent pipe connecting the pipe d, of the regulating apparatus to the pipe f, of the meter, in the upper end of which is shown one of the improved apparatus for measuring the flow of the fluid before it enters the delivery pipe g. The measuring apparatus consists of the pipe f, with the spiral or curved divisions f_1, and of the revolving wheel f_2, the vanes of which are straight on their faces to allow air to pass without giving motion to the index. The lower edge of the vanes in the wheel are bevilled to suit the bevil of the upper edge of the stationary divisions f_1, the object of which being to allow foreign matters to pass through the meter without injury to it. The arbor or spindle, on which the vane-wheel f_2 is fixed, is made free in its bearings, so that the increased pressure caused by foreign matters contracting the passage may cause the vane-wheel to rise a little and allow the obstructing matter to pass. The registering apparatus shown in the chamber g^1 consists of the arbor or spindle, on which is a worm that works in a wheel fixed to a pinion gearing into a wheel the axis of which passes through the side of the chamber, and gives motion to the index on the outside, which index may be of the ordinary kind.

The engraving represents the various parts of the regulating apparatus in the positions they occupy when the valve c, is fully open, and the full quantity of water is supposed to be passing through the pipes. On the attendant wishing to reduce the flow in the main pipe, he turns the handle a^{16} in the direction of the arrow, until the plug a^2 assumes the position to direct the fluid to the underside of the piston instead of to the upper as before, and at the same time causes the plug a^7 to close the passage a^9 and open the passage a^3, to allow the fluid in the upper part of the cylinder b, to pass off. As the conical valve c, is raised by the ascent of the piston, it contracts the annular passage in the seating c^1, and thereby reduces the flow of the fluid. The principal advantage derived from this arrangement of machinery is that the pressure of the water in the main pipe a, is made to raise or lower the regulating valve c, by the attendant exerting only the power required for reversing the cocks a^2 and a^7, as before described.

Fig. 2 represents an elevation, partly in section, of another of the improvements in regulating the flow of fluids. To the underside of the delivery pipe g, is cast a branch g^2, to which is bolted the double-elbow pipe h, upon the longer leg of which and the blind branch g^3 the air-chamber i, is bolted; i^1 is a floater attached to a rod which passes through a stuffing-box at the bottom of the air-chamber. To this rod are fixed set collars, which act upon the lever j, to open and close the cocks a^2 and a^7 in the manner hereinafter explained. In order that the fluid may rise into the air-chamber i, a small orifice is made at i^3, which allows the air to escape until the fluid raises the small floater i^2 sufficiently high to cause the short arm of the elbow-lever i^4 to close the orifice. When the fluid in the delivery pipe is at its usual pressure, the floater is maintained near the upper end of the air-chamber, and the lever j, has its right-hand end supported by the set-collar, in which position of the lever the tap a^2 admits the fluid into the cylinder b, above the piston, so as to cause it to keep the valve c, open. When, from the bursting of a pipe or other cause, the fluid in the delivery pipe g, falls much below the usual pressure, the floater descends, and the set-collar, by depressing the right-hand end of the lever j, causes the opposite end, through the links j^1 and a^{10}, to reverse the positions of the plugs a^2 and a^7, in which latter positions the fluid enters the cylinder b, below the piston, which then elevates the valve c, into the position indicated by dotted lines, and closes the passage for the fluid.

The peculiar shape given to the branch pipe g^2, which is open on its upper side to the main pipe g, will allow any greatly increased velocity of the current in the discharge pipe g, to reduce, by friction, the pressure in the air-chamber i, below the pressure in the discharge pipe, and consequently the valve to be speedily closed.

Measurement of the Flow of Fluids.

Fig. 3 represents a transverse sectional elevation of an improved oscillating meter for measuring the flow of fluids; fig. 4 is a longitudinal, and fig. 5 a plan view of the same, also in section. m, is the outer casing, furnished with the lids m^1, m^2; n, is the inner cylinder, which oscillates on the trunnions n^1, supported in bearings attached to the outer casing m. The lids n^2, n^3, close the ends of the oscillating cylinder, which is provided with a piston n^4, made tight in any approved manner. The fluid enters the outer casing m, through the pipe m^3, screwed into the lid m^2, and into the oscillating cylinder n, when in the position shown in the engraving; through the port n^5 in the lid n, and urges the piston n^4 in the direction of the arrow in fig. 4, forcing the fluid between the piston and the lid n^3 (whenever fluid is being drawn off); through the port n^6 in the lid n^3, and the port m^6 in the partition m^7; through the passage m^4 and pipe m^{10}. When the piston n^4 arrives nearly close to the lid n^3, the set-screw in the piston acts against the pin o, in the lid n^3; and the head of the pin o, by pressing against the spring-catch o^1, liberates its upper end from the retaining catch o^2 attached to the casing, and thereby sets the right-hand end of the cylinder at liberty to descend by the gravity of the piston, and to elevate the left-hand end of the oscillating cylinder, which is, after the change has been made, retained in that position by the catches o^4, o^5, during which retention the ports n^5 and m^5 coincide, and the port n^6 has dropped below the port m^6, as shown by dotted lines in fig. 4; consequently the fluid from the outer casing enters the oscillating cylinder through the port n^6, and forces the piston towards the left-hand end of the cylinder. The fluid between the piston and the end n^2 then makes its escape into the passage m^4 by the ports n^5, m^5. The spring m^9, placed between the trunnion and the end of the bearing, is to hold the faces of the ports in contact; the same object may also be attained by placing the meter in a slightly-inclined position. In the partition m^7, are openings m^8, shown by dotted lines in fig. 4; these openings are covered by metallic lids p, which are made fluid-tight by packings of vulcanised india-rubber or other suitable elastic substance, the yielding of which when the ports are changed will maintain the pressure on the outgoing fluid without perceptible check to the flow.

The registering apparatus is set in motion by the tappet p^4, fixed to the cylinder n; this tappet acts upon the lever p^1, to which is attached the spring catch p^2, that takes into the ratchet wheel p^3, which gives motion to the index-wheels outside the casing in the ordinary manner. The floater q (seen best in fig. 3) is attached to an elbow-lever q^1, the short arm of which acts as a valve to the opening q^2; the object of this apparatus is to allow the escape of air from the casings. The oscillating cylinder n, is also provided at each end with a small opening covered with a valve or lid n^7, for the like purpose.

Pumping Machines.

The improvements in machinery or apparatus for pumping are represented in fig. 6, as applicable to pumping or forcing water or other fluid from ships' holds, and for other purposes. A, is the pump-wheel, which in this example is shaped like the frustrum of a cone, and furnished with curved or inclined vanes, attached at their inner edge to the conical boss A^4, which is keyed to the vertical shaft A^1, and at their outer edge to the conical shell A^3; the breadth of the vanes is greater at the upper than at the lower edge, but the area of the conical space in which they are fixed is nearly the same at top and bottom. On the shaft A^1, which may be driven in any convenient manner, is keyed the fly-wheel A^2, which, together with the shaft and vane-wheel A^4, is rather more than equal in weight to the column of fluid which the pumping wheel has to sustain. C, is a circular grate bolted upon the chamber C^1, and made conical that the vane-wheel may readily be put into its place when immersed in water. C^2, is a sheet-metal cover resting on a shoulder of the grate C, the use of which is to prevent foreign matters entering the pump. At the upper end of the discharge-pipe E, is a valve D, fixed on the rod D^1, to which is also fixed a floater D^2. When the requisite velocity is given to the vane-wheel A, the water acted upon is forced through the chamber C^1, up the pipe E, and under the valve D, which, when the water is sufficiently high to pass off copiously through the discharge-pipe E^1, is held open by the floater D^2. As the valve D, is supposed to be less than 30 feet above the vane-wheel, it will follow that when the pump is stopped, the valve D, will close and thus retain the column of water in the pipe E.

Screw Propulsion.

The improvements in machinery or apparatus for forcing fluids are represented in fig. 7, as applied to the propulsion of vessels on water, and consist in making the boss of screw propellers much larger than usual in order that the vanes may act more effectively on the water, and in extending the bosses backwards far enough to admit of their being tapered or otherwise formed so as to allow the water to close upon them without a counter-current being produced. F, is the stern of a vessel, and F^1 the stern-post, on each side of which is a boss F^2, made the same diameter as the bosses of the propellers G; the bosses F^2 are softened off into the body of the vessel, as shown The propellers G, may each have six or more vanes, which in the respective propellers are set at opposite angles, and the propellers made to revolve in contrary directions, so as to impart a steady motion to the vessel. The bosses of the propellers terminate in a cycloidal or other suitably-shaped projections G^1. The diameter of the boss should be equal to at least one-third that of the propeller-wheel, and the width of the vanes about equal to one-sixth the diameter of the propeller.

Machinery for Agitating Fluids.

The improvements in machinery or apparatus for agitating fluids are represented in figs. 8 and 9, and consist of a new combination of parts forming a churn. H, is a framing or stand to which is fixed the upright stud H^1. I, is a circular chamber or vessel attached to a bevil pinion I^1, gearing into the driving-wheel J, fixed on the driving-shaft J^1. Near the top of the stud H^1, is a cross-piece H^2, from which depend four studs for supporting the splashers K; these splashers are also partly supported by the diagonal stays K^1. When motion is given to the shaft J^1, it imparts motion to the vessel I, the fluid in which is elevated by centrifugal action up the curved sides of the vessel I, until it is caught by the splashers, down which the fluid flows in thin sheets into the vessel, to be elevated as before. By the agitation of fluids in the manner just described, every portion of the fluid is speedily brought in contact with the atmosphere, which in the process of churning is particularly desirable.

In figs. 10 and 11 is shown another of the improvements in machinery for agitating fluids, applicable to the machines known by the name of "Hydro-extractors" and to centrifugal force apparatus used in treating saccharine fluids; the object being to prevent the vibration caused by centrifugal apparatus of the ordinary construction. Fig. 10 is a sectional elevation of an apparatus for separating the fluid from the crystalline particles of sugar, and fig. 11 is a plan of the same. L, is a perforated sheet-metal or wire drum of the usual construction, suspended by the cords, chains, or links L^1, from the double cross-levers L^2, fixed to the upright shaft L^3. The drum L, is attached to a heavy metal clock L^4, through which is made a conical hole of sufficient size to allow the drum L, to move sideways until the centre of gravity of the mass is in the centre of rotation, without coming in contact with the shaft L^3. The necessary rotary motion is given to this shaft in any convenient manner, and is communicated to the drum L, by means of the cross-levers L^2, and the cords, chains, or links L^1, before mentioned.

Machinery for Evaporating Fluids.

The improvements in machinery or apparatus for evaporating fluids are represented in figs 12 and 13. These improvements are applicable to evaporating the moisture contained in warps, yarns, and piece goods. Fig. 12 is part of a machine for drying warps to which the apparatus is applied, the other parts of this machine are omitted, as they are not required for illustrating the application of the present improvements. The yarns or warps to be dried are conducted under the two rollers M and M^1, and carried upwards in two separate parts, as shown by the dotted lines; theythen pass over the rollers O, and are conveyed to the beaming roller, after passing under the rollers P. N is a moveable casing, and N^2 is a chimney, the upper part of which is funnel shaped and has a bevilled flange to prevent the wind from breaking down the vapours rising from the chimney. The lower part of the machine is heated by the steam-pipes N^1, or by other suitable means. When the machine is at work the moveable casing is in the position shown by dotted lines, inclosing the whole apparatus, consequently the heat employed for evaporating the moisture in the warps produces rarefaction in the chimney N^2, and a strong current of air to carry off the vapour is the result. Fig 13 represents a mode of applying the same invention to the drying of piece goods in any of ordinary stretching machines; P is the fabric passing through the trunk or chamber P^1, heated by steam in pipes under the fabric, by a current of warm air admitted at P^2, or in any approved manner; P^4 and P^5 are rollers between which the fabric passes; P^3 is the chimney for carrying off the vapour; the upper part of the trunk P^1, is made to open for the convenience of working the machine. The patentee remarks here, that the amount of draught in machines for evaporating fluids may if necessary be increased by the admission of a current or a jet of steam into the chimneys in connection with them, the application of which requires no explanation as it is well known to all conversant with locomotive engines.

Another of the improvements in evaporating fluids consists in introducing a number of bent tubes into the fluid to be evaporated, the outer ends of which are open to the atmosphere. The vessel containing the fluid to be evaporated is covered by a chimney or flue, and the heat evolved by the liquid rarefies the air in the chimney, which causes a current of air to flow through the perforated tubes in the liquid, and by carrying off the vapour to accelerate the process of evaporation.

Motive Power from Fluids.

Fig. 14 shows the improvements in apparatus for obtaining motive power from fluids. R is a pipe forming the longer leg of an inverted syphon through which the water descends; R^1 is a bent pipe, to which is bolted the chamber R^2 containing the stationary curved divisions, R^3, for directing the current of water. The interior of the chamber R^2 is formed in the shape of an inverted cone, in the upper end of which is a bearing for the foot of the shaft S; near the lower end of this shaft is fixed the vane-wheel or turbine S^1, and above it a fly-wheel and bevil-wheel gearing is fixed which communicates motion to the machinery. From the foregoing description it will be seen, that the water in passing through the chamber R^2, receives from the divisions R^3, such a direction as makes it act with great propulsive effect on the vane-wheel or turbine S^1.

Another modification shows two vane-wheels or turbines placed immediately one above the other. The upper vane-wheel or turbine is fixed on a hollow shaft, through which the shaft S passes.

Dock Gates—Swing Bridges—Hooping Casks—Hydraulic Press.

Another of the improvements in obtaining motive power from fluids consists in the application of the power from a column of

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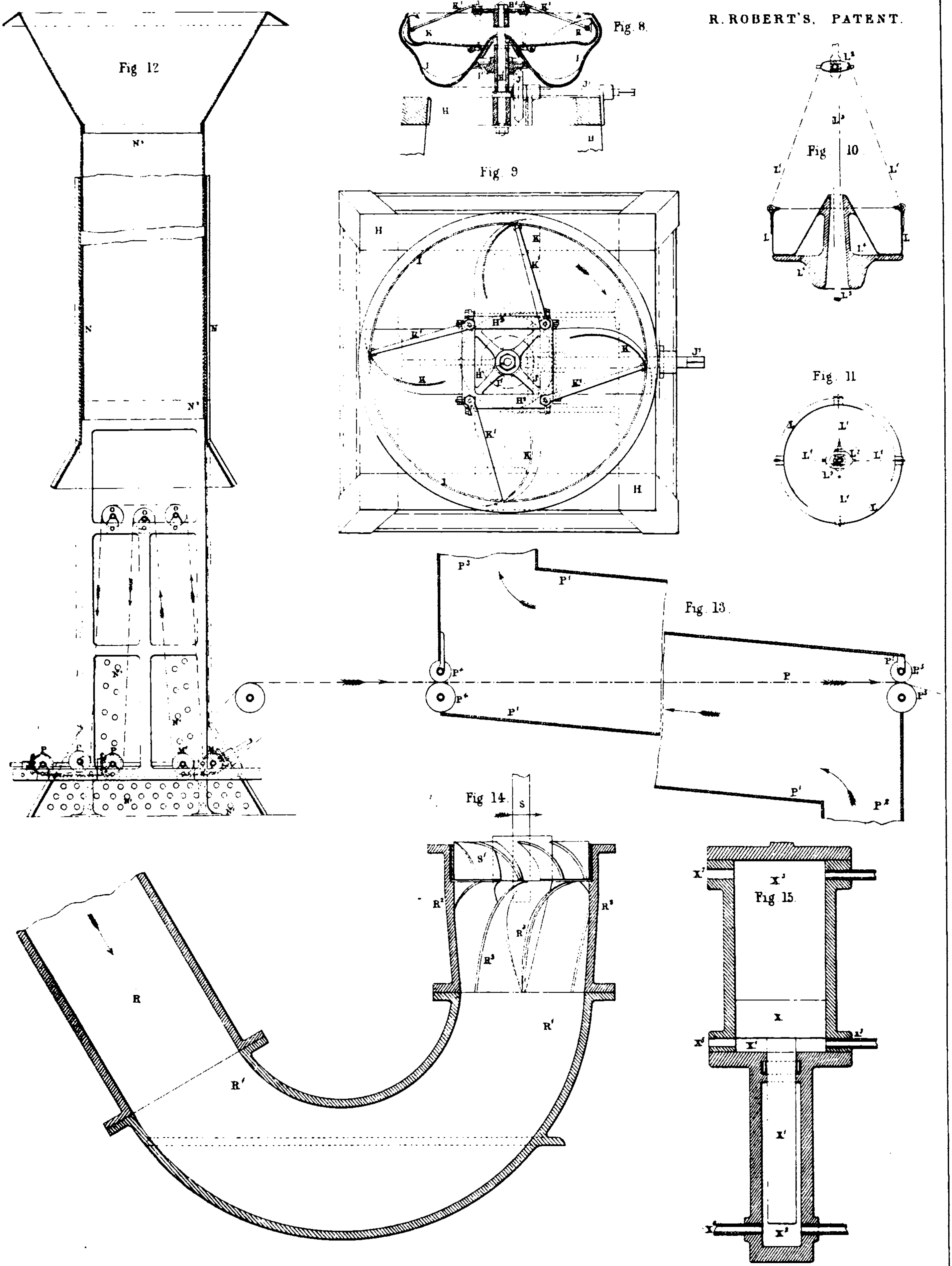
R. ROBERT'S. PATENT.



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water acting on a piston for opening and closing lock and dock gates, swing bridges, and other machinery of the like nature, as shown and described with reference to fig. 1.

The next improvement in obtaining motive power from fluids consists in the application of a column of water to the forcing of hoops on casks, and barrels, and to raising the rams of hydraulic presses used for baling goods.

In working hydraulic presses it is customary to employ at first a large pump to raise the ram rapidly, whilst there is little resistance to overcome, and afterwards a smaller pump to complete the operation.

In the improved mode of applying the force of fluids, the larger pump is dispensed with, by employing instead thereof the direct action of the loftiest column of water at command; and when that has ceased to be effective it is shut off and the small pump is employed in the usual way.

Instead of the small the differential hydraulic ram, shown in fig. 15, may be employed; the larger part of this ram is marked X, and the smaller X^1.

When water is admitted into the chamber X^4, through the opening X^5, the ram X is raised, and the chamber X^2 is filled with water through the pipe X^6. After the ram X has been raised, the opening X^5 is closed, and the pipe X^8 is opened to let off the water. After which, water is admitted into the chamber X^3, through the opening X^7, which, by forcing down the ram X, causes the water from the chamber X^2 to act with a force as much greater than the column of water employed as the two rams X and X^1 differ in area. It will be apparent that almost any amount of power may be applied to hydraulic presses by this arrangement of differential rams, and that the operations may be repeated as often as is necessary to obtain the pressure required. When a column of water is not available for these purposes, high-pressure steam may be made to act on a piston in direct connection with a press, or on an ordinary hydraulic press, by means of a piston similar to that marked X, in connection with a ram X^1, acting in the manner above described.

Claims.

First, for regulating the flow of fluids by the application of power derived from the fluid to be regulated, as shown and described in reference to figs. 1 and 2.

Secondly, the application of curved or spiral divisions to rotary meters, for measuring the flow of fluids in the manner and for the purpose described.

Thirdly, constructing the wheels of rotary meters with straight vanes, as shown.

Fourthly, tapering the lower edges of the vanes of rotary meters.

Fifthly, making the outer circumference of the vanes of rotary meters slightly conical, and the casings in which they revolve to correspond.

Sixthly, the application of an oscillating cylinder or chamber to meters for measuring the flow of fluids, as shown and described in reference to figs. 3, 4, and 5.

Seventhly, the peculiar application of yielding substances to maintain the flow in the exit-pipe uniform, or nearly.

Eighthly, the application of self-acting apparatus, for allowing air to escape from fluid-meters.

Ninthly, the modes of constructing the apparatus for the ingress and egress of the fluid to be measured, as shown and described in reference to figs. 3, 4, and 5.

Tenthly, the combination and arrangement of parts for pumping, as represented and described with reference to fig. 6.

Eleventhly, the application of cycloidal or other suitably-shaped bosses to machinery or apparatus used in forcing fluids, as shown and described in reference to fig. 7.

Twelfthly, the peculiar combination of machinery for agitating or evaporating fluids, represented in figs. 8 and 9.

Thirteenthly, suspending the drums of centrifugal action machines when used for agitating or evaporating fluids in the manner described in reference to figs. 10 and 11.

Fourteenthly, the mode hereinbefore described, in reference to figs. 12 and 13, of increasing the draught in chimneys or flues used in combination with machinery or apparatus for evaporating fluids.

Fifteenthly, the mode hereinbefore described of producing rarefaction, by admitting a current or a jet of steam into chimneys or flues used in connection with machinery or apparatus for evaporating fluids.

Sixteenthly, the mode hereinbefore described for accelerating evaporation, by the introduction of tubes into the fluid to be evaporated, and by connecting the vessel containing the fluids with a chimney or flue.

Seventeenthly, the peculiar combination of machinery and apparatus for obtaining motive power from fluids, as shown and described in reference to fig. 14.

Eighteenthly, the application of the power of a column of water to opening or closing lock or dock gates, and swivel bridges, and other machinery of the like nature, as hereinbefore described; and,

Lastly, the direct application of the pressure of steam, or of water, for compressing and packing goods, hooping barrels and casks, and for the like purposes, as shown in fig. 15, and as described.

BENDING AND ANNEALING GLASS.

Frederick Hale Thomson, of Berners-street, Middlesex, gentleman, and George Foord, of Wardour-street, chemist, for *improvements in bending and annealing glass.*—Patent dated September 25, 1851. [Reported in *Newton's London Journal.*]

Claim.—The combination of means and apparatus for bending and annealing glass.

This invention consists in combining means and apparatus for bending and annealing sheets of glass, so as to obtain the same in concave forms, suitable for reflectors and other uses, according to the shape of the moulds employed. The moulds are made, by preference, of cast-iron, with a small hole or air-passage through the centre of each; and, on the under side, they are suitably formed to admit of being fixed upon an upright axis within the muffle or oven in which the glass to be bent is heated. The muffle or oven has a fire on each side externally, the heat and flame from which ascend and enter at the upper part of the muffle, by a long opening, extending from front to back, on either side thereof; so that the flame and heated products from the opposite fire-places meet in the middle of the arch or roof over the muffle, and pass off through openings in the arch or roof; and, by this means, the greatest heat will be at the upper part of the muffle. The door of the muffle has an opening or sight-hole in it, through which the workman can see when the glass is sufficiently heated. Through a hole in the bottom of the muffle projects an upright axis, which is capable of rising and falling, and has a rotary motion given to it by suitable gearing.

The workman places on the upright axis, within the muffle, a mould of the proper shape and size for the circular sheet of glass to be bent; so soon as the mould has become heated to such an extent as would cause it to present a slightly-red appearance in the dark, he removes it from the muffle, and places the circular sheet of glass just within the upper part of the mould; and then he replaces the mould upon the upright axis, which is at this time to be at its lowest position, in order that the sheet of glass may be subjected at first to the lowest degree of heat. The axis is kept constantly rotating, and is raised by degrees, so as to bring the upper part of the mould and the sheet of glass nearer the top of the muffle; and, when the workman sees that the glass has arrived at the bending heat, he presses upon it a convex surface or piece of cork or soft wood (previously dipped into water), fixed at the end of a handle; whereby, as the axis rotates, the glass is pressed into and caused to assume the form of the interior of the mould. The mould and glass are now removed from the muffle, and another mould introduced to be heated, in order that a fresh sheet of glass may be operated upon. The hot mould, containing the bent sheet of glass, is to be covered, when taken from the muffle, with a cover of sheet-metal; and the bent glass is to be allowed to cool down with the mould; whereby it will be partially annealed. The annealing is completed by placing a number of such bent sheets of glass in an annealing muffle, wherein the glass is heated and cooled down in a suitable manner for effecting that object.

IRON MANUFACTURE.

Joseph Stenson, of Northampton, engineer and iron manufacturer, for *improvements in the manufacture of iron, and in the steam apparatus used therein; part or parts of which are also applicable to evaporative and motive purposes generally.*—Patent dated December 27, 1851.

Claims.—1. The treating and mixing of the materials so as to produce certain combinations described, as an improvement in the manufacture of iron. [These improvements are applicable to that class of metal derived from the iron-stone found in Zealand, and from the Indian stone called "Woost." In the manufacture of iron from these materials the following process should be pursued. After burning limestone in the ordinary way, in order to expel the carbonic gas, the lime should be mixed with clay (that of a ferruginous kind being preferred by the patentee). This should be mixed with the iron-stone in the proportion of one-twelfth to one-seventh of a ton of the iron, if of the Zealand kind, and one-sixth to one-eighth of a ton of iron of the "Woost" sort. The mass is then broken into lumps for the purpose of charging the furnace, charcoal being previously mixed to promote porosity. Chalk, sand, or shale would answer the intended purpose equally well, but clay is preferred by the patentee. These materials may be deprived of their moisture, by being placed in an ordinary furnace.]

2. The employment and adaptation of double-jet tuyeres to blast furnaces. Also the employment and adaptation of hoppers to the blast-pipes of furnaces for applying carbonaceous matter. [In order to promote the more equal distribution of the blast, and to induce a greater amount of combustion than is obtained under the means at present employed, the patentee gives to the blast-pipe a double opening, upon the principle of the "swallow-tail" gas burner. In order to promote combustion, the patentee employs a pipe in connection with the blast-pipe, one end of which is fastened by a cap to prevent the exit of air under pressure, but capable of being removed when required. At the bottom of this pipe are placed fluted or other rollers (turned by the motive power peculiar to furnaces), which grind the carbonaceous materials supplied from above. These materials, when reduced to powder, are carried by the blast into the interior of the furnace.

3. The construction of a pile by a combination of a series of narrow bars, arranged and disposed in the peculiar manner described. Also the constructing piles according to the several arrangements described. [This arrangement consists in placing the bars across one another, at an angle of 45°, with a hollow space in the middle, to promote a more equal distribution of the heat.]

4. The welding such piles, by hammering them immediately on leaving the mill furnace, and previous to being rolled into the finished bar.

5. Certain steam generators and boilers constructed in a peculiar manner described, when used as auxiliary boilers in connection with reverberatory furnaces. Also, certain other steam generators and boilers, whether used for supplying steam to the engine or engines, by which the motive machinery of ironworks is or can be worked, or whether used for evaporative and motive purposes generally.

COATING AND ORNAMENTING ZINC.

Francis Hastings Greenstreet, of 32, Southampton-street, Strand, for *improvements in coating and ornamenting zinc.*—Patent dated December 31, 1851.

Claim.—The mode of coating and ornamenting zinc and zinced surfaces by compounds acting chemically on the surface. It is to be understood that there is no claim to the use of a solution of nitrate or sulphate of copper, such as is now employed for writing on pieces of zinc used as labels.

These improvements consist in coating and ornamenting zinc or zinced surfaces by means of acids, alone or combined with other matters capable of acting chemically on the surfaces. The solutions used may be applied by sprinkling, dabbing, marbling, or spreading; and the surfaces coated are capable of further ornamentation by painting, which may be done with common oil colours.

The *Sprinkling* process is always followed in cases where a very thick coating is to be given to the zinc; it is done by shaking the preparations out of pieces of sponge fastened to the ends of suitable sticks, and the process is repeated a number of times, until the surface of the zinc is perfectly coated.

Dabbing is done by striking the surface of the zinc with sponge or hemp, moistened with the preparations, and produces a dappled, marble-like appearance on the zinc, but not a very strong coating.

Spreading is only adopted in a comparatively few cases; it consists in painting the surface of the zinc with the preparations laid on with a fine hair pencil, or a roll of soft leather or cloth.

Marbling is a method of giving the zinc the appearance of veined marble, as follows:—Lay over the clean surface of the zinc a piece of thin blotting-paper, or any kind of thin unsized paper, and then apply the preparation over the paper with a sponge or soft brush, in such a manner that the liquid may soak through to the zinc beneath; or apply the preparation underneath the paper directly upon the surface of the zinc; the latter method is generally to be preferred when pigments are used for the purpose of producing a coloured marbling. The gas formed by the action of the preparation upon the zinc will raise the paper into irregular bladders, and the paper should be left untouched upon the zinc until the action has ceased, which will generally be the case in two or three hours; it may then be lifted off, and the surface of the zinc underneath will have the appearance of veined marble.

Among the preparations which the patentee recommends for coating and ornamenting zinc surfaces, are the following:—

1. Muriatic acid diluted with water to a strength of about 1·114. The coating produced by this solution is of a light ash colour.

2. Chrome yellow, ground fine with soft water, and mixed with preparation 1 to a liquid consistency. This gives a yellowish grey colour.

3. The pigment known as "mountain or Saxony green," mixed gradually with preparation 1 to a thin paste, and stirred till effervescence ceases. This produces an iron grey colour tinged with green.

4. White lead, ground fine with soft water, and mixed with preparation 1, produces a grey coating. Where expense is not an object, Kremnitz white may be used instead of the white lead.

5. Flour of sulphur ground fine with water and mixed with preparation 1. This mixture gives a yellowish white coating.

6. Butter of antimony may be mixed with the before-mentioned preparations. When used alone it produces a black colour, but when mixed does not affect the colour of the preparation with which it is used. It produces a good ground for subsequent painting or other application.

7. Butter of antimony diluted with distilled water. This produces a fine coating, resembling in colour indian-ink.

8. Butter of antimony mixed with spirits of turpentine. This preparation, when applied alone, produces a black colour; it may have pigments of different kinds mixed with it, and the effect will then vary according to the nature of the colour employed.

The surfaces after having been coated by the means above-mentioned, and further ornamented if thought desirable, should be protected by a coating of varnish. Copal varnish may be used for this purpose; but the patentee recommends the use of wax, or mixtures containing wax, as this substance is an effectual preservative against oxidation, and easily renewed or kept in good condition.

ROTARY ENGINES.

David Napier, of Millwall, engineer, for *improvements in steam-engines.* Patent dated December 31, 1851.

The improvements in this patent relate to that class of rotary engines in which the power is obtained by a drum of a cylindrical shape, revolving eccentrically within a cylinder, the steam abutment being formed by a slide moving in and out through a slot formed in the outer cylinders.

The novelties of which the patent consist are as follows:—*Firstly*, in reducing the pressure from the slide by means of a parallel motion and radius rods, or by rollers between the sides of the slide and other smooth metallic surfaces. *Secondly*, in working the slide by means of eccentrics fixed on the main shaft, the throw of the eccentrics being exactly equal to the diameter of the internal cylinder. *Thirdly*, in fitting a moveable joint to the foot of the slide, so as to keep it constantly in steam-tight contact with the internal cylinder at all points of its revolution. *Fourthly*, in a mode of packing the ends of the internal cylinder, by means of split rings of steel, one of which is compressed into an angular groove formed in each end of the cylinder, the elasticity of the steel ring giving it a constant tendency to press outwards, and thus forming a steam-tight joint between the meeting surfaces. *Fifthly*, in fixing the internal cylinder on to the main shaft to form a portion of the periphery of such cylinder, instead of fixing the shaft wholly inside of such cylinder.

In addition to these improvements, the patentee proposes the use of hollow fire-bars, bent to an angle at one end, and provided with a cock for clearing out the tubes when required, and the other end being connected with the boiler. He also proposes the placing a fan in the engine-room of steamers, to be worked by the machinery; by this means not only increasing the supply of air to the fires, but keeping the engine-room cool. He also describes an arrangement whereby, by means of a valve, both the engines of a steamer (there being generally two on board) may be stopped, sent a-head, or reversed by a single movement.

The patentee observes, in conclusion—"In case there may have been some of these things, unknown to me, done already, I therefore propose claiming not only for the parts separately, but the combination."

STEAM-ENGINE VALVES.

William Cook, of Kingston-upon-Hull, working coppersmith, for *certain improvements in the construction of steam-engines, consisting of a rotary circular valve for the regular admission of steam from the boiler alternately into the chambers of the two cylinders of double-acting engines.*—Patent dated January 12, 1852.

Claim.—For a rotary valve divided and arranged as described.

The position occupied by the valve is between the two cylinders of the engine, and is driven by a cog-wheel at the top of the piston-rod, gearing on to the engine crank-shaft. The advantage to be derived from the use of this patent is the diminution of friction and consequent economy in the use of fuel, grease, &c. It is capable of application both to locomotive and marine engines, and may be used with single or double cylinders.

STEERING APPARATUS.

Robert John Smith, of Islington, gentleman, for *certain improvements in machinery or apparatus for steering ships and other vessels.*—Patent dated January 13, 1852.

Claims.—1. A grooved, concentric tiller-head or disc, fixed or keyed upon the cap or upper portion of the rudder-shaft which the patentee terms a "drum-head." [Connected with the steerage wheel by means of chains, and placed horizontally with the deck, is a screw-bar, the grooves of which are slightly inclined. This screw-bar is capable of being turned in either direction by a movement of the steering wheel, which also causes the chains to move and thus drag round the screw-bar. The grooves of the screw-bar gear upon the top of the rudder shaft, and cause it to move round in whatever direction the wheel may be urged.]

2. The intervention of a yoke or lever for increasing or multiplying the speed of the said drum-head.

3. The application of a grooved spiral screw and socket-shaft motion, of whatever length of rake or size of thread employed, for obtaining a transmitting power direct from the steersman to the rudder, by which the half turn of the steering-wheel is effected.

4. The application of a yoke or segment-beam for transmitting increased motion from the tiller direct to the rudder.

5. The application of auxiliary power (derived from steam or other convenient source) to steering machines or apparatus generally, so that the operations of the helmsman may be greatly assisted thereby. [In connection with the steerage machinery is placed a small cylinder, the slide of which is moved backwards or forwards, by means of a driving-wheel in connection with the steerage-wheel, which driving-wheel is worked by a cord passing round its circumference and round the axis of the steerage-wheel; the piston-rod of this cylinder is connected by a crank with the rudder-shaft, and its movement materially assists the steering of the vessel by taking a large portion of the labour of the steerage-wheel.

BRICKS AND TILES.

Arad Woodworth, 3rd, and Samuel Mower, of Boston, United States, for *improvements in machinery for manufacturing bricks, tiles, or other articles of similar character.* Patent dated January 24, 1852.

The present improvements have relation to machinery for the manufacture of bricks, tiles, &c., in which percussion is used to consolidate the plastic materials in the moulds.

Claims.—1. The combination of a percussion ram and its piston or pistons (whether in connection or separately) with a mould or moulds, and a lower expulsion piston or pistons, made to operate so as to compress the clay or plastic material in, and afterwards expel it from the mould or moulds. And auxiliary thereto, or in combination therewith, machinery for elevating the lower piston or pistons in the mould or moulds, in order to produce direct compression on the lower face of the brick or other article in the mould.

2. The construction and use of a sliding mould-charger in connection with the ram and piston or pistons, in such manner as to render it a part of the mould during and for some time after a percussion of the ram.

3. The construction of the moulds with flaring or inclined sides, and the combination therewith of mechanism for lifting the moulded article a short distance before the second percussion, so as to free the moulded article of its adhesiveness to the mould, and permit the compressed air to escape, thus depriving the material of a large amount of friction.

4. The combination with the percussion ram and its auxiliary contrivances of additional machinery, to produce compression of the top surface of the brick.

5. The construction of the orifices of the mould-charger with sides inclining inwards towards each other as they descend.

6. The combination of an adjustable striker with the mould-charger and hopper, for striking off at any required point the top surface of the clay deposited in the mould-charger.

7. The combination with such adjustable striker of mechanism to cause it to rise up as the mould-charger moves forward, for the purpose of leaving the clay higher at the back than at the front part thereof, in order to obviate the difficulty of the clay being more condensed in the front than in the rear part of the charger when its back movement is made.

RAILWAY RAILS.

Annet Gervoy, of Lyons, director of the Lyons Railway, for *means to prolong the durability of rails on railways.*—Patent dated February 13, 1852.

Claim.—The means described of prolonging the durability of rails used on railways.

It has been observed that the wrought-iron rails of railways become, by exposure to the weather, and by the passage of locomotives and other machines over them, very much weakened, losing their fibrous structure, and assuming, instead, a crystalline appearance. The patentee therefore proposes to prolong the durability of such rails by the application of his method, which consists in the application to them of heat, after eight or ten years' use; by this means restoring to them their fibrosity. The intervals at which it will be necessary to subject them to this process will depend upon the quality of the iron, and on the traffic to which they are subjected, and which may be decided by any engineer. For the purpose of heating the rails, the patentee employs a furnace divided into two compartments, and connected by flues through which the heat passes from one division to another, and capable of being opened or closed. The rails are placed in the furnace and laid upon bars, sufficiently near to preclude their bending when red hot, and while the rails in one division are being rendered red hot, those contained in the other department are allowed to cool. When they have become sufficiently cool, they are withdrawn from the furnace and restored to their original use.

COMBINATION REFLECTORS.

In the last number of the *Journal* (p. 204), we gave a paper "On the Admission of Daylight into Buildings," by Mr. Hesketh. For the want of drawings, the description of "the Combination Reflectors" does not appear to be easily understood: we have therefore obtained the engravings the better to illustrate the subject.

Let A B E F (fig. 1) be a section through a rectangular opening for light exposed to a hemisphere of sky, the section being at right angles with two of the sides of the rectangle. Let the sides A C, B D, of the opening be square with the face, and let C E, D F, be splayed off at equal angles one to the other. Let us consider first only the plane of the section. Join B C and B E, and bisect them in G and L respectively. With centre G rad. G C describe circle C H B, passing through A (because B A C is a right angle). With centre L rad. LE describe circle EHB. Produce EC cutting circle OHB in H. Join HB. Then H is a point in circle EHB also, because EHB is a right angle. Through B draw MK parallel to EH. Now BE is the line of *one* of the two extreme oblique rays which can pass through the opening (AF being the other). Also from every point in that part of the sky which is intercepted between EB and FA produced, triangles of rays will pass through the opening limited by its sides. These rays, if systematised according to their parallel directions, will form parallelograms parallel to every line between BE and AF. Taking these parallelograms in order, from the line of the extreme ray BE to the line of the other extreme ray AF, their widths on BE is o; their widths then continually increase up to the perpendicular to AB, and then continually diminish till on AF they are again o.

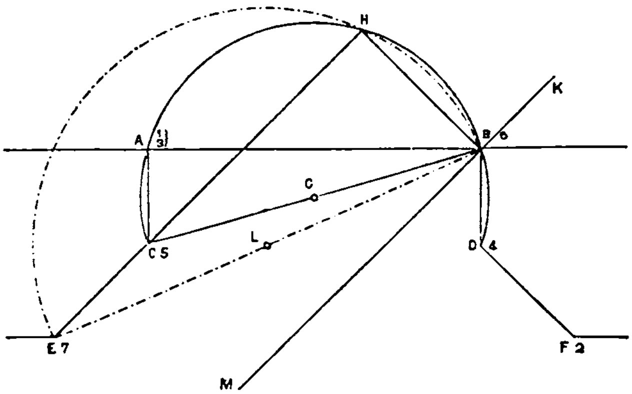


FIG. 1.

A very approximate proportional value of these parallelograms may be obtained by taking the widths at certain small equal angular intervals as they pass from BE to AF. These small intervals will subtend equal angles so long as the centre lines of the successive parallelograms pass through the centres of the circles on which the degrees are measured, and let us take *two* degrees as the equal intervals. Take any such parallelogram HEKM—then, therefore, CHB is a right angle, therefore BH (or chord of arc BH) measures its width. So the chords of the arcs from B to BH (rad. LB), taken at two degrees intervals, measure all the parallelograms at such intervals as far as the parallel of EH. Thus far B and E have been the points which limit the widths of the parallelograms; but on passing the parallel of EH, B and C become the limiting points. At this parallel BH is the chord of both circles—BHE and BHC. Also the chords from arc BH to arc BHA, taken at such 2° intervals, will measure all the remaining parallelograms at similar intervals, as far as the perpendicular to AB. Therefore the sum of the chords of arcs from B to arc BH (rad. LB), added to the sum of the chords from arc BH to arc BHA (rad. GB) will measure proportionably all the parallelograms passing at such intervals through the opening from BE to the said perpendicular to AB. Also the same will measure the parallelograms passing through the opening from AF to the said perpendicular to AB. Therefore twice the said sums of chords will measure all the parallelograms passing at such intervals through the opening on the plane of the said section. But the chord of an arc $= 2 \times$ sine of $\frac{1}{2}$ the arc. Therefore (taking now degrees as the intervals instead of 2 degrees) $2 \times$ sum of sines from B to $\frac{1}{2}$ arc BH $\times$ rad. LB $+ 2 \times$ sum of sines from $\frac{1}{2}$ arc BH to $\frac{1}{2}$ arc BHA $\times$ rad. GB measure the same.

But $\frac{1}{2}$ arc BH rad. LB is represented by $\angle$ BEH ($= \frac{1}{2} \angle$ BLH)
And $\frac{1}{2}$ arc BH rad. GB is represented by $\angle$ BCH ($= \frac{1}{2} \angle$ BGH)
And $\frac{1}{2}$ arc BHA rad. GB represented by $\angle$ BCA ($= \frac{1}{2} \angle$ BGA)

Now, putting the diameter* BE for twice the rad. LB and the diameter* BC for twice the rad. GB we have, BE $\times$ sum of sines from 0° to $\angle$ BEC $+$ BC $\times$ sum of sines from BCE (supplement of BCH) to BCA measure the same. A similar formula will apply to the section perpendicular to the other two sides of the rectangular opening, and the results of the two formulæ multiplied together will give *a number proportionate to the quantity of light passing through the opening.*

* These are hereafter called diagonals, as more expressive of lines passing through the angles formed by the sides of the opening.

The following general theorem may be deduced in like manner. Let fig. 2 represent a section perpendicular to two sides of a rectangular opening, the sides being irregular. Figure the two points which are in the line of one of the extreme rays 1, 2. Then considering the successive parallelograms which

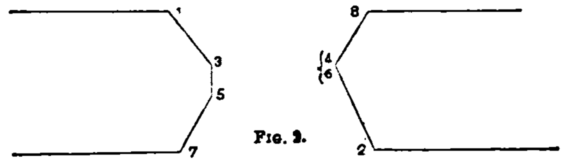


FIG. 2.

would pass through the opening, beginning from line 1, 2, these points 1 and 2 will at first limit the width of such parallelograms. The succession continuing, another point will perhaps become one of the limiting points instead of either 1 or 2. Let this point be instead of 1, and figure it 3; say the next limiting point is instead of 2, and figure it 4; the next is (say) instead of point 3, and figure it 5; now suppose the next limiting point is instead of 5 (and therefore on the same side of the opening as 5), in this case recur to point 4, and assign a second figure 6, then figure the limiting point instead of 5, 7; let the next be instead of point $\left\{\begin{matrix}4\\6\end{matrix}\right\}$ and figure it 8, and so on. The even numbers will thus be on one side and the odd numbers on the other side of the opening. This being done, the table which follows will give the proper result:—

Diagonals	Sum of Sines.	
1 — 2	$\times$ from 0° to $\angle$ 213	$\times \frac{1}{2} =$
2 — 3	$\times$ from $\angle$ 132 to $\angle$ 324	
3 — 4	$\times$ from $\angle$ 243 to 90° + 90° to $\angle$ 435	
$\left\{\begin{matrix}4 - 5\\5 - 6\end{matrix}\right\}$	$\times$ from $\angle$ 354 to $\angle$ 657	
6 — 7	$\times$ from $\angle$ 576 to $\angle$ 768	
7 — 8	$\times$ from $\angle$ 687 to 0°	
&c.		

The following are the rules for constructing the table:—(1.) Put diagonals in order 1 . 2, 2 . 3, &c., as far as the figures on the diagram extend. (2.) If the same diagonal is represented on two lines, bracket them as $\left\{\begin{matrix}4 . 5\\5 . 6\end{matrix}\right\}$. (3.) Put (or suppose) zigzag lines from 2 to 1, 1 to 3, 3 to 2, &c., as shown. This forms the first column of *diagonals.* The second column shows the angles between which the *sums of the sines* are to be taken at successive intervals of degrees. (4.) Look to the column of diagonals and take the angles in the zigzag order as shown, 213, 132, 324, &c. The first line will be from 0° to $\angle$ 213, the second $\angle$ 132 to $\angle$ 324, &c., and the last line will be from the last three figures (as above, 687) to 0°. (5.) If two obtuse angles come in the same line (as in the third line above), put down from first angle to 90° added to 90° of the second angle. (6.) The third column is the multiple $\frac{1}{2}$. The use of the table is as follows:—(1.) Measure the diagonals 1 . 2, 2 . 3, &c., and put down the measures in order in feet and decimals. (2.) Measure the angles 213, 132, &c., and put down the number of degrees in order. (3.) Find from the table *below* the sums of sines (taking the supplements where obtuse) and note them in their place. (4.) The result is found as follows: Diag. 1 . 2 $\times$ sum of sines from 0° to $\angle$ 213 . + diag. 2 . 3 $\times$ sum of sines from $\angle$ 132 to $\angle$ 324, and so on. The sum of the quotients to be multiplied into the third column ($\frac{1}{2}$).

So long a formula will seldom be required in practice. Where the sides of the opening are similar it will be sufficient to go only up 90° from the line of the extreme ray. Thus in fig. 1, which is figured according to the rule, the formula is—

Diagonals.	Sum of Sines.	
$\left\{\begin{matrix}1 - 2\\2 - 3\end{matrix}\right\}$	$\times$ from 0° to 324	$=$
3 — 4	$\times$ from 243 to 435	
4 — 5	$\times$ from 354 to 546	

The third line is nil, because 354 and 546 are both right angles. The third column ($\frac{1}{2}$) of the formula is cancelled, because we have considered only the parallelograms up to the perpendicular to A B, and the result would have had therefore to be doubled.

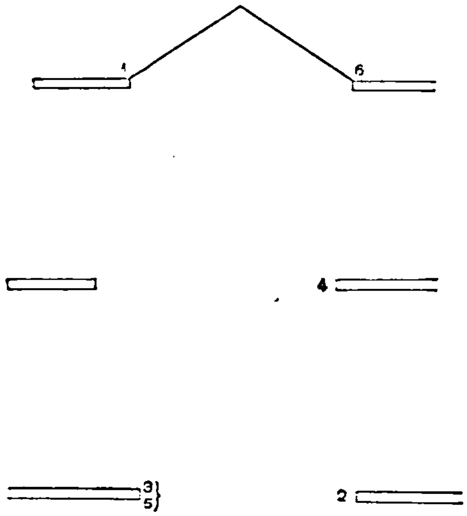


FIG. 3.

Fig. 3 is a diagram showing the application to openings through floors, &c., as well-holes under a skylight. The figures apply to the quantity of light passing through the bottom opening $\left.\begin{matrix}3\\5\end{matrix}\right\}2$. The formula is—

Diagonals.	Sum of Sines.
1 . 2	× from 0° to 213
2 . 3	× from 132 to 324
{3 . 4 / 4 . 5}	× from 243 to 546
5 . 6	× from 465 to 0°

$\Bigg\} \times \frac{1}{2} =$

TABLE *of the Sums of Sines of Arcs taken at intervals of Degrees from* 0° *to* 90°, *Radius* 1 *to* 2 *decimal places.*

Deg.	Sums of Sines.	Deg.	Sums of Sines.	Deg.	Sums of Sines.
1	. 02	31	8 . 44	61*	29 . 95
2	. 05	32	8 . 97	62	30 . 84
3	. 10	33	9 . 52	63	31 . 73
4	. 17	34	10 . 07	64	32 . 63
5	. 26	35	10 . 65	65	33 . 53
6	. 37	36	11 . 24	66	34 . 45
7	. 49	37	11 . 84	67	35 . 36
8	. 63	38	12 . 45	68	36 . 30
9	. 78	39	13 . 08	69	37 . 23
10	. 96	40	13 . 73	70	38 . 17
11	1 . 15	41	14 . 38	71	39 . 11
12	1 . 36	42	15 . 05	72	40 . 06
13	1 . 58	43	15 . 73	73	41 . 02
14	1 . 82	44	16 . 43	74	41 . 98
13	2 . 08	45	17 . 13	75	42 . 95
16†	2 . 36	46	17 . 85	76	43 . 91
17	2 . 65	47	18 . 59	77	44 . 89
18	2 . 96	48	19 . 33	78	45 . 87
19	3 . 28	49	20 . 08	79	46 . 85
20	3 . 63	50	20 . 85	80	47 . 84
21	3 . 98	51	21 . 63	81	48 . 83
22	4 . 36	52	22 . 41	82	49 . 82
23	4 . 75	53	23 . 21	83	50 . 81
24	5 . 16	54	24 . 02	84	51 . 80
25	5 . 58	55	24 . 84	85	52 . 80
26	6 . 02	56	25 . 67	86	53 . 80
27	6 . 47	57	26 . 51	87	54 . 80
28	6 . 94	58	27 . 36	88	55 . 79
29	7 . 43	59	28 . 21	89	56 . 79
30	7 . 93	60	29 . 08	90	57 . 79

Note.—To find the sum of sines between any two arcs deduct the number opposite the smaller arc from that opposite the larger arc, thus: sum of sines from 16° to 61° = 29 . 95* − 2 . 36† = 27 . 59. It will be generally sufficient to use only *one* decimal place for the sums of sines, and *one* only for the parts of a foot in measuring the diagonals.

We extract the following additional particulars relative to the practical application of the invention, from a pamphlet issued by Messrs. Boyd and Chapman, of Welbeck-street, who are the sole manufactures of the Combination Reflectors.

Reflectors are required to be in *combinations*, for the following reasons:—

1st. *Single* reflectors, having to be placed so as to reflect the light from the sky to a particular part, would generally have to be fixed *askew*, and in such a manner as to *project* in an inconvenient or unsightly manner either outside or inside of a window.

2nd. If *projecting outside*, many of the rays from either side *will be reflected upon the outside of the wall;* if *projecting inside*, many of the side rays will be *intercepted by the jambs* of the window before reaching the reflector.

3rd. Single reflectors are difficult to *regulate*.

4th. If made of a material which will stand the weather and atmosphere of towns, the *cost* will increase in a much greater ratio than the increase of *size*.

Now, a reference to these four objections in order will show reasons for the adoption of the combinations.

1st. *Combination* reflectors are arranged in *any given plane*, and within *any given thickness;* such as in the reveal of a window, in the space occupied by a dwarf window-blind, &c.

2nd. Being disposable within the thickness of the wall of the opening, the side rays of light are not *intercepted by the jambs*, and after reflection pass *at once into the room*.

3rd. The combination may be regulated by a simple lever movement, so as to regulate or vary tbe light at pleasure, and instantaneously from the inside of the room.

4th. The combinations consist of comparatively *small* reflectors, and the required number of smaller ones will be much less costly than one larger one of equal area: for instance, in the article of glass alone, where ten pieces of glass, each 1 foot superfical, cost 13*s.* 4*d.*, one piece of 10 feet costs 2*l.* 1*s.* 8*d.*

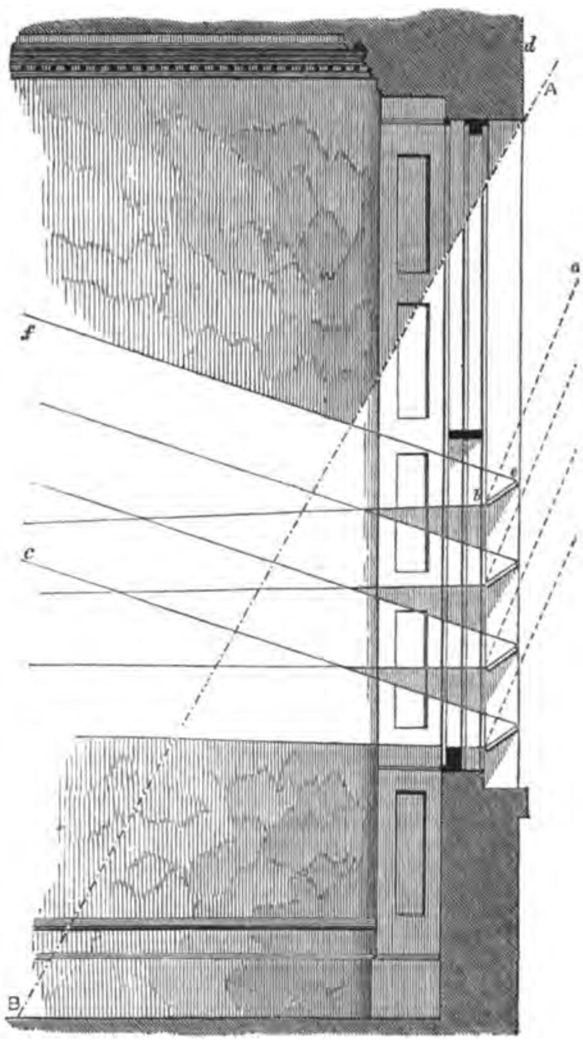


FIG. 4.

The reflectors used to resist the action of the atmosphere are made by chemically depositing metallic silver upon the back of glass, by which a reflector more brilliant than a common mirror is obtained, and no air or damp can come in contact with the reflecting surface. This process cannot be applied without great additional expense, and risk of failure, to large surfaces.

The general system may be best explained by the diagram (fig. 4), which represents the section through a window 7 feet high, giving light to a room which opens into an alley supposed to be 6 feet wide, and to have the opposite buildings 18 feet high above the window-sill. The limit of the *direct* light which enters is shown by the line A B, so that it falls on the floor only to the extent of 4 feet.

Now, suppose a reflector placed within the reveal 5 inches in width, and as long as the opening is wide, as at *e b*, then the ray *a b*, from the top of the opposite building, will be reflected in the direction *b c*, and the ray *d e* will be reflected in the direction *e f*; *b e* and *e f* show, therefore, the extent of the reflected light from the reflector *e b*.* If three other reflectors, as shown, are placed under *e b*, then they will reflect the light as represented by the other diverging lines. The reflected light from all four reflectors will traverse the whole room, whatever may be the distance of the back wall from the window. If the back wall were 30 feet from the window, the light would cover the upper 8 feet of the wall, and the ceiling to 7 feet from that wall.

If the reflectors are moved so as to be nearer the horizontal position, the light will be thrown more upon the ceiling; if they are turned to be nearer the vertical position, the light will be lowered towards the floor. Owing to their being placed within the thickness of the wall, the rays which come from either side of the opening up and down the alley are reflected sideways into the room, so as to illumine the side walls.

The diagram shows the combination as applied to the lower half of the window. This will give the *greatest quantity* of light with *least cost*. But if they are placed in the upper part of the window, they will give *a more pleasing* light.

It will be easily seen, that if the reflectors are, instead of being parallel planes, placed at different angles with the horizon, the reflected light may either be diffused to a greater extent, or be more concentrated as may be desired.

In some instances an oblique arrangement will be most suitable.

The following are the usual applications of this combination:—

1.—Where a *defined* effect is required, the reflectors are fixed so as not to be moveable.

2.—They are made to be easily regulated by movement from the inside, so as to produce, at pleasure, different effects of light.

3.—They are made with wrought-iron backs, so that, in an instant, they may be closed, by a lever movement, as before mentioned, and thus form, at once, a *fireproof shutter* externally, and a *brilliant reflector* internally, so as to assist the artificial illumination of the room at night, and be ornamental also.

4.—They may be combined with glass ventilating louvres.

5.—They may occupy the place of dwarf window-blinds. These are made either with reflectors of flat glass, or with reflecting glass prisms.

6.—Fig 5 shows a combination H K, fixed on a wall under a skylight A B, to reflect the rays into the part under C D, which may be continued to a considerable distance. A G shows the *direct* ray, which enters furthest under C D. But the reflected light from the combination penetrates under C D to *any distance* up to the furthest wall. The ray falling from A on the top reflector *a b* is reflected to *d*. That from B is reflected to *c*, so that the reflected light from the reflector *a b*, is bounded by the lines *a c*, and *b d*. The directions of the rays from the other reflectors of the combination are shown by the other diverging lines. The reflectors of such a combination may (as in the first-described system) be disposed so as either to diffuse the light more, or to concentrate it, as may be desired.

One great advantage in this system of lighting apartments is, that the light may be reflected upon the ceiling, which, being generally the lightest coloured surface in the room, is the best for diffusing the light by secondary reflection, and, being above the sight, reflects the light in the most agreeable manner.

* An advantage of the combination may here be noted; viz. that if any Reflector, as *e b*, would diffuse the light over say 15 feet width of surface, one 4 times the width would not cover so much as 15 feet, though of course the light would be more intense.

In many instances, as in Manchester warehouses, and other places where the light requires careful regulation, there will be the advantage of obtaining, at pleasure, any angle of incidence.

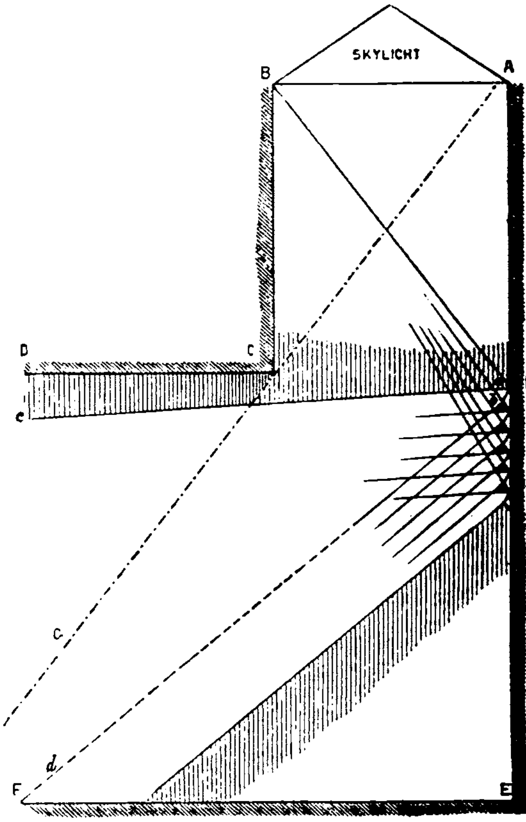


FIG. 5.

In many cases where sufficient daylight is obtained, much valuable space has been lost by the necessity of having large uncovered yards to the houses, of confining part of the buildings to one story, or of forming shafts or well-holes in the floors to allow the light to pass to a lower story. A *much larger* space may now be covered with building than could otherwise be so covered, because by the use of these Reflectors *much less* space is required than formerly for obtaining a sufficiency of daylight.

INCLINED PLANE ON CANALS.

In our last number (p. 201) we gave a description of the Blackhill Inclined Plane, from a paper read by Mr. Leslie, at the Royal Scottish Society of Arts. Since the paper was published the author has learned that three inclined planes for boats were constructed about ten years ago by Sir William Cubitt, on the Chard Canal, Somersetshire, and that they have acted quite satisfactorily. One near Chard, which is a single incline, takes the boat, lying dry on a carriage having four wheels, over a summit, and down another incline into the upper reach of the canal. The height of this incline is about 86 feet, and the gradient 1 in 8. The motive power is a turbine wheel at the foot of the incline, working a wire rope over the top of the carriage.—Another at Wrantage takes the boat afloat in a caisson, set on a carriage having six wheels. This is a double incline, with a chain passing round a horizontal drum or sheave at the top, and the motion is communicated by running more water into the descending than the ascending caisson, breaks or other apparatus being provided for stopping or checking the motion. The caisson is 28 ft. 6 in. by 6 ft. 9 in. inside; but as the gates open inwards the boat cannot be longer than 25 or 26 feet. The height of this incline is $27\frac{1}{2}$ feet, and the gradient 1 in 8.—A third incline at Ilminster is of similar construction to the last described.

REVIEWS.

Rome in the Nineteenth Century; containing a complete account of the Ruins of the Ancient City, the Remains of the Middle Ages, and the Monuments of Modern Times. By CHARLOTTE A. EATON. Fifth Edition, 2 vols. Bohn's Illustrated Library. London: H. G. Bohn. 1852.

MRS. EATON's book still remains the special book on Rome, and Mr. Bohn has rendered a considerable service by bringing it before the public in a cheaper and more accessible form. While popular in its style, this work is not wanting in those references to classical authorities which are essential to give it a standard character. The notes of this class are numerous, as indeed they must be if the structures of ancient Rome are properly illustrated. By the public this work will be received as supplying a great want, and furnishing them with sound information on a subject which is always of interest; and younger professional readers will find here those general details which will prepare them to receive and appreciate the engravings and descriptions of the great edifices of antiquity and of their modern rivals. In a work so wide in its subject, it is of course impossible to expect a completeness of delineation on any one subject. Thus to the architectural student the space devoted to St. Peter's will appear too scanty; but this is unavoidable, for it requires volumes for itself, and atlases of drawings. Mrs. Eaton has, however, an artistic appreciation which makes her a good painter of Rome in its ancient and modern condition. We cannot necessarily expect architectural essays, or novelties in archæological research, but we may read with interest the views of such a writer upon the monuments of Rome, even if in some cases they involve depreciating comments on the buildings of Michael Angelo.

It is not so, however, with St. Peter's; and to the architect anxious to know the effect produced on the mind by such a great work, the following will be welcome. What may be called architectural sensations are seldom expressed fully except by acknowledged critics, and we rarely get a measure of public feeling. To an architect, however, the impression produced on the mind by a great work is a subject of interest, for whatever reasons he may have for imagining that in the design of his own works he has complied with all requirements, still he is anxious to know how far the public are impressionable. The conviction of being able to achieve a great success in this way is one of the strongest inducements to the exertions of a man of genius. Mrs. Eaton says:

"The interior burst upon our astonished gaze, resplendent in light, magnificence, and beauty, beyond all that imagination can conceive. Its apparent smallness of size, however, mingled some degree of surprise, and even disappointment, with my admiration; but as I slowly walked up its long nave, empanelled with the rarest and richest marbles, and adorned with every art of sculpture and of taste, and caught through the lofty arches opening views of chapels, and tombs, and altars of surpassing splendour, I felt that it was, indeed, unparalleled in beauty, in magnitude, and magnificence, and one of the noblest and most wonderful of the works of man.

"We paused beneath the lofty dome—which, like heaven itself, seems to rise above our head, and around whose golden vault the figures of the Apostles appear enshrined in glory;—and leaning against the rails of the Confessional of St. Peter, looked down to that magnificent tomb, where, lighted by a thousand never-dying lamps, and canopied by the wreathed pillars and curtained festoons of the brazen tabernacle—the mortal remains of the Apostle repose. On every side the Latin cross opened upon us in lengthening beauty, and decked in various splendour, which the labour of ages, the wealth of kingdoms, the spoils of ancient times, and the proudest inventions of modern magnificence, have combined to furnish. Yet, with all its prodigality of ornament, it is not overloaded; and while its richness charms the eye, its purity and harmony satisfy the taste. There is no vulgarity, no show, no glare, no little paltry detail, to catch the attention and take from the grandeur of the whole. All is subservient to the general effect. The interior, indeed, on the whole, as far surpassed my highly-raised expectations, as the exterior fell short of them. Yet, notwithstanding its beauty, I was conscious of a species of disappointment too commonly felt, when what we have long dwelt on in fancy is seen in reality. It was equal, perhaps superior, to what I had expected, but it was different; for we cannot avoid forming some idea of anything we think of so much; and St. Peter's, in the inside as well as the out, was as unlike the image in my mind as possible. I had pictured it to myself less beautiful, and far less magnificent, but more sublime. With an imagination deeply impressed with the imposing effects of the Gothic Cathedrals of our own country, I expected, from the immensity of St. Peter's, even more of that religious awe and deep solemn melancholy, which they never fail to inspire; and I was unprepared for its lightness, decoration, and brilliance;—and, above all, for that impression of gaiety, which the first sight of its interior produces. I knew, indeed, it was Grecian; but the lengthening colonnade and majestic entablature had dwelt on my fancy, and I was surprised to see the Corinthian pilaster and the Grecian arch: and that arch, however noble in itself, from the necessity of proportioning it to the magnitude of the building, has the unfortunate effect of diminishing the apparent length, which the perspective of a Grecian colonnade, or a Gothic aisle, uniformly appears to increase. There are only four arches in the whole length of the nave of this immense church, and the eye, measuring the space by the number, becomes cheated in the distance. This I cannot but consider a capital defect. You may indeed argue your understanding, but not your senses, into a conviction of the size of St. Peter's: the mind believes it, but the eye remains unimpressed with it.

"The windows, too, are mean and poor-looking, and offensive to the eye. It is easier, however, to point out the fault than the remedy; for windows do not enter gracefully into the beautiful combinations of Grecian architecture. They did not originally form an integral part of it. The temples, the porticoes, the theatres, and perhaps even the houses of the ancient Greeks and Romans, had none. In Gothic churches, on the contrary, how grand and majestic an object is the arched and shafted window! Indeed, if I may venture to own to you the truth, it is my humble opinion, that though Grecian architecture is admirably adapted to palaces and theatres, and places of public assembly, and public buildings of almost every other kind, it is not suited to churches; and though it possesses a grace, a lightness, an elegance, a gaiety, and a refinement, that harmonise well with the amusements and business of life, it does not accord with the solemn purposes of Christian worship, to which the simplicity and grandeur of the Gothic, and its impressive effect upon the mind, are so peculiarly fitted, that I could almost fancy its conception to have been an emanation from that devotion it is so eminently calculated to inspire.

"The Gothic would be as misplaced in a theatre as it is appropriate in a church. This may certainly arise in some degree from association, but I think there is something in its intrinsic fitness. Before we drove away, I stopped to take another view of the façade of the church, in hopes of finding more to admire; but I am sorry to say, I only found more to condemn.

"Certainly some apology may be found for its defects, in the frequent changes of plans, and architects, and Popes, during the building of it; and in the real or imaginary necessity of having an upper balcony for the purpose of giving the benediction; a circumstance which has been so ruinous to its beauty, that we might say with truth, that the blessings of the Popes have been the perdition of the church. But whatever be the cause, the faults of the front of St. Peter's are unredeemable and unpardonable. I believe Carlo Moderno was the name of the man who had the merit of its present frightfulness. It is singular, that neither this church, nor that which ranks next to it (St. Paul's, in London), should have had their original admirable plans completed. But we must judge of churches as of men, by what they are, not by what they ought to be; and I must say that the exterior of St. Paul's, with all its faults—and they are many—is, on the whole, superior to St. Peter's in architectural beauty. Nay, I am persuaded that if it were of the same magnitude, built of the same rich and stainless stone, placed in the same advantageous situation, and surrounded with the same noble accompaniments, it would be far more grand, and more chaste."

The above comparison between St. Peter's and St. Paul's is one commonly made by the English, and is perhaps in no way tainted by prejudice. Speaking of the *baldacchino*, the writer says:

"But I forget that I have left you standing all this time in the Tomb of St. Peter and St. Paul, whilst I am talking scandal about defunct queens.

"Emerging from those gloomy, magnificent sepulchral regions of darkness and death, to upper day, we stopped to survey the great altar which stands above the Confessional of St. Peter, and beneath the dome, but it is not exactly in the centre, which rather hurts the eye. It is a pity St. Peter had not been buried a little more to one side.

"Above it rises the *baldacchino*, a gilded and brazen canopy, with four supporting twisted columns, made from the bronze, or precious Corinthian metal plundered from the Pantheon, by Urban VIII., who showed as little taste in applying, as judgment in appropriating it.

"So small does this ugly canopy look in the vast size of the church, that it is scarcely possible to believe the fact, that it is quite as high as a modern castle.

"At the upper extremity of the great nave, the figures of the four doctors of the church, made of ancient bronze, and handsomely gilded, support the famous chair of St. Peter; which venerable relic is also so well encased in the same precious material, that it is difficult to see any part of the old worm-eaten wood of which it was composed. This apostolic seat was unhappily broken, an accident typical, surely, of the fall of those whom it is metaphorically said to support; metaphorically—for it is held up at such a height by the brawny arms of its supporters, that a Pope must really be a mountebank—which one of our Scotch farmers' wives used to call him—and have served a successful apprenticeship to the art of vaulting and tumbling before he could seat himself in it. From the gigantic size of these four doctors, we must allow them the praise of being strong pillars of the church."

Of the other modern architecture of Rome, including even, as we have said, the productions of Michael Angelo, Mrs. Eaton has but an unfavourable opinion, and devotes but little space to their details. On the Basilica of St. John Lateran there are the following among other observations:

"Contiguous to the palace, Constantine built the Basilica; but all his exertions have long since disappeared. It has been burnt down, and built up, and enlarged, and improved, and new-fronted, so many different ways, and at so many different times, and embellished by so many different Popes, that, take it as a whole, it is one of the largest and ugliest churches you can see anywhere. Its southern elevation is, however, imposing, notwithstanding its load of ornaments, and its glaring defects. As a proof of the taste which has beautified its interior, I need only mention that Borromini, the last architect who *improved* it, built up the ancient columns of oriental granite that supported the great nave, in his huge whitewashed buttresses; I could not but mourn, as I contemplated them, over the loss of the imprisoned granite columns within, and the waste of marble in the uncouth colossal statues of the apostles without—one of which, like a watchman in his box, is placed in every buttress.

"The high altar carries above it a huge tower, intended, as I was assured, for ornament—than which nothing can be more frightful. In a semicircular sort of gallery, which runs behind the upper end of the church, there is, at one end, an altar decorated with four ancient columns of gilt bronze, said to be the identical columns made by Augustus from the *rostra* of the ships taken in the battle of Actium, and dedicated by Domitian on the Capitol. So, at least, Marliano asserts, without assigning any proof. However, the fact seems assumed by various contemporary writers, as if of acknowledged truth; and, probably, they knew them at least to have been brought from the Capitol. At all events, they are unquestionably ancient columns, and, I believe, the only ancient columns of bronze in the world. At the other extremity of this gallery, on each side of the organ, are two magnificent ancient columns of *giallo antico*, one of which was taken from the Arch of Constantine by Clement XII., who replaced it by one of white marble.

"The Corsini chapel in this church, in the unrivalled beauty and splendour of the ancient marbles which line its walls, the columns which sustain its rich frieze of sculptured bronze, the gilding which emblazons its dome, the polished marbles of its variegated pavement, the precious stones which gem its altars, and the prodigality of magnificence that enshrines the tombs of its Popes—far surpasses all that a transalpine fancy could conceive. It is built in the form of the Greek cross; but the eye is withdrawn from its perhaps too unobtrusive architecture by the splendour of its decoration, which is, however, remarkably chaste."

To Santa Maria Maggiore the writer devotes a few remarks:

"The Basilica which holds the third rank in Rome, is that of Santa Maria Maggiore. It stands on the highest of the two summits of the Esquiline Hill, and is believed to occupy the site of the ancient Temple and Grove of Juno Lucina, an opinion which seems to have derived its origin from a black-and-white mosaic pavement, which was found at an inconsiderable depth below the pavement of the church, during some alterations made in it in the time of Benedict XIV., and was attributed to that temple.

"In the fourth century, an old pope was instructed in the proper situation of this church, by a miraculous shower of snow that fell in the middle of summer, exactly covering the spot. I suppose his Holiness must have correctly imitated, in the building, every dent and curvature of the snow; for nothing else can account for the eccentricity of its external shape. It would puzzle an able geometrician to define to what figure it belonged. It can only be described by negatives. It is not long, nor square, nor round, nor oval, nor octagonal, nor yet triangular—though it approaches the nearest to that of anything. Nobody could suspect it of being a church, but for the deformity of an old brick belfry, which sticks up in a singularly awkward position from the roof. It has more faces than Janus, and they resemble each other in nothing but their ugliness. In the advance of one of these stands the solitary marble column brought from the Temple of Peace, and erected by a pious pope on a disproportioned pedestal. The other front boasts one of the Egyptian Obelisks that stood before the Mausoleum of Augustus.

"The inside of the church owes all its beauty to its ancient Ionic columns, which are supposed to have belonged to the Temple of Juno Lucina. The roof of the nave is tawdry, flat, and low. The graceful line of the colonnade is broken by arches, that open into lateral chapels of rival magnificence. The least dazzling is that of Sixtus V.; but then it contains a tomb, in which lies the body of that pontiff, miraculously unchanged by death, and working great and unceasing miracles. So, at least, I was informed.

"The splendour of the opposite Borghese Chapel so far surpasses my feeble powers of description, that I shall leave it all to your imagination—to which you may give abundance of latitude, for it can scarcely surpass the reality. It contains one of St. Luke's precious performances, a miraculous image of the Virgin; but those who, like me, have been blessed with the sight of many of that Evangelist's works, will probably prefer the paintings of Guido, the only ones worth seeing in the whole church, though even they will not particularly reward the observer.

"Poor Cigoli went mad, in consequence of Paul V.'s refusal to allow him to obliterate his paintings on the dome of this church, which he ardently desired, in order that he might endeavour to execute something more worthy of his genius.

"You may be sensible of the obligations you owe me for my moderation in respect to this church, when I tell you that a description of it has been published in a large folio volume! I had nearly left it without telling you that it contains the real cradle of Jesus Christ; or, as the *Custode* reluctantly confessed, half of the real cradle only."

What Mrs. Eaton observes of palaces we shall leave to her own introduction:

"Palaces, to an English ear, convey an idea of all that the imagination can figure of elegance and splendour. But, after a certain residence in Italy, even this obstinate early association is conquered, and the word immediately brings to our mind images of dirt, neglect, and decay. The palaces of Rome are innumerable; but then every gentleman's house is a palace,—I should say, every nobleman's, for there are no gentlemen in Italy except noblemen; society being, as of old, divided into two classes, the patricians and the plebeians: but though every gentleman is a nobleman, I am sorry to say, every nobleman is not a gentleman; neither would many of their palaces be considered by any means fit residences for gentlemen in our country. The legitimate application of the word, which, with us, is confined to a building forming a quadrangle, and enclosing a court within itself, is by no means adhered to here. Every house that has a *porte cochere*, and many that have not, are called palaces; and, in short, under that high-sounding appellation, are comprehended places whose wretchedness far surpasses the utmost stretch of an English imagination to conceive.

"Rome, however, contains *real* palaces, whose magnitude and magnificence are astonishing to transalpine eyes; but their tasteless architecture is more astonishing still.

"Though they have the great names of Michael Angelo, Bramante, Verospi, Bernini, &c. &c. among their architects; though they are built of travertine stone, which, whether viewed with the deepened hues of age in the Colosseum, or the brightness of recent finish in St. Peter's, is, I think, by far the finest material for building in the world; and though, from the grandeur of their scale, and the prodigality of their decoration, they admitted of grand combinations, and striking effect, yet they are lamentably destitute of architectural beauty in the exterior; and in the interior, though they are filled with vast ranges of spacious apartments, though the polished marbles and precious spoils of antiquity have not been spared to embellish them, though the genius of painting has made them her modern temples, and sculpture adorned them with the choicest remains of ancient art, yet they are, generally speaking, about the most incommodious, unenviable, uncomfortable dwellings you can imagine.

"I know it may be said, that comfort in England and in Italy is not the same thing; but it never can consist in dulness, dirt, and dilapidation, anywhere. Italian comfort may not require thick carpets, warm fires, or close rooms; but it can be no worse of clean floors, commodious furniture, and a house in good repair.

"In habitations of such immense size and costly decorations as these, you look for libraries, baths, music-rooms, and every appendage of refinement and luxury; but these things are rarely to be found in Italian palaces. If they were arranged and kept up, indeed, with anything of English propriety, consistency, order, or cleanliness, many of them would be noble habitations; but, in the best of them, you see a barrenness, a neglect, an all-prevailing look of misery—deficiences everywhere and contemptible meannesses adhering to grasping magnificence. But nothing is so offensive as the dirt. Among all the palaces, there is no such thing as a palace of cleanliness. You see (and that is not the worst) you smell abominable dunghills, heaped up against the walls of splendid palaces, and foul heaps of ordure and rubbish defiling their columned courts; you ascend noble marble staircases, whose costly materials are invisible beneath the accumulated filth that covers them; and you are sickened with the noxious odours that assail you at every turn. You pass through long suites of ghastly rooms, with a few crazy old tables and chairs thinly scattered through them, and behold around you nothing but gloom and discomfort.

"The custom of abandoning the ground-floor to menial purposes, except when used for shops, which is almost universal throughout Italy, and covering its windows, both for security and economy, with a strong iron grate without any glass behind it, contributes to give the houses and palaces a wretched and dungeon-like appearance.

"It is no uncommon thing for an Italian nobleman to go up into the attics of his own palace himself, and to let the principal rooms to lodgers.

Proud as he is, he thinks this no degradation; though he would spurn the idea of allowing his sons to follow any profession save that of arms or of the church. He would sooner see them dependants, flatterers, eaves-droppers, spies, gamblers, *cavalieri serventi*, polite rogues of any kind, or even beggars, than honest merchants, lawyers, or physicians.

"The Fiano Palace has its lower story let out into shops, and its superior ones occupied by about twenty different families; among which the duke and duchess live, in a corner of their own palace.

"It is the same case with more than half the nobles of Rome and Naples. But the Doria, the Borghese, and the Colonna, possess enough of their ancient wealth to support their hereditary dignity, and their immense palaces are filled only with their own families and dependants. Not but that, though lodgings are not let at the Doria Palace, butter is regularly sold there every week, which, in England, would seem rather an extraordinary trade for one of the first noblemen in the land to carry on in his own house. Yet this very butter-selling prince looks down with a species of contempt upon a great British merchant."

The Villa or Casino of Raphael is a favourite with the writer:

"Since I have been in Rome, many are the visits I have paid to the Casino of Raphael, which was the chosen scene of his retirement, and adorned by his genius. It is about half a mile from the Porta del Popolo. The first wooden gate in the lane, on the right of the entrance into the grounds of the Villa Borghese, leads you into a vineyard, which you cross to the Casino di Raffaello; for it still bears his name. It is unfurnished, except with casks of wine, and uninhabited, except by a *contadina*, who shows it to strangers.

"We passed through two rooms, painted by his scholars; the third, which was his bedroom, is entirely adorned with the work of his own hands. It is a small pleasant apartment, looking out on a little green lawn, fenced in with trees irregularly planted. The walls are covered with arabesques, in various whimsical and beautiful designs—such as the sports of children; Loves balancing themselves on poles, or mounted on horseback, full of glee and mirth; Fauns and Satyrs; Mercury and Minerva; flowers and curling tendrils, and every beautiful composition that could suggest itself to a mind of taste, or a classic imagination, in its most sportive mood. It is impossible to describe to you the spirit of these designs. The cornice is supported by painted Caryatides. The coved roof is adorned with four medallions, containing portraits of his mistress, the Fornarina—it seemed as if he took pleasure in multiplying that beloved object, so that wherever his eyes turned, her image might meet them. There are three other paintings, one representing a Terminus with a target before it, and a troop of men shooting at it with bows and arrows, which they have stolen from unsuspecting Cupid, who is lying asleep on the ground, his quiver empty beside him. One or two roguish-looking Loves are creeping about on the ground, one of them bearing a lighted torch. The marksmen are all bending forward, and some are quite horizontal, with their feet in air.

"The second picture represents a figure, apparently a god, seated at the foot of a couch, with an altar before him, in a temple or rotunda; and from gardens which appear in perspective through its gay intercolumniations, are seen advancing a troop of gay young nymphs, with something of the air of Bacchantes, bearing on their heads vases full of fresh-gathered roses. I could not make out the image to be a female, or else I should have supposed it to be the feast of Flora; therefore, for want of a better explanation, I concluded it meant for the feast of the god of the Gardens.

"The last, and best of these paintings, represents the nuptials of Alexander the Great and Roxana. I never saw a figure of more exquisite loveliness—more touching modesty and grace. She is seated at the foot of a couch; a little Love beside her is drawing off a veil which yet half conceals her beauty. Hymen, with his saffron robes and torch, leads in Alexander, disarmed, but wearing his helmet. A crowd of attendant Loves are employed in their service; some are carrying off his sword, &c.; and one, a comical little Love, has put on his heavy coat of mail, which is ridiculously large for it, and, having tumbled down, is unable to get up again.

"I have perhaps described with too much minuteness the Casino of Raphael: but in general he painted for others—here he painted for himself—and it is interesting to see those sports of his mind, and to trace the fond delight with which he amused his leisure hours in decorating his home, the scene of his pleasures."

As to ancient Rome, Mrs. Eaton is more rapturous:

"Crossing over to the opposite side, beneath the broken and defaced triumphal arch of Titus, fast tottering to its fall, but beautiful even in decay, we beheld the grandest remains of antiquity in the world—the majestic ruins of the mighty Colosseum. No relic of former greatness—no monument of human power—no memorial of ages that are fled, ever spoke so forcibly to the heart, or awakened feelings so powerful and unutterable. The art of the painter, or the strains of the poet, might avail in some degree, to give you a faint image of the Colosseum—but how can I hope, by mere description, to give you any idea of its lofty majesty and ruined grandeur? How convey to your mind the sense of its beautiful proportions, its simplicity, its harmony, and its grandeur; of the regular gradations of Doric, Ionic, and Corinthian orders, that support its graceful ranges of Grecian arcades; of the rich hues with which Time has overspread its massy walls, and of all that is wholly indescribable in its powerful effect on the eye, the mind, and the imagination?

"It stands exactly where you would wish it to stand—far from modern Rome, her streets, her churches, her palaces, and her population, alone in its solitary grandeur, and surrounded only with the ruins of the Imperial City. On one side, the magnificent Triumphal Arch of Constantine still stands in undiminished beauty, adorned with the spoils and the trophies of better times. Above it rises the Palatine Hill, overshadowed by aged evergreens, and covered with the ruins of the palace of the Cæsars. At its southern base, extends the long line of the *Via Triumphalis*, crossed with the lofty arches that once bore the Claudian waters to Nero's Golden House. Behind it appears the dark ridge of the Cœlian Mount, covered with the majestic remains of ruined aqueducts, with mouldering walls and substructures, the very purpose of which is unknown; and on its height, amidst deep groves of melancholy cypress, stand the quiet towers of the Convent of St. John and St. Paul.

"On the other side of the Colosseum, vestiges of the Baths of Titus, and the weed-covered summit of the Temple of Peace, are indistinctly seen; and on a gentle eminence, between the Colosseum and the Forum, appear the remains of the double Temple of Venus and Rome, the richly ornamented roof of which still hangs over the vacant altar-piece of the dethroned deities. Around it are widely strewed, in every direction, huge fragments of colossal granite columns, half-buried in the earth, whose gigantic shafts, it would almost seem, no human power could have broken, and that this scene of tremendous ruin must have been the work of the vengeful gods, whose glittering fane lies here overthrown.

"We walked round the vast circle of the Amphitheatre. In no part has it been completely broken through, but in only a small segment is the external elevation preserved entire. On this is still affixed the cross placed there by Benedict the Fourteenth, who, by proclaiming the Colosseum to be consecrated ground, hallowed by the blood of the martyrs, saved it from the total demolition to which it was rapidly hastening, and merited the gratitude of posterity. That there ever should have been martyrs, one cannot but most seriously lament; but since they were to be martyred somewhere, I hope it is no great sin to rejoice that they were sacrificed here rather than in any other place; and most fervently do I deplore the cold-hearted insensibility of former Popes, in not recalling their sufferings before the work of destruction had advanced so far. Had Paul V. consecrated the Colosseum to their memory instead of pulling it down to build his huge palaces, how we should have venerated him for such an act of piety!

"In the inside the destruction is more complete. The marble seats are all torn away; the steps and the vomitories overthrown, and the sloping walls and broken arches which once supported them, are now overgrown with every wild and melancholy weed, waving in all the luxuriance of desolation.

"In the centre of the grass-grown arena stands a huge black cross, which liberally promises two hundred days' indulgence to every person who kisses it (heretics not included, I presume); and many were the kisses we saw bestowed upon it;—no wonder, indeed! The pious persons who saluted it afterwards applied their foreheads and chins to it in a manner which they seemed to feel highly comfortable and consolatory.

"The French—who perhaps did not expect to profit by its indulgences—showed it no indulgence on their part, but took the liberty to knock it down; remorselessly depriving the Romans of the benefit of two hundred days of indulgence, for which they certainly deserved to be condemned themselves without benefit of clergy. They also carried off, at the same time, the pictured representations of the fourteen stages of Christ's pilgrimage under the cross, which are again reinstated in their ancient honours, and stand round the beautiful elliptical arena, grievously offending the Protestant eye of taste, however they may rejoice the Roman Catholic spirit of piety.

"There are other of their improvements which have been suffered to remain, that we would rather have seen removed. French taste has formed a little public garden at the very base of the Colosseum, so wofully misplaced, that even I, notwithstanding my natural passion for flowers, longed to grub them all up by the roots, to carry off every vestige of the trim paling, and bring destruction upon all the smooth gravel walks.

"We ascended, by a temporary wooden staircase, to the highest practicable point of the edifice—traversed the circling corridors, and caught, through the opening arches, glimpses of the scattered ruins, the dark pine trees, and purple hills of the distant country, forming pictures of ever-varying beauty and interest. We looked down on the vast arena; its loneliness and silence were only broken by some Capuchin friars kneeling before the representations of our Saviour's last suffering pilgrimage, and muttering their oft-repeated prayer as they told their beads.

"The clear blue sky, in calm repose above our heads, breathed its serenity into our minds. The glorious sun shed its beams of brightness on these walls with undiminished splendour. Nature was unchanged, but we stood amidst the ruins of that proud fabric, which man had destined for eternity. All had passed away—the conquerors, the victims, the imperial tyrants, the slavish multitudes; all the successive generations that had rejoiced and triumphed, and bled and suffered here. Their name, their language, their religion, had vanished—their inhuman sports were forgotten, and they were in the dust.

"But let me restrain myself. Meditation here is inexhaustible, but to others, our own meditations can rarely be interesting. There is a charm in these magnificent ruins, powerful but indefinable, which every mind of reflection and sensibility must feel—and we lingered amongst them till the day was done."

Reports by the Juries on the Subjects in the Thirty Classes into which the Great Exhibition was divided. London: Printed for the Royal Commission, by William Clowes and Sons. 1852.

These reports are now of individual rather than of general interest, but they will be perused by many persons because they give in a cheap form reports in some cases by eminent persons of the present state of various branches of industry. Of a work so multifarious it is impossible to speak generally, and we must therefore limit ourselves to extracts from portions more particularly bearing on subjects of interest to our readers. Class VI. was devoted to Manufacturing Machines and Tools. The Jury say of Engineers' Tools:

"Amongst the machine tools, *lathes*, as might be expected, appear in the greatest number and of every variety of size and arrangement, from the powerful machines, which are capable of turning wheels 7 or 8 feet in diameter, or shafts 36 feet in length, down to the delicate lathes used by amateurs, or the makers of small machines and apparatus. However, it must be remarked, that in this collection, complete as it is, several important machines are not represented, as, for example, the colossal lathes which are employed for boring cylinders.

"A magnificent railway-wheel lathe, with two opposite head-stocks and face-plates, and two compound slide-rests to correspond, capable of turning wheels above 7 feet in diameter, is exhibited by Messrs. Sharp, and one of smaller dimensions by Messrs. Whitworth and Co., who also contribute two of their patent duplex lathes, in which the work is acted upon simultaneously by two tools cutting at the opposite extremities of the same horizontal diametrical line. Thus vibration and deviation of the work in shaft-turning is wholly prevented. The beds of these lathes are 18 feet and 36 feet in length respectively, and the latter is provided with two duplex slide-rests, which can be made to travel simultaneously by self-action, either in the same or opposite directions at pleasure, so as to economise the time required for finishing the work. They also exhibit a 5-inch self-acting foot-lathe, with complete arrangements for sliding, screwing, and surfacing. Large lathes of excellent workmanship, each having some peculiar facilities in the details, and adapted for sliding, screwing, and surfacing by self-action, are exhibited by Messrs. Smith, Beacock, and Tannett; Parr, Curtis, and Madeley; Sandford, Owen, and Watson; and Shepherd, Hill, and Spink. Mr. Muir contributes a well-made small foot-lathe, with a variety of screw stocks and other tools.

"In the American department, a lathe sent by the Lowell Machine Shop, of 12-inch centre and 13-feet bed, with the usual arrangements for self-action, will be looked on with great interest, as a specimen of first-rate transatlantic workmanship in this branch, and as offering various peculiarities of form and distribution of metal, the latter being employed as sparingly as possible on account of the great cost of iron. Hence a lightness of construction carried to the extreme point consistent with strength and stiffness, which presents a singular contrast to the solid proportions adopted by our own engineers.

"In the smaller class of lathes Messrs. Holtzapffel and Co. take the lead, by exhibiting a first-rate amateur lathe, provided with all the apparatus required for ornamental turning, such as oval, eccentric, and drilled work, and a variety of tools and contrivances appertaining thereto, of the most elegant and perfect workmanship. Mr. Dalgety has a highly-finished lathe, to which is appended, amongst other things, his useful chuck, which is capable of fixing perfectly central a wire of any size not larger than ¾-inch. Other lathes are contributed by Mr. Williams, with a new tool-holder and self-acting screw-cutting apparatus; by the Messrs. Knight, who have fitted up a complete amateur-work cabinet, and by Messrs. Eades and Son. Messrs. Mordan, Sampson, and Co., send a new machine for tracing rose-engine patterns. M. Hamann has a highly-finished amateur lathe, adapted for turning either in metal, or wood and ivory, and provided with a variety of the usual chucks and apparatus.

"*Planing Machines.*—Six planing machines are to be found in the collection, amongst which, of course, those of the largest size are not sent, on account of their bulk and weight, and because their arrangements are the same as those of the medium size, of which excellent specimens are exhibited by Messrs. Sharp, Parr, and Co., and Messrs. Whitworth, the latter sending two, of which one is provided with his revolving reversing tool, which enables the machine to plane both ways. The varieties of construction by which these admirable machines are individually distinguished, although they are perfectly similar in general form and purpose, afford the most interesting studies for the engineer and mechanist. This remark may be applied with equal force to the slotting and shaping engines about to be described, and indeed to many other groups of machines in the present collection. Messrs. Whitworth also send a small planing machine (2 ft. 6 in. long) moved by a crank, arranged to give a slow cutting action and a quick return; and Mr. Shanks a diminutive hand-machine for the use of opticians.

"*Slotting Machines.*—Of slotting and paring machines we find one large specimen from Messrs. Sharp, and two smaller ones by Messrs. Whitworth. One of the latter is provided with a complex bed for sustaining the work, composed of four rectilinear slides, and one rotating disc, by means of which any form composed of a combination of eccentric circular arcs, and straight lines, may be pared and finished upon the machine.

"*Shaping Machines.*—The shaping machine, as it is called, is a kind of planing machine in which the tool is attached by proper slides and holders to the end of a horizontal bar, to which a reciprocating motion for cutting is communicated in the direction of its length, by a crank or eccentric. The work is either fixed to a horizontal table with longitudinal and vertical adjustments, or to an arbor, and the machine is employed for shaping levers and cranks or curved and plane forms in general; and as it is susceptible of many varieties of construction and detail; the six specimens which are here exhibited by several leading engineers will be compared with great interest by mechanists. The largest is contributed by Messrs. Parr, in which the tool has a stroke of 12 inches, and the bed is 7 feet long; two lesser ones are sent by Messrs. Smith, Beacock, and Co., and one by Messrs. Whitworth. Messrs. Sharp exhibit one of a very neat and compact arrangement, but not possessing all the capabilities of those just mentioned, and there is also one sent by Mr. Shanks.

"*Drilling and Boring Machines.*—There are six drilling machines of various sizes and capabilities; amongst them Messrs. Whitworth again appear, as the exhibitors of a large radial drill, the framing of which may be selected as an admirable specimen of casting in iron. The arm of this machine is moveable through an arc of 190°. Messrs. Hick contribute a large radial drilling machine, the pillar of which is formed into a screw that allows the arm to be turned completely round, and raised to any required altitude.

"Excellent self-acting vertical drilling and boring machines, with various arrangements of the table, are exhibited by Messrs. Whitworth, Smith, and Co., Parr and Co., and Williams."

The details of the steam-engine department being given in a tabular form, do not admit of convenient extract. Of Hydraulic Machines, Jury X. say:—

"In reporting upon the Hydraulic Machines exhibited, it is impossible to refrain from adverting to the general neglect of those elementary principles of scientific knowledge on which the perfection of such machines always depends, and, in some cases, their whole usefulness in an economical point of view. The Exhibition affords positive evidence of the sacrifice of a large amount of capital, and of much mechanical ingenuity, due simply to the ignorance of certain acknowledged principles of hydraulic science. In adverting to this fact, the Jury cannot but observe that the success with which the principles of mechanical science, in their application to practical questions, are beginning to be cultivated in France, appears in the superiority of the French hydraulic machines. Thus their water-wheels have attained a perfection which is probably nowhere else to be found in the application of water-power. The total amount of such power derivable from the running waters of France, and applicable to manufacturing purposes, has been largely increased, by expedients of a scientific character. Among the most remarkable of these is the introduction, now almost universal in France, of the curved float-boards of M. Poncelet in undershot and breast-wheels, and of the turbine of M. Fourneyron. It is not however, only in the adoption of new forms of water-wheels in France, that the improvement has been apparent, but in the better establishment and more skilful working of the old forms; such as are in use in this country.

"Of all such expedients for the economical application of water-power, it is a principle that, as far as it may be possible, the water should be received on the machine, without shock, and that it should leave it without velocity. For that there is power lost by the shock of water is apparent from the fact that the whole power of a fall of water may be absorbed in the reservoir into which it falls, by the shock and commotion of its particles; and it is plain that if the water which works a machine leaves it with any velocity which might have been avoided, then the power which must have been expended in giving it that velocity has been thrown away. It is another condition, founded on the same principle as that of avoiding a shock of the water, that there should be no sudden contractions or expansions of the influent or effluent streams. It is, we repeat, on the scientific application of these principles that all expedients for the economical working of hydraulic machines are founded. We have, however, only to pass through the rooms of the Exhibition assigned to this class of machines to find them almost universally ignored.

"The record of this fact is important, as placing in an obvious point of view the necessity of other means than are now afforded for the scientific education of mechanical engineers."

The particulars of centrifugal and other pumps contain many valuable details, but we cannot profit by them on this occasion. Water-Meters are thus mentioned:—

"The labours of the Health of Towns Commission have given fresh importance to the invention of water-meters. To afford an unlimited supply of water, it is necessary that some means should be afforded of measuring the quantity each house consumes. If each house were provided with a reservoir, into which the water for its consumption were from time to time received, and from which it was distributed, this would be comparatively easy by means of a meter constructed on the principle of a rain-gauge, with a divided chamber and a tumbling shoot. The desideratum is, however, to measure the efflux directly from the pipes, under whatever pressure the service may be made, and to dispense with the reservoir.

"Five different contrivances for this object are exhibited. The Jury has, however, found none so far perfected as to satisfy the conditions of a good meter. In the majority of them the measurement is made by the revolution of a fan, like a screw-propeller, fixed within the pipe, and driven round by the effluent stream. Among other objections to which this principle of construction is liable, is the fact that a considerable leakage may be obtained without giving sufficient motion to drive the fan.

"A water-meter, exhibited by Bryan Donkin and Co., is constructed on the well-known principle of the disc steam-engine. Although this is free from the defects which belong to meters constructed on the principle of the revolving fan, it is open to those of insecure packing and unequal wear.

A Manual of Mathematical Geography; comprehending an inquiry into the Construction of Maps, with rules for the formation of Map-Projections. By WILLIAM HUGHES, F.R.G.S. Second Edition. London: Longmans. 1852.

As this is a second edition, we can say little more of it than that it fully maintains the reputation of the first issue, and will be found highly useful by professional students, as giving the whole science of map drawing. The first edition of the work was, by order of the Indian government, translated into Hindostanee for use in the Civil Engineering College at Rourkee and other schools.

The Engineer's and Contractor's Pocket Book for the years 1852 *and* 1853. London: Weale.

THE Engineer's Pocket Book contains not only the usual tabular and standard information, but many new tables and additional matter of equal value. Of a work that had attained a standard character we can hardly say that it is much improved, but everything has been done to keep up the character of the work, and meet the requirements of professional men.

The Student's Guide to the practice of Designing, Measuring, and Valuing Artificers' Work. Second Edition. By E. LACY GARBETT, Architect. London: Weale. 1852-3.

THIS work has been in three competent hands. The manuscript was originally compiled by an architect and surveyor of fifty years' experience; it was prepared for the press by Mr. Edward Dobson, a practical surveyor; and the second edition is undertaken by Mr. Edward Lacy Garbett. It embraces every branch of the building trade, with practical instructions for measurement, and with comments on construction from Mr. Garbett.

The Practical Lithographer. By CYRUS MASON. London: Mason. 1852.

WE are glad that the subject of chromo-lithography is being taken up in earnest by the members of the profession, believing, as we do, that it wants but a slight degree of cultivation to place us on an equality with the Germans, those masters of the art. At the same time, there is no doubt but that we have improved—witness the late "Blue Lights" of Messrs. Day and Son. The object of the author, as stated by him, is not to depreciate former works on the subject, but, by the collation of a variety of hints communicated to him from time to time by different professors of the art, native as well as foreign, to remove the difficulty felt by the beginner in obtaining the necessary information preparatory to the practice of Lithography. In this laudable endeavour he has succeeded in such a manner as to leave nothing further to be desired by the student of his book.

THERMOMETER SCALES.

MR. JAMES ELMES, of Lewisham, has forwarded to the *Times* a few easy formulæ for the reduction or conversion of the three thermometric scales at present in use in Europe, from the one stated into that which is best known or understood by the querist. He says: "The heat of boiling water is described to be as 212° Fahrenheit, 80° Réaumur, and 100° centigrade; freezing point 32° Fahrenheit, 0° Réaumur, and 0° centigrade. In the absence of a comparative table, or of a thermometer graduated into these three scales, I think you will find the following rules more simple and easier to perform, by the first three rules of arithmetic—namely, addition, subtraction, and multiplication—than by the decimal formulæ given in Dr. Ure's 'Dictionary of Chemistry':—

1. To reduce or convert the degrees of Fahrenheit into those of Réaumur:

$$\frac{F^\circ - 32^\circ \times 4}{9} = R^\circ;$$

because Fahrenheit's scale is equal to $\frac{9}{4}$ths of Réaumur, and Réaumur = $\frac{4}{9}$ths of Fahrenheit.

2. To convert the degrees of Réaumur to those of Fahrenheit:

$$\frac{R^\circ \times 9}{4} + 32^\circ = F^\circ.$$

3. To convert the scale of Fahrenheit's thermometer to that of the centigrade:

$$\frac{F^\circ - 32 \times 5}{9} = C^\circ.$$

4. To convert the scale of the centigrade thermometer into that of Fahrenheit:

$$\frac{C^\circ \times 9}{5} + 32^\circ = F^\circ.$$

5. To convert the scale of Réaumur's thermometer to that of the centigrade, and *vice versâ*, we have but to remember that 80° Réaumur is equal to 100° centigrade, and consequently is relatively as 8 to 10, or as 4 to 5.

In Russia they mostly use De l'Isle's thermometer, which marks the boiling-water point as 0° (zero), and divide the scale downwards to the freezing point into 150°. This scale can be similarly reduced, or converted into those of Fahrenheit, Réaumur, and the centigrade, but, as it is so rarely quoted, examples are unnecessary."

ON MARBLE AND STONE WORK.

By Prof. D. T. Ansted, M.A., F.R.S.

[*Exhibition Lecture delivered at the Society of Arts, London.*]

The manufacture of marble and stone, except in the case of inlaid work, offered little that is new, and no deviation from the long-known and established methods seems to have been illustrated in the Exhibition. Many of the more simple forms, both straight and round, are easily cut and polished by machinery, which may, of course, be driven either by water or steam power. The latter has been effectively employed, both in the neighbourhood of London, and elsewhere, to reduce the cost of marble work. The harder kinds of stone, particularly the jaspers of Russia and Norway, are, however, much more difficult to cut, and in some cases involve a vast expenditure of manual labour, combined with much ingenuity; but there seems to be no great amount of cultivation or skill required to produce those singular monuments of patience or perseverance, of which the carved jades of China and India, as well as the jasper vases of Russia, are alike examples. These mere results of the constant repetition of minute touches, so characteristic of a people in a state of inactive civilisation, are curiously contrasted with the granite obelisks and columns prepared for the occasion, and brought into their places with almost unequalled rapidity and precision, by some of our own exhibitors; and they are likely to remain unimitated, not only because we have not in England any material so hard as some of the Siberian rocks, but because there are no means of obtaining sufficient human labour at a low rate of wages to allow of the economical production of such objects. It occurred to me, however, in examining the collection of jades and agates from India and China, that for certain purposes we might with advantage make use of the patience and cheap work of the Eastern people, by sending over models of various articles that it would be desirable to have constructed in the hardest stone.

As the most numerous and varied examples of sculptured stone and marble work not inlaid were, as might have been expected, of English make, and as this source of industry is much followed amongst us, in consequence of the great variety and abundance of the material with which we are provided by nature, it will be well to commence with a sketch of the condition of the manufactures in this country, and the probable effect of the Exhibition in respect to them.

Very few countries exist in which so many and such excellent materials for construction of so varied a character exist in so small an area, and in such great abundance, as England.

Several very distinct kinds of limestone and magnesian limestone, both uncrystalline, and partially or completely crystalline; several kinds of slate adapted for different purposes, of the best quality and in almost infinite abundance; numerous grits and sandstones, some of them the finest in the world; different kinds of granite and porphyry, including several of excellent quality and almost perfect durability, besides great beauty; these may be met with at the surface in various places, may be quarried readily, at little cost, and may generally be conveyed away either by land or water-carriage at small expense. With these advantages it might have been expected that stone-work would be met with in perfection in all our towns—that our public monuments would be noble illustrations of this source of national wealth—and that we should have only too many proofs of the skill of our workmen and the taste and genius of our architects. This, however, is, as we all know, by no means the case. Our metropolis and every town in our island abound with illustrations of material, badly selected, badly worked, improperly exposed, and in every sense discreditable.

That there are numerous exceptions I would not for a moment deny, but the rule is as I have said. To save a very small proportion of the first cost, some cheap stone is commonly selected for public as well as private edifices and for public monuments; little or no pains have been taken, at least till very lately, to learn the true relative value of different materials, and thus, in the course of time, we find ourselves surrounded with specimens whose greatest use is that they may serve as warnings, if not as examples.

As far as the Exhibition could be said to represent the present state of this country as to the use of material for construction, it was not, however, unsatisfactory, and indicated an increasing demand for good stones. The valuable grits from Yorkshire and Edinburgh, the yet more valuable and beautiful granites and porphyries from Cornwall, Aberdeen, Peterhead, and elsewhere, and the paving-flags from various previously known districts, were all not only illustrated, but well and effectually shown; but of the English limestones scarcely any were to be seen, except as raw material. The case was, however, quite different with regard to slates; these being not only well, but lavishly, sent from all the principal sources whence the material is obtained. A great amount of novelty was shown in the application of slate, and some modern and very economic adaptations received much and deserved notice.

Although the English limestones were by no means well illustrated, and there was not a single exhibitor of Caen stone in any form from France, this beautiful and useful material was well represented in the English mineral and archæological courts by several monumental works—a font, a chimneypiece, and other well-chiselled and admirably designed objects. We mention these as highly creditable to the English workers in stone; but the material is universally acknowledged as one of the finest known for architectural and monumental work, and generally for internal decoration where stone is required.

The use of marble in England has not hitherto been so considerable and extensive as the abundance of the common kinds renders desirable and possible. Every one must have noticed the comparative abundance of marble in slabs and ornamental house furniture, in most parts of the continent of Europe, and its rarity in English houses of the middle classes. There is no sufficient reason for this; and it may be hoped that, before long, both Derbyshire and Devonshire will be greatly benefited by a very large increase in the consumption of a material of which they possess an inexhaustible supply of admirable quality, and which they can furnish at prices which will, I am satisfied, command attention. In order to illustrate in some measure the state of the case, I have obtained from a marble-works at Bakewell (the proprietors being the Messrs. Lomas, who make use of water power and machinery for the principal part, not only of their flat, but round work), a number of specimens of the ordinary marbles of Derbyshire; and I am enabled to state that chimneypieces of the common grey kind, of good form and properly finished, can be prepared now at a price not more than 15*s.* for bed-rooms, and 20*s.* to 30*s.* for ordinary sitting-rooms, while slabs for wash-stands and other purposes may be obtained at corresponding rates. Messrs. Lomas have sent for the museum of the Society, and for constant reference, a series of excellent samples of the different marbles. I am able to state that the marble trade in Derbyshire is increasing, but there is nothing like the activity that ought to prevail in furnishing a substance so cheap, clean, durable, and elegant.

The taste displayed by the exhibitors of marble work for furniture was, on the whole, inferior and unsatisfactory, especially in those cases where there appeared the smallest pretence of originality or style. Thus the marble chimneypieces and the forms of slabs were, with few exceptions, either overloaded with ornament or badly designed for the kind of decoration, or else ill adapted for the purposes for which they were intended. I feel obliged to include in this somewhat sweeping censure most of the marble and stone chimneypieces, whether of English or foreign material, sculptured in England, and sent by native exhibitors.

Amongst the strictly decorative objects constructed of marble or such-like material, the variety was considerable, and the taste in some cases decidedly good, though rarely original. A comparatively new material also was exhibited, hitherto little used for general purposes, although greatly admired and extremely beautiful. I allude to the Cornish serpentine, a spotted marble of red or green colour, of which were constructed a pair of obelisks, a font, candelabra, and other articles, placed in a very prominent position. This serpentine, and the steatite from the same district, offer many advantages, from the facility with which they are cut and the brilliancy of their greens, reds, and other colours; but they are very apt to show ugly white streaks, and can rarely be obtained in large slabs of good quality. They are worked for the most part at the same establishments as those which cut and polish the finer Cornish granites; and in justice to the exhibitors of such objects, it must be said, that the forms selected are not only good in themselves, but, on the whole, well adapted to the objects manufactured—a matter of no little consequence in the application of a substance admitting of but limited use. The manufactures of alabaster from England were in no sense remarkable.

The black marble goods sent from Derbyshire were worthy of particular notice, not only as illustrating the use of a material probably the best of its kind to be obtained at present in Europe, but as being a really valuable key to the state of the local and general taste in decoration among the higher class of purchasers. With little reason from the expense, either of the material or the labour bestowed upon it, this black marble is not common, and is made for the most part into forms so monstrously bad that it may be matter of congratulation that this is the case. It is true, indeed, that several good illustrations of its use may be found readily in Derbyshire, both simple and inlaid; but these are chiefly large and costly, owing apparently to the want of demand for things really excellent on a moderate scale. The most important uses at present are in the manufacture of the finer kinds of dining-room chimney-pieces, and in the tables to be inlaid in the Derbyshire imitation of Florentine mosaic. I am happy to state, that in a very recent visit to the marble manufactories of Derbyshire, I have seen some admirable and quite novel forms introduced, which are, there is reason to believe, amongst the early results of the Exhibition; and I feel certain that much good has been done already in this quarter, which requires only to be encouraged to produce greatly improved models. Good black, as well as coloured, marbles (especially the fine green varietyfrom Connemara), are obtained abundantly in some parts of the west of Ireland, and would fully justify an endeavour to establish a manufactory in that district.

By far the most remarkable and ornamental among the marble manufactures of England is that imitation, or rather application, of the method of inlaying, long known as Florentine mosaic, which was introduced into Derbyshire some years ago, and has since been greatly extended. It affords now an important and increasing employment to a considerable number of ingenious workmen.

The inlaid work of Derbyshire is performed on solid slabs, generally of black marble, on which the forms to be inlaid are first sketched in outline, and then cut out to a small depth by proper tools. The marble to be inlaid, having been first sawn into thin veneers, is cut into the required shapes by saws and files, and cemented into the recess prepared for it, either by a soft cement, or by shell-lac. The whole surface is afterwards polished together. From the nature of the method it will be seen that the chief ingenuity consists in the selection of proper patterns, and their adaptation to the marbles which can be obtained for inlaying; and there has hitherto been very little attempt at originality in so preparing designs as to be fitted to the exact conditions obtainable in the present state of the manufacture. Imitations of Florentine work (a very different manufacture, as I shall presently explain), copies of Roman pavements, usually in clay tesseræ, and the most unmeaning geometrical forms, have hitherto been the chief results: but here again I am happy to be able to point to an unquestionable improvement arising from the Exhibition; and I look forward to the introduction of taste and ingenuity that will, before many years are over, elevate the manufactures of Derbyshire into a very distinct and prominent position.

I cannot here omit the name of Mr. Grüner, who supplied the pattern for an elegant border to a table exhibited in the Fine Arts Court by Mr. Woodruffe (the property of His Royal Highness Prince Albert), and who has since then, on learning more accurately the nature of the material and the details of manufacture, provided another design of singular beauty, which promises to be in the highest degree successful. It is right to say that the Derbyshire mosaic is by no means costly compared with other similar works, and may easily be obtained at prices little, if at all, higher than those commonly asked for imitations of Florentine work of far less artistic or mechanical merit.

Besides the Derbyshire mosaic, there is a somewhat similar but inferior manufacture carried on both in Derbyshire, and Devonshire, and in many other places, in which geometric and other shapes of marble in veneer are fastened by cement on a flat slab of slate or marble. Numerous specimens were exhibited, but, with the exception of a large and very beautiful table of Devonshire marbles, there is no need that I should refer to them in this place.

The manufacture of fluor spar (locally called Blue John) into vases and other ornaments is another source of occupation to a limited number of persons in Derbyshire. The spar is generally of a deep purple tint, and rarely clear, but, on exposure to a moderate heat, the tint becomes much less muddy and passes into a pink, and would in time be discharged. With proper care, the commoner kinds are thus rendered available, and are largely used in the construction of ornaments.

In concluding a reference to the mosaic work of England, I might refer to the use of malachite, were it not that this material is so much better, as well as more largely, employed in Russia, and that its application with us is rarely to be justified, owing to the bad selection of objects manufactured of it. Many other foreign marbles, and a number of pastes and glasses, are also used from time to time where particular colours are required. Even shell is sometimes employed in the same way. There can, I think, be little doubt that this practice of resorting to artificial stone, generally of different hardness from marble, is unworthy of the artist, and in every sense undesirable. By taking advantage of the stores that nature has provided in foreign countries, much may certainly be done, but the limitation of the pattern to colours and markings that can be obtained is the true mode of escape from the difficulty. Few things can be more incongruous or in worse taste than the insertion of a piece of malachite to represent a leaf, or of a fragment of shell with nacreous reflections for the petal of a flower. These are faults which may still be noticed in Derbyshire work; and I fear the error of taste is at least as great in the purchaser as in the mosaicist.

I pass on now to the stone and marble manufactures of other countries, and amongst these Italy claims the first notice, not less for the exquisite beauty and taste of many articles than for the relative importance which these products bear to the whole group of objects exhibited. Of stone-work, indeed, Italy sent hardly any examples, and these few were by no means remarkable; but in marble of all kinds, alabaster, spars, and mosaics in *pietre dure*, the series was highly interesting, though the absolute novelties were very few. Of all European countries Italy is the most rich in available marbles, and the variety obtainable seems inexhaustible; but the marbles of other countries are also there worked, and, perhaps one of the most perfect specimens of marble work that has been seen in this country was the vase of Egyptian alabaster (a peculiar form of carbonate of lime) exhibited in the east nave, near Rome, whose rich and soft tint of colour was only surpassed by the beauty of the form into which it was chiselled and its admirable workmanship. The whole of this vase was cut from a single block of stone, and the quality of the stone itself was unequalled.

Several fusts, or portions of columns, of brecciated and other marbles, several slabs, more or less completely formed into tables, and a number of less finished specimens, besides some figures that were intended to belong rather to the class of Fine Arts than that of Mineral Manufactures, bore testimony to the importance of the marble trade in Italy, and were worthy of study. A large vase of true alabaster, executed in Volterra, was a noble instance of the application of this material; and there were also some other illustrations of its use in a pair of candelabra and other articles, not so well adapted or so elegant.

But the most remarkable of the Italian works in marble and stone were the specimens of Florentine mosaic. This art consists in the preparation of a very thin slab of black marble, on whose surface is first etched some design to be inlaid; the marble is then cut away from these portions, and prepared stones in a finished state are inserted with the greatest care. The stones thus inserted are not marbles, but chalcedonies, agates, and other siliceous pebbles, of which a singular variety occurs in the bed of the Arno; but with them are mixed lapis lazuli, jaspers, and some other foreign minerals. The hardness of these being so much greater than that of the marble, the polishing cannot be effected after the inlaying is completed, and the stones being very difficult to work, and often of small size, the whole manufacture is essentially different from that followed in Derbyshire. The inlaid plate, when completed, is cemented on a slab of black marble, and may then be finished off. True Florentine mosaic is thus a far more costly manufacture than that of Derbyshire, and is also much more durable. The city of Florence has long been justly celebrated for several manufactories remarkable for the simple elegance of the designs inlaid; and the specimens exhibited, although offering little that is new, fully kept up the high character that has been obtained.

In speaking of Italy I have not included the northern provinces, which are politically Austrian. These sent a number of works in stone and marble, including amongst them a variety of marble chimney-pieces, more remarkable for their elaborate design than for their fitness or adaptability. From Austria proper the variety of marble and stone manufactures was inconsiderable, and the degree of originality very small.

From the island of Malta (almost a part of Italy in manufactures of this kind) there were several groups of objects sent for exhibition, proving the anxiety of some of the manufacturers to take a high position both in stone-work and marble mosaic. The former consisted of numerous carved vases, worthy of careful examination and much praise, while the latter included excellent specimens of a modern adaptation of the Italian work in *pietre dure*, the stones not being harder than marble, and the whole veneered on a slab of slate or stone—generally the latter. The value of this manufacture may be regarded as intermediate between that of Florence and the better kind of Derbyshire work, but there was decided originality and some merit in the designs, a reference to the material being especially observable. It may be well to mention that the materials of the Malta tables were not generally from the island, with the exception, I believe, of a very beautiful dead white limestone, which might be introduced with great advantage into England.

France was by no means remarkable for the stone or marble manufactures sent to the Exhibition; and, owing to the utter want of all arrangement either in the building or the catalogue, it was equally difficult to discover and refer to any object from that country that one might wish to study. The chimneypieces were the only marble manufactures of the kind having any claim to notice, but these were in no way remarkable for excellence.

Belgium is rich in marbles of ordinary quality; but with a few exceptions, in the case of some fine black marble, and a large and well-executed chimneypiece of Carrara marble, there were few important works in this department of manufacture. A very well-constructed pinnacle, in a hard even-grained stone of good colour, may be mentioned as an exception. Germany also offered but little, although a few specimens were sent of the Silesian marbles, which include some of great beauty and others of considerable but unequal hardness. Sweden and Norway exhibited very fine specimens of granite-polishing and inlaying, while Spain and Portugal sent many remarkable and beautiful samples of material, but nothing in the way of finished manufacture that requires special notice.

Far different, however, is the case of Russia, which offered, as has been already hinted, some illustrations of an extent of human labour almost fabulous in modern times, and some examples of a gorgeous and truly Oriental magnificence in the veneered malachite work so abundantly shown. The former consisted of a few vases of a jaspic stone of the most extraordinary toughness and hardness, of which we can say little more than that the best-tempered and hardest steel tool turns aside from it without producing any impression, although the form and decorations of the vases exhibit an amount of manipulation and undercutting, and are executed with a freedom which could scarcely have been surpassed if they had been made of alabaster. The total absence of any useful result, and the very small amount of any kind of beauty, must, however, be regarded as greatly diminishing the interest felt in this singular manufacture.

The malachite work for which Russia has been long celebrated was never seen in western Europe in anything like perfection until the occasion of the Exhibition induced the princely owners, both of the mineral and the manufactory, to make extraordinary exertions in order to illustrate this very remarkable fabrication. Single specimens, some of them of large dimensions and of great value, had been occasionally sent as imperial presents to various distinguished persons, but these were for the most part put together before certain recent improvements had been introduced, and they had never been exposed to minute and careful examination. This part of the Russian exhibition was, in some respects, more remarkable than anything else among the mineral manufactures; and if an intention, at one time expressed, of preparing a malachite apartment had been fully carried out, the effect would, doubtless, have been greater than it was.

I need not detain you with any account of the raw material (blue carbonate of copper) made use of in this manufacture. As a substance available for veneering it is found chiefly in a single locality in Russia, in lumps of moderate size, rarely so large as a child's head, and is cut for use into thin slices, which are fastened on a copper, iron, or marble surface, prepared for the particular use designed. Formerly the slices were with straight edges, and were put together without much reference to the continuity of the natural lines of veining; but, by a very ingenious set of contrivances of modern date, most of the surfaces are now curved, and not only fit into corresponding curves, but the veining is made continuous as in nature, so that extremely simple but elegant patterns are produced, giving an appearance as if the whole of a large surface were of one piece. The effect is greatly heightened by a peculiar cement, made of broken fragments and powder of the malachite itself, imitating accurately a natural breccia frequently occurring in the lumps. The rounded and other surfaces are all cut out of the solid block by saws constructed for this purpose; and the labour incurred in making any large object, together with the enormous amount of waste in the raw material, combined with the original costliness of the stone, render the expense very considerable. The prime cost of fine malachite at St. Petersburgh varies from 12*s.* to 15*s.* per pound avoirdupois, according to the quality, and at least two pounds are wasted for every pound used. Estimating the thickness of the veneers used in the manufacture of the doors at one-eighth of an inch, and the surface covered at about 120 square feet, there must have been required for these objects alone at least 3000 pounds weight of rough malachite, the value of which in the country could not have been less than 2000*l.* sterling, exclusive of all cost of labour.

For some time past there has been a manufactory at St. Petersburg, originally conducted by Florentine workmen, and repeating in *pietre dure* many of the well-known Florentine patterns, cut from pebbles obtained even from the Arno itself. Samples of imitative Italian work from this manufactory (now conducted by native Russians) were very creditable, but there was also a novel modification, more striking, if not requiring so much skill. I allude to the box or jewel-case belonging to the Empress of Russia, remarkable for the presence of selected stones in high relief, represented by natural peculiarities of colour, texture, and appearance, such fruits as pears, grapes, currants, &c. Nothing could well be more pleasing of its kind, but at the same time the difficulties were rather those surmounted by patience than genius. The design was, however, very pleasing.

From extra-European countries, marbles and polished stones, as well as marble mosaics, were only numerous and remarkable in the case of India, although from China also were some very extraordinary works, apparently constructed of jade. The Indian marble work was admirably illustrated by a set of garden chairs, presented to her Majesty, which are well worthy of notice for the extreme delicacy and finish observable throughout, and the perfection of the mechanical part of the work. The design in this case is perhaps hardly equal to the execution, but there is considerable elegance in the pattern. In a smaller way, but involving much labour, I would remind you of the numerous articles manufactured in agate, cornelian, bloodstone, jasper, and jade, which employ a considerable population at Cambay, and which might certainly be rendered available for many purposes in this country. I cannot omit noticing also the lattice work in stone, of which there were some extremely delicate and beautiful examples exhibited.

But chief amongst the Indian mineral manufactures must be mentioned the remarkable and exquisitely delicate mosaics in hard stone, of which it is difficult to know which most to admire and wonder at, the design or the execution. The designs are generally free, simple, flowing, and, as befits objects generally of moderate size, they are small and delicate. It would seem that this manufacture is of very ancient date in India, but it is certainly carried on now as well, and nearly after the same fashion, as it was at least two centuries ago; and according to Dr. Royle it is chiefly confined to one district in Northern India. It is perhaps to be regretted that advantage has not been taken of this elegant manufacture to obtain ornamental furniture of various kinds for the English market.

The articles made of jade sent both from India and China were chiefly ornamental, and in most cases appeared to be merely illustrations of great mechanical difficulty overcome. Thus plates, bottles, cups, pots, boxes, and other things, were inlaid with rubies or emeralds in singular profusion, grotesque figures were represented, and small models executed in this material. It would be well if suggestions made through the proper quarter might encourage a somewhat more useful and practical application of this industry.

RAILWAY TRAFFIC.

It appears from the report of Captain Simmons, R.E., of the Railway Department of the Board of Trade, that the number of passengers travelling on railways in England and Wales, which, in 1850, amounted to 58,514,435, reached 70,471,179 in 1851, showing an increase of 20 per cent., while the receipts from those passengers rose from 5,888,603*l.* to 6,952,612*l.*, being an increase of 18 per cent. The mean length of railway upon which this traffic was conducted had increased in the same period only 6·6 per cent. It appears that in the preceding years for which returns of traffic have been prepared the average annual increase in the length of railways in England and Wales had been 21 per cent., being more than three times the rate of last year; and that while the average number of passengers has increased annually 11·03 per cent., the receipts from passengers has increased 6·4 per cent. Hence it would appear, that although the railway communications in England and Wales, have in the past year, increased at a rate much below the average (being about one-third), the number of passengers has increased at a rate nearly amounting to double the annual average, and the receipts derived from them at nearly three times the ordinary rate of increase. The number of passengers in the last year has exceeded the number which would have been conveyed by railways, if they had only increased at the ordinary rate, by 5,502,602; and the receipts from them in the same manner by 687,138*l.* This increase is in a great measure to be attributed to the vast facilities for travelling afforded to the public by means of excursion trains, which in 1850, had received a great impulse, but was developed in an extraordinary degree in the past year during the Exhibition. The mean length of railway open for traffic in Scotland during the year has increased 6·2 per cent., while the number of passengers has only increased from 8,844,191 to 9,286,313, or 4·9 per cent., and the receipts from them from 600,082*l.* to 622,549*l.*, or 3·7 per cent. The mean length of railway open for traffic in Ireland during the year has increased 12½ per cent., while the number of passengers conveyed has only increased from 5,495,796 to 5,633,603, or 2·5 per cent.; the receipts from them having risen from 339,076*l.* to 365,603*l.*, or 7·8 per cent. In England and Wales the receipts for goods have risen from 5,480,771*l.*, to 6,044,183*l.*, or 10·3 per cent.; in Scotland from 721,176*l.* to 814,053*l.*, or 12·8 per cent.; in Ireland from 174,959*l.* to 198,459*l.*, or 13·4 per cent. The general results of traffic over all the railways in the the united kingdom show that the aggregate number of passengers conveyed in 1850 amounted to 72,854,422; in 1851, to 85,391,095; being an increase of 12,536,673, or 17·2 per cent. The gross receipts from passengers in 1850 amounted to 6,827,761*l.*; in 1851 to 7,940,764*l.*, showing an increase of 1,113,003*l.*, or 16·3 per cent. The gross sum received for the transport of goods amounted, in 1850, to 6,376,907*l.*, and, in 1851, to 7,056,695*l.*, showing an increase of 679,788*l.*, or 10·6 per cent. The gross revenue of all the railways, arising from traffic of all descriptions, which in 1850 amounted to 13,204,668*l.*, amounted, in 1851, to 14,997,459*l.*, or very nearly 15,000,000*l.*, showing an increase of 1,792,791*l.*, or 13·5 per cent.

RAILWAY NOTES.

Capt. Galton, R.E., Mr. Bass, C.E., and Mr. Ogilvie, contractor, have gone over the works of the Farnham and Alton new branch of the South-Western Railway. The line is nine miles in length, and will be immediately opened for traffic.—— The Liverpool, Crosby, and Southport Company has just completed and opened their extension line from Birkdale to Southport, the watering-place of the manufacturing district.——On the 30th of June the Newport and Pontypool Railway was opened for public traffic, Captain Laffan having on the previous day inspected the line, and pronounced it in a fit state for traffic.

Holland and Belgium.—A convention has been concluded between the governments for the junction of the railways of both countries. The great artery, which begins at the port of Antwerp, will be extended to Rotterdam, and there communicate with the Dutch railways. The Bavarian government has offered an indemnity of 1,400,000fl. to the administration of the Palatinate Railway, on condition that it will complete within a short delay the works of the Ludwigshafen and Wissemburg Railroad. It is in that direction the Strasburg line is to be prolonged, on the side of France, towards the frontier.

Austria.—The railroad from Szolnok to Szegedin is nearly finished, and it was decided that the line between Szolnok and Debrezin, by way of Puspok-Ladany, should be completed as soon as possible. Plans for railways between Grosswardein and Puspok-Ladany, and between Szegedin and Temesvar, are being prepared. The military frontiers, Agram and Warasdin, will probably be brought into immediate connection with the metropolis by means of branch lines communicating with the great Trieste-Vienna railway. It is intended to raise a loan for the constrnction of railroads, which are to be given as security to the mortgagees.

Turkey in Europe.—The projected English railroad through the northern Turkish European provinces excites much attention there, and is pronounced by the *Wanderer* to be a matter even more important than the Egyptian Railway. It appears that six English engineers have already examined the country between Constantinople and Belgrade; and in a letter from the latter city to Agram, a hope is expressed that the Servian government will also construct a line from Alexinac (probably Alexinitza, near Nissa, on the western frontier of Bulgaria) to Belgrade. Four English vessels, laden with wrought and sheet-iron, are said to be on their way from the Main to Vienna.

NOTES OF THE MONTH.

Thames Embankment.—An act of parliament of the last session empowers the Commissioners of Public Works to construct an embankment and public road on the bank of the Thames from Vauxhall Bridge to Chelsea Gardens. Why not extend it so as to take in Chelsea as far as Battersea Bridge or Cremorne Gardens?—we should then have one section of the river completed.

St. Luke's Church, Chelsea.—A very elegant stained glass window has been recently put up in St. Luke's Church, Chelsea, from the design of Mr. Gibbs, of Camden Town. The top (the part to which we wish to direct public attention,) represents the Twelve Apostles, the figures being alike remarkable for truthfulness of desigu and richness of colouring. The work is in thorough keeping with the elegant architecture of the church it ornaments, and will repay a visit from those interested in works of this character.

Porter's Patent Anchors.—The Privy Council have granted an extension for six years of this patent, granted in 1838. Several witnesses were examined to prove the superiority of this anchor—as improved by Mr. Trotman, a nephew of Mr. Honiball (the assignee of Porter's anchor), and who offered no opposition,—over ordinary anchors. The peculiarity consisted in its strength as compared with its weight, the tenacity with which it held in the ground, the facility with which it came into its position, its non-liability to become fouled, and its convenience in stowage and transport. It is used in upwards of 150 men-of-war, and by several of the large steam companies. It appeared that hitherto there had been a loss of about 15,000*l.* in working the patent. The Attorney-General tendered no opposition.

Berrington's Knapsack.—The Privy Council have recommended an extension, for five years, of this patent, granted in 1838. They expressed surprise that so great a lapse of time should have taken place without the knapsack being adopted in any one of Her Majesty's regiments.

Paris.—The ceremony of laying the foundation stone of the grand gallery which is intended to connect the Tuileries with the Palace of the Louvre, parallel to the Rue de Rivoli, was performed on the 25th.—The French government has sent M. Emile Chevalier to England, for the purpose of inquiring into the construction and operation of the model lodging-houses.

Cape Town.—An excavation for the accommodation of the fast increasing shipping at this port, has been for some time in contemplation. A suitable position has been pointed out near the Chavonne Battery, and it is proposed to procure, as speedily as possible, plans, estimates, &c., for the satisfaction of the public and the formation of a company, should it be determined to execute the work as a private concern. In connection with this work, and simultaneously with it, the breakwater, so long determined on, should certainly be commenced. The stones excavated to form the docks would be used in the construction of the breakwater. In the meantime, some additional convenience for coaling the steamers is urgently required.

Netherlands and Hanover Junction Canal.—A company is in course of formation the object of which is to complete the chain of canal communication between the Zuydersee and Meppen, on the river Ems, in Hanover, and to purchase about 12,000 acres of valuable peat land in Holland. This communication is to commence from the Zuydersee, to run up the river Yssell, thence by canal to Zwolle, from which the Dedems Canal extends as far as Gramsbergen, within a short distance of the frontier town of Kœvordon—thel ocal authorities of which place have voted the requisite sum to complete the line of communication to that town. The total cost of the canal and the other necessary outlay is estimated at about 125,000*l*. By this project, two hundred miles of tedious and dangerous navigation will be saved to the shipping of Hanover, which brings the timber and other produce of that country and Prussia to the various ports of the Zuydersee and other parts of the Fatherlands.

Danube Navigation.—M. d'Erichsen, director-in-chief of the Danube Navigation Company, has left Vienna on a visit to France, England. Scotland, and the north of Germany, in order to study the systems of constructing vessels and steam-engines which have been adopted in those countries, with the intention of applying them to the numerous steam and sailing vessels which the company intend to have built.

Tunnelling in Hungary.—A tunnel, 10 English miles long, leading from the shores of the river Gran to the mines in the Schemnitzer Hills, is now advancing towards completion. It is intended to answer the double purpose of a channel to drain off the water accumulating in the works, and of a railway to transport the ore from the mines to the river.

Separation of Gold from Arsenical Pyrites.—The mines of Reichenstein, Silesia, abandoned for more than five centuries, have been recently opened with advantage, in consequence of the application, on a large scale, of a method invented by Professor Plattner, and adopted by Mr. W. Guettler, for separating gold from the waste of arsenical ores. The ore at Reichenstein is an arsenical pyrites, containing about 200 grains of gold in the ton. The ore is roasted in a reverberatory furnace, surmounted by a large condensing chamber, in which the arsenious acid is condensed as fast as it is volatilised. There then remains, on the floor of the furnace, oxide of iron mixed with a certain quantity of arsenic, together with the whole of the gold. This is placed in a vessel, so arranged that a current of chlorine can be passed through it, by which the gold and iron are taken up, and afterwards separated from the residuum by the aid of a certain quantity of water, and the gold is afterwards precipitated from this solution by sulphuretted hydrogen. To prevent the admixture of iron at this stage, a small dose of hydrochloric acid is added to the solution before the sulphuretted hydrogen is introduced. The auriferous compound having been separated from the liquor, is washed and heated in an open porcelain crucible, to drive off the sulphur, by which the gold is reduced to the metallic state by fluxing in the usual manner. This simple and ingenious method, which has made it worth while to re-open the Reichenstein Mine, is equally applicable to the vast quantity of refuse accumulated near many other old works.—*Mining Journal.*

LIST OF NEW PATENTS

GRANTED IN ENGLAND FROM JUNE 24, TO JULY 22, 1852.

Six Months allowed for Enrolment unless otherwise expressed.

Samuel Lusty, of Birmingham, for improvements in manufacturing wire into woven fabrics and pins.—June 24.

Thomas Bell, of Don Alkali Works, South Shields, for improvements in the manufacture of sulphuric acid.—June 24.

Joseph Morgan, of Manchester, patent candle-machine manufacturer, and Peter Gaskell, of the same place, gentleman, for improvements in the manufacture of candles.—June 24.

Charles James Wallis, of Clarendon Chambers, Hand-court, Holborn, civil engineer and mechanical draughtsman, for certain improvements in machinery for crushing, pulverising, and grinding stone, quartz, and other substances. (A communication.) —June 24.

Thomas Basley, of Manchester, cotton-spinner, for improvements in machines for combing cotton, flax, silk, and other fibrous materials.—June 24.

John M'Conochie, of Liverpool, engineer, for improvements in locomotive and other steam-engines and boilers, in railways, railway carriages, and their appurtenances; also in machinery and apparatus for producing part or parts of such improvements. —June 24.

Thomas Allan, of Edinburgh, engineer, for improvements in producing and applying electricity, and in apparatus employed therein.—June 24.

Thomas Hoblyn, of White Barns, Hertford, esquire, for certain improvements in the art of navigation.—June 28.

Matthew Augustus Crooker, engineer, of New York, America, for certain improvements in paddles for steam-vessels.—June 28.

James Edward Coleman, of Porchester House, Bayswater, gentleman, for improvements in the application of india-rubber and gutta-percha, and of compounds thereof. —June 28.

Duncan Mackenzie, of London, gentleman, for certain improvements in machinery and apparatus for reading in and transferring designs or patterns, and for cutting, punching, and numbering, or otherwise preparing, perforated cards, papers, or other materials used or suitable in the manufacture of figured textile fabrics by Jacquards or other weaving looms or frames.—June 29.

Lazare François Vandelin, of Upper Charlotte-street, Fitzroy-square, for improvements in obtaining wool, silk, and cotton from old fabrics in a condition to be again used. (Partly a communication.)—June 30.

Richard Hornsby, of Spittlegate, Grantham, Lincoln, agricultural-implement maker, for improvements in machinery for threshing, shaking, riddling, and dressing corn —July 3.

Edward Clarence Shepard, of Duke-street, Westminster, gentleman, for improvements in electro-magnetic apparatus suitable for the production of motive power, of heat, and of light. (A communication.)—July 6.

Martyn John Roberts, of Woodbank, Bucks, gentleman, for improvements in the production of electric currents, in obtaining light, motion, and chemical products and effects by the agency of electricity, part or parts of which improvements are also applicable to the manufacture of acids, and to the reduction of ores.—July 6.

William Tanner, of Exeter, leather-dresser, for improvements in dressing leather. —July 6.

Edward Maitland Stapley, of Cheapside, for improvements in cutting mouldings, grooves, tongues, and other forms, and in planing wood. (A communication.)—July 6.

Moses Poole, of the Patent-office, London, gentleman, for improvements in reaping and mowing machines, and in pulverising land. (A communication.)—July 6.

Jules Lemoine, of Courbevoie, near Paris, chemist, for an improved composition applicable to the purposes of varnish, to the waterproofing of fabrics, to the manufacture of transparent fabrics, to the fixing of colours, and to other useful purposes. —July 6.

Thomas Blakey and Joseph Skaife, of Keighley, York, millers, for improvements in mills for grinding.—July 6.

James Higgins, of Salford, Lancaster, machine-maker, and Thomas Schofield Whitworth, of the same place, mechanic, for certain improvements in machinery or apparatus for spinning and doubling cotton and other fibrous substances.—July 6.

Harold Potter, of Over Darwen, Lancaster, carpet manufacturer, and Matthew Smith, of the same place, manager, for certain improvements in looms for weaving, and in the manufacture of terry fabrics.—July 6.

John Henry Johnson, of Lincoln's inn-fields, Middlesex, and of Glasgow, North Britain, gentleman, for certain improvements in steam-engines. (A communication.) —July 6.

Alfred Henry Gaullie, of Paris, sculptor, for an improved plastic composition applicable to manufacturing purposes.—July 6.

William Septimus Losh, of Wreay Syke, Cumberland, gentleman, for improvements in obtaining salts of soda.—July 6.

James Murdoch, of Staple's-inn, Holborn, Middlesex, for an improvement in the manufacture of certain kinds of woollen fabrics. (A communication.)—July 6.

John Andrews, of Fairoak-terrace, Minde, Newport, Monmouthshire, contractor, for certain improvements in coke ovens, and in the apparatus connected therewith.— July 6.

Frederick Sang, of Pall-Mall, artist in fresco, for certain improvements in machinery or apparatus for cutting, sawing, grinding, and polishing.—July 6.

Friedrich Gesswein, of Cannstadt, Wurtemberg, stone-mason, for a method of preparing for baking and burning masses of clay of any given form and size, and baking and burning the same when so prepared, as thoroughly and completely as a common brick can now be baked or burnt.—July 6.

John Ramsden, of Manchester, screw-bolt manufacturer, for certain improvements in machinery or apparatus for cutting screws.—July 6.

Joseph Jepson Oddy Taylor, of Gracechurch-street, London, machinist, for an extension for the term of four years, from the 1st day of May last, for part of his invention described in the original letters patent under the title of, "An improved mode of propelling ships and other vessels on water.—July 6.

Warren Stormes Hale, of Queen-street, Cheapside, candle-maker, and George Roberts, of Great Peter-street, Westminster, miner, for improvements in the manufacture of night lights or mortars.—July 8.

Alfred Vincent Newton, of Chancery-lane, mechanical draughtsman, for improvements in machinery for cutting soap into slabs, bars, or cakes. (A communication.) —July 10.

Thomas Jordan, of Old Broad-street, London, for improvements in disinfecting essential oils, and in treating fatty matters obtained from shale, schistus, or other bituminous substances, and in retorts employed in distilling such minerals.—July 12.

Joseph Baron Palur, of Castle-street, Holborn, for an improved mode of baking bricks, tiles, and other kinds of pottery or earthenware.—July 13.

Charles Burrell, of Thetford, Norfolk, and Matthew Gibson, of Rollington-terrace, Newcastle-on-Tyne, for improvements in reaping machines.—July 15.

George Hinton Bovill, of Abchurch-lane, London, for improvements in manufacturing wheat and other grain into meal and flour.—July 15.

Moses Poole, of the Patent office, London, gentleman, for improvements in boots shoes, clogs, and similar articles. (A communication.)—July 15.

Henry John Gauntlett, of Charlotte-street, Portland-place, Middlesex, doctor in music, for improvements in organs, seraphines, and other similar wind instruments, and also improvements in piano-fortes. (A communication.)—July 15.

Charles Barrington, of Philadelphia, United States, gentleman, for an improved steam-boiler water-feeding apparatus, and furnace therefor. (A communication.)— July 15.

Charles James Pownall, of Addison-road, Middlesex, gentleman, for improvements in the treatment and preparation of flax and other similar fibrous vegetable substances.—July 15.

Thomas Richards, of St. Erth, and Samuel Grose, of Gwinear, both in Cornwall, for certain improvements in machinery for reducing and pulverising ores, minerals, stones, and other substances.—July 15.

John Hunt, of Rennes, France, gentleman, for certain machinery for washing and separating ores.—July 16.

William Fawcett, of Kidderminster, Worcester, for certain improvements in the manufacture of carpets.—This patent being opposed at the Great Seal, was not sealed till 17th instant, but bears date the 2nd February last, by order of the Lord Chancellor.

Joseph William Schlesinger, of Brixton, Surrey, gentleman, for improvements in fire-arms, in cartridges, and in the manufacture of powder. (A communication.)— July 20.

Julius Friedrich Phillipp Ludwig Von Sparre, of Brewer-street, Golden-square, mining engineer, for improvements in separating substances of different specific gravities, and in the machinery and apparatus employed therein.—July 20.

Stribblehill Norwood May, of Fitzroy-square, gentleman, for certain improvements in the manufacture of thread, yarn, and various textile fabrics from certain fibrous matters.—July 20.

Emery Rider, of Bradford, Wilts, manufacturer, for improvements in the manufacture or treatment of india-rubber and gutta-percha, and in the application thereof.— July 20.

John Shaw, of Dukinfield, Chester, cylinder-maker, for certain improvements in machinery or apparatus for carding cotton, wool, flax, and other fibrous materials.— July 20.

Sir William Burnett, Knight Companion of the most Honourable Order of the Bath, of Somerset House, Middlesex, an extension for the term of seven years from the 26th day of July 1852, being the expiration of the original grant of his patent for improvements in preserving wood and other vegetable matters from decay—July 20.

John Francis Egan, of Covent-garden, for improvements in the manufacture of sugar. (A communication.)—July 20.

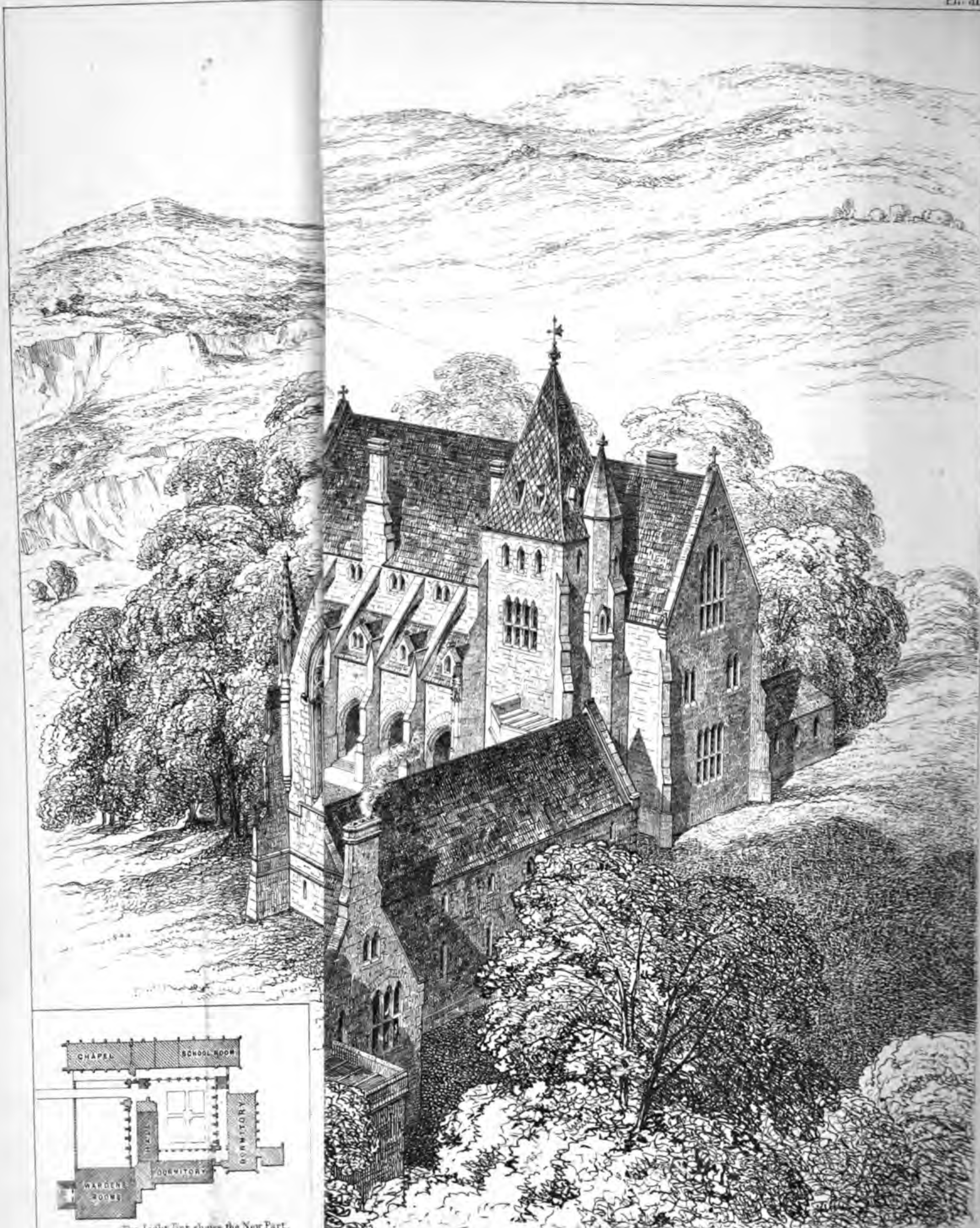
James M'Henry, of Liverpool, merchant, for certain improvements in machinery for manufacturing bricks and tiles. (A communication.)—July 20.

Richard Besley, of Radcliffe, Lancaster, bleacher, for certain improvements in apparatus used in bleaching.—July 20.

George Augustus Huddart, of Brynkir, Caernarvon, esquire, for improvements in the manufacture of cigars.—July 20.

Richard Birckton and Thomas Lawson, both of Leeds, York, manufacturers, for certain improvements in the adaptation and application of a new manufactured material to certain articles of dress.—July 21.

John Kirkham, of the New-road, Middlesex, civil engineer, and Thomas Nesham Kirkham, of Fulham, Surrey, civil engineer, for improvements in the manufacture of gas for lighting and heating.—July 22.



The Light Tint shows the New Part.

ST. COLUMBA COLLEGE, DUBLIN.

P. C. Hardwick, Esq., Architect.

(*With an Engraving, Plate* XXXI.)

The College of St. Columba is situated at Holly Park, near Dublin, and occupies a most beautiful position overlooking the bay and harbour of Kingstown, with the Hill of Howth in the distance; and immediately behind the grounds belonging to the College, rise the Wicklow mountains. The College was established in the year 1845, at Stackallan, in the county of Meath, and removed to the building it now occupies in the year 1850. The main object of the College is to form a public school for Ireland, on somewhat the same footing as the great public schools in this country; but without those defects which lapse of time and change of manners have produced in many of the English schools. As well as forming a school, the object of the College is to educate a certain number of students in the Irish language, with a view to their ultimately taking holy orders, and being able to preach to the Irish in their own language.

The College is presided over by a warden, which office is now held by the Rev. G. Williams, Fellow of King's College, Cambridge, well known by his work on Jerusalem, and other books. Besides the warden, there are several fellows and masters who superintend the education of the boys. At present, the chapel and schoolroom are temporary wooden buildings; the dormitory and hall have been recently erected, and the warden and fellows inhabit the old house belonging to the estate.

The Plan shows the new buildings that are now proposed to be erected, as soon as sufficient funds are collected for the purpose. The chapel will be 65 feet long by 30 feet wide; the hall 60 feet long by 22 feet wide; the schoolroom 75 feet long by 30 feet wide. The dormitories will contain about ninety cubicles, one of which is devoted to each boy.

Mr. Moyers, of Dublin, is the builder. The cost of the buildings to be erected will be about 11,000*l.*

ON THE EMPLOYMENT OF COLOUR IN THE DECORATIVE ARTS.

By Owen Jones, F.R.I.B.A.

[*Exhibition Lecture delivered at the Society of Arts, London.*]

As architecture is the great parent of all ornamentation, it is from the study of architectural monuments that we shall best obtain a knowledge of the principles which govern the employment of ornament and of colour generally. In all ages but our own the same ornaments, the same system of colouring, which prevailed upon their buildings pervaded all they did, even to their humblest utensils: the ornaments on a mummy-case are analagous with those of the Egyptian temple; the painted vases of the Greeks are but the reflex of the paintings of their temples; the beautiful cushions and slippers of Morocco of the present day are adorned with similar ornaments, having the same colours as are to be found on the walls of the Alhambra.

It is far different with ourselves. We have no principles, no unity; the architect, the upholsterer, the paper-stainer, the weaver, the calico-printer, and the potter, run each their independent course; each struggles fruitlessly, each produces in art novelty without beauty, or beauty without intelligence. The architect, the natural head and chief of all who minister to the comforts and adornments of our homes, has abdicated his high office; he has been content to form the skeleton which it should also have been his task to clothe, and has relinquished to inferior and unguided hands the delicate modelling of the tissues and the varied colouring of the surface;—who can wonder at the discordance and incongruity of the result? Until very recently the employment of colour on buildings has had but few advocates in this country; we are still imbued with the prejudices left us by our immediate ancestors and developed in our early education.

Although we now know that many of the monuments of antiquity were entirely covered with colour and ornament, while of others we have evidence that they were partially painted, and are further bound to conclude that they were entirely so, yet this is still disputed, and not long since the Royal Institute of British Architects were unable to vanquish this prejudice amongst their own body; and it remains to this day with them, alas! a disputed question to what extent the monuments of Greece were coloured. There are artists more willing to believe that the Greeks were imperfectly organised for the appreciation of colour, and consequently misapplied it, than that the defect can lie with ourselves, and our imperfect knowledge of what they did and why they did it.

I will ask you to believe that the stupendous monuments of the Egyptians, the Greeks, the Arabs, and other Eastern civilisations, with the nearer-to-us Gothic buildings of our own forefathers, were not in vain covered with a most elaborate system of ornamentation requiring colour for its development, but rather in obedience to a patient observation of Nature's works, where we find everywhere colour assisting in the development of form and adding many charms which but for this were wanting. In asking you to watch the means by which these additional charms were given, I do not wish you to understand that what the ancients did we should now repeat, but should follow them only so far as we find they acted on principles by them universally recognised and running through all time, and which we may now presume to be discovered truths, and therefore not wisely to be rejected.

He who should set about forming a new style for himself, without regard to the past, would be like a student in astronomy who should reject the discoveries of Newton, and endeavour to work out every process for himself. Yet, on the other hand, where would the science of astronomy be now if successive students had been content to receive the discoveries of Newton as final truths, instead of employing them as the bases of fresh researches? The successful labours of past ages are our inheritance, and should not be rashly squandered or unprofitably hoarded: we should not be content blindly to follow any in their steps, but rather endeavour to go forward, patiently working out the great principles which the experience and practice of successive ages have evolved.

Regarding our present subject from this point of view, I have put together a series of rules, which I believe are axioms, but which we will call "Propositions." They will be found, I trust, available and safe guides in the employment of colour in the decorative arts. Some are derived from the observation of the works of nature; others are the teachings of science; others, again, gathered from the practice of all those nations who have carried the decorative arts to the highest perfection.

I. *Colour is used to assist in the development of form, and to distinguish objects or parts of objects one from another.*

The most cursory glance at the works of nature will establish the truth of our first proposition. We see everywhere in nature colour assisting form in producing distinctness: thus flowers are separated by colour from their leaves and stalks, and these again from the earth in which they are planted; and, not to fatigue you with examples, it is at once evident how much in nature would be meaningless but for the many charms of colour spread over the earth so lavishly. Had nature applied but one colour to all objects they would have been indistinct; but, by an ever-changing variety, each has its proper tone and hue, from the modest lily in the field to the parent of all colour, the glorious sun in the heavens. The ancients ever obeyed this law: thus the capitals of their columns are separated by colour from the shafts; and these, again, by colour from their bases or pedestals.

II. *Colour is used to assist light and shade, helping the undulations of form by the proper distribution of the several colours.*

But for light and shade we should have been unable to recognise the distinctive forms of objects; without it a globe would be but a circle,—the light on the exposed surface and the shade on the retiring surface alone convince us of its rotundity. We find therefore in nature's works, colour assisting light and shade; by its help the modulations of form are rendered more apparent; were it otherwise it would be to little purpose that the flower should be distinguished by colour from the leaf, if the individual form of the flower and the leaf had been extinguished in the process.

III. *These objects are best attained* (*i.e.* objects or parts of objects are distinguished one from another, and the undulations of form are assisted) *by the use of the primary colours on small surfaces, and in small quantities, balanced and supported by the secondary and tertiary colours on the larger masses.*

This proposition will not so readily be accepted as the two preceding. There are many who will object that the primary colours are the delight only of the savage and the uncultivated, but I answer that the primary colours are never vulgar or discordant when properly applied; the defect will lie, not with the colours, but with the want of skill of the hand that applies them. They must be used as in nature, with a sparing hand, on small surfaces, and in small quantities; the secondaries and tertiaries in larger masses, and on larger surfaces, atoning for their lesser brilliancy by their greater volume.

We find in the works of the Egyptians, Greeks, Arabs, and Moors, during the best periods of their art, this beautiful law invariably followed: but, on the contrary, when the art of each civilisation declined, the primaries are no longer the ruling harmonies; the secondaries and tertiaries from being subordinate, became dominant, and muddiness and indistinctness resulted.

In Egypt, during the reigns of her native kings, the primaries mainly prevailed; whilst under her Greek rulers art languished, and being practised rather from imperfect tradition than from poetic inspiration, the secondaries usurped the place of the primaries, and the beautiful harmonies which had before been produced by their combination were lost.

The progress to further decline is again remarkable under the Romans, who taught the Egyptians to build up temples of greater magnitude, with stones more nicely fitted, with the mechanical processes more advanced, but with the poetic fire wanting, and naught but a barren work of skill remaining.

The same decline may be observed with Greek architecture. In the temples of Greece, as far as we are acquainted with them, the primaries were dominant; whilst in Greek towns under Roman rule, the true principles of their noble ancestors were thrown aside, and the caprices of their Roman masters substituted.

When the truly-enchanted palaces of the Moors fell into the hands of the Catholic kings, who despised a civilisation they were unable to appreciate, the true principles which the Moors had learned in their worship and observation of nature's works were despised and rejected, because, as now, not understood. Their blues and reds were repainted with green and purple, without law or reason.

Trace the history of our own Gothic buildings, of stained glass, turn over the pages of the illuminated MSS. of every age, you will find everywhere the same cause at work.

Each civilisation in the ascendant goes to nature for its principles, and enriches its own invention with the choicest conceptions of antecedent ages; while for this admirable union of conscientious erudition and fertile originality, declining civilisations substitute only a series of decrêpit, disordered, and faithless caprices.

We possess the inestimable advantage of living in an age when nothing of the past remains a secret; each stone of any monument of every clime has told its tale, which is now brought within the reach of our own firesides: yet, hitherto, how little have we shown ourselves worthy of this great privilege!. The ease with which our knowledge might be obtained has made us indifferent of its acquirement, or led us to substitute an indolent and servile imitation for an intelligent and imaginative eclecticism.

IV. *The primary colours should be used on the upper portions of objects, the secondary and tertiary on the lower.*

This proposition, founded also on observation of nature's works, was generally obeyed in the best periods of art, but nowhere so well or so universally as in the buildings of the Moors, who confined the primary colours entirely to the upper portions of their buildings, and the secondary and tertiary to the lower. In Egypt we do see occasionally the secondary (green) used in the upper portions of their temples; but this arises from the fact that ornaments in Egypt were symbolical, and more nearly represented natural objects than in other styles. If a lotus-leaf were used in the upper portions of a building, it would necessarily be coloured green, but the law is true in the main: the general aspect of an Egyptian building gives us the primaries above and the secondaries below.

Even in Pompeii we find this sometimes; in the interior of their houses there is a gradual gradation of colour downwards from the roof, from light to dark, ending with black: but this is by no means so usual as to convince us that they felt it as a law, for there are many examples of black immediately under the ceiling. This law will be found of great use in the decoration of the interiors of our dwellings. Ceilings and cornices may be decorated with the primaries of prismatic intensity on the small surfaces of their mouldings; the walls, on the contrary, from presenting larger masses, should be of secondary colour, of low tones and hues. The dados still stronger in colour and more broken in hue. The carpets should be darkest of all, composed of broken secondaries and tertiaries, so interwoven and neutralised that they retire from the eye, both as furnishing repose for the colouring of the upper portions and as backgrounds to the furniture placed upon them.

The favour with which the colouring of the interior of the Great Exhibition building, after running the gauntlet of much adverse criticism, was ultimately received by the public, emboldens me here to refer to it as a familiar illustration of the practical working out of our four first propositions. The objects I had proposed to myself were—First, so to bring out the construction of the building that it should appear higher, longer, and more solid; secondly, so to colour each particular part that its light and shade should be assisted, and its peculiar form made most manifest; thirdly, so to balance the primary colours used for this purpose that they should harmonise with the varied contents of the building of every imaginable hue, and to which I trusted for the completion of the scheme.

I may be permitted to say that these objects were, if not fully attained, yet were so beyond what the most sanguine could have hoped. The effect which I had sought of the colours of the building forming a neutralised bloom over the whole of the contents, was attained to such an extent that those who only saw it when completed looked in vain for that vulgar and discordant colouring of which they had heard so much during the progress of the works.

The blending of the three primary colours in the roof of the nave, where the effect could be seen uninterruptedly, was most complete, and produced an artificial atmospheric effect of a most surprising kind. This artistic effect has been lost since the removal of the canvas from the roof; and although there are many who will prefer it, as it is more like their Crystal Palace, yet it is no longer an art problem resolved. By reason of the glare from the glass the red and yellow have disappeared, and we see simply a repetition of blue girders with sky between. The consequence is, that the effect of aeriel perspective which it had has disappeared; the girders at the extremities of the building fall so rapidly one on the other that they present but a mass of blue. The nave, judged of now from the perspective of the roof, appears two or three hundred feet shorter than it did; because the eye has lost the power of measuring beyond a certain distance, whilst when the canvas was on the roof the eye was able to distinguish girder from girder down to the very last one.

The columns also have lost much by the removal of the background—they were painted light in order that they might tell out strongly in relief on the articles exhibited: these being removed their lightness is now a defect—they lose in appearance of solidity.

V. *The primaries of equal intensities will harmonise or neutralise each other in the proportions of* 3 *yellow,* 5 *red, and* 8 *blue,—integrally as* 16.

The secondaries, in the proportion of 8 *orange,* 13 *purple,* 11 *green,—integrally as* 32.

The tertiaries. citrine (composed of orange and green), 19; *russet* (orange and purple), 21; *olive* (green and purple), 24; *integrally as* 64.

It follows that,

Each secondary (being a compound of two primaries) *is neutralised by the remaining primary in the same proportions; thus,* 8 *of orange by* 8 *of blue,* 11 *of green by* 5 *of red,* 13 *of purple by* 3 *of yellow.*

Each tertiary (being a binary compound of two secondaries) *is neutralised by the remaining secondary; as* 24 *of olive by* 8 *of orange,* 21 *of russet by* 11 *of green,* 19 *of citrine by* 13 *of purple.*

We derive these valuable rules from the works of Field, who was one of the earliest to establish the fact now universally received, that the prismatic ray consisted of 3 colours and not 7. He has shown, by direct experiment, that a ray of light consists of yellow, red, and blue, in the proportion of 3 yellow, 5 red, and 8 blue.

It is evident that the nearer we can approach to this state of neutrality the more harmonious will colouring become. An examination of the best ancient specimens of colouring will show that this law has been well observed; that is to say, broadly, there has been as much blue as of yellow and red put together: thus the light and the shade balancing each other.

VI. Each colour has a variety of tones when mixed with white, or of shades when mixed with grey or black.

When a full colour is contrasted with another of a lower tone, the volume of the latter must be proportionally increased.

This follows naturally from Prop. V., for if 5 red is neutralised by 11 green of equal intensities, it is evident we should require a much larger quantity of pale green to effect the same purpose.

VII. Each colour has a variety of *hues*, obtained by admixture with other colours, in addition to white, grey, or black: thus we have orange yellow on the one side, and lemon yellow on the other; so of red, scarlet red, and crimson, and of each every variety of tone and shade.

When a primary, tinged with another primary, is contrasted with a secondary, the secondary must have a hue of the third primary.

Thus, orange yellow will require to neutralise it blue purple; lemon yellow, red purple; scarlet red, blue green; crimson red, yellow green.

The truth of these two last Propositions is so self-evident that they would hardly require discussion here, were we not reminded by all we see around us how much they are every day disregarded.

It is evident that for the proper balancing of such infinite varieties of tones, shades, and hues, no mechanical means can be found of estimating the value of the colours, or the relative areas they should occupy; but we are fortunately endowed with an organ as susceptible of cultivation in this respect as the ear for sound; and although many amongst us are more favourably endowed than others, both with ears for sound and eyes for form and colour, it is by study and cultivation alone that any approach to perfection can be reached, and he who can carry in his mind the proportions which science thus teaches us will be in a far better condition to arrive at success than he who trusts to his unaided instincts and natural gifts.

In the East Indian collection of textile fabrics at the Great Exhibition the perfection at which their artists have arrived is most marvellous; it was hardly possible to find a discord,—contrasting colours appeared to have just the tone and shade required; the contrivances by which they corrected the power of any colour in excess are most ingenious. It would occupy too much of your time more particularly to refer to them here; but, fortunately, a portion of the collection has been purchased by the government, and is now being exhibited to the public: if examined with attention they will afford most fruitful lessons, not only to the student but to every cultivated mind. The additional charms which colour gives to everything which surrounds us should render none indifferent to the cultivation of the faculties implanted in them to enable them to understand and appreciate it.

As Field wisely says, "He who can regard nature with the intelligent eye of the colourist has a boundless source of never-ceasing gratification, arising from harmonies and accordances, which are lost to the untutored eye."

It would be very desirable that we should be made acquainted with the manner in which, in the education of the Eastern artists, the management of colour is made so perfect. It is most probable that they work only from tradition and a highly-endowed natural instinct, for which all Eastern nations have ever been remarkable: they have the further advantage of working out the style which grew up with their religion, with which every thought and action of their daily life is interwoven.

Since the Reformation, which with us separated the tie which should exist between religion and art, we have been deprived of this advantage: the want of unity in feeling has caused a want of unity in expression; there is the same disorder in the art as scepticism in the mind. This acting generation on generation, each descends lower and lower.

Children born in an age of ugliness cannot hope to have their instincts quickened for the beautiful; but, on the contrary, the natural instinct will be extinguished, and will no longer be born with them. I can conceive a paternal and wise government visiting with punishment all those who produce abortions in art as justly as those who lower the tone of the morals of society; in either case they rob the rising generation of their birthright.

If it be true, as Field says, "That whatever refines the taste improves the morals, enhances the powers, and promotes the happiness of the people," the converse is true also.

VIII. *In using the primary colours on moulded surfaces we should place blue, which retires, on the concave surfaces; yellow, which advances, on the convex; and red, the intermediate colour, on the underside: separating the colours by white on the vertical planes.*

When the proportions required by Prop. V. cannot be obtained, we may procure the balance by a change in the colours themselves: thus, if the surfaces to be coloured should give too much yellow, we should make the red more crimson and the blue more purple; and we should take the yellow out of them: so, if the surfaces should give too much blue, we should make the yellow more orange and the red more scarlet. Red never looks well when seen in a strong light; it is too positive and painful to the eye: on the contrary, in soffites, in hollows or depths of any kind, it looks most brilliant.

In the Exhibition alarm was caused by my painting the under sides of the girders red: had they been painted blue they would have appeared curved upwards; if yellow, downwards; they would appear straight only as red.

IX. *The various colours should be so blended that the objects, when viewed at a distance, should present a neutralised bloom.*

Colours should not only be used in the proportions laid down by Prop. V., VI., VII., but they should be so interwoven that no one colour should attract the eye to the exclusion of the others; when viewed at a distance they should melt into one another.

In the Oriental patterns we find this result invariably attained; they seem ever awake to correct the least tendency of any one colour to overpower the others: for instance, it is very common with them when they have a massive gold ornament on a coloured ground to allow the ground colour to reappear on the gold ornament as another ornament: so that not only the volume of gold, when in excess, is thereby lessened, but the ground colour is carried into it, so that a perfect balance is obtained.

X. *No composition can ever be perfect in which either of the three primary colours is wanting, either in its natural state or in combination.*

This is evident. Blue and yellow, red and yellow, red and blue would be discords; so green and yellow, purple and blue, orange and red; yet each of these discords may be resolved by the interpositions of the neutrals white or black, which contain all colours in the positive and the negative state.

They are also harmonised by the interposition of metallic gold, of which more hereafter. They, of course, may exist on parts of objects, if the third colour is so near at hand as to be comprehended in the same glance.

The Propositions XI., XII., XIII., XIV., are derived from the "law of the simultaneous contrast of colours" of Mons. Chevreul, who, by a series of experiments, carried on for a number of years, established the fact that colours juxtaposed influence each other in a remarkable degree. He establishes two kinds of contrast: the one, contrast of tone, or the modification which each colour suffers in intensity; the other, contrast of colour, or the modification which each colour suffers in hue. He tells us that all coloured bodies, besides reflecting the coloured rays proper to their particular colour, reflect a certain number of white rays and a certain number of others, which are complementary to the colour of the particular bodies: for instance, a red body at the same time that it reflects red rays in a large quantity, reflects also white rays and a certain number of green rays.

XI. *When two tones of the same colour are juxtaposed, the light colour will appear lighter and the dark colour darker.*

We have here the contrast of tone: as the light colour will reflect more white rays than the dark colour, their superior force will extinguish the white rays reflected from the darker colour; hence this will appear darker. This may be readily tested by placing two halves of the same sheet of paper of a light colour, and the two halves of the same sheet of paper of a darker colour, on a white screen. Placing the half of the light-coloured sheet edge to edge with the dark-coloured sheet, and placing the other halves at a little distance on either side, it will be seen that the light-coloured sheet standing by itself will appear darker than where it joins the dark-coloured sheet, and that the dark-coloured sheet by itself will be lighter than where it joins. The effect is strongest at the edges, and goes on diminishing to the extremities.

XII. *When two different colours are juxtaposed they receive a double modification: first, as to their tone, the light colour appearing lighter and the dark colour darker; secondly, as to their hue, each will become tinged with the complementary colour of the other.*

If we take two half sheets of pale red, and two half sheets of dark blue, and place them as in the former experiment, we shall see the pale red become paler, and at the same time tinged with orange, and the dark blue will become darker and be tinged slightly with green.

XIII. *Colours on white ground appear darker, on black ground lighter.*

The white, by its superior force, extinguishes the white rays reflected by the colour, and we see the colour purer—as black reflects but few white rays, the white rays reflected by the colour appear more prominent by contrast, and the colour appears lighter.

XIV. *Black grounds suffer when opposed to colours which would give a luminous complementary.*

As light colours have dark complementaries, the dark added to the black increase its brilliancy; those, on the contrary, which have light complementaries must diminish its intensity.

Thus, orange on a black ground would add blue to the black, and make it more intense; but blue on a black ground would add orange to the black and destroy its brilliancy.

It will be evident how valuable a perception of this law of contrast must be to any one engaged in any way with the employment of colour, as any colour can be subdued or heightened in effect by juxtaposition. In fact colours are mere relative terms;—they change at every instant; that which appears deep red when compared with an orange red becomes orange red when compared with a still deeper red. Blue, red, yellow, and all other colours, can exist only in the mind.

Chevreul mentions a case in point: he says that a shopkeeper exhibiting to a customer a number of pieces of red silk, one after the other, of the same colour, those last shown would invariably appear more feeble in colour than the first. A shopkeeper, wise in his generation, should, after showing one or two pieces of red silk, interpose a silk of another colour—green, for instance—to restore the judgment of the eye.

We now come to a series of Propositions, which we derive chiefly from the study of Oriental works, and which may be seen in great perfection on the textile fabrics of the Indian collection purchased by the government and now exhibited at Marlborough House.

XV. *When ornaments in a colour are on a ground of a contrasting colour, the ornaments should be separated from the ground by an edging of a lighter colour; as, a red flower on a green ground should have an edging of lighter red.*

The reason of this we gather from the law of contrast, that when the eye dwells upon a spot of colour on a contrasting colour, each has a tendency, by reason of the strong contrast, to furnish the complementary colour of the other; and this effect is strongest towards the edges: so that the colours have a tendency to fuse one into the other, and indistinctness results. To confine the eye, therefore, within the ornament it is necessary to define the form, and this is well effected by the outline of the lighter colour.

XVI. *When ornaments of any colour are on a gold ground, the ornament should be separated from the gold ground by an edging of darker colour.*

The reason of this is, that the gold ground, from its greater power, has a tendency to invade or overflow on to the coloured ornament, and this is at once arrested by the darker edging.

XVII. *Gold ornaments on any colour should be outlined with black.*

The cause here is the same—viz., the tendency of the gold to overrun the ground, which is arrested by the black line; and as gold must be regarded as a neutral, it is best effected by the neutral black.

XVIII. *Ornaments of any colour may be separated from grounds of any other colour by edgings of white, gold, or black.*

White, black, and gold are neutrals, and, therefore, by their interposition prevent the simultaneous contrasts from being sensibly felt, and preserve the integrity of the colours.

XIX. *Ornaments in any colour may be used on white or black ground without outline or edging.*

The white ground reflecting all the rays, destroys by its superior intensity the white rays reflected by the coloured body, and its form becomes perfectly defined. The black ground absorbs all the rays, or reflects but very feebly white rays so as scarcely to modify the colour juxtaposed.

XX. *In self-tints tones or shades of the same colour, or of the same hue, a light tint on a dark ground may be used without outline; but a dark ornament on a light ground requires to be outlined with a still deeper tint.*

The reason of this is, that the light tint being the most advancing is able to detach itself from the ground, but the dark tint has a tendency to pierce through the ground if not arrested by a darker outline. Ornaments in relief do not appear to require the interposition of white or any other colour; the light edge on the one side, and the shadow on the other, is sufficient to prevent harshness of contrast. This may help to explain how it is that ornaments in metallic gold may be placed on grounds of any other colour without discordance. Green and gold are well known as most harmonious, yet green and yellow are equally well known to be discordant: one cause is, that gold, more in the nature of a secondary, is slightly orange; and, moreover, from its granular surface, a series of hills and valleys, and furnishes both light and shade.

Our two last propositions belong only incidentally to the subject; but I offer them for discussion here, as I think it most desirable that attention should be directed to the subject, for the prevention of practices which have increased, and are increasing daily, and are fraught with most disorganising influence on the taste of the present generation.

XXI. *Imitations, such as the graining of woods and of the various coloured marbles, allowable only when the employment of the thing imitated would not have been inconsistent.*

There has often been much discussion upon the propriety of imitations in decorative art, such as imitations of the graining of woods and various coloured marbles. There is no doubt that, of late years, the skill obtained by our artisans in producing these imitations has caused the practice to be very much abused, but it need not for that be entirely discouraged.

The principle which should regulate the employment of imitations has never yet been defined: it appears to me that *imitations are allowable whenever the employment of the thing imitated would not have been inconsistent.*

For instance, there can be no objection to grain a deal door in imitation of oak, because the mind would be perfectly satisfied if the door were oak; but it would be an absurdity and abuse of means to paint it in imitation of marble.

Again, the practice of covering the walls of halls and staircases with paper in imitation of costly marbles is very objectionable; because the employment of marble to such an extent would be inconsistent with the character of most houses, and, consequently, the sham is much too glaring: on the contrary, were the pilasters and columns of a hall only painted, the objection would cease, seeing that the mind would be satisfied with the reality. A violent instance of the abuse of graining existed formerly in the Elgin Room at the British Museum, where beams on the ceiling thirty feet long were splashed in imitation of granite. Here was a manifold absurdity, as no granite beam could have supported itself in any such situation. The door-jambs of an opening, on the contrary, might be imitation granite without inconsistency, as in such a situation granite would be useful as indicating strength.

In the outcry against the mode of colouring I proposed for the interior of the Great Exhibition, my opponents fell into an error of this kind; led away by the desire of having the metallic character of the building expressed, the majority were in favour of colouring the whole of that vast edifice in imitation of bronze, entirely forgetting that the employment of so costly a material for such a structure would have been impossible, and would have had the further disadvantage of being too weak to stand: therefore its imitation would have been an absurdity, quite independent of the artistic objections to such a mode of colouring, which were many.

The mode I adopted treated the whole as a painted surface, and the eye was left at liberty, and was quite able to distinguish the material painted by its form and scantling; no one, as was often prophesied, mistook the columns for wooden posts, because no wooden posts could have existed in such a form under such circumstances.

XXII. *Flowers or other natural objects should not be used as ornament, but conventional representations founded upon them, sufficiently suggestive to convey the intended image to the mind without destroying the unity of the object they are employed to decorate.*

We find this law universally obeyed in all the best periods of art, and equally violated when art declines; those who conventionalised the most were the Mahometan races, who, forbidden by their creed to represent living forms, carried the conventionality of ornament to the highest perfection.

The Egyptians, with whom every ornament was a symbol, yet took care so to use them as never to violate a sense of propriety. The Greeks equally conventionalised in their ornaments, and although the law will not appear to hold good in their application of sculpture to architecture, yet we see here they adopted a conventional treatment both of pose and relief, and very different to that of their isolated works.

In the later Gothic buildings the floral ornaments have a much nearer approach to nature, and are less conventional in arrangement than those in the earlier buildings. In the early illuminated MSS. the ornaments were conventional, and their illuminations were in flat tints with little shade and no shadow; whilst in those of a later period highly-finished representations of natural flowers were used as ornament, casting their shadows upon the page: the illuminations also were highly-finished pictures, evidently unfit for the pages of a book where the affected relief was in danger of crushing.

The Chinese, whose works, however wanting refinement and art-knowledge, yet steer clear of this; and all their figures, buildings, and flowers are so conventional in treatment that they never shock the eye or destroy the unity of the object which they decorate.

If our proposition, then, be sound in theory, and be fortified by the practise of past ages, it applies with great force to the mural decorator, the paper-stainer, the calico-printer, the weaver, and the potter; and, in fact, to all engaged in the decorative arts.

First, *mural decorators*. It is very evident that the treatment of a picture in fresco should be very different to that of a painting in oil: in the painting in oil, all the resources of art are invoked to make, as far as possible, the picture appear a reality; within his frame the painter has to himself a world. But it should be far different with a fresco; the flatness of the wall should never be disturbed; all chiaroscuro should be avoided, and the figures should appear on one plane: in fact, a true fresco should be little more than a painted bas-relief. Such were the early frescos, or more early still, the mosaic paintings.

The art of the *paper-stainer*, in the next place, has been very much neglected in this country, and is, indeed, but little better in France, although they have brought to bear upon the subject a great deal of mechanical skill in printing, and much good drawing and designing; yet it is drawing and designing mostly on false principles. It is evident that one of the first principles to be attended to in the adornment of the walls of an apartment is, that nothing should disturb their flatness; yet it is very difficult to find a paper that does not in some way violate this rule: they are either large masses of conventional foliage, generally a variation of the eternal acanthus-leaf surrounding patches of unbroken colour, or representations of fruits or flowers twisted into the most unwarrantable of positions. Here are specimens of English papers, than which nothing can be more absurd,—a wall covered with repetitions of the same subject, men and horses standing on each other's heads, or steamers floating on each other's masts. You will say they are cheap papers, below criticism; but here we have a French paper, which has had a great run in this country: you see it is a wall of strawberries. Now, in what are the English papers more absurd than this? Beautiful as this strawberry pattern is, well drawn, well printed, the colours nicely distributed over the surface, it is yet offensive, because it violates the first of all rules—propriety.

We say, therefore, that all direct representations of natural objects in paper-hangings should be avoided: first, because it places these objects in unseemly positions; secondly, because it is customary in almost every apartment to suspend on the walls pictures, engravings, or other ornamental works, and therefore the paper should serve as a background, and nothing on it should be obtrusive or advancing to the eye. Diaper-patterns in self-tints are safest for this purpose, but when varieties of colours are used, the Oriental rule of so interweaving the form and colour as that they may present a neutralised bloom when viewed at a distance, should never be departed from.

The prevailing colours of the walls of rooms hung with printed paper should, of course, vary with the character of the room and the aspect. Halls and staircases look well hung with green, because the eye on entering a house is generally fatigued with the strong glare of daylight, and the green is the most refreshing. Studies and dining-rooms look well with dull reds in diapers or flocks, which may be enriched with gold; these form good backgrounds for engravings or pictures, but the reds or greens must never be positive colours, but low-toned and broken, so as not to disagreeably impinge upon the eye. In drawing-rooms, where the paper has to do more towards furnishing and beautifying a room, they may be more gay; almost any tone and shade of colour heightened with gold may be used, provided always that the colours are so arranged, and the forms so interwoven that a perfect balance be obtained, and the eye never attracted to any one portion.

The *calico-printer* and the *weaver* violate our proposition at every step. We have ladies' dresses, ribbons, furniture-prints, carpets, which are the more and more admired from the more perfect knowledge of botany they display, violating the sense of propriety at every step: we walk on flowers and tropical plants crushing beneath our feet; we have chintzes covered with roses in violent contortions over the sinuosities of our furniture, or broken in twain by the folds of curtains; ladies robed in rose, shamrock and thistle (a high achievement); the fast man with race-horses and ballet-girls printed on his shirt, and pointers woven on his neckerchief.

The *Potter* keeps pace with his fellows; without his flowers he believes his art would cease to be: with him consistency is disregarded,—he serves us flowers with every dish, magnified and microscopic.

So runs the fashion of the present day; would that its sun were set, that we might awake to a more healthy dawn!

ON THE PRINCIPLES WHICH SHOULD DETERMINE FORM IN THE DECORATIVE ARTS.

By M. Digby Wyatt, F.R.I.B.A., Assoc. Inst. C.E.

[*Exhibition Lecture delivered at the Society of Arts, London.*]

It has pleased the benificent Designer of "the world and all that therein is," not only to surround man with the ever-varying and inexhaustible beauties of nature, and to endow him with the gift of sight to perceive her graces, but He has been pleased also to confer upon him a mind to understand, and a hand to imitate them. These gifts are clearly talents committed to our charge, and to be accounted for by us. The same Power

> "That gave us in this dark estate
> To know the good from ill,"

conferred upon us also an unerring natural test to distinguish the beautiful from the mean or ugly. That test is the sensation of delight which invariably accompanies our recognition of beauty, moral or physical. Whenever the powers of the mind are concentrated upon any of the great external evidences of Omnipotence—upon "the heavens above, or on the earth beneath, or in the waters which are under the earth"—it is impossible to refrain from pouring forth a tribute of silent but heartfelt admiration; and at such moments the Creator, as if to mark his approbation of the sacrifice, lulls for a while all memory of earthly pain or care, and pours peace and happiness into the soul. Thus it is that "a thing of beauty is a joy for ever." It is impossible to examine the smallest object upon which the skill of Divinity has been exercised—a shell, a flower, or an insect—without feeling a longing to know somewhat of the mysterious laws which make that individual specimen of design so perfect, and without experiencing a desire to emulate the marvellous powers of creation. The first sensation of the exercise of such powers we feel to be God-like. Thus it is man naturally attempts, in his feeble way, to emulate the loftier faculties of Divinity; and thus "'tis to create, and in creating live a being more intense, that we endow with form our fancy." From such exertions spring all that is ideal or poetical in every art.

Whenever we attempt to penetrate the wondrous system that makes all nature one vast harmony, it is impossible to refrain from feeling that "God moves in a mysterious way His wonders to perform;" and that it is as yet our portion only to see the full light of His majesty "as through a glass darkly." Enough, however, is still apparent to teach us that there are conditions of harmonious relation which pervade the most exquisite forms in Divine creation; and it is only while catching a faint reflection from their glories that we can hope to succeed, in the slightest degree, in throwing a veil of beauty over our comparatively insignificant productions.

The first operation indispensable to any attempt to define the principles which should determine form in decorative art must obviously be an investigation into those conditions of divine design in concord with which all human attempts at its imitation must be moulded before a supreme sensation of delight can be produced. The occurrence of such a sensation we have already pointed out as the constant and unerring test of real beauty.

We propose, therefore, in the first place, to draw such general inferences together, concerning the great scheme of design manifested in the noblest works of nature, as we have been enabled to collect, either from the experiences of others or our own study of the subject.

The second operation must evidently be to trace the application of these general inferences to the various material branches into which the different necessities of man or his sympathies have divided all those decorative arts which minister to his cravings for enjoyment on all occasions. We purpose, therefore, in the second place, to take a rapid survey of the principal members of that great family, and to point out some of the innumerable enactments of nature, specially affecting several of the most important individual "departments of practical art." Never in the whole history of the past has such a body of appropriate illustration of this branch of our subject been collected as was brought together in the vast extent of the ever-memorable Palace of Industry, and it was impossible to examine carefully the rich store of material inclosed with its glassy walls, without gathering some few valuable hints.

In entering on the first division of our perhaps too ambitious attempt, we are overcome with a sense of the infinite minuteness of our knowledge of the great conditions of creation. We recognise an almost universal beauty throughout the works of nature by the exercise of some faculty as intuitive as memory, and not less inexplicable when we essay to predicate concerning its ineffably mysterious constitution. It has been well observed by some metaphysical writer that in the development of the intellectual powers the first effort is to realise, the second to enjoy, and the third to reason. In obedience to this theory, the first and constant effort of every child is to feel, to see, to use its senses, and to verify the fact of its existence by ascertaining its physical relation to all by which it is surrounded. Its second and occasional effort is to eat, to drink, to smell, to show pain and pleasure, likes and dislikes, and to observe and treasure up such experiences as can affect its subsequent enjoyment. The third effort is to exercise the gift of thought, and to form conclusions by other processes than those of direct sensation. Now we, as respects our knowledge of Divine beauty, can be regarded only as very little children; and, if we should improve upon our condition of ignorance, instinct leads us onwards through parallel states of progress. Let but the first effort of one totally uneducated in art be to see and to feel nature, to look upon her works with an observant eye, and he will almost instantly find himself led on by unerring sensations of delight to the second stage of advancement. In that stage he will enjoy, discriminate, select, store in his memory, and at length endeavour either to reproduce, or cause to be reproduced, those natural objects, contact with which has caused him the greatest amount of pleasure. Thus the first phase of all art is rude direct imitation. No sooner does he arrive at the full development of his secondary condition than he passes into the third. He begins to speculate upon the sensations he experiences, upon the phenomena of their recurrence, and on the means whereby he may be enabled by his own descriptions or imitations of the original types, to convey to others the pleasure he himself derived from a contemplation of them: thus the ignorant may grow into the connoisseur, and thus the child into the artist.

A knowledge of the sequence of these natural phases of transition points out the course by which alone special education in decorative art can be brought to a successful issue. Surround the pupil with every attainable example of general beauty of form, if he is to be a general artist or draughtsman; make him acquainted with all the antecedent productions in his specialty, if he is to be a special designer. Show him only as much as possible of what is good, whether general or special; then his sense of enjoyment will teach him selection, and he will store his memory with the best. Practise his hand as you educate his senses, and the feeling of power will soon come upon him. Reason will assert its empire, and inquiry will be stimulated. Once roused, effort will succeed effort, and thus in time the pupil will grow into the master. As it is impossible to arrive at correct theories in science, except by the analysis of accumulated observations, firstly of things, secondly of properties, and thirdly of relations, so it is impossible to assume any general conclusions concerning Divine design without passing through the three stages of realisation, enjoyment, and reflection.

When we take into consideration, on the one hand, the shortness of life and the limitation of the powers of man, and, on the other, the extent and illimitable divisibility of matter, and its incessant changes in form and application, we cannot but feel conscious in how slight a degree the best disposed and most talented student of nature can have become aquainted with her innumerable phenomena, a thorough knowledge and enjoyment of which we have shown to be indispensable to any just general conclusions. It is only by the transmission from generation to generation of accumulating experiences and deductions, that the very few points we are about to indicate have been assumed as universal recurrences in the external forms in which nature pours forth her bounteous gifts to man.

The first quality with which the observer must be struck is the infinite *variety* of form which pervades creation. On attempting to reason concerning it, he perceives its dependence upon the functions each object and the component parts of each object are ordained to fulfil; hence he will at once recognise the fact that form is in every case, if not dependent on, at least coincident with, structural *fitness*. When the most complex flower is submitted to the test of a scientific botanical examination, no particles are found to be adventitious—all are concerned in fulfilling the appointed functions of vegetable physiology. As those functions vary with the growth of the plant, so in every case does its form—changing from tender bud to blooming flower, and from blooming flower to reproductive seed-pod, as each successive change of purpose progresses. Infinite *variety* and unerring fitness thus appear to govern all form in nature.

While the former of these properties demonstrates her infinite power of complexity, the latter restrains the former, and binds all in beautiful *simplicity*. In every case ornament appears the offspring of necessity alone, and wherever structural necessity permits the simplest lines in every case consistent with the variety of the uses of the object are adopted. Thus the principal forest trees, which spring erect and hardy from the ground, in their normal state, uninfluenced by special conditions of light or heat, shoot straight aloft, with boughs equally balanced on all sides, growing so symmetrically that a regular cone or oviform would, in most cases, precisely define their outline; and thus the climbing plants, from their first appearance, creep along the ground in weak and wayward lines until they reach something stronger and more erect than themselves; to this they cling, and from it hang either vertically or in the most graceful festoons; to each its character of form as of purpose—to each the simplest line consistent with its appointed function and propriety of expression. From Nature's delight in *simplicity* man probably derived his earliest perception of geometrical figures. The term horizontal at once betrays the source from which our idea of such a line may have been derived. Upon the horizon, as a base, endless perpendiculars are erected in every plant that pierces the soil at right angles to its tangent. A plain in nature furnishes the idea of a plane in geometry. Every variety of triangle is indicated by the outline of the snow-clad peaks of the loftiest mountains; every kind of cone by their substance. The thin clouds that sweep along the sky at sunset, hanging over the distant blue line of the ocean form exquisite parallels, and where cut by the lines of trees and plants suggest every variety of square and oblong, rhombus and parallelogram. Where compactness is indispensable, the honey-yielding hexagons abound, and in her endless variety of crystals nature has furnished us with models of the most exquisite solids. In the rainbow we have her noblest arch; in the parabola at once one of her most graceful curves and most elegant formulæ of projection.

While a consideration of the quality of *fitness* binds us to *simplicity*, that of variety, as if in counterbalance, conducts us to a just recognition of the value of *contrast* throughout all the works of creation. Simplicity becomes appreciable only when opposed to complexity; while complexity itself will, on analysis, be found to consist only of the combination of parts, individually of extreme simplicity. Mr. Owen Jones has told us respecting the beautiful laws of the simultaneous contrast of colour, so that we may for the present content ourselves with noticing the parallel effects, produced in obedience to the laws of the "simultaneous contrast of form." The researches of Mr. Penrose have lately developed many of these most interesting phenomena; and have not only demonstrated the fact of the scientific acquaintance of the Greeks with their peculiarities, but have shown how essential an attempt to apply such knowledge has been to the production of those exquisite monuments which, from the first moment of their creation to the present time, have maintained a position of unquestionable supremacy over every other work which human art has yet produced. The general result of Mr. Penrose's investigations tends to the assumption, that no two lines can come in contrast with one another, either in nature or in art, without the direction of the one acting, either attractively or repulsively, upon the other, and tending to diminish or exaggerate the mutual divergence of both lines—*i. e.* to increase or lessen to the eye the angle at which they meet. Thus, if to a perfectly horizontal line another be drawn, meeting it at an angle of six degrees (about half the angle at which the inclined sides of the best Greek pediments leave the surface of the cornice), it will be difficult to convince the eye, as it traces the direction of each line, that the angle has not been materially increased by an apparent deflection of the base line, and an apparent very slight drawing down of that with which it actually forms an angle of six degrees only. In order to remedy similar apparent distortions in their monuments, the Greeks have given entasis, or swelling to their columns, inclination of the axes of their pillars towards a central line, a tendency outwards to their antæ, and exquisite convex curves to the horizontal lines of their cornices and stylobates, which would otherwise have appeared bent and crooked.

Nature, in working out her harmonies of contrast, abounds with similar optical corrections. The infinitely gentle convexity of her water sky line is precisely corrected into perfect apparent horizontality by contrast with any line at right angles to a tangent to its curve. It is by attention to the optical effects produced by the impact of lines upon one another in nature, that the artist can alone store his mind with the most graceful varieties of delicate contrast. Thus it is alone that he can appreciate the extreme beauty of her constant, minute, and generally inappreciable divergence from the precise mathematical figures, in approximation to which simplicity demands, as we have already shown, that her leading forms should be modelled.

We have now arrived at a recognition of the four principal elements which invariably concur in producing those emotions of delight which may be regarded as infallible tests of our contact with real beauty in the productions of nature—Variety—Fitness—Simplicity—Contrast.

Before leaving our consideration of these elements we cannot refrain from drawing attention to that which is the crowning illustration of the effects of their co-operation—the Human Body. That theme, upon the reproduction of the external features of which the highest powers and the profoundest study have been lavished by the greatest artists of all time. In its structure, the anatomist, aided by microscopic examination, discovers a *variety*, to which that of the Great Exhibition was monotony itself—a *fitness*, to which the most exquisite machines therein contained displayed no parallel—a *simplicity* of external form, which, without the slightest display of all that marvellous internal mechanism, confines the whole in a space precisely adapted for the free working and protection of every part, and yet covers all with a soft and undulating surface, the curves of which are gentleness and simplicity itself. *Contrast* between curve and curve, between one line of limb and another, produces in motion incessant *variety* of expression, still in obedience to the bounding conditions of simplicity. The swelling muscles, increasing as the angles of approach are diminished by their action, counteract otherwise apparent ungraceful concavities; and in that loveliest of created things, the perfect female form, every quality of beauty is freely and exquisitely balanced and united.

To recapitulate the sequence of these four great impressions, we may state, that when the attention of the student of nature is first concentrated earnestly upon her works, his senses are bewildered by the variety of her charms. His first discovery will probably be that of the perfect individual fitness of some one object upon which he may fix for analysis; he will subsequently recognise fitness as universal. In perfect fitness he will marvel at perfect simplicity; and as he becomes acquainted with normal forms, isolated or at rest, he will learn to gather general impressions when he witnesses their combination, or varying forms in contrasted action. As from this point his experiences increase, he will begin to appreciate marvellous affinities; he will find certain conditions universally forming the basis of propriety in all imitations of nature. Thus he will recognise that she has a style of form and detail peculiar and appropriate to every material in which she works, and that this style of form and detail is, in every case, modified by the exact method in which her operations of manufacture are conducted. Of this no more perfect illustration can be given than the lines of fibrous reticulation which constitute the substance, and at the same time form the ornament of every leaf that blows. In the aggregate of every class he will trace general character, while the slightest variety of structure will infallibly be testified by some change in external outline. Gradually form will become with him an index to all leading attributes—a clue by which he will at once recognise the relation of bodies, or their properties, to one another. Thus, from form alone he will soon discern at a glance of what materials, and how, any particular object he may examine has been executed. This index or clue, be it remarked, never misleads; the "lamp of truth" never in nature burns dimly, nor with fallacious fires—never refuses to illuminate those who incline to learn in a truthful and reverential spirit. One material in her productions never looks like another. Rocks have their rugged outlines—minerals their appropriate crystals—metals their colours and glittering aspects—timber its bark and cellular section—flowers their delicacy and evident fragility—even transparent bodies their varying angles of refraction—water its glassy surface when at rest, and unmistakeable curves when agitated. Never does a flower look like a piece of metal—never a piece of timber like a rock.

As the student's acquaintance with these consistencies in nature increases, his power of generalising will become developed. He will learn to separate constants from accidents, and to trace the distinctive lines which convey the idea of each general family of materials, or modes of formation. He will begin to select, and to treasure up in his memory, those symbols of expression with which nature indicates the leading characteristics of every variety of object she produces. On the amount of the artist's acquaintance with such conventionalities, or, in other words, with the written language of nature, will entirely depend his possible success in producing by his labours sensations of delight at all equivalent to those excited by the aspect of her noblest works Direct imitation will do next to nothing, fanciful and ignorant invention still less: it is alone by his power of wielding her weapons of expression, and making in all cases the form and the object strictly concordant, as she does, that the artist may aspire to emulate the power of giving delight, which, above all others, appears to be her paramount prerogative. Time will not permit our dwelling further upon the general inferences deducible from a study of the wonderful beauties of nature. Enough may, however, have been enunciated concerning the most palpable principles, to warrant our assertion, that there exist conditions of harmonious relation which pervade the most exquisite forms in divine creation. It will be our pleasing task now to show how essential it is that we should catch a faint reflection from their glories, before we can hope to succeed in the slightest degree in throwing a veil of beauty over our comparatively insignificant productions.

In entering on the second division of our subject, we shall endeavour to trace the application of principles analogous to those on which we have lately dwelt,—in the first place, generally; and in the second, to the respective leading and special departments of practical art.

In the first place, then, it may be observed generally that the endless diversity of men's tastes, and the ever-changing conditions of their education and association of ideas, demand for their productions a *variety* almost as incessant as that which pervades creation. Whenever that craving after variety has been gratified, irrespective of *fitness*, novelty has degenerated into frivolity, design into conceits, and style into mannerism and vulgarity. Without a due attention to *simplicity*, fitness has never been adequately carried out; attention has been diverted from a proper estimate of every work of art or object of manufacture, and false impressions concerning its true and legitimate functions have been generated. Great care is necessary in applying nature's principles of *simplicity* to human productions, since many have erred by regarding simplicity as identified with plainness, or a bare and frigid style. The true office of simplicity is to limit form and ornament to a correct expression of whatever may be the predominant sentiment endeavoured to be conveyed by any object, and to reject all that is extraneous to that sentiment. Where, for instance, as in jewellery or in regal furniture, a sentiment of splendour is demanded, *simplicity* accords the same latitude that nature assumes in her most brilliant sunsets or most magnificent flowers. Where, however, in the ordinary vessels which minister to the material wants of man, *simplicity* prescribes a closer range; there the greatest amount of true good taste will be invariably found in the most modest form consistent with the perfect adaptation of the vessel to its office. It may, perhaps, sound paradoxical to assert, but it is nevertheless correct to believe, that the true principle of nature's just *simplicity* was scarcely less worthily represented by the gorgeous chair of the Rajah of Travancore than it was by the rude yet graceful articles of Hindoo pottery. A gown, relatively speaking, displays its just amount of simplicity, not by the dowdiness of its colour, pattern, or material, but by its due accordance with the age, position, claims to beauty, or other social accidents of its wearer.

Contrast teaches us to give a due relief to all which we would desire to call attention. A sudden break in a long straight line, a slender necking in a continuous sweep, a sudden concavity in a generally convex outline, a bold projection starting forward from an even plane, right lines opposed to curves, segments to sections of the cone, smooth to rough surfaces, conventional forms to direct imitations of nature, all carry out the desired object, and are every one subject to the phenomena of simultaneous contrast of form. To obviate such optical delusions allowances must be made in every case by the artist; many such corrections are constantly perceived and effected by the eye, but few, alas! by rule. In reference to such corrections, it is justly remarked by so ancient a writer as Vitruvius that "the deception to which the sight is liable should be counteracted by means suggested by the faculty of reasoning. Since the eye alone," he continues, "is the judge of beauty, and where a false impression is made upon it through the natural defects of vision, we must correct the apparent want of harmony in the whole by instituting peculiar proportions in particular parts." It is singular that this passage should occur in connection with the subject of entasis, and the theory of those subtle proportions in the construction of temples, on which the Greeks bestowed such exquisite refinements of study. We cannot afford in the present lecture to dwell further on this department of the study of form, deeply interesting though it be, since we have a full-length sketch to give, and but a kit-cat to execute it upon.

When we turn to a consideration of the united action upon human design of the general principles of consistency exhibited in the works of nature, we find that of all qualities which can be expressed by the objects upon which our executive ability may be occupied, the noblest and most universally to be aimed at is plain and manly truth. Let it ever be borne in mind that design is but a variety of speech or writing. By means of design we inscribe, or ought to inscribe, upon every object of which we determine the form, all essential particulars concerning its material, its method of construction, and its uses—by varying ornaments, and by peculiar styles of conventional treatment, we know that we shall excite certain trains of thought and certain associations of idea. The highest property of design is, that it speaks the universal language of nature, which all can read. If, therefore, men be found to systematically deceive—by too direct an imitation of nature, pretending to be nature—by using one material in the peculiar style of conventionality universally recognised as incident to another—by borrowing ornaments expressive of lofty and high-minded associations, and applying them to mean and paltry objects—by hiding the structural purpose of the article, and sanctioning by a borrowed form the presumption that it may have been made for a totally different object, or in a perfectly different way—such men cannot clear themselves from the charge of degrading art by systematic misrepresentation, as they would lower human nature by writing or speaking a falsehood. Unfortunately, temptations to such perversions of truth surround the growing designer. The debilitating effects of nearly a century's incessant copying without discrimination, appropriating without compunction, and falsifying without blushing, still bind our powers in a vicious circle, from which we have hardly yet strength to burst the spell. Some extraordinary stimulant could alone awaken all our energies, and that stimulant came,—it may not, perhaps, be impious to esteem Providentially,—in the form of the great and glorious Exhibition. It was but natural that we should be startled when we found that in consistency of design in industrial art those whom we had been too apt to regard as almost savages were infinitely our superiors. Men's minds are now earnestly directed to the subject of restoring to symmetry all that had fallen into disorder. The conventionalities of form peculiar to every class of object, to every kind of material, to every process of manufacture, are now beginning to be ardently studied; and instead of that vague system of instruction by which pupils were taught that anything that was pretty in one shape was equally pretty in another, a more correct recognition of the claims of the various branches of special design, and the necessity of a far closer identification of the artist with the manufacturer, in point of technical knowledge, have been gradually stealing upwards in public estimation. Let us hope that success will crown exertion, and that in time the system of design universally adopted in this country will offer a happy coincidence with those lofty principles by means of which the seals of truth and beauty are stamped on every emanation from the creative skill of Divinity.

In approaching the more directly, though not essentially, practical portion of our subject, that of the application of nature's principles to some of the special departments of practical art, represented in the Exhibition, we shall premise by a few considerations on architecture and sculpture, and the plastic arts.

It would be difficult to imagine a juster and more comprehensive view of the extent of direct imitation admissible in each department of the fine arts than that which was presented in the appendix to the third report of the commissioners, by Sir Charles Lock Eastlake, and republished in his 'Contributions to the Literature of the Fine Arts.' In a note to one of those important essays the writer observes that "the *general* style of the formative arts is the result of a principle of selection as opposed to indiscriminate imitation. It consists, therefore, in qualities which may be said to distinguish those arts from nature. The specific style of any one of the arts consists in the effective use of those particular means of imitation which distinguish it from other arts. Style is complete when the spectator is not reminded of any want which another art or which nature could supply."

Now the specific style of architecture is especially worthy of study, since not only do similar conditions pervade all branches of design into which structural forms enter as principal elements, but of all the arts it is obviously the least imitative and the most abstract. The effects of delight which can be produced by it are dependent not upon a reproduction of any objects existing in creation, but upon a just display by the architect of his knowledge of those subtle general conditions, a few of which we have recognised as pervading every perfect work of nature. The beauty of civil architecture we are told by the best writers upon the subject, depends upon—first, Convenience; secondly, Symmetry or proportion; thirdly, Eurythmia, or such a balance and disposition of parts as evidences design and order; and, fourthly, on Ornament. In too many modern buildings, alas! we find that either convenience has been attended to and all other qualities left to chance, or, what is still worse, ornament alone aimed at and all other considerations disregarded. Let us, for the sake of example, trace the operation of the principles to which we have alluded, all of which will be found to have their origin in the provisions of nature. The wise architect will begin by considering the purpose of his building, and will so contrive its plan and leading form as to fulfil all the utilitarian objects for which it was proposed to be constructed; in other words, he will be governed by a sense of *convenience* or *fitness*.

He will then consider how all the requisites can be most agreeably provided, and harmonious proportion combined with an expression of purpose. He will find, on recurring to nature, that every substance suitable to be employed in construction exhibits endless *variety* in strength, weight, and texture. He will study these various qalities, and by experiment ascertain that each material possesses a certain scale of proportions and a certain series of solids, by the employment of which, in fixed positions its functions may be at once most economically and most fitly employed. Acting on such data, he will distribute his lines of substructure, his columns of support, his load supported, his walls to resist the driving of the elements, and he will assign to each its special proportion and form—never confounding those of one substance with another—never using iron as he would stone, or wood as glass should be. Thus aided by his sense of the functions of each portion of the structure, the material of which it may be constructed, and its condition of relative importance, the architect adjusts the appropriate dimension of every part. His work is as yet, however, only half done; his materials require bringing into graceful and regulated distribution. At this point Eurythmia, the original of "the fairy order," steps in, bringing geometry in her train. Doors, windows, columns, cornices, string-courses, roofs, and chimneys, are instantly disposed so as to contrast with, and balance one another, showing by the symmetry of their arrangements the artist's appreciation of that method and evidence of design, which indicate the restraining power of mind over matter throughout all nature—wild as her graces may occasionally appear. The crowning difficulty yet remains behind in the adjustment of appropriate ornament. In all other departments of his art the architect employs only pure abstractions, harmonising with his general deductions of leading principles of beauty: in his application of ornament, however, his resources are somewhat more expanded. All decoration, the forms of which are borrowed from nature, to be pleasing, must undergo a process of conventionalising; direct imitation, such as that which would be produced by casting from a gelatine mould, would infallibly disappoint, since the perfect reproduction of the form would lead to demands for reality in colour, in texture, and in other qualities which it might be utterly beyond the power of any other material or processes to render, than those which nature has herself employed in the original. The duty of the architect is, therefore, to study, first of all, to employ such forms as harmonise and contrast with his leading lines of structure,—and then, in those few instances where, for the sake of adding more immediately human interest to his work, or for explaining its purpose more directly. he may desire to suggest the idea of some object existent in nature—then, and in such a case, it is his duty to symbolise rather than to express and to strive to convey an idea of particulars and qualities only, instead of to make a necessarily imperfect reproduction, which conveys no idea at all.

The exact amount of resemblance which the hieroglyphic may be permitted to bear to that object, some ideal property of which it is intended to express, must depend upon so great a variety of circumstances that it obviously becomes one of the most delicate operations of the artist's skill to adjust the precise form in which he shall work out his ornament. The treatment of the honeysuckle by the Greeks, and the lotus by the Egyptians, are probably the happiest existing illustrations of refined appreciation of the mysteries of judicious conventionalising.

As a general rule the less closely the artist attempts to embody nature the more safe he will be, but as there are, we conceive, some few cases which justify a nearer approximation than is generally admissible, we shall proceed to enumerate the most important of them, premising that, paramount over every other consideration, must reign an exact regard to the conventionalities incident to the material employed, and the absolute necessity of arranging the forms of the ornament so as to contrast rightly with the adjacent geometrical lines of structure.

First, that imitation may approximate to nature only in an inverse ratio to the resemblance of the material in which the work is to be executed to the object to be copied. Thus, the smoothness of flesh may be imitated with delicacy in white marble, and the idea of rock-work only conveyed in the same material by a completely formal and geometrical method of representation.

Secondly, that as imitation in all cases interests and attracts attention, it becomes necessary to restrict its use sparingly to particular situations; thus we may on the one hand, with propriety employ decorations suggestive of natural types, in those few important points on which we wish the eye to dwell, such as the centre of a façade, the principal doorway or window, the starting of a staircase, or the end of a boudoir; but if, on the other hand, we employed in such leading situations mere conventional patterns, and in less important parts, ornaments in convention approaching imitation, then we should find attention concentrated on those meaner portions of the structure, and the really principal features of the design passed over and neglected. A striking illustration of the consequences of this want of discrimination was shown by the sculptor Lequesne, in his various groups in the Great Exhibition; the care he bestowed in working up his accessories, his weeds, foliage, rocks, earth, and everything else, almost entirely neutralised the interest which should have been excited by the finished treatment of the flesh of his unhappy mother and her miserable infant. The admiration which might otherwise have been given to his two groups of dogs and boys, were completely absorbed by admiration at the patience with which "each particular hair" was made to curl. To all the above-described faults the works of M. Etex offered a truly remarkable contrast, the labour in them being applied at exactly the right points.

Thirdly, that where ornament is contrasted by evident connection with geometrical lines of structure, conventional imitation may be introduced. Thus in many of the marble chimney-pieces in the Exhibition, and in much of the furniture, the structural forms of which made regular panels or conventional framework, the introduction of nicely-carved flowers or fruit, of the size of nature, and in low relief, produced an agreeable effect. Where, in others (and more particularly in some of the Austrian), the foliage, scrolls, cupids, and all sorts of things, completely ate up the whole surface, and made up the whole structure, the effect was eminently objectionable.

Fourthly, that where the copy differs absolutely in bulk from the original, minutiæ of surface detail may be introduced. Thus when we reduce a subject, such as a bunch of grapes, from the round or full relief to the lowest relievo, much of the conventionality which would otherwise be essential may be dispensed with.

Fifthly, that considerable differences of scale in things of unvarying dimension justify an approach to natural form. Thus, when we materially diminish in our reproduction any object the smallest size of which is generally known never to equal that to which it is lowered in our copy, we may safely attempt as close a conventional transcript as the material in which we work admits of. On this account delicate flowers, such as those which decorate small Dresden china vases, and which are executed with such skill in biscuit by Mr. Alderman Copeland, Mr. Minton, Mr Grainger, of Worcester, and others, form not unappropriate ornaments when confined to a scale considerably smaller than nature. In cases, however, such as that of the Dresden white camellia tree of the Exhibition, where an attempt is made to copy nature on her own scale, the effort altogether fails, and the labour so far from giving pleasure, utterly fails, and becomes a trick not less inimical to good taste than the veiled figures.

Sixthly, that where in ornament the leading forms are geometrically disposed, as in regularly recurring scrolls or other curves, which could never take so formal a position in nature, a rendering of her spirit, though not of her substance, may be permitted in the leaves and accessories. Thus, in much of the elaborate wood-carving produced by Mr. Rogers and others, the artificial disposition alone of the beautifully-executed objects redeemed many of the groups from the charge of too close a reproduction of nature.

We have dwelt at some length upon these special circumstances, which modify conventional treatment in ornament, partly because we felt that the data applied generally to most varieties of enrichment as well as specially to architecture, and partly because we felt it necessary to indicate some of the exceptions, the comparative rarity of which tends generally to a confirmation of the accepted dogma, which prescribes that architectural ornament shall be in a remote style of convention only.

Before proceeding to the subject of sculpture, we would fain offer one or two remarks concerning what is called style in art, for fear lest our recommendations to systematic study of elementary principles should be misapprehended. In what are generally understood as styles in the history of art, such as the Grecian, the Roman, the Gothic, the Renaissance, &c., may be recognised deeply interesting accumulations of experience concerning the nature of men's intuitive affections for certain concatenations of form. Styles are usually complete in themselves; and though not of uniform excellence, are still generally concordant among all the various members that compose them. Whatever may have been the dominant form in each, or whatever the favourite set of ratios, proportion usually pervades each whole monument, as it may be generally traced in a few detached mouldings. Styles, therefore, may be regarded as store-houses of experiments tried, and results ascertained, concerning various methods of conventionalising, from whence the designer of the present day may learn the general expression to be obtained, by modifying his imitations of nature on the basis of recorded experience, instead of his own wayward impulses alone. Canova, Gibson, and many of the greatest masters in art, held and hold the creed, that nature, as developed in the human form, can only be rightly appreciated by constant recurrence to, and comparison with, the conventionalities of the ancient sculpture of Greece. Mr. Penrose has shown us what beautiful illustrations of optical corrections in line may be gathered from the study of her architectural remains. Mr. Dyce, who has made himself deeply acquainted with ancient styles, thus expresses himself on the subject:—"In the first place," he remarks, "the beauties of form or of colour, abstracted from nature by the ornamentist, from the very circumstance that they are abstractions, assume in relation to the whole progress of the art the character of principles or facts, that tend, by accumulation, to bring it to perfection. The accumulated labours of each successive race of ornamentists are so many discoveries made—so many facts to be learned, treasured up, applied to a new use, submitted to the process of artistic generalisation, or added to. A language and a literature of ornamental design are constituted; the former of which must be mastered before the latter can be understood; and the latter known before we are in a condition to add to its treasures. The first step, therefore, in the education of ornamentists must be their initiation into the current and conventional language of their art, and by this means into its existing literature." By this last passage we may fairly assume that Mr. Dyce would recommend first the study of the conventionalities of the student's specialty, and then as much as life is long enough to learn. The great previous error in art-education has been to grasp at so much vaguely and attain so little practically.

The modifications which nature receives at the hands of the intelligent sculptor are so various, and frequently so subtle, that it would require a volume to enumerate them, and an Eastlake to write it. We can at present glance but at a very few. The first condition of the highest class of sculpture is, that it should be allied with the noblest architecture, to which it should serve as an inscription, explaining to those capable of reading its ideal expression those purposes of the structure which it is not in the power of architecture alone to convey. In all such cases *fitness* prescribes the subject—*simplicity*, its sublimest treatment—*contrast*, the general conditions of the lines of its composition. In order to give to his works that commanding language which speaks to the heart (the phonetic quality in Mr. Fergusson's admirable theory of beauty in art), the sculptor requires to select from his observation of the expression of individual forms, those precise lines he learns from study and experience invariably convey the particular sensations it is his office to communicate to the mind of the beholder. It is by some such process that an approach was made by the Greek sculptors of old to attain an embodiment of their conceptions of divinity and the *beau ideal* in loveliness of form. Time will not permit a longer reference to this topic, but it may be found touched upon with the utmost acuteness and good taste in an article on physiognomy in the last number of the "Quarterly Review," written, if any confidence may be placed in internal evidence of style, by one worthy in every respect to occupy herself in kindred studies to those which engage the attention of the President of the Royal Academy.

The peculiar refinements of form and texture which fall within the especial province of the sculptor to carry to their highest pitch of perfection, he constantly heightens by availing himself of the effects on the senses of the simultaneous contrast of form. Thus he exaggerates the roughness of the hair and the coarse texture of every object coming in contact with his flesh, in order to give to it the exquisite smoothness of nature; he introduces straight lines, equally balanced folds, and angular breaks into his draperies, in order to bring out the tender sweeping curves of the outlines of the limbs he so gracefully disposes. His is of a truth the happy art which begins by collecting all that is most sweet and fresh; and then, by one additional touch, one further artful contrast, he "throws a perfume on the violet." In sculpture, as in every other of the decorative arts, changing circumstances bring ever-changing conventionalities, and as supreme arbiters over the propriety of one and all, still preside our original great principles—*variety, fitness, simplicity, and contrast.*

In turning to those departments of practical art into which sculpture enters as a predominant ingredient, metal-work first presents itself to our notice. Nothing can be more apparent than the variety of properties and qualities of the several metals, nothing more consistent than to prescribe a different mode of treatment to each. Sculpture in metal, partly on account of the much greater ductility and tenacity of the material, and partly on account of its peculiar colour and power of reflecting light, can rarely, however highly its degree of finish may be carried, be mistaken for that which it professes to imitate. Hence it arises that elaborate execution of details may, and indeed should, be carried in metal to the most minute perfection. Works in gold or silver should, as a general rule (except in instances where an overpowering display of wealth is intended, in which case art does not much signify), be confined to small dimensions, and those relatively correspondent to the associations of idea connected with the rarity and value of each. It was from inattention to these conditions that many of the largest pieces of plate in the Exhibition failed to interest us, and that the eye dwelt with much greater complacency upon the smaller than upon the larger objects.

In parcel-gilding inattention to the just amount of profusion of the several metals is frequently lost sight of. The gold instead of the silver, is allowed to preponderate on the surface, and the improbable idea conveyed that the vessel is made of the nobler metal, and inlaid with the baser. It would be a sad want of a due recognition of rare talent if in allusion to metal work an acknowledgment was omitted of the rare talents of M. Vechte, by whom the exquisite vase and unfinished shield, exhibited by Messrs. Hunt and Roskill, were made for those enterprising manufacturers. Whoever examines the marvellous grace and refinement of the modelling and chasing of these objects will admit that there is ample room for improvement in English silversmith's work of the highest class,—and for refinements which, though perhaps little appreciated at present, must sooner or later become estimated at a value equal to those fabulous sums which are constantly paid for mutilated etchings of the great masters, cabinet pictures by Hobbima, Wouvermans, and Metsu, or factitious specimens of the great Cellini. It was gratifying to be enabled to notice, with regard to furnishing brass-work, that direct imitations of things, which, however beautiful they may be in nature, have no business stuck about one's curtains; lilies and convolvuluses, looking all alive, were on the decrease; and that correct conventionalities, the unobtrusive and graceful forms of which were suitable for execution in metal, were rapidly taking their place.

When we pursue the subject of sculpture or plastic art, as carried out in other materials, such as the woods which are used for furniture, &c. &c., we are led at once to apply in all cases the test of fitness before we can unhesitatingly approve the principles upon which the greater portion of what was shown in the Exhibition appeared to have been designed, and much, we are sorry to say, would not quite stand the ordeal. In too many instances, in the furniture, fitness and structure were entirely disregarded; table-tops were supported on bulrushes, and what should have been the simple and rigid portions of looking-glasses, cabinets, &c., all made up of flowers, scrolls, figures, and so on, which apparently no material, and certainly no spiritual connection held together. In the treatment of furniture much was to be learnt from the sensible construction of poor Pugin's mediæval woodwork. In it the refinements of joinery were all made the most of; the object was well put together and serviceable; while in the panels and other intervals of the framework as much ornament was inserted as was consistent with the purposes of the article. Where nature puts her most delicate work she always contrives a special shelter for it; her most exquisite spars and stalactites are ever protected, her tender shoots are always shielded until they acquire strength to stand exposure. It would be well if many of our wood-carvers in that respect followed her example.

The mere possession of an elaborate bed such as that in which, according to a satirical Frenchmen, "On ne pourrait même bailler sans casser un Cupidon," would be a continual annoyance. The very idea would be irritating of having a looking-glass covered over with all sorts of statuettes and ornaments in high reliefs, from which any morning the slightest touch of a housemaid's brush might bring down two or three little "unprotected females." The true system of arranging ornament is, in that respect generally, thoroughly understood by the French, who, if they put delicate ornament to look at, insert it where it will be quite safe from accident, and put strength and flatness to use or come in contact with. Not only in a technical, but in an artistic point of view, this subduing of ornament is excellent, since while the effect of decoration is obtained the bounding lines and surfaces are kept broad and simple. Any one unacquainted with the attention habitually paid to this preservation of ornament, who had been allowed to pass his hand over the richly-ornamented pistols, daggers, vase-handles, finest bronzes, and best French furniture, would have been much surprised at the comparative little obstruction it would have ordinarily met with in its passage over even the richest objects. We cannot leave the subject of furniture without glancing at the extremely appropriate mode of ornamenting it by *marqueterie*, or inlaid wood. That process is to woodwork something like what enamelling or damascening should be to metal-work. Among the specimens of cabinet-carving in wood were many which it would appear impossible to surpass as pieces of execution, although in several the extreme attenuation of substance was suited rather for metal than for woodwork. In several of the plastic materials, such as gutta-percha, carton-pierre, papier-maché, canabic, stamped leather, &c., much good design was exhibited, although the tendency, more particularly in the gutta-percha, was rather in the direction of a plethora of ornament. Nature, it should be recollected, abhors monotony even of beauty, and there is nothing so cloying and fatiguing as too much sweetness, from which perpetual plainness would be a haven of refuge. In respect to these materials a good deal of misapprehension has prevailed of late years; they have been called "shams," and a variety of names which they intrinsically in no wise deserve. When people paint and grain papier-maché to make it look like oak or other valuable woods, or when they dust sand over carton-pierre to make it look like stone, then certainly they perpetrate meannesses at which good taste is disgusted the instant the deception is found out; but when the materials are used simply as ornaments, either in a uniform colour or picked out with any variety of tints, everybody recognises the nature of the material; and there can, then, be no more *sham* or *trick* in employing them than there could be in using Caen stone for a pulpit instead of marble, or iron for a column instead of gold.

There is, perhaps, no substance in the manufacture and design of which so great an improvement has taken place in this country within the last ten years as in that of glass. Witness for manufacture the Glass Palace and its wonderful fountain. The subject of glass, its materials, appropriate form, colour, and other conditions, having been most ably treated in the last lecture of this series, renders it unnecessary now to make any further observation on the subject. Never at any other period has anything corresponding to the present perfect execution of glass-work existed; and that so soon as the cumbrous, lumpy decanters, tumblers, and rummers, in which our fathers delighted, shall have been all broken, there will be very little left to desire in respect to table-glass.

With regard to china and the group of analogous materials, such as porcelain, terra-cotta, &c., time compels us to be brief. In all such objects, the fragility of the material warns us against rash projections, and yet we constantly recognise them stuck on, as though merely for the purpose of being knocked off. The primitive arrangement of the potter's wheel, and the plasticity of the material, yielding beneath his hand curves, which in Etrurian and Magna Grecian ware we admire as exquisite, direct us as it were to simplicity in all works in such materials. So long as by the readiest means, and by a little education of the workman, we might obtain forms quite as beautiful and as various as those which we always have and always shall admire in the antique, there can exist no excuse for casting octagon and hexagon jugs, or making teacups up out of half-a-dozen curves.

In many respects it was gratifying to observe that the most beautiful objects, upon the production and decoration of which the highest artistic talent of France had been employed in the Royal Manufactory at Sèvres, almost without exception, were rigidly simple in their outlines, and produced structurally by that primitive instrument, we must ever respect and associate with pottery—the potter's wheel. Much information as to the proprieties of the form and ornament of china might be derived from a study of some of the beautiful Indian and Tunisian ware; and if our exquisite mechanical execution were combined with their feeling for pure form, and the proper application of not too much ornament, effects of surpassing beauty might doubtless be produced.

We have now very hurriedly run through the leading classes of objects on which practical art operates directly, and which possess what the Germans call "selbstandigkeit," that is to say, an independent structural existence. There remain for us to notice those which apply particularly to surfaces, and the treatment of which consequently involves the consideration of superficies only. We are told most truly, that one "guiding principle of their admirable Oriental ornamentation appears to be that their decoration was always what may be called surface decoration. Their general guiding forms were first considered and these forms decorated. Their flowers are not natural flowers, but conventionalised by the material in which they worked. We do not see, as in European works, a highly-wrought imitation of a natural flower, with its light and shade struggling to stand out from the ground on which it is worked, but a conventional representation sufficiently near to suggest an image to the mind, without destroying the unity of the objects it is intended to decorate. There is a total absence of shadow. The patterns of their shawls and fabrics are harmonious and effective from the proper distribution of form and colour, and do not require to be heightened in effect by strong and positive oppositions; the great aim appears to be that objects viewed at a distance should present a neutralised bloom—each step nearer exhibits fresh beauties, a close inspection the means whereby such effects are produced. In their diapers and scroll-work, one of the means whereby their harmonising effect is produced, appears to be that the ornament and the ground occupy equal areas; to obtain this requires no ordinary skill, and can only be arrived at by highly-trained hands and minds. In their conventional foliage in all cases, we find the forms flowing out from a parent stem; the space which has to be filled, however varied in form, being accomplished with the most exquisite skill. We never see here ornaments dotted down, as in modern works, the existence of which cannot be accounted for; every flower, however distant, can be traced to its branch and root."

These are but a few of the general principles which should aid the designer of surface decoration, hundreds more there are which vary in their precise form of application with every special case and subject. Where, for instance, on the one hand, drapery has to be ornamented, which is intended to cling tightly to, and exhibit the form it covers, it would obviously be absurd to introduce a bold pattern of strong contrasts, the lines of which would arrest the eye, instead of allowing it to travel over the outlines and inflections of the form it is intended to veil, but not conceal; where, on the other hand, material has to fulfil the office of a hanging, such as a porteire or curtain, or a loose covering, there a bold pattern may frequently be introduced with the happiest effect. This principle of costume was finely understood by the Venetian and Florentine weavers, and by the Italian ladies of the sixteenth century, as may be seen in many a splendid old female portrait by Titian, Giorgione, or Parmegiano.

Of the various appropriate modes of conventionalising nature, scarcely any is more agreeable than that which is frequently adopted by the skilful paper-stainer, in what are commonly called panel papers. It consists in treating as a picture flowers and other objects, grouped with scarcely any apparent artifice, in their natural forms and sizes, and with all their lights, subdued shades and reflections, but with no cast shades. This, at first sight, would appear to be too direct an imitation of nature to be agreeable, and therefore liable to objection—and so, unless care is taken, it very frequently is. Now the method of preserving all that is requisite is effected by representing the flowers by successive blotches of body colour dabbed on, with no attempt to soften the edges or conceal the method by which the effect is produced. Thus, at a little distance the decoration looks, not like a group of flowers, for that would be a mistake, but like a very clever sketch of a group of flowers framed and inserted in the panel. Where direct imitation of natural flowers, with endless tiresome repeats, are carried out, either in paper-hangings, block or cylinder printed goods, in carpets, damasks, or other woven hangings, the effect is rarely, if ever, agreeable, however marvellous the manufacturing power may be which can effect such elaborate reproductions. In woven goods the conditions of manufacture constantly modify the structure of patterns; and those even which have been originally derived from nature frequently become reformed to such an extent in putting on or draughting, that the best mode of convention, that which is induced by the process of manufacture makes that agreeable, which if it could have been more perfectly carried out would most probably have been extremely faulty.

The subject of surface decoration is one which involves such infinite varieties of conventional treatment, which demands so large a study of the effects of complicated geometrical subdivisions in mosaic; and, in fact, so large a field of vision, that we feel that within the limits of one lecture it is quite impossible to systematise a subject which could scarcely be fitly treated in half-a-dozen. We are fain, therefore, to draw to a close this our most difficult attempt to define the principles which should determine form in the decorative arts. In doing so, however, we would pause for a few moments to remark that, although for the sake of perspicuity, we have throughout this lecture adopted the language of analysis, it must be borne in mind that our divisions are altogether arbitrary, and have no existing prototypes in the great scheme of creation. In that, subdivide as we may, all is unity and omnipotence. *Variety*, *fitness*, *simplicity*, *contrast*, and perfect *truth*, all are swallowed up in one thing perfectly good, and therefore perfectly beautiful—Divine will—that Divine will, which in the beginning created the heaven and the earth, and saw that everything created was very good. Surely we, whose privilege it is to be fashioned in God's own image, may strive to follow reverently and closely, though at an infinite distance, that great example which has been given us; and study, so far as lies in human power, to insure that all we do, and all we make, may, like the great works of nature, be all "very good."

VENTILATION OF THE HOUSES OF PARLIAMENT.

The Select Committee appointed to consider the best means of improving the ventilation and lighting of the house and its appendages, have made their second report. They say the only portion of the New Palace under the superintendence of Dr. Reid is the House of Commons, with its division and gallery corridors, the House lobby, and the Speaker's and Cabinet rooms; all the remainder is under the control of the architect. At the commencement of the Session the lighting of the House was in charge of Sir C. Barry, but since that period it has been transferred to Dr. Reid.

The Committee are of opinion that the condition of ventilation of the House of Commons and its appendages is still unsatisfactory.

The system of Lighting adopted by Sir C. Barry (viz. by large gas chandeliers descending for a considerable distance into the body of the House), however well it may have accorded with the general architectural character of the room, rendered the requisite control over the ventilation difficult, if not impossible; the heat radiating from these highly heated surfaces pervaded every part of the House, and rendered the Galleries almost intolerable.

In consequence of defective arrangements in regard to the gas, much of it escaped from the pipes and burners, and contaminated the air which was drawn into the House from the corridors.

The plan of forcing air into a building by mechanical power, to produce what is called plenum or plus ventilation, combined with the extracting powers of a shaft with furnace or steam jet to effect what is termed vacuum ventilation, with ascending and descending currents for the supply of fresh and abstraction of vitiated air, is, in the opinion of the Committee, a complicated system, and one which they are not prepared to approve.

The vaults used for the purpose of transmitting the air to the House of Commons are liable to be affected by damp and impurities arising from bad drainage; and unless this evil be effectually remedied those vaults ought not to be used as air channels.

The air is deteriorated at times by over-heating, which it experiences when in contact with iron pipes, heated some by steam, others by hot water, contributing to produce the disagreeable taste and smell which has been complained of. This disturbance of the wholesome condition of the atmosphere renders complicated manipulation necessary to restore the balance, an operation attempted in both the systems adopted in the New Palace, and without success.

No satisfactory evidence has been obtained in regard to any apparatus for warming which shall dispense with metal surfaces for heating the air. Some more appropriate material, such, for instance, as glass, or glazed earthenware, will be found to be applicable to this purpose; and they trust the subject will not altogether be lost sight of.

The present practice of heating a certain portion of the air beyond the ultimately required temperature, and then cooling it down by the admixture of cold air, is not only injurious to the quality of the air, but is productive of ascending currents of air of different temperatures.

One of the causes of defective ventilation in the House of Commons is the want of a sufficient area of openings at the floor of the House, and the necessity which thence has arisen for admitting the air through the interstices of the carpet. This operation, it is found, causes the dust to rise with the ascending current of air, and produces grave inconveniences. The openings for the admission of air at or near the floor of the House should be so enlarged as not to require any portion of the air to be drawn through the fibres of the carpet, which never can be free from dust and other impurities.

As regards the ventilation of the Committee-rooms, which is in an extremely defective state, much improvement would be effected by an enlargement of the openings both for the supply and discharge of air.

The present structural arrangements for ventilation and warming are stated to be sufficient, and susceptible of easy adaptation, at a moderate outlay, to any other system that may be considered preferable.

The Committee desire to give it as their opinion that the failure of the ventilation of the House of Commons, at the commencement of the Session, cannot fairly be imputed to any radical defect in Dr. Reid's system, because the House was hastily occupied with an infinity of arrangements incomplete; and the lighting, from which the greatest amount of mischief arose, was neither contrived by Dr. Reid nor under his control; and in surveying the whole of this matter it is perhaps only fair to that gentleman to bear in mind, that his original plan was a comprehensive scheme for the ventilation of the entire building, of the superintendence of the greater portion of which he was deprived when the works were more than half completed. As regards future management, the entire responsibility of ventilating and lighting the House, and its appendages, should be confided to one competent person, under the direction and supervision of the Board of Works; and with a view to secure proper attention to any complaints that may hereafter arise, a committee should be named, at the commencement of each Session, to confer with the Board of Works upon any measures that may appear necessary to remove such complaints.

Dr. Reid's *Arrangements for Warming and Ventilating the New House of Commons.*

Dr. Reid, in a report dated April 5, 1852, states as follows:—

"These arrangements having been introduced when Dr. Reid was deprived of means and resources, the use of which had been previously provided, and were always contemplated during the period when the ventilation and lighting was under his directions at the New Houses of Parliament, they are to be considered as the result of a system that forced upon him the necessity of sustaining a continued protest since 1846, and compelled him to act under disadvantages, and amidst incessant alterations, of which he had often no notice till he saw them in process of execution on the works.

It is also necessary to mention that the warming and ventilating arrangements executed were proposed on the distinct understanding that a system of lighting should be adapted to them that would in no way interfere with them, and Dr. Reid proposed a plan accordingly in unison with the instructions conveyed to him, but this plan was set aside on Sir Charles Barry objecting to it, though Dr. Reid never once had the opportunity of submitting previously any answer to Sir Charles Barry's objections.

1. *Source of Supply.*—*a.* From the highest available part of the Clock Tower, which would alone be used, could it be preserved at all times free from the action of smoke-shafts at the Houses of Parliament and other sources of vitiated air, and connected with all parts of the House where a supply is necessary. *b.* From the level of the ground-floor, immediately under the north portion of the Central Hall; a supply is also available from this level at either side of the House, to be used only under very special circumstances, or in the event of any accidental overflowing of the vaults. *c.* From the level of the roof, by a channel opening on the east side of the central portion

of the river front, and on the west side at a turret opposite Westminster Abbey.

2. *Purification of Air.*—The deposition of dust and soot. when the air is loaded with these materials, are the principal ingredients which it is desirable to remove. Until the arrangements for the supply of water shall be more advanced, this can only be effected by temporary measures. When the heat is great, the barometer low, and analysis proves a very marked excess of carbonic acid and other impurities in the air, special chemicals have occasionally been used with great relief; but as a general rule they are avoided, with the exception of water and lime.

3. *Modes of Heating.*—By hot water apparatus, worked usually at a temperature of 90° during the sitting of the House, but capable of giving to the tempering chambers any warmth that may be required in preparing them for the sittings of the House. In some places a local heat from steam counteracts the action of cold windows in the corridors, but the measures for this purpose are not yet completed. The fires introduced in the division corridors and cabinet rooms are intended for the special use of those who desire them.

4. *Mode of Cooling.*—*a.* By the introduction into the vaults of air from the greatest possible altitude. *b.* By the action of cold water within the apparatus used in winter for heating air. *c.* By the direct action of water when the air is dry and requires moisture, though the direct action of water is at other times considered very objectionable, frequently saturating the air with moisture, and diminishing exhalation from the body when it is most grateful.

5. *Moistening the Air.*—*a.* By the evaporation of water previously purified when necessary. *b.* By the action of steam, used alone when unobjectionable in quality, or made to assist the evaporation of water.

6. *Drying the Air.*—Generally by the action of heat, which may produce this effect practically for ordinary use without the actual removal of moisture. A space is provided for the occasional use of absorbents of moisture, such as have been used under special conditions of the atmosphere with great relief.

7. *Moving Power.*—The air can receive any adequate impulse from a steam-engine below (at present replaced by manual labour), and from a smaller engine above. Power is also obtained both from the ceiling and the floor, by the action of the shaft; *see* No. 9. These, however, are brought into use so as to assist, under those restrictions which the structure imposes on the natural movements of tempered air around the person, the right development and action of which is considered the most important object which they can facilitate or sustain, according to the ever-varying circumstances of the case, in a building surrounded entirely with corridors or passages at two different levels, exclusive of those connected with higher levels.

8. *The Distribution of the Supply of Air* is as universal as could be given, though far below the amount used by me in rooms where the decorations afforded no obstacle to the introduction of universal diffusion at the walls, floor, and ceiling. The surface of the floor may, with the exception of certain fixed places, be considered completely porous, though from the state of the paint it has hitherto been only partially brought into use. In the ceiling there is an aperture on each side of the panels, the whole opening amounting to nearly 270 feet in area. In the lower corridors the whole floor is porous. The supply is by perpendicular surfaces, the discharge by panels in the ceiling. In the upper corridors it was found impracticable, except at a cost and delay which were considered objectionable, to obtain any supply except that accorded at the upper portion of the inner walls. The discharge is by panels in the ceiling. In the House lobby there are supplies at the angles on the floor, and at a high level, to be used under different circumstances. The discharge is effected by panels in the ceiling.

9. *The Discharge* is under the special control of a ventilating shaft, which can by the action of valves be brought to bear in any required proportion on the House and division corridors and lobbies, so that air shall leak from the House into the corridors, or from the corridors into the House, as may be desired.

10. *Action of the Ventilation.*—This can only be understood satisfactorily by a reference to diagrams. It will therefore be sufficient here to state that a general ascent from the level of respired air, with a supply from below, alone, or combined with a certain amount of descent from a portion of the ceiling, constitutes the general movement by which the ventilation is effected. Hitherto, from the leakage of gas, the want of proper doors, or excessive heat upon the forehead produced by the lamps, the House has never once known what the ventilation is when not injured by these causes. From certain portions of the floor a perpetual descent is maintained."

Method employed for warming and ventilating the House of Lords and other portions of the New Palace at Westminster, amounting to about four-fifths of the entire Building, under the control of the Architect, Sir Charles Barry, R.A.

"Steam and hot water constitute the heating power employed, and the motive power for the supply and discharge of air, independent of gravity caused by differences of temperature, consists of a powerful fan worked by a steam-engine, local rarefactions, and steam-jets; the steam-boilers and engine employed are placed in a court to the south of and contiguous to St. Stephen's Crypt.

The supply of atmospheric air is taken solely from the turrets of the Victoria Tower, at the base of which the air is purified by a spray of water from a steam-jet; it passes through screens [this process frees the air from any mechanical impurities that it may acquire from the atmosphere, as well as adds to its hygrometric quality], and then passes through a main channel in the basement of the building, aided, where necessary, by the tractive power of the fan, which forces it into a chamber under the Central Hall; it is there tempered to any degree of temperature which may be considered desirable, according to the season of the year and the state of the external air. From this central chamber the air passes, or is forced, as may be necessary, by other main air-channels of distribution, to the several portions of the building, namely, southwards, to the House of Peers, Royal Gallery, &c.; eastwards, to the Libraries, Committee-rooms and Refreshment-rooms, &c., belonging to each House; in the River-front westwards, to St. Stephen's Hall, St. Stephen's Porch, the Cloisters, and Westminster Hall, &c.; and vertically, to the Central Hall. By means of valves in these main flues of distribution, the whole supply may be thrown at pleasure upon any one portion of the building, as the exigency of circumstances may require. Each of the abovenamed portions of the building, and the several chambers within each portion, have respectively a separate warming apparatus in the basement for special use, a coil heated by steam, when a high temperature is required; and each of the windows of the principal rooms towards the river has a similar warming apparatus beneath it within the room, to counteract the cooling effect of the glass in severe weather. Its effect is to do away with the cooling power of a very large proportion of glass, when considered in comparison with the cubic contents of the room; it is employed for the purpose of counteracting those effects before the rooms are occupied, and is either kept in action or not, as according to circumstances. Great advantage would result from the double glazing of the windows in the east front. The House of Peers, the Prince's Chamber, Royal Gallery, House Lobby, and the Libraries, Committee-rooms and Refreshment-rooms, &c., of each House, are supplied with air in a tempered state, by means of vertical flues in the walls connected with the main air-channels of distribution in the basement, which air enters through a portion of the ceiling of each room, as well as partially through the skirtings and wall framing, and is delivered in such abundance as to create a plenum within the room, by which all ingress of air, and consequent draughts by the opening of doors, may be avoided. The supply to every chamber is separately controlled by valves; the vitiated air from each chamber is discharged through a portion of the ceiling separated from that which is used for supply; and in respect of the House of Peers, partially through the floor, into the main foul-air flues in the roofs of the building, from whence it is conveyed into exit shafts in the Royal Court and Speaker's Court, the Central Tower, or tower used for the smoke flue of the boilers west of the Central Tower, a tower west of the Public Lobby of the House of Peers, and a tower at the north end of the House of Commons, wherein rarefying apparatus and steam-jets are employed, to insure a constant current of sufficient force and velocity for the purpose required. The smoke from the whole of the fires is also carried into main smoke-flues in the roofs of the building, which terminate in the same exit-shafts. The total area of supply is, or will be, about 100 superficial feet, and that of discharge about 230 superficial feet. The cubic space warmed and ventilated amounts to about 3,644,000 feet."

EXPANSION OF ISOLATED STEAM, AND THE TOTAL HEAT OF STEAM.

By Charles W. Siemens.

[*Paper read at the Institution of Mechanical Engineers.*]

The object of this paper is to lay before the members the results of certain experiments on steam, purporting, in the first place, to corroborate Regnault's disapproval of Watt's law, "that the sum of latent and sensible heat in steam of various pressures is the same;" in the second place to prove the rate of expansion by heat of isolated steam; and, in the third place, to illustrate the immediate practical results of those experiments in working steam-engines expansively.

The author pursued these experiments at long intervals since the year 1847, with no other object in view than to extend his own information; and, consequently, without pretence to generalisation or extreme accuracy. The question, however, is one of great practical importance to engineers, and with the advantage of valuable suggestions and the co-operation of his friends Mr. Edward A. Cowper and Mr. William P. Marshall, the author has again taken up the experiments, which, having been referred to at the previous meeting by Mr. Cowper, he feels himself called upon to lay before the Institution in their present state, though incomplete.

The amount of heat required to convert one pound of water into steam of different pressures has occupied the attention of natural philosophers from the earliest periods of the modern steam-engine.

Dr. Black observed, about a century ago, that a large quantity of heat was absorbed by water in its conversion into steam (not accompanied by an increase of temperature), which he termed "the latent heat of steam." His apparatus consisted simply of a metallic vessel containing water, which he exposed to a very regular fire; and from the comparative time which was occupied, first, in raising the temperature of the water to the boiling point, and, secondly, in effecting the evaporation, he approximately determined the *amount* of latent heat. Resuming the experiment, in conjunction with Dr. Irvine, he employed a different apparatus, consisting of a steam generator, and of a surface condenser, or a serpentine tube, surrounded by a large body of cold water. The steam which condensed in the serpentine tube was carefully collected and weighed, and the rise of temperature of the surrounding water was observed, which, multiplied by its known quantity, represented the total quantity of heat which the steam had yielded. The quantity of heat requisite to raise the temperature of one pound of water through 1° Fahr. being taken for the unit of heat, Black and Irvine obtained for the total quantity of heat in

Steam of atmospheric pressure, the number	954
Southern	1021
Watt obtained the number	1140
Regnault	1145
Dr. Ure..	1147
Desprer, 1136, but later..........................	1152
Brix	1152
Gay Lussac, and Clement	1170
Count Rumford	1206

All of these eminent experimentalists employed essentially the same apparatus, and the differences between their results proves its great liability to error. Brix, of Berlin, was the first to investigate those errors, and to calculate approximately their effect upon the results obtained.

While such a large amount of labour and talent has been expended to determine the latent heat in steam of atmospheric pressure, a far more important question seems to have been passed over with neglect—namely, What is the relative amount of heat in steam of various densities? The celebrated Watt justly perceived the importance of this question, but contented himself with one experiment upon which he based his law, *that the sum of latent and sensible heat in steam is the same under all pressures.*

Southern repeated the experiment, and found that steam of greater density contained absolutely more heat than steam of lower pressure, which induced him to adopt the hypothesis that *the latent heat of steam was the same at all pressures.*

Subsequent experiments and general reasoning seemed to be in favour of Watt's law, which enjoyed the general confidence until it was attacked, only a few years since, by Regnault, of Paris, who proved, by a series of exceedingly elaborate and carefully conducted experiments that neither the law of Watt nor that of Southern was correct, but that the truth lay between the two. The apparatus employed by M. Regnault may be said to be a refinement upon those previously employed, and with the advantage of Brix's labours to determine the amount of errors, he seems to have succeeded in measuring the absolute amount of heat in steam of various pressures with surprising accuracy. The costly and complicated nature of the apparatus employed by M. Regnault has hitherto prevented other experimentalists from repeating the experiment, and in the meantime practical engineers still continue to adhere to Watt's law.

Shortly after the publication of Regnault's experiments by the Cavendish Society in 1848, the idea occurred to the author of the present paper that their results might be brought to a positive test by a simple apparatus, which he placed before the meeting in operation, shown in fig. 1. It consists of an upright

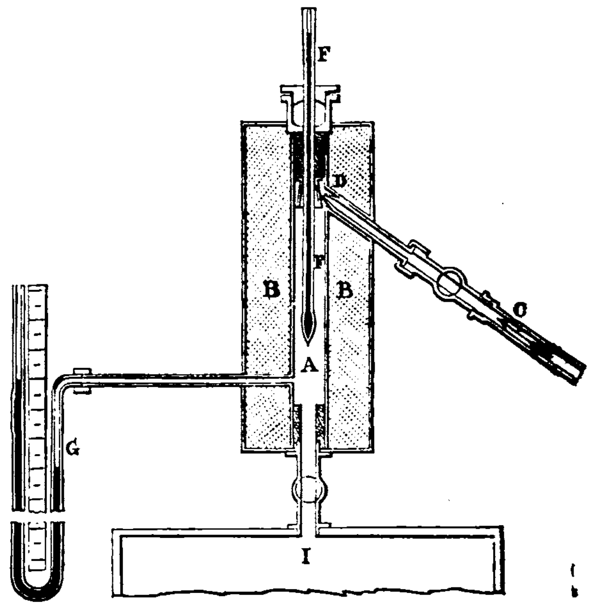


Fig. 1.—Apparatus for Measuring the Total Heat of Steam.

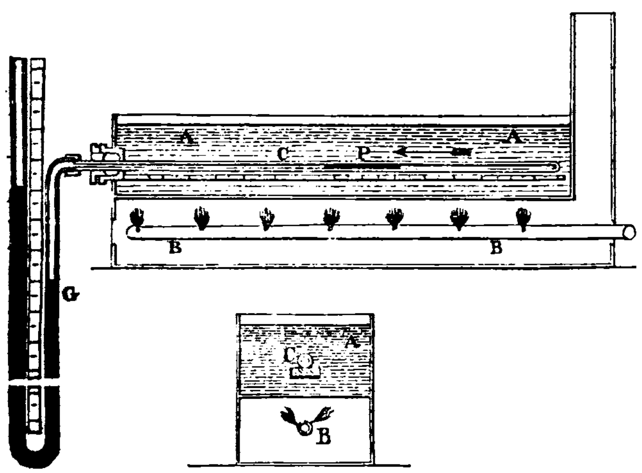
cylindrical vessel of tin-plate A, which is surrounded by an outer vessel filled with charcoal BB, or other non-conducting material. A steam-pipe C, with a contracted glass vein D, enters the inner vessel in a slanting position, in order that the water of priming from the boiler, and of condensation within the pipe, may return to the former, allowing only a small jet of pure steam to enter the vessel, where it suddenly expands and communicates its temperature to the bulb of a thermometer E, which is inserted through a stuffing-box from above. The lower extremity of the inner vessel A is connected on the one hand to a mercury gauge G, and on the other to a condenser, by means of a stop-cock to regulate the pressure. The pressure and temperature of the steam within the boiler being known, and the temperature of the expanded steam observed, it will be seen whether that temperature coincides with the temperature which is due to pressure indicated by the mercury gauge. If it did, then Watt's law would be confirmed, but since the temperature rises higher than is due to the pressure, it follows that the high-pressure steam contains an excess of heat, which serves to *super-heat* the expanded steam. All losses of heat from the apparatus would tend to reduce the temperature, and be in favour of Watt's law; but it will be shown that those losses may be entirely eliminated, and a true quantitative result be obtained. For this purpose the pressure in the boiler should first be raised to its highest point, and the indicating apparatus be well penetrated by the heat; the fire under the boiler should thereupon be reduced, and observations made simultaneously, and at regular intervals, of the declining pressure within the boiler, and temperature of the expanded steam of constant pressure. The pressures being nearly equal, the fire under the boiler is again increased, and the observations continued until the maximum pressure is once more obtained; and the loss of heat by radiation, &c., may be correctly estimated by a comparison of the two series of observations.

The second portion of this paper relates to the rate of expansion of isolated steam by heat—that is, steam isolated from the water from which it is generated. The author has not been able to meet with any direct experiments on this subject, except some at a recent period by Mr. Frost, of America, which, however, do not seem entitled to much confidence. The rate of expansion of air and other permanent gases by heat was first determined by Dalton and Gay Lussac simultaneously, who determined that all gases expanded uniformly, and at the same absolute rate, amounting to an increase of bulk equal to $\frac{1}{480}$th part of the total bulk at 32° Fahr. for every one degree Fahr., or $\frac{1}{660}$th part of the total bulk at 212°. Dulong and Petit confirmed the law of Dalton and Gay Lussac, but it appears that these philosophers confined their labours to the permanent gases and atmospheric pressure, and merely supposed the general applicability of their discovery.

Being interested in the application of "super-heated" steam, the author tried some direct experiments on its rate of expansion, in the year 1847, which confirmed his view, that vapours expand more rapidly than permanent gases, or, in other words, *that the rate of expansion of different gases and vapours is equal, not at the same absolute temperature, but at points equally removed from their point of generation.*

The apparatus employed in these experiments is shown in the annexed engraving, fig. 2, and its simplicity, when seen in operation, is such that the result can hardly be doubted. It

FIG. 2.—Apparatus for Measuring the Expansion of Isolated Steam.



Transverse Section.

consists of a metallic trough AA, containing oil, which is placed upon a furnace BB, heated by gas flames. One end of the trough is provided with a stuffing-box, through which a glass tube C, about $\frac{1}{16}$-inch diameter, and sealed at one end, may be slipped, which will rest horizontally upon a scale below the surface of the oil. The mouth of the glass tube is connected to an open mercury syphon G, with either the one or the other leg filled with mercury, to produce the desired pressure within the horizontal glass tube. A small drop of water and a piston of mercury P, being introduced into the bottom of the tube, it is placed in the oil bath, and connected to the syphon. The oil bath is then gradually heated, and the temperature observed. As soon as the boiling point of water under the pressure in question is reached, the mercury piston will move rapidly forward until all the water is converted into steam. The temperature continuing to increase, the piston will continue its course more slowly upon the scale, where its progress is noted from time to time, together with the temperature. The experiment is continued until the temperature reaches about 400°, when the oil begins to boil. The gas-flame is then withdrawn, and the bath allowed to cool gradually. The observations of the temperature and the position of the mercury piston are continued until the steam contained behind it is re-condensed. A comparison between the two series of observations gives the correct mean of the experiment, by which the effects of the friction of the mercury piston, any possible slight leakage of steam past it, and faults consequent on the slow transmission of heat, are completely neutralised.

The general result obtained from the above experiments may be stated as follows: that steam generated at 212°, and maintained at a constant pressure of one atmosphere, when heated out of contact with water to

230°	is expanded	5	times more than air would be.	
240°	ditto	4	ditto	ditto
260°	ditto	3	ditto	ditto
370°	ditto	2	ditto	ditto

An extension of our knowledge on the properties of steam is a matter of such evident importance to engineers, that it would be useless to dwell upon its practical importance. Suffice it to say, that it has been theoretically demonstrated that a perfect Boulton and Watt condensing engine (abstracting friction and all losses of heat in the furnace and through radiation) would only yield about seven per cent. of the mechanical force, which would be equivalent to the expanded heat. It may be argued from this that the steam-engine is destined to undergo another great modification in principle, and, in the author's humble opinion, this crisis will be accelerated by inquiries into those properties of gaseous fluids which have hitherto excited but little attention, and especially into the properties of dry steam or isolated steam.

Table of Experiments on the Expansion of Isolated Atmospheric Steam.

Temperature in Degrees Fahrenheit.	1 Ascending	2 Descending	3 Descending	4 Ascending	5 Descending	6 Ascending	7 Descending	8 Ascending	9 Descending
209	05·0	..	..	..	..	..	..	..	..
210	5·00	..	..	..	..	..	..	..	..
212	8·00	8·00	..	10·00	9·70	..	8 00	..	9·04
213	..	..	10·00	..	..	..	..	..	..
214	..	8·40	10·40	..	10·05	..	9·50	..	..
215	8·80	8·68	10·52	10·12	10·16	..	9·90	..	9·30
217½	9·00	8·90	10·66	10·20	10·32	..	..	9·30	9·45
220	9·10	9·11	10·84	10·30	10·50	..	10·50	9·50	9·57
222½	9·22	..	10·94	10·48	10·61	..	..	9·60	9·65
225	9·32	9·34	11·01	10·53	10·70	..	10·70	9·68	9·74
227½	..	..	11·11	10·60	..	..	..	9·75	..
230	9·54	9·58	11·21	10·68	10·86	..	11·00	9·81	9·91
232½	..	..	11·29	..	..	..	..	..	..
235	9·68	9·70	11·34	10·84	11·00	..	11·16	9·95	10·02
240	9·80	9·85	11·46	10·94	11·12	..	11·34	10·06	10·13
245	9·94	9·96	11·58	11·04	11·28	..	11·49	10·19	10·23
250	10·10	10·05	11·70	11·18	11·35	..	11·60	10·29	10·33
255	10·21	10·15	11·80	11·36	11·47	..	11·71	10·40	10·44
260	10·31	10·25	11·90	11·40	11·59	..	11·83	10·50	10·54
261	..	..	..	..	..	11·90	..	..	..
265	10·41	10·25	12·00	11·51	11·70	..	11·94	10·60	10·64
268	..	..	..	..	..	12·10	..	..	..
270	10·51	10·44	..	11·61	11·80	12·18	12·08	10·70	10·75
275	10·60	10·53	..	11·73	11·91	..	12·16	10·80	10·85
278	..	..	..	..	..	12·30	..	..	..
280	10·70	10·62	..	11·85	12·02	12·35	12·28	10·90	10·96
284	..	..	..	..	..	12·45	..	..	..
285	10·80	10·72	..	11·98	12·14	..	12·40	11·00	11·06
290	10·90	10·81	..	12·10	12·26	12·55	12·50	11·10	11·17
294	..	..	..	..	..	12·64	..	..	..
295	10·98	10·91	..	12·20	12·39	..	12·60	11·20	11·27
298	..	..	..	..	..	12·75	..	..	..
300	11·08	11·01	..	12·30	12·50	12·79	12·70	11·30	11·38
305	11·18	11·11	..	12·40	12·58	12·88	12·80	11·40	11·48
310	11·26	11·21	..	12·51	12·69	13·00	12·95	11·50	11·58
315	11·36	11·31	..	12·62	12·80	13·10	13·08	11·60	11·69
320	11·46	11·42	..	12·73	12·90	..	..	11·71	11·79
325	11·56	11·52	..	12·85	13·02	..	..	11·81	11·89
330	11·63	11·64	..	12·98	13·15	..	..	11·91	11·99
335	11·73	11·75	..	13·10	13·25	..	..	12·02	12·08
340	11·83	11·85	..	13·21	13·36	..	..	..	..
345	11·93	11·95	..	13·33	13·41	..	..	..	..
350	12·02	12·05	..	13·48	13·50	..	..	..	..
355	12·11	12·15	..	..	..	..	..	..	..
360	12·20	12·26	..	..	..	..	..	..	..
365	12·30	12·40	..	..	..	..	..	..	..
370	12·40	12·50	..	..	..	..	..	..	..
375	12·50	12·55	..	..	..	..	..	..	..
380	12·60	12·60	..	..	..	..	..	..	..

The present paper will be confined to showing the effect of the above experiments upon the rate of expansion of steam within the steam-cylinder of an engine. It was demonstrated by the first-named experiments that *expanded steam is super-heated steam;* and, by the second, it is shown what is the expansion of bulk due to an increase of temperature. Supposing the results of the experiments to be correct, the expansion curve as laid down by Pambour, and which is based upon Watt's law, requires a modification due to the excess of temperature in expanded steam; and it will be observed that this correction in the curve of expansion is in favour of working engines expansively, as a greater average pressure is obtained during expansion than would be the case if the expanded steam were not thus super-heated. Its correctness is corroborated by some actual observations by Mr. Edward A. Cowper in taking diagrams of expansive engines previous to his acquaintance with the above experiments. It moreover appears, that in Cornwall, engineers have been practically acquainted with the fact that expanded steam is super-heated steam, and more economic in its use than saturated steam; for it is a practice with them to generate the steam at very high pressure, and to expand it down to the required pressure previous to its reaching the steam cylinder.

Another remarkable practical observation is, that a jet of high-pressure steam does not scald the naked hand, while a jet of low-pressure steam does, although the high-pressure steam is the hotter substance. The cooling effect of a jet of high-pressure steam is so powerful, that, as the author has been informed, ice has been actually produced in the heat of summer in America by blowing a powerful jet of steam of 400 lb. pressure per square inch against a damp cloth. This phenomenon may be explained by the perfectly dry and under-saturated state of expanded steam, which, with a strong tendency to re-saturate itself, produces a powerful evaporation on moist surfaces with which it comes in contact. The rapid rate of expansion of steam by heat, when still near its boiling point, proves the economy of heating the steam-cylinder either by a steam-jacket or by the application of fire. It is, however, important to observe that the specific heat of steam seems to diminish the more the temperature exceeds the boiling point.

ON THE EXPANSIVE WORKING OF STEAM IN LOCOMOTIVES.

By Daniel Kinnear Clark, C.E.

[Abstract of a Paper read at the Institution of Mechanical Engineers.]

(*With Engravings, Plate* XXXII.)

In locomotives, the adoption of a low standard of boiler-pressure is the first obstacle in the way of carrying out the expansive working of steam, as the more expansively the steam is worked, the less is the work done by the engine. The second obstacle is, in many locomotives, the exposure of the cylinders, by which the steam within is partially condensed. Moreover, the proportion of steam so condensed increases with the degree of expansion, in a very formidable ratio, which will be afterwards submitted to examination.

The object of this paper is to show at what rate in practice the efficiency of steam is increased by expansive working in locomotives with the best existing arrangements of cylinders, valves, and valve-gear, and to point out the conditions on which expansive action may be most successfully carried out.

I.—*Of the Action and Capabilities of the Link-Motion.*—The action of the valves in the "distribution" of the steam (a term borrowed from the French) is regulated by three elements, the lap, the lead, and the travel. When these are given, the point of the stroke of the piston at which the steam is admitted to the cylinder, cut-off, exhausted, and compressed or shut up, are all deducable by model, by diagram, or by calculation. This can be done, whether the valve derives its motion from a single eccentric, or from a link-motion, as the motion of the valve is virtually the same in both cases. The way in which the valve is caused to cut-off or suppress the steam earlier by the link-motion, is by *shortening the travel of the valve;* this is accomplished by means of the reversing gear, in such a manner that whatever be the reduction of travel communicated to the valve, the lead is always at least the same as in full gear, and with the shifting-link is rather increased.

In working out the four changes in the distribution of the steam, already enumerated, which regulate the movements of the steam, the action of the link-motion is such that, 1st, the sooner the steam is cut-off, the sooner it is exhausted, the sooner the port is closed for exhaustion, and the sooner the port is opened for the admission of steam.

2nd. That though every change is made earlier—as measured in parts of the stroke—there is less difference in the position of the points of exhaust, compression, and admission, than in that of the cutting-off. Consequently, the shorter the admission, the longer is the expansion, as the exhaust-point does not recede so much as the point of cutting-off.

3rd. That by the shifting link-motion, the steam may be cut-off at from ⅛th to ⅞th of the stroke.

4th. That though the exhaust takes place earlier for every increase of expansion, it does not in any case take place within the first half of the stroke. For mid-gear it occurs in fact at 54 per cent. of the stroke; and the steam is expanded into 3½ times the length of stroke at which it is cut-off.

5th. That the period of compression, increasing as the admission is reduced, amounts to about one-half stroke in mid-gear.

6th. That the pre-admission of the steam, not above 1 per cent. of the stroke in full gear, reaches about 10 per cent. in mid-gear.

These results prove that the link-motion is capable of cutting off steam as early in the course of the stroke as can ever be advisable in practice.

It has been seen that the earlier the steam is cut-off, the *earlier also it is exhausted;* until in mid-gear it may be released at half-stroke. This has been deemed a serious objection to the use of link-motions for high expansion, as it is supposed to lead to a serious loss of expansive action, by exhausting prematurely. This loss is, however, a mere trifle in practice. The escape of the steam is by no means instantaneous, as is easily proved by the diagrams in fig. 1 (Plate XXXII.), taken by the writer from the "Caledonia" passenger-engine, by means of M'Naught's Indicator, at speeds of 1 and 2 miles per hour. The numbers in the diagrams indicate the number of the sector-notches to which the reversing lever was placed, while the diagrams were described. Referring to No. 1, taken under full gear, the steam is shown to be admitted to the cylinder a little before the beginning of the stroke, at A. From B to C the steam is admitted, at C shut off, expanded to D, and thence exhausted to E the end of the stroke, whence it continues to be exhausted till the point F in the return stroke, where the exhaust-port is closed. Now, the exhaust line D E shows that nearly all the period of exhaust for the steam stroke is employed for the complete evacuation of the steam. And if this be the case for speeds of 1 and 2 miles an hour, it is much more so for the regular working speeds of trains. To select from a very admirable series of Indicator diagrams, with copies of which the writer has been favoured by Mr. Daniel Gooch, by whom they were taken from the cylinder of the "Great Britain" locomotive, on the Great Western Railway, the figs. 4 and 5 contain diagrams taken at 17 and 55 miles per hour respectively, under the 1st, 3rd, and 5th notches of the sector. The following are the conditions of the valve-motion of this engine, when the diagrams were taken.

State of the Valves of the "Great Britain" Locomotive, G.W.R.

Cylinder, 18 x 24 inches; Wheel, 8 feet; Lap, 1¼ inch; Constant Lead, ⅜-inch; Travel in full gear, 4¾ inches; Blast orifice, 5⅛ inches diameter.

No. of Notch.	Position of Points of Distribution.			Period of Exhaust during Steam-Stroke.
	Cutting-off	Exhaust.	Compression.	
	inches.	inches.	inches.	inches.
1	16	21⅜	3	2⅝
3	11¾	19¾	5	4¼
5	7	17⅝	7⅛	6⅜

On the diagrams the points of cutting-off and exhaust are marked, and the steam-line falls only very gradually during the period of exhaust, especially at the high speeds. The expansion curves are shown by dotted lines A, B, C, figs. 4 and 5, continued to the end of the stroke. These are easily calculated in terms of the relative volumes of steam, from the pressures indicated at the points of exhaust, and are such as would have been described had the exhaust been delayed till the end of the stroke. The shaded areas A, B, C, inclosed between these dotted curves and the curves actually described, express the *power lost* by exhausting the steam *before the stroke is completed.* Averaging them for the whole stroke, they are as follows:—

	Low Speeds.		High Speeds.
1st Notch,	⅞ lb. per in. loss	....	1 lb. per in. loss
3rd „	2¼ lb. „	....	1 lb. „
5th „	3⅛ lb. „	....	⅜ lb. „

The losses at high speeds are very small,—merely nominal; and curiously enough, the loss by the *earlier* exhaust of the 5th notch is actually less than that under the 1st notch. The losses are of course greater at the low speeds; but even then, in the 1st notch, which is the only notch employed at very low speeds, the loss does not amount to 1 lb. per inch. The

CLARKE ON EXPANSION OF STEAM.

Indicator Diagrams from Locomotive Engines.

Fig. 1. *Slow Speed.* *Caledonian Engine, No. 13.*

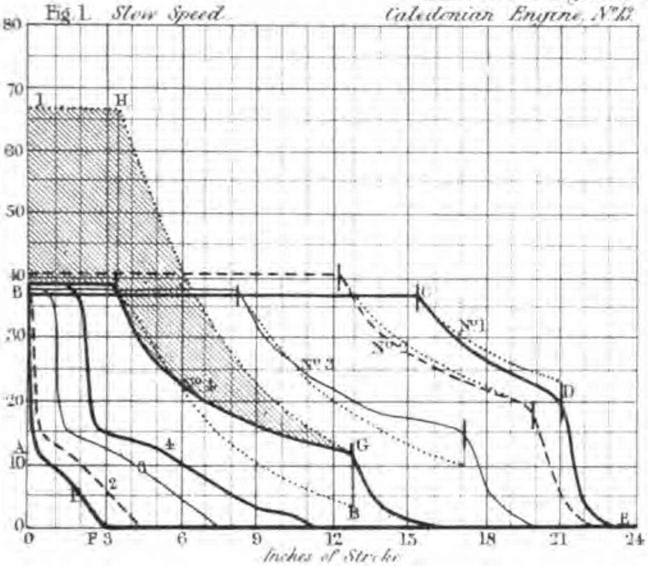
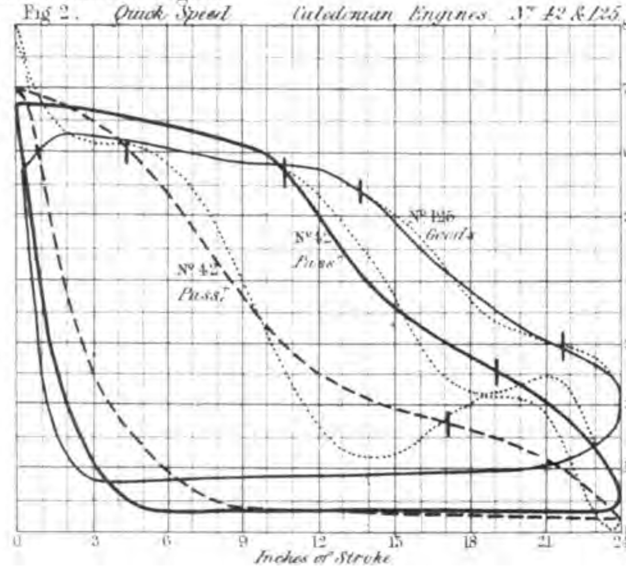
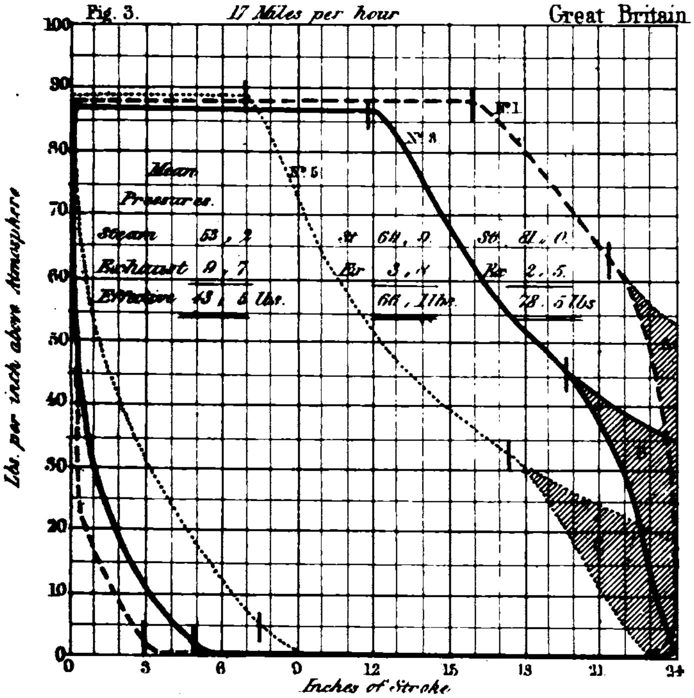


Fig. 2. *Quick Speed.* *Caledonian Engines. No. 42 & 125.*



Great Britain Locomotive

Fig. 3. *17 Miles per hour*



55 Miles per hour Fig. 4.

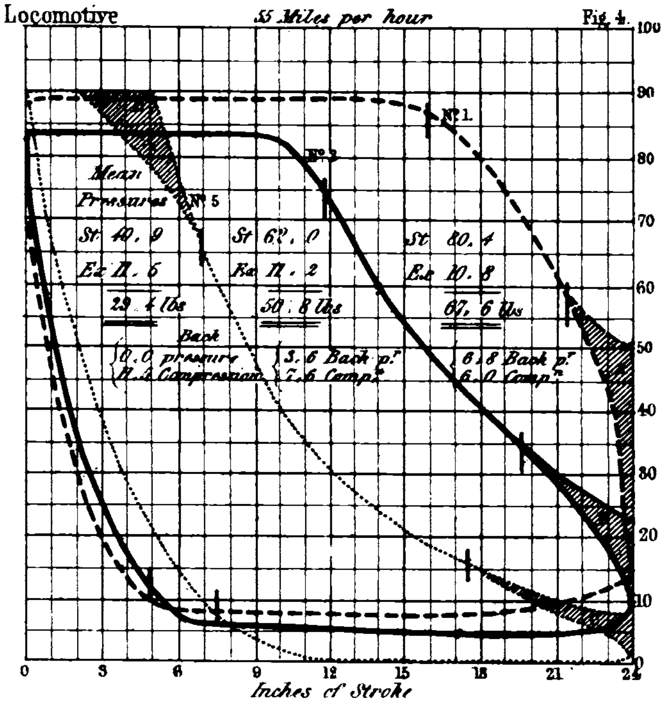
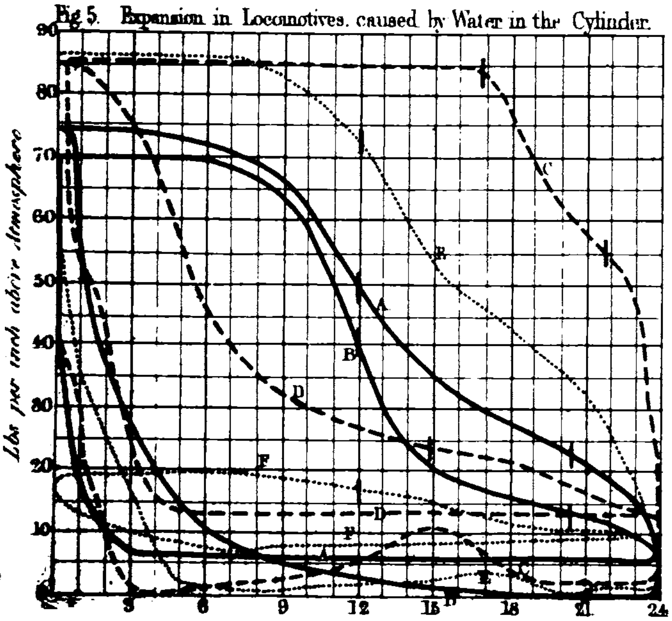


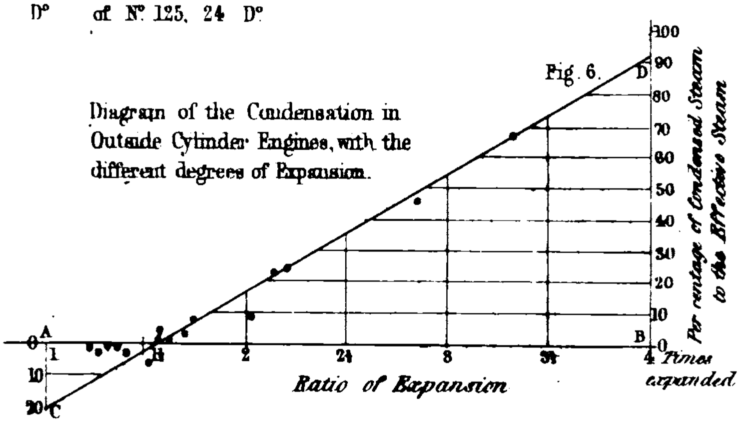
Fig. 5. Expansion in Locomotives, caused by Water in the Cylinder.



A & B *Orion Passr. Engine, 39 Miles per hour*
C & D *No. 127 Goods Engine 18 , ,*
E & F *Do. Do. 15 , ,*

Stroke of No. 13, 20 Inches.
Do. of No. 42, 20 Do.
Do. of No. 125, 24 Do.

Fig. 6.



and 5th notches are employed only at speeds much above 17 miles per hour, and the loss by them is of no practical moment.

Upon the whole, it follows that the possible *loss by the early exhaust* yielded by the link-motion is of *no importance.* On the contrary, it can be proved to be *beneficial*, as an early exhaust is at high speeds essential to a perfect exhaust during the return-stroke. It plainly appears, therefore, that with the existing arrangements of locomotives, any attempts to eke out the power on the steam-line, by prolonging the expansion materially beyond what is accomplished by an ordinary valve and link-motion, are not only useless, but highly prejudicial.

Another objection to the link-motion is, that the steam is injuriously *wire-drawn* by it when under great expansion. Hence the numerous attempts to supersede the link by the employment of a separate expansion-valve. The diagrams, fig. 5, may be referred to as examples of wire-drawing by the link. They were taken nearly consecutively with one opening of the regulator; and it is clear that the steam attained fully as high a pressure in the cylinder under the 5th notch as under the 1st. The pressure falls considerably towards the point of cutting off, but from the form of the steam-line, it is plain that very little additional steam is admitted for an inch or two before the cutting-off actually takes place. The most of the steam is admitted at the higher pressure, and in fact a partial expansion of the steam already admitted takes place for some distance before the expansion nominally begins. Thus the *wire-drawing* is, to a great extent, equivalent to an *earlier cutting-off*, and a greater degree of expansion. The whole possible loss by wire-drawing is comprised within the dotted line D, added to the diagram, which is merely an extension of the expansion curve to meet the steam line, drawn horizontally to represent a free admission up to an imaginary point D of cutting-off, 5 inches from the beginning of the stroke. This shaded area D amounts exactly to a mean loss upon the whole stroke of *one pound per square inch*, by *wire-drawing*, under high expansion. For the 1st and 3rd notches, the amount of loss by wire-drawing must obviously be still less; and, in short, the objection of *wire-drawing by the link-motion*, when of liberal proportions, is of *no practical weight.*

Another objection to the link-motion, and apparently the most formidable one, is the large fraction of power neutralised by the *compression* of the exhaust steam, and which increases with the degree of expansion. Compression, however, involves no loss of efficiency; for as by compression a quantity of steam is incidentally reserved and raised to a higher pressure, it gives out the power so expended in compressing it, during the next steam-stroke, just as a compressed spring would do in the recoil. But, apart from this general argument, the actual efficiency of the steam in the cylinder, with and without compression, may be exactly estimated. The most direct method of doing so is, to find the quantities of water consumed as steam for one stroke, under the two conditions, and to compare them with the relative effective mean pressures. It will suffice to analyse, as an example, the high-speed diagram, fig. 5, under the 5th notch, No. 5. The volume of steam admitted is measured by the product of the area of the piston, (254·47 in.), and the period of admission, *plus* the total clearance in the cylinder and steam-passage; the clearance being measured for simplicity in inches of stroke, we have $7 + 1·8 = 8·8$ inches, for the total volume admitted. The pressure of the steam when cut-off is 65 lb., for which the relative volume of water is 359. Therefore the volume of water as steam, or the water-equivalent of the steam admitted, is

$$\frac{254·47 \times 8·8}{359} = 6·24 \text{ cubic inches.}$$

From this is to be deducted the quantity of steam reserved by compression; the volume so reserved is measured by the period of compression, *plus* the clearance ($7·5 + 1·8 = 9·3$), and the pressure at the point of compression is 8 lb., for which the relative volume is 1125. Then the water equivalent of the reserved steam is—

$$\frac{254·47 \times 9·3}{1125} = 2·10 \text{ cubic inches;}$$

subtracting, there remains $6·24 - 2·10 = 4·14$ cubic inches of water as steam, actually expended for one stroke of the piston.

Were there to be no reservation of exhaust steam by foreclosing the exhaust-port, the whole area of resistance by compression would be removed, and there would be a reserve of steam of atmospheric pressure equal in volume to the clearance only. The relative volume of atmospheric steam is 1669, and the water-equivalent of the reserve would be—

$$\frac{254·47 \times 1·8}{1669} = 0·27 \text{ cubic inches;}$$

the expenditure per stroke would be $6·24 - 0·27 = 5·97$ inches of water.

Now, the positive mean pressure during the steam-stroke, as indicated, is	40·9 lb. per inch,
And the mean resistance by compression is	11·5 lb. ,,
Thus the effective mean pressure is	29·4 lb. ,,

This effective mean pressure of 29·4 lb. is maintained by a consumption of 4·14 inches of water per stroke; and it has just been found that with the compression removed, the positive mean pressure of 40·9 lb. per inch would be maintained by a consumption of 5·97 inches of water per stroke. The effective pressure created per cubic inch of water is, therefore,

$$\text{In actual practice ....} \frac{29·4}{4·14} = 7·1 \text{ lb.}$$

$$\text{And would be by removing compression } \frac{40·9}{5·97} \doteq 6·9 \text{ lb.}$$

These quantities are expressions of the relative efficiency of steam employed with and without compression; they are virtually identical, and show that the resistance by compression in the cylinder, due to the action of the link-motion, does not in the slightest degree impair the efficiency of the steam.

The last objection to the use of the link, requiring notice, is that at *high speeds* considerable *back exhaust-pressure* is created. The amount of this is very various, and it depends also on circumstances for which the link-motion is not responsible; such as a deficiency of inside lead (which is regulated by the lap), small ports, a small blast-orifice, and imperfect protection of the cylinder. It suffices on the present occasion to point to what can be done by superior arrangements, as exemplified in the diagrams, fig. 5, taken from the "Great Britain." The cylinders of this engine are in a manner suspended in the smoke-box, and thoroughly protected; the steam-ways are very large, 13×2 inches, being in area about $\frac{1}{10}$th of the cylinder; the exhaust-passage is very direct; and the blast-orifice is $5\frac{1}{4}$ inches diameter, or about $\frac{1}{17}$th of the area of cylinder. As a whole, these proportions are superior to those of any other engines with which the writer is acquainted; and the diagrams prove that the per centages of back exhaust-pressure, in terms of the positive mean pressure, at 55 miles per hour, are—

For the 1st notch	$8\frac{3}{8}$ per cent.
For the 3rd notch	$5\frac{3}{4}$ per cent.
For the 5th notch	nothing.

Better results than these should not in practice be required, for when locomotives are adapted to their work, and running at high speeds, they ought not to require an admission of steam above half-stroke. However, the area of blast-orifice rules the back exhaust-pressure; and, when the cylinder is duly proportioned to the boiler, it is quite practicable, by a few modifications in detail, still further to increase the orifice, sufficiently to banish all traces of back-pressure of exhaust at all practicable speeds.

II.—*Of the Rate of Efficiency of Steam worked Expansively in the Locomotive, by the Link-Motion.*—To determine this ratio experimentally, under the actual circumstances of clearance, wire-drawing, and back-pressure, the writer has analysed twenty-six of the indicator-diagrams from the "Great Britain" already referred to, taken at speeds of 15 to 56 miles per hour, of which the figures are examples. The following table contains in the first nine columns an analysis of these diagrams; the effective horse-powers, col. 10, are estimated in terms of the diameter and stroke of cylinder the diameter of wheel, and the effective mean-pressures in the 9th column. The water-equivalents, columns 11, 12, and 13, are estimated from the indicated pressures and the period of the distribution for each notch, in the way already exemplified. The expenditure of steam per hour, column 14, is deduced from column 13, in terms of the speed, the cylinder, and the wheel; and, dividing that by the effective horse-power, we have the contents of column 15 in inches, and of column 16 in pounds. Column 17 contains the coke consumed per horse-power per hour, deduced for the

Results from Indicator-Diagrams, taken from the "Great Britain" Locomotive, G. W. R., in 1850.

No. of Diagram	Speed of Engine in Miles per Hour.	Indicated Steam-Pressures in Cylinder, in lbs. per Square Inch							Effective Horse Power Indicated	Water Equivalents.						Coke consumed per Effective H. P. per hour, allowing 1 lb. for 8lb. of Water.
				Back Pressures.												
						Sum of Back Pressures.										
		Maximum Pressure during Admission	Positive Mean Pressure.	Exhaust	Compression.	Pressure.	Per Cent. of positive Steam Pressure.	Effective Mean Pressure.		Total Admitted for One Stroke, measur'd from Diagram.	Reserved by Compression	Actually expended during 1 steam Stroke.	Actually expended per Hour.	Actually expended per Effective Horse Power per Hour.		
	Miles.	lb.	lb.	lb.	lb.	lb.	Per Cent	lb.	H. P.	Cub. inch	Cub. inch	Cub. inch	Cub. feet	Cub. in	lb.	lb.
1	15	70	63·8	1·6	2·4	4·0	6·1	59 8	190	13·32	1·00	12·53	89·83	817	29·5	3·69
2	17	88	80·3	0·6	1·9	2·5	3·0	77·5	284	15·89	0·82	15·07	124·53	758	27·4	3·42
3	21	95	86·2	1·2	3·0	4·2	4·7	82·0	372	16·71	1·09	15·62	159·45	741	26·8	3·35
4	24	85	76·7	0·9	1·6	2·5	3·1	74·2	384	15·30	0·82	14·48	168·95	760	27·5	3·44
5	27	80	70·6	1·5	2·2	3·7	5·3	66·9	389	13·89	0·91	12·98	170·37	757	27·4	3·42
6	31	90	79·6	1·7	3·7	5·4	6·7	74·2	497	15·62	1·13	14·49	218·35	759	27·4	3·42
7	31	80	73·2	2·9	2·2	5·1	6·9	68·1	456	14·76	1·00	13·76	207·35	786	28·4	3·55
8	49	60	51·4	3·6	4·4	8·0	15·5	43·4	459	10·73	1·34	9·39	223·60	842	30·4	3·80
9	54	89	80·4	6·8	6·0	12·8	15·8	67·6	763	15·62	1·56	14·06	369·07	836	30·2	3·77
1st Notch—Means		82						68·2							28·3	3·54
10	17	88	69·9	0·0	3·8	3 8	5·4	66·1	242	12·19	1·10	11·09	91·65	654	23·7	2·96
11	18	70	55·3	0·8	4·5	5·3	9·4	50·0	194	10·33	1·35	8·98	78·57	700	25·3	3·16
12	21	92	72·3	0·0	4·2	4·2	5·7	68·1	309	12·50	1·16	11·34	115·78	647	23·4	2·92
13	26	72	57·1	0·0	4·9	4·9	8·5	52·2	293	10·55	1·41	9·14	115·52	681	24·6	3·07
14	31	79	60·3	1·2	6·0	7·2	11·9	53·1	356	10 87	1·48	9·39	141·50	687	24·8	3·10
15	32	86	64·4	0·8	4 9	5·7	8·4	58·7	407	11·33	1·29	10·04	156·20	663	24·0	3·00
16	40	76	55·7	0·4	4·7	5·1	9·1	50·6	437	9·78	1·35	8·43	163·87	648	23·4	2·92
17	51	70	49·1	2·0	6·2	8·2	16·6	40·9	450	8·65	1·54	7·11	176·30	677	24·5	3·06
18	55	84	62·0	3·6	7·6	11·2	18·0	50·8	603	10·54	1·66	8·88	237·42	680	24 6	3·07
3rd Notch—Means		80						54·5							24·3	3·03
19	17	89	53·2	0·0	9·6	9·6	18·0	43·5	159	7·90	1·85	6·05	50·00	543	19·6	2·45
20	18	70	42·1	0·5	6·6	7·1	16·7	35·0	136	6·59	1·76	4·83	42·26	537	19·4	2·42
21	21	93	56·5	0 0	6·3	6·3	11·1	50·2	228	8·20	1·42	6·78	69·21	525	18·9	2·36
22	28	74	41·8	0·4	6·2	6·6	15·7	35·2	213	6·87	1·68	5·19	70·64	537	20·7	2·59
23	31	83	46·5	0·0	7·4	7·4	15·5	39·1	262	7·29	1·59	5·70	85·89	566	20·5	2·56
24	36	80	39·0	0·0	8·5	8·5	21·1	30·5	237	6·08	1·85	4·23	74·02	540	19·5	2·44
25	50	77	34·7	0·5	8 0	8·5	24·4	26·2	263	5·52	1 76	3·76	91·39	600	21·7	2·71
26	56	90	40·9	0·0	11·5	11·5	28·1	29·4	353	6·24	2·10	4·14	113·20	554	20·1	2·51
5th Notch—Means		82						36·1							20·1	2·51
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**

several diagrams from the consumption of water, column 16, allowing 1lb. of coke to evaporate 8lb. of water.

Referring to the contents of the last two columns of this table, it is obvious that the consumption of water as steam, or of coke, for a given amount of work done, becomes less the more expansively the steam is worked; and the means of the several quantities for the notches separately are as follows:—

Consumption per Horse-power per Hour.

For the 1st notch, 28·3 lb. water, or 3·54 lb. coke.
„ 3rd „ 24·3 „ „ „ 3·03 „ „
„ 5th „ 20·1 „ „ „ 2·51 „ „

As the results under each notch vary very little, the means above stated may be adopted for all practical speeds without material error. From these mean quantities the following rule is derived:—

RULE I.—*To find the consumption of Water as Steam per Horse-power per hour, for a given period of admission.* Multiply the part of the stroke in inches during which the steam is admitted by 22, and divide by the length of stroke in inches; and add 14 to the quotient. The sum is the required consumption in pounds. Let L = length of stroke, S = the period of admission of steam, and W = the consumption of water in lbs. per horse-power per hour; then

$$W = 22\,\frac{S}{L} + 14 \quad . \quad . \quad . \quad . \quad . \quad . \quad (1.)$$

Allowing 8 lb. of water to be evaporated by 1 lb. of coke, we have the following rule for the consumption of coke:—

RULE II.—*To find the Consumption of Coke per Horse-power per Hour, for a given period of admission.* Multiply the period of admission in inches by 2·75, and divide by the length of stroke in inches, and add 1·75 to the quotient. The sum is the consumption in pounds per horse-power per hour. Making C the consumption of coke, we have

$$C = 2{\cdot}75\,\frac{S}{L} + 1{\cdot}75 \quad . \quad . \quad . \quad . \quad . \quad . \quad (2.)$$

These rules may be employed with safety for all periods of admission between 10 and 75 per cent. of the stroke, which are the utmost limits worth regarding in the locomotive engine. They are applicable also for maximum pressures during admission, ranging betwen 60 lb. and 120 lb., though based on results from steam of 80 lb. to 84 lb maximum pressure. For extreme pressures, the results by the rule are slightly too small in the case of lower pressures; and rather greater for the higher,—these divergences being due to the constant deduction of 15 lb. for atmospheric resistance from the total pressure. It is presumed that engineers will not return to the error of low-pressures in locomotives, and that high-pressures will be cultivated. For pressures above 80 lb., the rules are perfectly safe, as they err rather by excess on the safe side. The following table is worked out by Rule I., to show the efficiency of steam by expansion in the locomotive cylinder, under good conditions in actual practice. The 4th column contains the theoretical maximum relative efficiency of steam, expanding to the end of the stroke, according to the law of Boyle, with a perfect vacuum behind the piston, and without clearance, back-pressure, or compression; extracted from the ordinary tables on the subject. In col. 5 are given the relative amounts of work done by steam, under the admissions named in col. 1, being directly as the effective mean pressures in the cylinder, which are found by a rule to be afterwards given.

Efficiency of Steam by Expansion in the Cylinder of the Locomotive in Actual Practice.

For Maximum Pressures during admission of 60 lb. to 120 lb.

Periods of Admission or Points at which the Steam is Cut off in parts of Stroke.	Water as Steam consumed in Pounds per H. P. per Hour.	Relative Efficiency of Steam in Actual Practice.	Possible Maximum Efficiency.	Relative Work done by Steam of the same Maximum Pressure in the Cylinder.
Per Cent.	lb.			
10	16 2	2·22	3·30	15
12·5	16·7	2·15	3·08	20
15	17·3	2·08	2·90	24
17·5	17·8	2·02	2·73	28
20	18·4	1·96	2·60	32
25	19·5	1·85	2·39	40
30	20·6	1·75	2·20	46
35	21·7	1·66	2·05	52
40	22·8	1·58	1 92	57
45	23 9	1·50	1·80	62
50	25·0	1·44	1·69	67
55	26·1	1·38	1·60	72
60	27·2	1·32	1·51	77
65	28·3	1·27	1·43	81
70	29·4	1·23	1·35	85
75	30·5	1·18	1·28	89
100	36·0	1·00	1·00	100

The periods of admission of steam to the cylinder may be varied by link-motion from 75, the greatest useful period, to 10 per cent. of the stroke. By the table, the relative efficiency varies within these limits from 1·18 to 2·22, the variation being as 1 to 2 nearly. It follows that under the most favourable existing circumstances, *the utmost possible efficiency of steam worked expansively* in the locomotive by the link-motion, is *about twice* that of the steam when worked *under full gear;* that is, the *same quantity of steam does twice the quantity of work.*

By a consideration of the effective mean-pressures in the first table, it appears that the average rate at which it increases with the period of admission is expressed by the following rule:—

Rule III.—*To find the effective Mean-pressure in the Cylinder, in terms of the Maximum-pressure, for a given per centage of admission.* Multiply the square root of the per-centage of admission by 13·5, and subtract 28 from the product. The remainder is the effective mean-pressure in per cent. of the maximum pressure of steam admitted. By this rule the following table is composed.

Effective Mean Pressure in the Cylinder for various Admissions.

For Maximum Pressures of 60 lb. to 150 lb.

Periods of Admission in parts of the Stroke.	Effective Mean Pressures in parts of Maximum Pressure.	Periods of Admission in common fractions of Stroke.	Effective Mean Pressure in common fractions of the Maximum Pressure.
Per Cent.	Per Cent.		
10	15	1-10th	1-7th full
12·5	20	....	....
15	24	1-8th	1-5th
17·5	28	....	....
20	32	1-6th	1-4th
25	40	1-5th	1-3rd
30	46	1-4th	1-2 5th
35	52	1-3rd	1-2nd
40	57	....	....
45	62	....	....
50	67	1-2nd	2-3rds
55	72	....	....
60	77	....	....
65	81	2-3rds	4-5ths
70	85	....	....
75	89	3-4ths	9-10ths

In all well-protected cylinders, with blast orifices not less than $\frac{1}{18}$th of the area of the cylinder, the foregoing rules and tables of data apply to the action of steam at speeds under 30 to 40 miles an hour, as the writer has fully shown in his work on 'Railway Machinery.' For speeds amounting to 55 to 60 miles an hour, the loss by imperfect exhaust causes a large increase of consumption per horse-power per hour, of from 33 to 12 per cent., according to the amount of admission. With steam-ports of about $\frac{1}{12}$th, and blast-orifices $\frac{1}{14}$th of the cylinder, the rules likewise apply, at speeds under 30 to 40 miles an hour. At the higher speeds, the useful power is considerably impaired by imperfect exhaust.

The proportions of the "Great Britain," from the performance of which the foregoing results are deduced, may be repeated here as standard ratios for practice, until superior results are obtained.

Sectional area of cylinder........................ 1
" " of steam-port 1-10th
" " of blast-orifice 1-11th

Lap of valve, $1\frac{1}{4}$ in.; travel, $4\frac{3}{8}$ in. in full gear; lead, $\frac{1}{4}$ to $\frac{3}{8}$ in.

In a second paper, the writer discusses the *conditions* necessary for the successful expansive working of steam in locomotives. The following is a comparison of the actual results of engines working with ordinary *gab-motions* and with *link-motions.* The engine "Europe," on the Edinburgh and Glasgow Railway, cylinder 16 × 18 inches, wheel 6 feet. Doing one week's work in 1849, with *gab-motion*, consumed an average of 19 cwt. of coke per day, and 2 cwt. of coal. As, in the locomotive boiler, coal is about two-thirds of the value of coke, two cwt. of coal is equivalent to 1·33 cwt. coke; and the consumption per day may be stated at 20·33 cwt. coke.

The same engine, fitted with *link-motion*, used at the same season in 1851, and doing the same work, 12 cwt. of coke, and 3 cwt. of coal daily, equivalent to 14 cwt. coke; over a run of 94 miles, the expenditure becomes

24·22 lb. per mile with gab-motion
16·70 " " link-motion

7·50 lb. reduction, or 30 per cent. with link.

The periods of admission in the two cases would be about 70 and 45 per cent., and by the table of efficiency the consumption would be as 1·50 to 1·23, showing an economy of only 18 per cent., or barely two-thirds of what was actually made. The greater actual efficiency must in great part be due to the superior opportunity of working with high-pressure, during the admissions offered by the link.

Again, the test may be applied by measuring the water consumed. The following are a selection of cases from the writer's own experience and observation:—

Engine with Link-motion, Cylinder 15 × 20 inches, Wheel 6 feet. Edinburgh and Glasgow Railway.

Date.	Engine.	Mean Speed. Miles Per Hour.	Average Train of Carriages.	Consumption of Water in feet, per Mile.	Remarks.
1851 26 Aug.	"Orion," ordinary train	19·6	16	2·97	Stiff Wind ahead
" "	Do. do.	24·4	7	2·01	Do. favourable
27 "	Do. do.	24·4	7	2·22	Do. ahead
" "	Do. Express	32·0	5	1·65	Do. favourable
1850 7 Sep.	Do. do.	32·7	5	1·65	Slight wind ahead

Engines with fixed Gab-motion, Cylinder 16 × 18 inches, Wheel 6 feet. Edinburgh and Glasgow Railway.

1850 3 Sep.	"America," ordinary	21·5	13	3·01	Wind favourable
10 Oct.	"Nile," Expr.	29·0	$7\frac{1}{2}$	3·00	Do. ahead
21 "	"Niger"	..	7	2·80	Calm

Express Engine, with fixed Gab-motion, Cylinder 16 × 18 inches, Wheel 6 feet.—North British Railway.

1851	Express	38 5	5	2·70	Calm
	"	38·5	5	2·70	Do.
	"	38·5	4	2·96	Wind ahead
	Mail	35·7	7	3·05	Calm
	Ordinary	22·0	12	3·45	Calm

These results show, as before, that under similar circumstances what has been deduced from an independent examination of indicator-diagrams, taken under the link-motion, as to the *economy* of steam *worked expansively*, is fully borne out by a direct appeal to the relative consumption of coke and water.

It is now proposed to consider the conditions on which the expansive working of steam in Locomotives may be most beneficially carried out.

The Condensation of Steam in the Cylinder by exposure, which takes place in certain arrangements of locomotives, is susceptible of proof in various ways: by the internal evidence of the indicator-diagram, in respect of its general form, the form and course of the expansion-line, and the back pressure; also by a comparison of the volume of sensible steam which is found to pass through the cylinder, with the volume of water found by measurement to be consumed from the tender and the boiler. The evidence of the expansion-line of the indicator-diagram will be first considered, both for well-protected and partially-protected cylinders.

Evidence of the Expansion-line of the Indicator-Diagram.—As the total heat of saturated steam is nearly constant for all pressures, being slightly greater the higher the pressure, there can be no condensation of steam during expansion, in a perfectly non-conducting vessel, but rather a slight surcharge. The surcharge is so slight, however, as not to require further notice in the present inquiry; we are only concerned in showing that perfectly-protected steam under expansion, without any deduction from, or accession to its heat, continues substantially in a state of saturation, and unaltered in quantity or mass; and that if the indicator-diagram show that at the end of the expansion the final quantity of sensible steam is either greater or less than the initial quantity at the beginning, and surcharge by condensation or otherwise must have taken place in the condition of the expanding steam. The initial and final quantities, or their equivalents in water, are readily found by dividing the capacity of the cylinder and the clearance occupied by the steam, by the relative volumes due to the initial and final pressures. By the same law we may find the expansion-curves, which would be described with a constant quantity of saturated steam under expansion; this has been done for the slow diagrams from No. 13, C. R. (fig. 1) and the curves of simple saturation thus found are shown in dotting. The deviations of these from the actual curves are all referable to one cause—*the condensation of the steam.*

In No. 1, the cylinder must have been at a lower temperature than the steam during the admission, and some condensation must have taken place, for no sooner is the steam cut off, than condensation is made visible by the sinking of the expansion-curve below the standard throughout the whole of its length. In No. 2, also, this takes place to a small extent for the first half of the curve, when the temperatures of the steam and the material of the cylinder become equal; after this, as the pressure continues to fall, and the temperature of the steam with it, the curve rises and meets the standard curve at the end, in virtue of a partial re-evaporation of the steam previously precipitated, caused by the cylinder itself, which, colder than the steam, and heated by it in the first stage of the expansion, is now relatively hotter, and partially restores the heat of which it had previously robbed the steam.

In Nos. 3 and 4, the process of successive condensation and re-evaporation is still more distinctly brought out. In these cases, the greater portion of the heat engaged in the restoration of the steam during expansion must have been absorbed by the cylinder, by condensation of the steam during admission. Under the 3rd and 4th notches, the observed final equivalents are shown to exceed the initial by 19 and 45 per cent. of the latter respectively; which proves that, in the two cases, at least 19 and 45 per cent. of the steam admitted *must have been condensed during admission*, as the additional steam can have been obtained from no other source. Although the actual expansion-curves, Nos. 3 and 4, indicate much higher mean pressures, *during expansion*, than the standard curves, and may so far be viewed as superior results, the favourable difference is only a partial amends for the much greater loss by initial condensation; and an expansion-curve may be constructed backwards, in terms of the indicated mass of steam at the end of the expansion, to show from what initial pressure this mass of steam could have expanded, had there been no condensation. Take No. 4, for example. The final pressure at G is 13 lb., for which the relative volume is 939, and the ratio of the initial and final total volumes, or the degree of expansion, is 1 to 2·66; then 939÷2·66 = 353, which is the relative volume for 66½ lb. steam at the point of suppression. Tracing the expansion-curve GH for this pressure, as in the drawing, for which any number of intermediate points may be found in the same way, and drawing a horizontal admission-line HI to the beginning of the stroke, the extra shaded area so inclosed is a representation of the real loss incurred by initial condensation of steam; and, without going into figures, it appears nearly as much again as the area, or power, actually obtained.

The diagrams just discussed are, of course, extreme cases, which might occur in any cylinder, outside or inside; and they have been selected simply for purposes of illustration. They have served to show in what way the expansion-curves of indicator-diagrams may be turned to account in developing the condition of the steam. Our business is now to find to what extent, in the ordinary working of locomotives, the condition of the steam is affected by the circumstances of the cylinder.

The first point is to show, by the expansion-line, that in well-protected cylinders the steam is not subject to condensation. Referring to the 26 diagrams obtained from the "Great Britain," of which the cylinders are suspended in and freely surrounded by the hot gases in the smoke-box, it appears that for each notch the influence of speed on the relation of the initial and final water-equivalents of the steam expanded is nearly inappreciable. Dealing therefore with the means, the mean differences by which the final are less than the initial equivalents are—

For the 1st notch, 3 per cent. of the initial equivalent.
" 3rd " 5½ " " "
" 5th " 2¼ " " "

These per centages are practically nothing, and the virtual constancy of the mass of expanding steam during expansion, thereby proved, shows that for the greatest observed degrees of expansion in the cylinder of the "Great Britain," no change in the condition of the steam is observable, and that there is, consequently, no condensation at all.

Experiments made by the writer on some of the engines of the Edinburgh and Glasgow Railway, with inside cylinders, lead to the same conclusion.

Numerous diagrams were obtained by the writer from the outside-cylinder engines of the Caledonian Railway, of which the cylinders are placed beyond the direct influence of the heat in the smoke-box, and considerably exposed to the atmosphere. Seventy-six were selected as average samples of diagrams obtained during the regular work of the engines. These have been analysed in the way adopted for those of the "Great Britain," and the mean results range from 9 per cent. deficiency, to as much as 67 per cent. excess at the greatest expansion. Specimens of the diagrams from No. 42, Passenger-engine, and from No. 125, Goods-engine, are given in fig. 2. These diagrams were taken by McNaught's Indicator, and the dotted lines show the actual curves which are affected by the oscillation, to which that indicator is subject at high velocities. The mean lines have been drawn on the diagrams on the principle which the writer has satisfied himself applies in the particular case of the indicator—that action and reaction are equal, and that therefore the mean line, or radical form, ought to inclose the same collective area of diagram as the fluctuations in the lines actually described, due partially to momentum, cutting off at one place as much as it incloses at another.

For the greater ratios of expansion, the final equivalent of the steam is much above the initial, and the greater the ratio the greater is the per centage of this excess, amounting to 67 per cent. with an expansion of 3½ times. This relation is just what was found for the slow diagrams from No. 13, and there is no doubt the excess of steam, at the termination of the expansion, is due to the same cause, namely—the condensation of the steam in the cylinder during admission, and during the first part of the expansion, and the subsequent re-evaporation of a portion of the precipitated steam. During the experiments there was at all times ocular demonstration of the existence of water in the cylinder, in the spray which escaped from it through the indicator, and *which was given off more abundantly the more expansively the steam was worked.*

To find the general rate at which the per-centage of condensation increases in these engines with the degree of expansion, the results obtained may be referred, as ordinates, to a base-line representing the ratios of expansion. Let AB, fig. 4, be a base-line divided to represent the total volumes by expansion in terms of the initial volumes; and from B draw the vertical scale to measure the relative per-centages of condensation.

From A set off on the base-line the ratios of expansion, and for each ratio set off perpendicular distances by the vertical scale, equal to the respective per-centages of the differences of water-equivalents, col. 13, and define their extremities by points, setting off *minus* per-centages below the line, and *plus* per-centages above. The mean line CD, drawn through these points, is straight, and represents the mean rate at which the indicated condensation increases with the degree of expansion. It is found to meet the vertical from division 1, at 20 per cent. below, crosses the base-line at a volume of 1·53, and terminates at E, the point due to an expanded volume of 3·4, and to a per-centage of 70, and would, if produced, meet the vertical from B, at 92½ per cent. The straightness of the line implies that the indicated per-centage of condensation increases uniformly with the relative volume by expansion. For an expansion of 1·53 times, the per-centage of condensation, or indicated difference of equivalents, is nothing; and, generally, for expansions advancing by half-volumes, the per-centages are as follows:—

Expanded Volumes, the Initial Volume being = 1.	Indicated Per-centages of Condensation.
1·5	−1¼
1·53	0
2	17½
2·5	36¼
3	55
3·5	73¾
4	92½

For every half-volume of expansion there is an increase of 18¾ per cent. of indicated condensation, and this becomes so serious that for an expansion of four times, if this were practicable with ordinary valves and link-motions, there would be 92½ per cent. of loss by condensation, or a loss of nearly one-half of the total quantity of steam admitted.

For ready reference it is expedient to find the relative expansion and indicated condensation for different periods of admission, yielded by ordinary link-motions. The following table contains in col. 2 the total expended volumes due by the nature of link-motion to the several periods of admission in col. 1, and col. 3 contains the relative indicated per-centages of condensation due to these expansions, measured from the diagram.

Of the Indicated Condensation of Steam in Outside Cylinders during the Admission of Steam.

Period of Admission in parts of the Stroke.	Total Volume by Expansion, the Initial Volume being = 1	Indicated Condensation, in parts of the Indicated Steam cut off.	Approximate Proportion of Steam Condensed, In parts of the INDICATED Steam consumed.	Approximate Proportion of Steam Condensed, In parts of the WHOLE Steam consumed, (including the Condensed Steam).
Per Cent.	Ratio.	Per Cent.	Per Cent.	Per Cent.
75	1·22	−12·0	12	11
60	1·40	− 5·2	12	11
50	1·54	0·0	12	11
40	1·78	9·4	21	17
30	2·07	19·9	32	24
20	2 45	34·1	46	32
12	3·17	66·1	73	42
1	2	3	4	5

Though the losses shown in the 3d column are great, the real losses must be still greater; because the restoration of condensed steam, by which the losses have been measured, cannot be entire. The indications, indeed, fail to show any loss at all, at 50 per cent., as the re-evaporation balances the condensation during expansion. For 75 per cent., the re-evaporation (if any) is so slight as to leave a deficit of 12 per cent., by condensation, during expansion, compared with what was indicated as cut off. Now, the whole tenor of the evidence shows plainly that the degree of condensation increases as the admission is shortened; and it may be safely inferred that as 12 per cent. is shown to be lost in full gear, there is at least 12 per cent. of loss for 50 per cent. of admission, cutting off at half-stroke. An approximate loss of 12 per cent. will, on this ground, be adapted for all admissions greater than half-stroke; and 12 per cent will also be added to the indicated losses for shorter admissions, as an approximation to the real conditions.

Col. 4 contains the approximate losses as thus revised, in parts of the *indicated* steam admitted. Adding the *lost* steam admitted to that indicated, the sum expresses the *whole* steam admitted and expended; and col. 5 contains the per-centage of approximate loss, expressed in terms of the whole steam so used, which is a more convenient form for reference. From this column it appears that for 40 per cent. admission, 17 per cent. or one-sixth of the steam, is condensed; for 30 per cent., one-fourth; for 20 per cent., one-third; and for 12 per cent., or mid gear, two-fifths, or not far from one-half.

It must be added that the foregoing deductions are based on steam-pressures under 60lb., generally about 50 lb., during admission. For higher pressures, and admissions above half-stroke, the condensation is proportionally less, as will afterwards be shown.

Proof of the Condensation of Steam in Outside Cylinders, by comparison of the indicated consumption of steam with the measured consumption of water.—Many experiments were made by the writer on this point; one was made with No. 42, passenger-engine, on the Caledonian Railway, during a trip of 105 miles, from Glasgow to Carlisle, with an average train of 6½ carriages, done in three hours 22 minutes, five stoppages included. Indicator-diagrams were taken from the cylinder at intervals of one or two miles, and the notch of the expansion-gear observed for each diagram, and the points of the line where each change of notch was made.

The several points of cutting off, expansion, and compression were accurately ascertained by means of the slow diagrams; from which were calculated the exact quantities and pressures of sensible steam actually consumed in each interval of the trip, and the water-equivalents for the several quantities of steam present in the cylinder; which, multiplied by the number of strokes of the two cylinders in each interval, gives the total quantity of water efficiently used as steam. The following final results were thus obtained.

Distance Travelled.	Water used as Sensible Steam.	Water Consumed as Measured.	Excess.
1. Glasgow to Motherwell	30 76 ft.	35·82 ft.	5·06 ft., or 14 per cent.
2. Motherwell to Carstairs	43·91 ft.	48·85 ft.	4·94 ft., or 10 do.
3. Carstairs to Beattock	57·28 ft.	67·74 ft.	10·46 ft., or 15½ do.
4. Beattock to Carlisle	62·42 ft.	79 50 ft.	17·06 ft., or 21½ do.
Total, Glasgow to Carlisle	194·37 ft.	231 91 ft.	37·54 ft., or 16½ ℘ cent.

The examination of the indicator-diagrams in the manner employed before, by comparing the initial and final water-equivalents of the steam during expansion, shows that at least 13 per cent. of this loss of 16½ per cent. was due to condensation, and it is probable that no appreciable proportion was due to priming; indeed the *least loss* was observed to take place with the least degree of expansion, and when the consumption of steam from the boiler is going on at the *greatest rate*, as we find on referring to the per-centages of admission; which is the reverse of the effect that would be observed if priming were a material cause.

Experiments made by the writer with other outside-cylinder engines, *or imperfectly-protected* cylinders, corroborate the above deductions obtained from the performance of No. 42; and they are still further corroborated by his experiments on inside *well-protected* cylinders, which show that in ordinary good condition there is no sensible excess of water of any importance, actually consumed from the boiler, above what is estimated from the indicated steam passed through the cylinder. These results are also confirmed by the results of the trials of Mr. D. Gooch, with the "Great Britain" and similar engines.

The increased *back pressure of exhaust* affords additional evidence of the presence of water in the cylinder. The back exhaust pressure is the consequence of the want of facilities for the timely discharge of the exhaust steam from the cylinder; and the impediments to its discharge are much increased by the presence of water amongst the steam, whether due to condensation or to priming. The presence of water is immediately made apparent by the increase in the back exhaust-pressure, shown by the indicator-diagram, as the writer has on many occasions had an opportunity of observing. The *effects of priming* from foulness of the water in the boiler are shown in fig. 3: A and B are indicator-diagrams taken from the well-protected cylinders of the "Orion," in which very little, if any, condensation could be detected. The diagram A was taken *before*, and the diagram B *after* the boiler was blown off and supplied with clear water, both being taken at the same speed, and showing 7 lb. back pressure caused by priming in the former case.

The diagrams C and D, fig. 3, show that the *total quantity of water* from condensation is considerably greater, with the greater degrees of expansion, where a *smaller quantity of steam* is admitted, and consequently the loss is more seriously felt. These diagrams were taken from the outside-cylinder goods engine No. 127, working at the same speed up and down an incline on the Caledonian Railway; the diagram C cutting off at two-thirds the stroke, and the diagram D at one-sixth of the stroke. The latter, D, though it had the advantage of a much earlier exhaust, and only one-fourth of the quantity of steam to discharge, was affected with 10 lb. more back pressure than the former, C, when working in full gear. This great back pressure was maintained over a continued run of twenty miles, when of course the cylinders had got into their working heat for that degree of expansion; and the inference is, that the steam was loaded with water of condensation, (proved also by the expansion-curve,) which was with difficulty expelled, and which only became proportionably less when the degree of expansion was diminished; and, consequently, the mass of steam increased that was to be cooled within the same superficies of cylinder.

That the *total mass of the steam* has much to do with the condensation is proved by the diagrams E and F, fig. 3, taken under the same degree of expansion, and at the same speed, but with 75 and 20 lb. steam respectively admitted to the cylinder. In the latter diagram, F, the back exhaust pressure is 7 lb. greater than in the former diagram, E, although the total quantity of steam to be discharged was so much less. In the latter case, indeed, there was found to be an excess of 18 per cent. of the whole water used over the indicated steam expended, which was most probably altogether by condensation, as the rate of consumption was so moderate as to preclude any likelihood of priming.

Now here is a case where, in the same class of engines, the back exhaust-pressure *increases* as the quantity of steam to be discharged *becomes less*, notwithstanding that the facility for exhaust increases at the same time. This is clearly a case of water in the cylinder, the quantity of which increases with the degree of expansion; and the water is as clearly a precipitation of steam by condensation. Also, though a full admission of steam at higher pressures may reduce the proportion of condensation, yet whenever expansive working is attempted by cutting-off earlier, the heavy back pressure and the course of the expansion-line alike show that no pressure of steam, however high during the admission, can mitigate the evils of condensation in exposed cylinders.

Evidence from the Proportions of the Valve-gear.—The greater the lap of the valve, the greater also is the inside lead, for the exhaust exposed cylinder, we should expect, would therefore require longer laps than well-protected ones, seeing that wet steam exhausts with difficulty. Accordingly, it has been found that in Sharp's inside-cylinder engines, on the Edinburgh and Glasgow Railway, which have only a ⅝-inch lap,—probably the shortest lap in present practice for a 15-inch cylinder—the exhaust is as perfect as in the Caledonian passenger-engines with 1¼ inch lap for the same cylinder. Further, in inside cylinders with clean boilers, it is practically a matter of indifference what amount of wear or slugger may have taken place in the valve-gear, so far as concerns the exhaust: in outsides, on the contrary, it is a very important object to maintain the gearing in the highest order, so as to keep up the inside lead, as the wear of the gearing directly reduces the lead, and thereby increases the back pressure. The Caledonian is perhaps the first line in this country on which the special advantage of long lap for outside cylinders was experienced.

The formidable degree of condensation which accompanies high expansion in partially-protected cylinders, accounts for the opinion held by men of experience of the inutility, for economical objects, of cutting off the steam earlier than at half-stroke, for the proved advantage of expansive working in inside cylinders is neutralised in outsides by the condensation. Mr. Buddicom, of the Rouen Railway, led the way in the re-introduction of outside cylinders in this country: and to this day, he, and some of his followers, have adhered to the fixed gab-motion.

Conditions on which the expansive working of steam in locomotives may be carried out with efficiency and success.—The first condition is to perfectly protect the cylinders, and to maintain them at a *temperature at least as high as that of the steam admitted to them.* Simple non-conducting envelopes are not sufficient; external supplies of heat must be employed, and the application of a steam-jacket to the cylinder would be advantageous, when other sources of heat are not readily available. The writer tried an experiment with the "Orion," Edinburgh and Glasgow Railway, which has its cylinders suspended in the smoke-box, like the "Great Britain's, in which, by the use of partitions, the hot air from the tubes was directed entirely round the cylinders, previously to its emerging by the chimney: but he could not detect the slightest change in the performance of the engine, probably because the hot air was really very little hotter than the steam, and the closer contact made no difference. For cylinders already well protected, more thorough modifications would be required to make a sensible improvement. The steam should also be surcharged, previously to entering the cylinder, by passing over an extensive heating surface, deriving its heat from the atmosphere of the smoke-box, or, if necessary, from a hotter source.

Mr. W. C. Hare, of Stonehouse, Devon, to try the value of surcharging the steam, experimented on a small engine, with cylinder 3½×8 inch stroke, and a boiler of 9 feet heating surface. He found that when the steam was passed over a surcharging surface of 5½ feet in a coil of copper tube, and heated to 400° before entering the cylinder, the consumption of water from the boiler was three gallons per hour; and when the communication with the surcharging pipe was cut off, and the steam led directly to the cylinder, the water used amounted to six gallons, or twice the other, while doing the same work, and involved a great increase of fuel consumed. To effect the reduction here noted, it appears that a surcharging surface equal to fully one-half of the heating surface has been necessary; and it is probable that for locomotives a considerable allowance must be made to produce a very decided change. The results of this experiment show that very much has yet to be done before the capabilities of the locomotive are fully developed.

As steam has been found so very sensitive to *exposure* on the one hand, and to *surcharging* on the other, it would probably be of advantage to *lead the hot smoke round the barrel of the boiler and the fire-box*, or the barrel only, *previously to its discharge by the chimney.*

The second condition of successful expansive working in locomotives is the combination of a sufficiently high boiler-pressure of steam, with suitable proportions of cylinder and driving wheel, to admit of highly expansive working consistent with the required duty of the engine. It is probable that 150 lb. per inch is about the highest pressure at which it is advisable to work a locomotive, consistent with the fair working and durability of its parts. The maximum pressure being settled, and it being assumed that the same pressure is to be maintained in the cylinder during admission, the degree of expansion to be adopted determines the capacity of the cylinder to develope the necessary average power. Long strokes are not advisable on the score of stability, at least for outside cylinders, and large diameters should rather be adopted; for the same reason, large wheels are preferable.

Thirdly, in the details of the mechanism, the cylinder should be arranged to have the shortest practicable steam-ways; as, for short admissions, a long steam-way deducts very much from the efficiency of the steam. Such an arrangement would be greatly promoted by the introduction of balanced valves, or such as have provision for preventing the steam-pressure on the back of the valve; as, by being balanced, they could with facility be made large enough to embrace the whole length of the cylinder. The loads which ordinary valves are forced to carry on their backs are enormous; and though there is certainly no momentum in these loads to contend with, yet the friction of surfaces due to the loads is very great, even at the most moderate computation.

Discussion.—Mr. Stephenson (the Chairman) observed that he felt much obliged to the author of the paper for explaining in such a clear and practical manner the action of the slide-valve and the link-motion; and the paper was particularly valuable for the actual numerical results that were given so completely of the variations in practical working, showing the improvements effected and the defects avoided.

Mr. M'Connell agreed that the link-motion was the most advantageous and useful of any valve-motions known for locomotive engines. He thought a hot-air chamber should be contrived, passing round the cylinders, to be kept at a temperature sufficient to maintain the steam perfectly dry.

Mr. Clark said, that in the Great Western engines, Mr. Gooch had carried the steam-pipe straight down in front of the tubes, instead of curving it on one side as usual; and the pipe being of $\frac{1}{16}$-inch copper, it absorbed the heat from the tubes rapidly, and surcharged or dried the steam.

Mr. Stephenson observed, that with regard to the question of surcharging steam, he remembered being told by Mr. Trevithick of an experiment which he made in Cornwall in 1830. He had to repair an old engine there, which had no steam-jacket to the cylinder, as most of the other engines had, to keep up the pressure of the steam; and he built a brick casing round the cylinder, leaving an air-space all round, and applied a small fire to keep this air heated. About one bushel of coals in twenty-four hours was consumed in heating the cylinder, and he found a great increase was effected in the duty performed by the engine, with the same consumption of fuel under the boiler as before. He then removed the fire from the cylinder, in order to find the relative efficiency of the coal when consumed under the boiler or under the cylinder, and he found that it took five bushels of coals applied to the boiler to produce the same effect as the one bushel of coals applied to the cylinder. Mr. Stephenson said, he had been so much impressed with the results of this experiment, that in the "Planet," one of the early locomotives made in 1832, he had the cylinders carefully inclosed inside the smoke-box instead of being outside, and there was found to be a considerable increase of power effected by the plan. That was the first locomotive constructed with heated cylinders, and it appeared the principle ought never to have been deserted; but it was singular how temporary prejudices sometimes caused a good thing to be departed from. Those inside cylinders were abandoned because the crank axles were found liable to break: but then, after that objection was subsequently removed by improved manufacture, the prejudice against the inside cylinders still remained; however, they appeared now to be going back to them. The construction of locomotives was still perhaps much influenced by these local prejudices arising from individual circumstances; and he was confident that this Institution would conduce greatly to the removal of them, by the mutual interchange of ideas and experience that was promoted by it; and nothing could assist more in forwarding such a desirable object than the reading of such papers as the present one by Mr. Clark. He quite agreed with the opinion stated in the paper on the great drawback to the application of expansion in locomotive engines caused by the condensation, from the cylinders not being heated: he considered some additional heat was required to be supplied during expansion to prevent condensation taking place, as it appeared the quantity of heat in steam was not sufficient to maintain the whole in the form of steam during expansion, but a portion returned to the form of water, as shewn in the able investigation of the expansion of steam given in Lardner's 'Treatise on Heat.'

Mr. Cowper described some experiments that had been made by Mr. Siemens and himself, which he thought showed that condensation did not take place during expansion. They took a cylindrical tin vessel closed at the top, about 12 inches high and 2 inches diameter, the metal of which was very thin, and coated thickly with felt outside to prevent any loss of heat. A small steam-pipe was connected at the top, but the bottom of the cylinder was open to the atmosphere; and a stream of 30 lb. steam was blown into the vessel from a very small orifice, and allowed to escape freely into the atmosphere at the open end of the cylinder. After a short time, when the cylinder had become hot, and was maintained just full with expanded steam at the atmospheric pressure, a thermometer inserted a short distance into the open end, showed a constant temperature of 214° to 215° instead of 212°, proving the total quantity of extra heat that is in high pressure steam; and no condensation could be perceived inside the cylinder, no vapour being visible until the steam had escaped from the cylinder into the atmosphere. This experiment was tried on several different occasions, and on one it happened that the boiler was priming slightly; and when a drop of water came over through the steam-pipe and dropped upon the bulb of the thermometer, it was observed to fall suddenly to 212°, and remained at that point until the water was boiled off, when it again rose 2° to 3° above the boiling point as before.

Mr. Stephenson said he did not think that mode of trying the experiment would give a correct result as regarded the present question, as the steam was escaping into the atmosphere instead of being all confined within the cylinder, and the temperature in the cylinder being maintained above the boiling point would prevent any condensation taking place during the expansion of the steam.

Mr. Cowper did not think that in a cylinder thoroughly protected from loss of heat by radiation or conduction, any condensation of the steam would take place during expansion, and that if any condensation occurred, it would be found to be owing to the steam having lost some of its heat, which it could not recover. The result that he obtained by indicator diagrams from a pair of 35-horse power, high-pressure, expansive, and condensing engines, which he had constructed some years since, fully bore out this view; the steam was expanded in the cylinder of each engine independently, and the practical expansion curve was obtained very accurately. The whole body of the cylinder was necessarily nearly at a mean temperature between the highest and lowest steam in the cylinder (the cylinder not having a steam-jacket), consequently the steam ought to be slightly cooled on entering the cylinder, and towards the end of the stroke, where it was at a lower temperature from expansion, it ought to be slightly warmed by the cylinder;—now the indicator figure showed both these circumstances to have taken place, for the actual curve during the first part of the stroke, after the steam had been cut off, was rather below the true expansion curve; and during the latter part of the stroke it was rather above; this also showed that the expansion curve required a slight correction for the extra quantity of heat in the high-pressure steam.

Mr. Clark remarked that he had found by the indicator diagrams that a great condensation of the steam took place in exposed outside cylinders during the first part of the stroke, from the coldness of the cylinders, and a considerable amount of condensation also was caused even in protected cylinders, where they were not artificially heated by exposure to the hot air in the smoke-box, because the temperature of the mass of metal in the cylinder remained about the mean temperature of the steam whilst expanding in the cylinder, which might be many degrees below the original temperature of the steam on entering from the boiler. This caused the actual pressure of the expanding steam to be below the theoretical pressure during the first half of the stroke, as shown in the indicator diagram, fig. 3; where the theoretical curve of expansion is shown by the dotted line BCD, allowing for the contents of the steam port and the clearance represented by the space AA. But about the middle of the stroke, the two curves coincide at C, as the steam was then at its mean temperature, and agreed with the temperature of the cylinder; and after that point, as the steam continued to expand and lower in temperature, the cylinder remaining nearly constant was hotter than the steam, and returned some of the heat it had robbed from the steam, re-evaporating more and more of the water that had been condensed, and raising the curve of actual pressure above the theoretical curve at the end D, where the exhaust commences. A portion of the lost steam is thus restored in the second half of the stroke, but a serious loss of power still remains; and the consideration of this action that is always going on to a greater or less extent in the cylinders of locomotives, however well they may be protected, except where they are artificially heated, shows what an important source of economy is to be found in carrying out that principle.

Mr. Crampton thought that enough attention had certainly not been paid to the condensation in the cylinders of locomotives at slow speed; he did not think it was of so much importance at high speeds. It was also particularly of importance in steam-boat engines, where the question had not received so much attention as it deserved. He remembered an experiment which showed a remarkable effect of condensation: four condensing engines, of equal size, were working coupled together in a boat, with the steam cut-off at one-quarter of the stroke and expanded; two of the engines were then disconnected, and the other two engines were worked, cutting-off at half-stroke, using, consequently, the same quantity of steam as the four engines did, cutting-off at one-quarter of the stroke; but a greater effect was found to be produced by the steam than when it was used in the four cylinders. This increase of effect appeared to be entirely due to the greater amount of condensation that took place in the four cylinders than in the two cylinders. There were no steam-jackets, only ordinary clothing on the cylinders, and he thought much improvement was required in this respect in marine engines, and it was a matter well deserving the consideration of engineers. In reply to an inquiry, he said the boilers were working with salt water, but he did not think that would affect the result.

Mr. Peacock suggested, that part of the effect in the experiment mentioned by Mr. Crampton might have been due to the smaller amount of friction in the two cylinders than in the four cylinders, when giving out the same total amount of power.

Mr. Crampton replied, that a greater effect was found to be produced after allowance was made for the friction, by taking indicator-diagrams, and the relative consumption of the water.

Mr. Whytehead thought the loss by back pressure would also be less in the case of the two cylinders than with the four.

AMERICAN DOCKS.*

The tidal position of the United States is so different from our own, and so peculiar, that the docking system has been carried out in a manner totally independent of that which has prevailed in this country. Accustomed to a considerable rise and fall of tide on the shores around our islands, it does not readily strike us that the position of any other country does not present the same local circumstances, and, so far as docking is concerned, the same natural facilities. There are few of our rivers and harbours in which a ship cannot be run into a dock at high water, and left dry at low water; and consequently, except in extraordinary cases, dock works for repairing ships do not go beyond the permanent water-line. Indeed, in many cases all we have to do is to embank a certain portion of the shore, and provide it with lock-gates. Except for particular purposes, the steam-engine is not required to empty docks, the ebb-tide leaving the vessel on the dock floor.

It is perfectly true that on the shores of our colonies the rise of tide is great, and in the Bay of Fundy to an enormous and unexampled extent; but as we go south, the tidal influence is less, and in many places the difference between high and low water on the shores of the United States is not more than two feet. Hence, until a comparatively late period, the construction of a floating dry dock was a formidable undertaking, inasmuch as any such establishment must be provided with machinery for emptying out the water. Where the depth of water in-shore is small, or the flats run out far, the difficulty of any such undertaking is enhanced. The consequence was, that both for public and private purposes, the want of docking accommodation was long felt, and, as compared with this country, the States were far behindhand. The ingenuity of our Atlantic brethren was, however, stimulated by these difficulties, and the result has been the successful working out of a number of valuable inventions, and the organisation of a system of docking thoroughly original.

Morton's and other slips for hauling ships bodily, at first chiefly engaged the attention of the engineers, but various forms of floating basins for inclosing shipping were proposed and ultimately carried out. Of these, by far the most copious account is that given by Mr. Hyde Clarke, in Weale's 'Quarterly Papers on Engineering,' under the head of the "Floating Dry Docks of New York." This contains practical descriptions and engravings of the earlier inventions, and brings down the history of the subject to a comparatively late date. This is continued by the work now before us, in which, under the title of the 'Naval Dry Docks of the United States,' General Charles B. Stuart, the Engineer-in-Chief of the United States Navy, describes not only the Floating and Sectional Dry Docks, but completes the subject by giving the description of those works lately constructed by the navy department, and which we better understand by the name of "Dry Docks."

The difficulties attending these latter works will be better conceived, when it is observed that it was not until 1845 that the works for the Dry Dock at New York were effectively begun, although the urgency of such an establishment for the United States Navy had long engaged the attention of public men. Our readers know well enough that however valuable the slip is for hauling up small vessels, yet that it is difficult to apply it to first-class war-vessels or steamers. So liable are vessels to strain, that among our own shipbuilders objections are entertained even to launching newly-built vessels from slips, and for that reason many prefer building them in dock and floating them out. Nevertheless, the exigencies of the commercial navy requiring it, New York had some gigantic slips, in which great operations have been conducted. Plans of machinery for this purpose will be seen in 'Weale's Papers.' The favourite plan in the Atlantic cities for some time was to bring the ships over a sunken and hollow raft, on the exhaustion of the water from which the ship was borne to the surface and lay on a cradle high and dry, with a good platform around her, on which the ship carpenters could work. The great advantage of most of these plans is, that the ship is kept in a horizontal or floatable position, and thereby the strain is diminished. Timber being cheap in the Atlantic States, and space abundant in the waters, the construction of these floating establishments, which can be steam-tugged to any required spot, presents great advantages.

The requirements of the naval establishments are otherwise; although at inferior navy establishments, and at San Francisco, floating and sectional timber docks have been authorised, from motives of economy. Yet at the great permanent establishments it is essential there should be a large dock in one fixed spot, where it can be fortified and defended. This explains the anxiety to construct what is called the "Granite Dry Dock" at New York.

We should observe that the work of General Stuart, who has had part in the operations, is one which is an accession to professional literature, and very honourable to the country which produces it. It is one of those works which must become a standard in the professional library, taking its place by the side of the productions of our leading men. The letterpress and the engravings, which are so much more important to practical men, have been produced in New York; they are of a very handsome style, and the latter numerous and copious in details. General Stuart has by this publication done a service which will be as much esteemed by his brethren and countrymen on this side of the Atlantic as by those beyond the broad sea, among whom he was born. It is one of the most important professional contributions we have yet received from the other side, and to us not without great practical utility, because with the extension of our relations, there are many places in our Indian empire and in our colonial possessions where works of a like character are required, and indeed in many foreign countries, on the Baltic and the Mediterranean, where our engineers practise, and where the value of this guide will be sensibly felt.

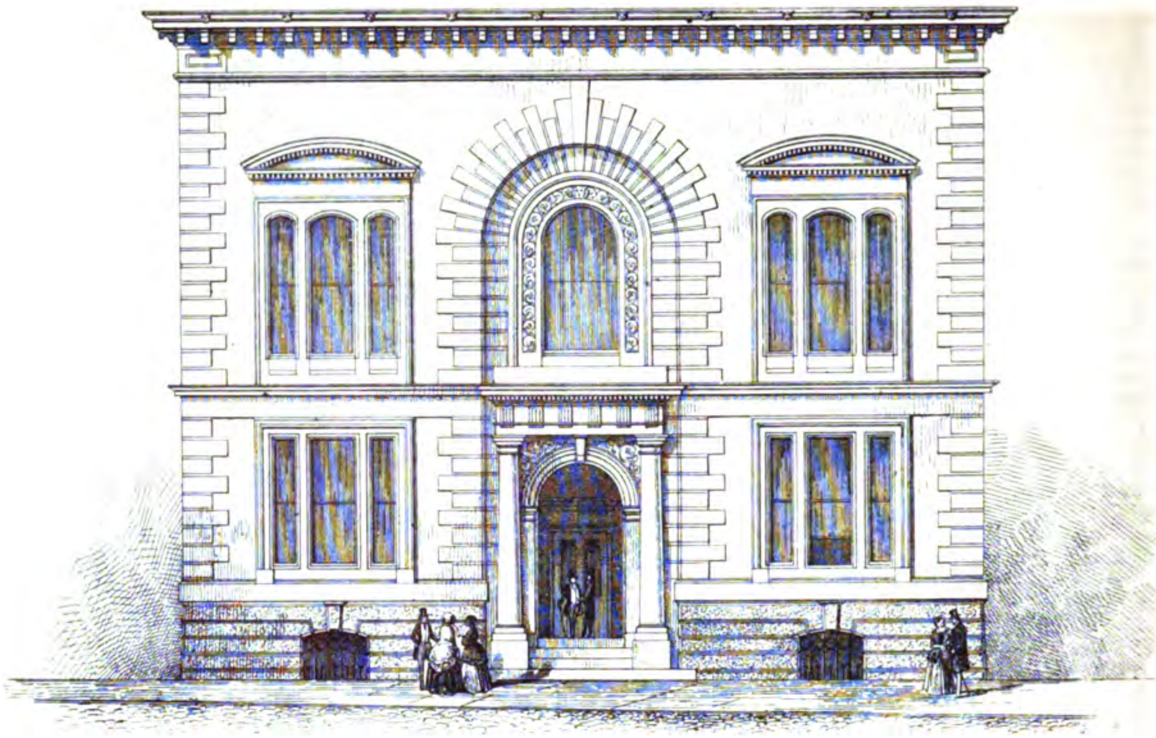
The greater portion of the volume and the most copious details are given to the New York Dock, and acquire the more valuable character as they are to a great degree derived from the General's own observations. Many of these details are of local reference, as the estimates of contractors and the price of works, but many of them are of general and practical application. Our space will not permit us to avail ourselves to any great extent of those portions of the text in which the writer enters upon many practical points of interest which arose during the progress of works so great and so difficult, and we must therefore content ourselves with a partial description.

The dock of which we are speaking was run out into Wallabout Bay, an arm of the East River, and required the construction of a cofferdam, within which the works had to be carried on. It may very well be conceived that such a cofferdam presented very great difficulties, inasmuch as piles of 50 feet in length had to be sunk without reaching hard ground, the bottom of the bay being 10 feet of slusher quicksand. Several breaches occurred in the progress of the works, which required skilful treatment, and these operations are fully narrated. The piles were first driven with a treadwheel, but afterwards the steam pile-driver was used with great economy of time, and we presume of money. At any rate, it was of importance to get the inclosure completed as early as possible, for it was only then that it could be stayed within so as to resist the great pressure of the waters of the inlet.

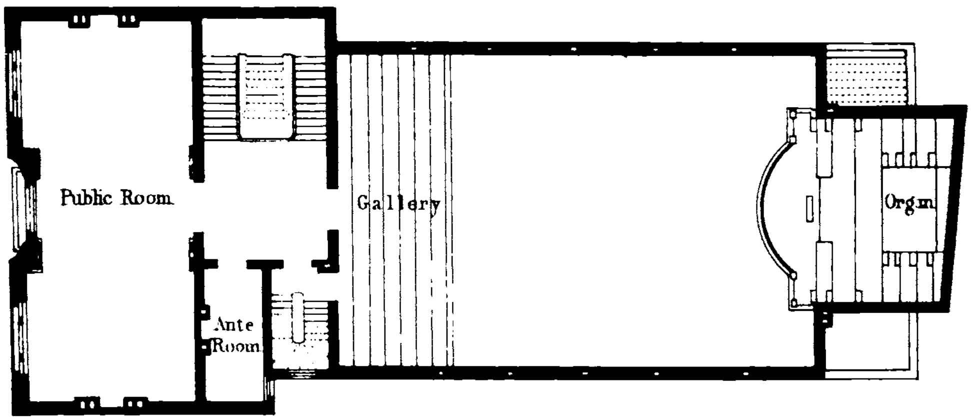
The temporary expedients of securing the coffering to the shore by chain cables were found very unsatisfactory, several cables having parted in storms, and the work requiring close watching. During the course of the work, green piles were substituted for seasoned piles, as it was found the latter being

* 'The Naval Dry Docks of the United States.' By Charles B. Stuart, Engineer-in-Chief of the United States Navy. Twenty-Four Steel Engravings. New York: Norton. London: Weale. 1852.

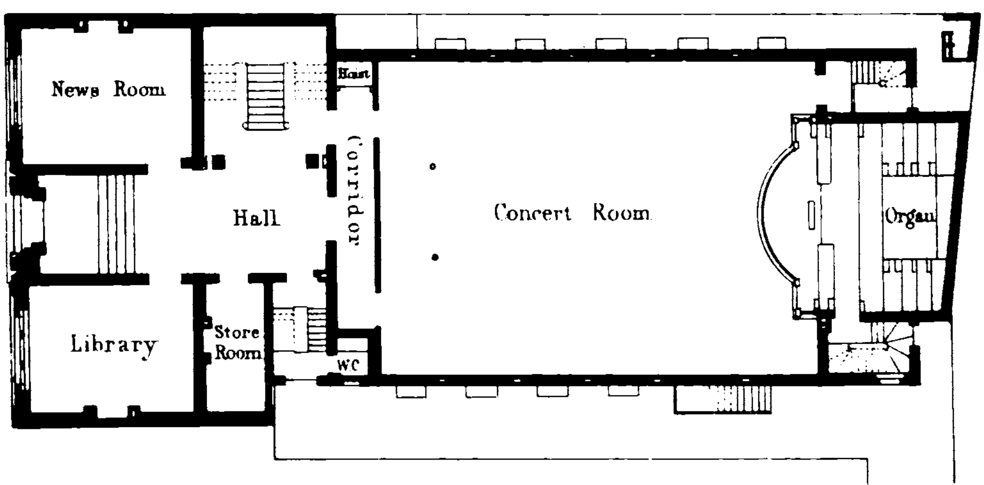
WIGAN PUBLIC HALL.



FIRST FLOOR PLAN.



GROUND FLOOR PLAN



Scale to Elevation
0 1 2 3 4 5 10 15 20 25 30 FEET

Scale to Plans
10 5 0 10 20 30 40 50 FEET

R. Lane, Archt. Manchester

J. R. Jobbins

drier, were readily split under the pile-driver. General Stuart gives many particulars as to the pile-driving, and as to the practice of Nasmyth's steam pile-driver, which will be found of value, because the extent of operations was great. In June 1847, a pile was driven 43 feet with Nasmyth's pile-driver, and then another pile, 15 feet deep, driven on the top of that. In some cases the piles were driven 25 feet through the subsoil, and yet the cofferdam was weak. The situation seems to have been one in which Potts's hydraulic process would have been valuable, but it had not then been practically applied on a large scale.

As might be expected, bottom springs were among the most troublesome opponents in carrying on the works. These springs were met with when the excavation had extended to within about 6 feet of the required level for the foundations. These springs, it may be noted, were of fresh water, although the bay water was salt; and they came evidently from a stratum of considerable depth, the veins of water, even when contiguous to each other, not being always connected together, and supplied, doubtless, from a high source. Their temperature was higher than that of the water in the Bay, and the flow was not affected by the rise and fall of the tides.

One difficulty attaching to these springs was, that they carried sand in suspension. This sand is described as so fine and impalpable that it insinuated itself even through the cheeks and cracks of the timbers, to the danger of the surrounding works. It was necessary, therefore, to provide for the flow of the water, and to check at the same time the escape of the sand.

One of the most powerful springs, says General Stuart, was that met with near the temporary pump-well at the north-east corner of the dock. The first case of undermining from this spring was the settlement of the piles driven to support the pumps and engine, rendering it necessary to change the pump-well; but the spring followed, and compelled another change of the well. This spring was driven out of the old well, by filling it with piles, but it immediately burst up among the foundation piles of the dock, near by. In a single day it made a hole, in which a pole was run down to the depth of 20 feet below the foundation timbers. One hundred and fifty cubic feet of cobble stone was thrown into this hole, which settled 10 feet during the night, and 50 cubic feet were thrown in the next day, which drove the spring to another place, where it undermined and burst up through a bed of concrete 2 feet thick. This new hollow was several times filled up with concrete, leaving a tube for the water to flow through; but in a few days it burst up through a heavy body of concrete, in a place 14 feet distant, where it soon undermined the concrete, and even the foundation piles, so that they settled from 1 to 3 inches. These foundation piles so affected were 33 feet in length, driven by a hammer weighing 2200 lb., falling 35 feet at the last blow, with an average of seventy-six blows to each pile, the last one of which did not move the pile above half-an-inch.

It may well be imagined that this last result was viewed with alarm, and that the most complete measures were resolved upon to prevent further injury. It was determined, therefore, to drive as many additional piles as could be forced into the space, and, by means of followers, to force those already driven as deep as possible. This work having been done, although under very disadvantageous circumstances, the old concrete was removed to a depth of 20 inches below the top of the piles; an area of about 1000 square feet around the spring was then planked, on which a floor of brick was laid in dry cement, and on that another layer of brick was set in mortar made of Roman cement. The space was next filled up with concrete, and the foundations completed over all, in the usual manner, and with the greatest dispatch possible. Several vent holes were left through the floor and foundations. After a few days' interval, when the cement had become well set, the spring was forced up to a level of 10 feet above the former outlet, and at this point it flowed clear and no longer charged with sand.

The other bottom springs were, it is said, forty in number, and were, many of them, of the same obstinate character, but were treated with equal success. Two of these springs, it seems, were accidentally closed by freezing in 1848, and forced up, in one case 800, and in the other 1200 square feet of the foundations. This injury took place between the lower timbers and the planking, lifting also the first course of the stone floor, which was from 12 to 15 inches thick. None of the springs were closed until the inverted arches of masonry had been laid, and the cement had become well set. Even then the pressure on the bottom of the floor was so great that the water came through the joints, though it did not disturb the stone. The arrangement proposed to be effected was to bring up all the springs through the foundation in lead pipes, and leave no pressure upon it until the masonry was laid, and the cement had become well set; but there were many minute veins of water unnoticed when the foundation was laid, which exerted a force upon the cement joints, rendering their setting very slow, and making it necessary to caulk them carefully with Roman cement and fine Rockaway sand, in 1850 and 1851.

Beside the main gate, hereafter to be described, there are balance gates of very ingenious construction carried out by General Stuart himself, and in which he introduced the latest English system of construction, but with some modifications, and carried out on the largest scale yet accomplished. The floating gate or caisson is a curious work, being an iron vessel or ship, with keel and stems made to fit the grooves in the masonry at the entrance of the dock. By admitting water into this vessel it sinks and settles in the grooves, and forms a barrier against the sea. It is removed from its place by pumping out water sufficient to raise it clear of the grooves, which are wider apart at top than at bottom. A contrivance of this kind is very seldom likely to be required in England.

After fully describing the details of the New York Dock, and giving general descriptions of the other docks, with engravings, the writer enters upon the second part of his subject, copious enough to make another volume, that of floating dry docks. The chief work here described is the Philadelphia Floating Dock. There is likewise described what is called a Balance Floating Dock, which has not yet been made known to the profession to any extent; and the Sectional Floating Dock, which is however more copiously illustrated, and on a larger scale, in Weale's 'Quarterly Papers.'

In concluding this short sketch of the work, we can but repeat what we said in the beginning, that it is one of a class which raises the character of the profession as well as that of the engineer by whom it is written; and we hope to welcome many like productions from General Stuart and our fellow countrymen,—no longer so far distant from us, but brought by the powers of steam within a few days' reach.

NEW TOWN HALL, WIGAN.

R. Lane, Esq., Architect.

(*With an Engraving, Plate* XXXIII.)

On the 11th August last, the foundation stone of this public hall was laid by N. Eckersley, Esq., the Mayor, in the presence of the corporation, the members for the borough, the local clergy, and a large number of persons. It is to be erected from the design of R. Lane, Esq., architect, of Manchester, by Mr. Fairclough, contractor, at a cost of 3240*l.*; but the expenses of lighting, warming, and fitting up the hall are anticipated to be about 700*l.* more.

The facade is of an Italian character, the lower compartment being of stone, with a granulated rustic basement, terminating with a deep facia and moulded stringcourse. The upper compartment is of stock brickwork, with stone quoins and dressings to windows, surmounted by a bold modillion cornice, facia, and neck-mould. In the centre is a circular-headed recess in stone, formed with quoins corresponding with those at the external angles of the building, inclosing a door-case with Doric columns, and entablature with triglyphs and dental cornice, having a circular-headed doorway with moulded imposts and archivolt, carved spandrils and key-stone. The central window over is circular-headed, and ornamented with a carved scroll band. The whole front, though simple in its forms, is rich and effective.

In the internal arrangements, a flight of steps, 13 feet wide, leads to the vestibule and principal staircase. On the right and left of the entrance is the library and news-room, and committee room, and from the centre of the vestibule are the doors leading to the large public room, 80 feet long by 40 feet wide, and 30 feet high, fitted up with a spacious orchestra at the end, adequate for concerts on a large scale. Over the library and news-room is a large saloon, 40 feet by 30 feet, for balls, public meetings, lectures, &c. The space below the large room is intended to be appropriated to the purposes of a mechanics' institution.

LONDON CATTLE MARKETS.

Sir—As public attention appears to be at present somewhat directed to the discussion of the future position of the London live cattle market, you may, perhaps, be so good as to insert in your valuable *Journal* the following observations on the subject. I venture to intrude them upon your notice because, firstly, I have had occasion to examine the subject in considerable detail; and, secondly, because I believe that the expression of a sincere opinion must always serve to elucidate truth, even should it be arrived at from imperfect data, or be incorrect in itself.

One of the most serious objections to the retention of a cattle-market in a city appears to me to consist in the interference with the traffic through the streets, and the sufferings the animals must endure whilst passing over the hard roads. This might, to a certain extent, be obviated by forming large lairs, able to receive the maximum number of cattle exposed, round the market. If this were done, it would be easy to drive the cattle at such hours that their entry into the market should take place when no carriages were passing through the streets; they would be taken to the lairs after being sold, and conducted to the different butchers' shops, or the various slaughterhouses, at the next period of cessation of traffic. The sufferings of the cattle do not, however, admit of so simple a remedy. The very fact of the market being in the centre of a city renders it impossible that the approaches should be other than paved roads, because in such positions the daily traffic would destroy any macadamised roads with frightful rapidity. But it may be questionable whether, after all, it be not a refinement of compassion for the animals to attach so much importance to their comfort during the hours immediately preceding their slaughter. Nor, if the market were sufficiently capacious to avoid unnecessary beating in order to arrange them, and sufficiently well arranged to obviate the necessity for the cruel mode of removing them which now prevails, does it seem to me that the question of the roadway is really of much importance.

There is another serious objection to the existence of a market in the interior of a city—viz., that in such cases it becomes the centre of a class of industry susceptible of becoming prejudicial to the public health, unless it be very carefully controlled by the municipal authorities. This is especially true in our own country, where all repressive action, in questions of nuisance, is *ex post facto*. It may be also true that when the power to control such trades lies, as it does in our corporations, with parties elected by and from the very people exercising them, such power will never be efficiently or carefully enforced. Be that as it may, it is certain that around all the English markets held in the middle of towns, we find the foulest and most disgraceful assemblages of corruption and iniquity accompanying such trades and callings carried on in such a manner as to revolt every well-regulated mind, even if the possessors of the latter should not have a *too* delicate sense of smell.

Indeed, Smithfield itself is a gross iniquity: but "worse remains behind"—the neighbourhood is fouler still. And moreover, it is to be observed that Smithfield is an intolerable nuisance for only two days out of the seven, whilst the neighbourhood is a permanent centre of mental and physical contagion.

Smithfield market is condemned; and sooner or later it must be abolished, although as the Act for its abolition was passed by the last Administration, it is more than probable that some ridiculous blunder will enable the City authorities still to resist. For, in passing, we may observe that the Whig Administration have very ingeniously contrived to spoil every measure they introduced for the improvement of our internal regulations, by the choice of their agents. Witness the Health of Towns Bill, the Sewers Commission, the Extramural Sepulture, the Water Supply, &c.; all founded upon good principles, and intended to meet the requirements of some urgent necessity, but all alike spoilt by the incapacity, or the carelessness, or the insolence of the agents to whom they were intrusted. In fact, as the Whigs *did* propose the Smithfield Abolition Bill, it is fair to assume *a priori* that they have again compromised a necessary measure—at least for a time.

The measure was necessary because, firstly, the value of land in the City is too great to admit of a market being ever constructed there sufficiently large to obviate the nuisances now attaching to the market itself; secondly, because if even a good market could have been constructed, it is essential that the various attendant trades should be removed elsewhere. It seems, however, that the City authorities have determined to carry the market to the Caledonian Fields, and that considerable opposition to that project has arisen on the part of the inhabitants of the neighbourhood.

On the score of nuisance I cannot say that I think that much injury will be inflicted upon them, because, to my mind at least, there will be an advantage in the substitution of a large, open, well-drained market for the evils usually attending brick-fields near London, or for the existing accumulation of filth so common in this abandoned part of the metropolis. Any person who will take the trouble to walk near the Regent's Canal and the Gasworks must at once have ocular and nasal demonstration that anything like a market—quoad market—which, by drawing together many people, will compel the parochial authorities to mend their ways, must produce a contingent good effect upon the neighbourhood far exceeding any nuisance it can itself create. But it may fairly be questioned whether the parochial authorities, who have allowed this district to become what it is, would be likely to regulate the slaughter-houses, tripe-boilers, bone-dressers, and other trades following in the wake of a market; and in case these nuisances should be allowed to develope themselves with all the rank luxuriance of the existing laystalls, possibly the new market would add to the actual evil. It would behove the City authorities to adopt such precautions as lie in their power to prevent such a contingency—it behoves the parochial authorities to suppress the evils which now exist, and hereafter they will be more justified in interfering with such others as may arise. It must, however, be repeated, that if a market be well situated and properly constructed, there are really no nuisances of necessity connected with *it;* so that, in fact, the question, so far as the public is concerned, resolves itself into this—"Is the situation proposed the best which can be found?" For several reasons I say "No; and, if the market must be in the northern suburbs of London, that the existing Islington Market is in a better situation."

First, Islington Market lies higher, and is, therefore, more easily susceptible of being drained.

Secondly, it exists *de jure*, and almost *de facto*, so that opposition on that score cannot be maintained.

Thirdly, as a very respectable neighbourhood surrounds the market, it is probable that great vigilance will be observed in preventing the establishment of the usual concomitant nuisances.

Fourthly, Islington Market is situated upon the principal line of arrival of cattle for the London market, and it has very commodious access on every side, which would not be the case on the west of the proposed site in the Caledonian Fields.

Fifthly, if Islington Market be somewhat farther removed from the Junction Railway than the proposed site, yet the nature of the works required to put it in connectiou therewith is much lighter. And as Islington Market could at present be purchased at a rate probably lower than the new site, it is reasonable to suppose that the capital outlay would be less.

Sixthly—and this is the most important consideration—if London be divided into a series of districts it will be found that Islington Market is considerably nearer to the mean centre of gravity of those districts than the Caledonian Fields; and that consequently the distance, to be traversed in going to and fro the market, will be less in the former than than in the latter case; and at the same time the access from all quarters is far easier.

I have, in the above remarks, studiously avoided entering into the question of the advisability of concentrating the whole of the cattle trade to one spot. Indeed, for many reasons it would appear to be preferable to form two, or perhaps three, markets at much greater distances. I have taken it for granted, however, that the Government project is to be carried into effect, and the great cattle-market formed at some spot in the northern suburbs; and really, if those very questionable considerations are to be accepted as the postulates in the discussion of the subject, it appears to me that Islington possesses such advantages over its more favoured rival as to warrant the expression of surprise at least that the vested rights of its proprietary should have been so entirely neglected.

G. R. B.

London, July 31st, 1852.

TIMBER AND ORNAMENTAL WOODS.

At the Great Exhibition there was exhibited a valuable collection of woods from all parts of the world, by Mr. W. W. Saunders, which was particularly interesting on account of its extent and arrangement, the woods being all labelled and classified; and their value is greatly enhanced by the publication of the following classified catalogue. The Jury awarded Mr. Saunders a Prize Medal for the series.

WOODS, NATIVE OF OR GROWN IN BRITAIN.

Name and Place of Growth	Weight per Cub. Ft.		Specific Grav.	Remarks.
	lb.	oz.		
Abele. *see* Populus				
Abies excelsa (spruce fir)—Oxfordshire	27	2	·434	Used for scaffold poles, ladders, carpentry, &c.
Acacia. *see* Robinia				
Acacia (?)—Mortlake . . .	47	6	·758	
Acer campestre (maple)—Oxfordshire	37	1	·593	Used for ornamental work when knotted; makes the best charcoal; turns well
,, ,, Epping	37	13	·605	
Acer pseudo-platanus (sycamore) Wandsworth	34	11	·555	Used in dry carpentry; turns well; takes a fine polish
Æsculus hippocastanum (horse chesnut)—Wandsworth	24	2	·386	Used for inlaying toys, turnery, and dry carpentry
,, ,, Epping	29	15	·479	Stem of a young, vigorous tree
,, ,, Oxfordshire	24	15	·439	
Alder. *see* Alnus				
Alnus glutinosa (alder)—Oxfordshire	23	8	·376	Used for common turnery work, &c.; lasts long under water, or buried in the ground
,, ,, Epping	26	2	·418	
Apple. *see* Pyrus				
Arbutus unedo (Arbutus) . .	44	12	·716	Hard, close-grained; occasionally used by turners
,, ,, Lakes of Killarney	45	6	·726	
Ash, common. *see* Fraximus.				
,, mountain. *see* Pyrus				
Aspen. *see* Populus				
Barberry. *see* Berberris				
Beech, common. *see* Fagus				
Berberris vulgaris (Barberry) .	37	11	·603	Used chiefly for dyeing
Betula alba (common birch)—Epping	34	14	·558	Inferior in quality; much used in the north of England and Scotland for staves of herring-barrels
Bignonia radicans—Mortlake .	19	3	·307	
Birch, common. *see* Betula				
Blackthorn. *see* Prunus				
Carpinus Betulus (hornbeam)—Epping	40	5	·645	Very tough; makes excellent cogs for wheels; forms a good charcoal; much valued for fuel
,, ,, ,,	38	0	·608	
Castanea vesca (sweet chesnut)—Epping	27	6	·438	Main stem, near the ground
,, ,, (chesnut)—Cornwall	36	7	·583	Used in shipbuilding; is much in repute for posts and rails, hop-poles, &c.
Catalpa syringæfolia—Mortlake .	26	4	·420	Said to be very durable; capable of a fine polish
Cedar of Lebanon. *see* Cedrus				
Cedrus Libani (cedar of Lebanon)	38	13	·621	Used for furniture, sometimes for ornamental joinery work
,, ,, ,, Kew Gardens	34	3	·547	
,, ,, (?) ,, (?)	36	12	·588	
Cerasus vulgaris (May Duke cherry—Wandsworth	41	1	·657	Cherry-wood is much used for common furniture
,, ,, (common cherry) .	33	3	·531	Excellent for common furniture, and much in repute; it works easily, and takes a fine polish
,, ,, ,, Epping	42	1	·673	
Cherry. *see* Cerasus				
Chesnut, horse. *see* Æsculus				
Chesnut, sweet. *see* Castanea				
Cork tree. *see* Quercus				
Corylus Avellana (common nut) .	36	0	·576	The young wood is used for fishing rods, walking-sticks, &c.
,, ,, (hazel)—Epping .	36	8	·584	
,, ,, (filbert)—Oxfordsh.	35	13	·573	
,, ,, ,, Epping .	37	4	·596	
Crab. *see* Pyrus				
Cratægus oxyacantha (whitethorn) Epping	45	14	·734	Hard, firm, and susceptible of a fine polish
Cupressus sempervirens — Mortlake	34	10	·554	Fine-grained and fragrant; very durable.
Cytisus laburnum (common laburnum)—Oxfordshire	45	9	·729	Hard and durable; much used by turners and joiners
,, ,, ,, Wandsworth				
Damson. *see* Prunus				
Elder, common. *see* Sambucus				
Elm. *see* Ulmus				
Euonymus europæus (lance-wood)	34	0	·544	Used for skewers; hard, and fine-grained
Euonymus?—Wandsworth .	32	6	·518	
Fagus sylvatica (common beech)—Epping	27	6	·438	From the lower branch of a large tree
,, ,, ,, Oxford	41	2	·658	Much used for common furniture, handles of tools, wooden vessels &c.; when kept dry, is durable.
,, ,, ,, Epping	39	14	·638	
Filbert. *see* Corylus				

WOODS, NATIVE OF OR GROWN IN BRITAIN—*continued*.

Name and Place of Growth.	Weight per Cub. Ft.		Specific Grav.	Remarks.
	lb.	oz.		
Fir, Scotch. *see* Pinus				
,, silver. *see* Pinus				
,, spruce. *see* Abies				
Fraxinus excelsior (common ash) Oxfordshire	36	11	·587	Very tough and elastic; much used by the coachmaker and wheelwright, and for making oars.
Furze. *see* Ulex				
Hazel. *see* Corylus				
Hedera Helix (Ivy) . . .	29	10	·474	
,, ,, Oxfordshire	37	12	·604	
Holly. *see* Ilex				
Hornbeam. *see* Carpinus				
Horse-chesnut. *see* Æsculus				
Ilex aquifolium (holly) . . .	41	9	·665	The best white wood for Tunbridge ware work; turns well; takes a very fine polish.
Ivy. *see* Hedera				
Juglans regia (common walnut)—Sussex	41	8	664	Wood of a large branch.
,, ,, ,, Sussex	36	1	·577	Taken from the main stem; used for ornamental furniture; much in repute for gunstocks; works easily
,, ,, ,,	36	7	·583	A very old tree
,, ,, ,, Sussex	20	5	..	Used for ornamental furniture
Laburnum. *see* Cytisus				
Lancewood. *see* Euonymus				
Larch. *see* Larix				
Larix europæa (larch)—Oxfordshire	35	0	·560	Used in house carpentry, and for shipbuilding; durable, strong, and tough.
,, (Scotch larch)—Scotland	29	4	·468	Used in shipbuilding
Laurel. *see* Prunus				
Lilac. *see* Syringa				
Lime. *see* Tilia				
Liriodendron tulipifera (tulip tree)	27	2	·434	Apparently of little value; attains to a large size
Locust. *see* Robinia				
Magnolia glauca	31	7	·503	
Magnolia grandiflora—Putney .	37	5	·597	In the United States grows with a clear stem of 60 to 80 feet high.
Maple. *see* Acer campestre				
Morus nigra (common mulberry)—Mortlake	41	5	·661	Sometimes used for furniture, and by turners; of little durability
Mountain ash. *see* Pyrus				
Mulberry. *see* Morus				
Negundo fraxinifolium — Wandsworth	33	15	·543	Rather fine-grained, but of little value
Nut. *see* Corylus				
Oak. *see* Quercus—Marden, Kent	50	8	·808	Dug out of a deep cutting of the South-Eastern Railway
Pear. *see* Pyrus				
Pine. *see* Pinus				
Pinus Picea (silver fir) . .	23	2	·370	Used for house carpentry, masts of small vessels, &c.
,, ,, Wandsworth	28	7	·455	
Pinus sylvestris (pine) — Oxfordshire	24	5	389	Much used for rafters, girders, and house carpentry
,, ,, (Scotch fir) ,, .	19	5	·309	Much used for house carpentry
Plane. *see* Platanus				
Platanus orientalis (plane) — Wandsworth	39	12	·636	An inferior wood; much used in the Levant for furniture, &c.
,, ,, ,, Wandsworth	33	7	·535	Shows a pretty mottled figure if cut with the ray
,, ,, ,,	35	9	·569	
Platanus sp. (Scotch plane)—Scot.	37	6	·598	
Plum. *see* Prunus				
Pomegranate. *see* Punica				
Populus alba (Abele) . . .	27	11	·443	Light and soft, of little value
,, (white poplar) — Wandsworth	25	9	409	
Populus dilatata (Lombardy poplar)—Wandsworth	21	13	·349	Soft and spongy; rapidly decaying unless kept dry
Populus tremula (aspen)—Epping	31	2	·498	The lower part of the main stem; used by turners, and for dry carpentry
Populus sp. (Scotch poplar)—Scotland	34	6	·550	
Prunus armeniaca (apricot)—Mortlake	46	13	·749	Hard and fine-grained
Prunus domes. (damson)—Wandsworth	45	8	·728	Hard and fine-grained; not very durable; used for turning, &c.
Prunus domestica (Orleans plum) —Oxfordshire	44	8	·712	
Prunus laurocerasus (laurel) . .	46	14	·750	Hard, compact, polishing well
,, ,, ,, Epping	42	5	·677	Specimen from an old plant
Prunus spinosa (blackthorn)—Oxfordshire	43	11	·699	Hard, capable of a fine polish, but apt to split
Punica granatum—Mortlake . .	39	4	·628	Hard and close-grained
Pyrus aucuparia (mountain ash)—Yorkshire	38	6	·614	Fine-grained, hard, takes a good polish; used in turnery, and for musical instruments
,, ,, Epping	39	8	·632	
Pyrus communis (Bergamot pear) —Bermondsey	38	9	·617	Strong, compact, close-grained; used for turning handles to tools &c., takes a good black dye.
,, ,, (pear)—Oxfordsh.	38	10	·618	
,, ,, (garden pear)—Epping	40	1	·641	Specimen from the upper part of the main stem
,, ,, (swan's egg pear) —Wandsworth	34	9	·553	
,, ,, (wild pear)—Epping	39	4	·628	A young tree cut near the ground
,, ,, ,, ,,	38	2	·610	Upper part of the main stem

WOODS, NATIVE OF OR GROWN IN BRITAIN—*continued.*

Name, and Place of Growth.	Weight per Cub. Ft. lb.	oz.	Specific Grav.	Remarks.
Pyrus malus (apple)—Oxfordshire	36	0	·576	
„ (garden apple)—Epping	39	7	·631	Specimen from the upper part of the stem
„ (crab)—Oxfordshire	45	5	·725	A tree about twenty years old
„ „ Yorkshire	45	6	·726	Hard, close-grained, strong
Pyrus sorbus (service tree)—Epping	46	11	·747	Hard, fine-grained, compact; much in repute by millwrights for cogs, friction rollers, &c.
Pyrus torminalis—Isle of Wight	42	7	·679	Strong, fine-grained; for turners
Quercus ilex (evergreen oak)—Wandsworth	47	5	·757	Wood very shaky when aged; is durable and strong; and makes an excellent charcoal
„ „	47	4	·756	
„ „ Surrey	40	2	·642	
Quercus pedunculata (English oak)—Sussex	39	0	·624	Much esteemed for shipbuilding; the strongest and most durable of British woods
„ „ (pollard oak)—Wandsworth	44	10	·714	An old tree
„ „ (common oak)—Epping	40	14	·654	Part of a large lower branch
„ „ „ Epping	40	11	·651	Part of a large branch
Quercus sessiliflora (Welsh oak)	37	11	·603	Good wood for shipbuilding; said to be inferior to common oak
Quercus suber (cork tree)—Botanic Garden, Chelsea	51	10	·826	Heavy and durable, but very apt to split
Quercus sp. (American oak)—Wandsworth	42	9	·681	Hard, compact
„ (bastard oak)—Tackley, Oxon	33	6	·534	
„ (Spanish oak)—Oxfordshire	43	13	·701	Close-grained, apparently a good wood
Rhamnus alaturnus—Mortlake	48	6	·774	Hard and close-grained
Rhamnus catharticus—Epping	34	11	·555	
Rhamnus frangula—Epping	25	8	·408	
Robinia pseudo-acacia (common acacia, locust)	44	1	·705	From upper part of the main stem; much used for treenails in shipbuilding, and is in repute in the United States for posts and rails
„ „ „ Wandsworth	40	11	·651	
„ „ „ Mortlake	55	6	·886	
Salix alba (white willow)—Surrey	24	14	·398	Used for toys, and by the millwright, tough, elastic, durable
Salix caprea (palm sallow)—Oxfordshire	24	8	·332	Tough, elastic; used for handles to tools, and makes good hurdles
Salix fragilis (crack willow)—Oxfordshire	32	0	·392	Light, pliant, tough; is said to be very durable
Salix —— ? (back sallow)—Oxfordshire	33	8	·512	Tough, elastic; well adapted for turning
			·536	
			·474	
Sallow. *see* Salix				
Sambucus nigra (common elder)—Oxfordshire	34	0	·544	
„ „ „ Epping	37	11	·603	
Scotch fir. *see* Pinus				
Service tree. *see* Pyrus				
Silver fir. *see* Pinus				
Spruce fir. *see* Abies				
Sycamore. *see* Acer				
Syringa vulgaris (lilac)—Wandsworth	48	15	·783	Very hard and compact
„ „ Surrey	48	13	·781	
Taxus baccata (yew)	41	9	·665	Used for making bows, chairs, handles, &c.; it is exceedingly durable, very tough, elastic, and fine grained
„ „ West Grinstead	50	12	·812	
Thuja orientalis—Mortlake	34	14	·558	
Tilia europæa (common lime)—Wandsworth	27	3	·435	Used for cutting-blocks, carving, sounding-boards, and toys
Tilia sp. (Scotch lime)—Scotland	30	5	·485	Used for turning and carving
Tulip tree. *see* Liriodendron				
Ulex europæa (furze)—Ilfracombe	52	8	·840	Heavy, hard, close-grained; in the north of Devonshire the stem reaches 6 in. diameter sometimes
Ulmus campestris (English elm)	30	9	..	Used in shipbuilding for under-water planking, &c., being very durable when kept wet or buried in the earth
„ „ „	26	5	·489	
„ „ „	..		·421	
„ „ „	41	9	·665	
„ „ (common elm)—Oxfordshire	34	13	·557	
„ „ „ Epping	39	7	·631	One of the lower branches of a young vigorous tree
„ „ (pollard elm)—West Grinstead	31	13	·509	From an old tree
Ulmus montana (wych elm)—Oxfordshire	35	14	·574	Thought to be better than common elm; used in carpentry, shipbuilding, &c.
„ „ „ Epping	36	5	·581	
Vine. *see* Vitis.				
Vitis vinifera (vine)—Wandsworth	42	11	·683	
Walnut. *see* Juglans.				
Willow. *see* Salix				
Yew. *see* Taxus				

WOODS OF EUROPE.

Name and Place of Growth.	Weight per Cub. Ft. lb.	oz.	Specific Grav.	Remarks.
Abies excelsa (Dantsic deal)	24	10	·394	
„ „	30	7	·487	Wood of good quality
„ „	28	2	·450	„ „
„ (spruce fir)—North of Europe	17	10	·282	Used for common carpentry work
„ (spruce)	25	13	·413	
Arbutus Unedo (Kouramia, Coumaro)—Albania	52	0	·832	Hard, close-grained; used by turners
Bay. *see* Laurus				
Beech. *see* Fraxinus				
Betula alba (Norway birch)—Norway	33	0	·528	Inferior wood; occasionally used in shipbuilding
Birch. *see* Betula				
Box. *see* Buxus				
Buxus sempervirens (box)—Gallicia	60	15	·975	Used by turners, &c.
„ „	54	10	·874	Much used by turners
Castanea vesca (chesnut)—Portugal	40	13	·653	Considered a good wood when not too old
Castano del Pais—Portugal	28	11	·459	Used in shipbuilding
Chesnut. *see* Castanea				
Chrysoxylon. *see* Rhus				
Citron. *see* Citrus				
Citrus aurantium (orange tree)—Albania	40	7	·647	Fine-grained; used by turners and for ornamental work
Citrus Medica (citron)—Greece	31	0	·496	Fine grained
Citrus limonum (lemon tree)—Albania	47	9	·761	Hard, compact, close-grained, and much like the orange
Coumaro. *see* Arbutus				
Cupressus sempervirens (oriental cypress)—Greece	36	5	·581	A very durable wood
Daphne. *see* Laurus				
Deal, Dantsic. *see* Abies				
„ Prussian. *see* Pinus				
Etia. *see* Salix				
Ficus Carica (fig tree)—Albania	34	8	·552	Shrinks in drying; of little value
Fig tree. *see* Ficus				
Fraxinus —— ? (beech)—Albania	39	0	·624	
Ftelia—Albania	40	1	·641	Probably an elm
Gavro „	38	14	·622	
Juglans regia (Nogal del Pais)—Portugal	35	4	·564	Used in shipbuilding
Juglans regia (walnut)—France	37	13	·605	Used for furniture
Kouramia. *see* Arbutus				
Koutsoupia—Albania	33	8	·536	
Laurus nobilis (Bay Daphne Gr.)—Albania	36	0	·576	
Leepa, or Lipa—Greece	28	13	·461	
Lemon tree. *see* Citrus				
Melikoukia—Greece	36	15	·591	
Melios. *see* Ornus				
Nogal del Pais. *see* Juglans				
Oak. *see* Quercus				
Olea europæa (wild olive)—Albania	52	14	·847	Close-grained; occasionally beautifully veined; much used for ornamental work.
Orange tree. *see* Citrus				
Oriental cypress. *see* Cupressus				
Ornus europæa (melios)—Albania	47	1	·753	The manna tree; wood compact
Philike, or feliki—Albania	48	0	·768	
„ „ „	52	10	·842	Heavy and compact
Pina del Pais—Portugal	28	13	·461	Used for common carpentry work
Pine—Gallicia	33	9	·537	ditto ditto
Pinus Laricio (sweet pine)—Portugal	28	15	·463	Strong and durable wood
Pinus sylvestris (Dantsic fir)—Prussia	32	4	·516	Used in carpentry work
„ (Riga fir)—Prussia	37	10	·602	ditto ditto
„ (Prussian deal)	43	6	·674	Used for decks of ships, and for carpentry work
Pinus —— ?—Cadiz	38	14	·622	A heavy, hard pine
Pournari. *see* Quercus				
Prunari. *see* Quercus				
Quercus cerris (Adriatic oak)—Trieste	37	15	·607	Strong and useful for shipbuilding
Quercus pedunculata (Baltic oak)—Prussia	37	12	·604	Extensively used in shipbuilding
Quercus sessiliflora (East country)	40	1	·641	ditto ditto
Quercus —— ? (Prunari Pournari)—Albania	51	13	·829	Heavy, but much given to split
Quercus sp., Adriatic oak?—Trieste	54	1	·865	Used in shipbuilding
Rhus cotinus (Chrysoxylon, young fustic)—Albania	38	0	·608	Produces a yellow dye
Ricchi—Albania	52	14	·846	Much used for charcoal in Albania
Roble del Pais—Portugal	64	0	1·024	Used for shipbuilding
Salix —— ? (Etia)—Albania	34	15	·559	
Salix —— ? (Sklythra)—Albania	27	8	·440	Probably a willow
Skiua—Albania	48	10	·778	
Sklythra. *see* Salix				
Spruce fir. *see* Abies				
Svedàmi—Greece	46	6	·742	
Young fustic. *see* Rhus				
Zinsiñn	47	7	·759	

WOODS OF ASIA.

Acacia —— ? (Popeeah)—Tavoy	23	3	·371	A large tree, used in housebuilding
„ „ „	23	3	·371	A very large tree, used for posts, bows, rollers, and cotton gins
Ægle marmelos (Bellee)—Ceylon	49	1	·784	
Amboyna. *see* Pterospermum				

WOODS OF ASIA—*continued.*

NAME AND PLACE OF GROWTH.	Weight per Cub. Ft.		Specific Grav.	REMARKS.
	lb.	oz		
Anacardium latifolium (Bhela)—Gualpara	37	0	·592	Used for making chests & couches
Andrachne apetala—India	33	14	·542	
Angelly wood. *see* Artocarpus				
Annan-beng. *see* Fagræa				
Artocarpus Chaplasha—India	34	12	·556	
Artocarpus hirsuta (Angelly wood)—Cochin	36	14	·590	Used in shipbuilding
Artocarpus integrifolia (Jack wood)—Travancore	35	10	·570	
Artocarpus ——? (Pynathe, Tanabeng)—Tavoy	..		..	
Aultoovanchee—Travancore	31	6	·502	
Auyanny—Travancore	32	11	·523	
Averrhoa Carambola—India	39	11	·635	
Bah-nah-thoa—Tavoy	..		..	Used in boat and house building
Bellee. *see* Ægle marmelos				
Betula Bhojpattra—Nepal	35	5	·565	Moderately hard, compact
Bhela. *see* Anacardium				
Bignonia chelonoides—Nepal	42	8	·680	A large tree
Bignonia ——? (Tathee)—Tavoy	49	8	·792	A very large tree
" (Thuggainee) "	40	4	·644	A large tree, used in housebuilding
Black ebony. *see* Diospyrus				
Booroota. *see* Swietenia				
Cadooca Marum—Travancore	38	3	·611	
Calophyllum ——? (Thurappe Chopee)—Martaban	43	0	·688	Used for masts, spars, and pestles to oil-presses
Cambogum—Travancore	28	11	·459	
Camoo	36	0	·576	
Camphor wood. *see* Laurus				
Cannal—Travancore	47	6	·758	
Cannao "	58	7	·935	
Caragagaloo "	33	0	·528	
Carapa ——? (Talla-oon)—Tavoy	36	0	·576	Used in housebuilding
Careya ——? (Kaza)—Martaban	46	0	·736	Timber large, used for posts, &c.
" (Kombo)—Gualpara	42	12	·684	Hard and strong; used for stocks of matchlocks
Caringosha—Travancore	45	5	·725	
Carivagah "	33	10	·538	
Caroogha "	44	10	·714	
Caroo Marnm "	47	11	·763	
Carrintha "	34	4	·548	
Cassia—India	41	9	·661	
Castanea indica—India	39	0	·624	
Castanea tribuloides (Cotoor, Chisee, Makoo Shingali)—Nepal	62	0	·992	Used for large mortars and pestles for grinding corn
Catunguin—Manilla	42	11	·683	Used in shipbuilding
Caultoo mooroonga—Travancore	45	15	·734	
Cedar—India	25	2	·402	
Cedar of Himalaya. *see* Juniperis				
Cedrela Toona (Toon, Tunga, Poma, Jeea)—Gualpara	36	0	·576	Wood very durable, and much used for furniture
" " " India	32	9	·521	
Chambagum—Travancore	37	11	·603	
Chana—Travancore	20	7	·327	
Chasepoo. *see* Laurus				
Chikagambhari. *see* Premma				
Chincona gratissima (Tungnusi)—Nepal	23	0	·368	Used for posts and rafters
Chisee. *see* Castanea				
Choomulloo. *see* Diospyrus				
Choo-muna. *see* Xanthophyllum				
Chopee. *see* Calophyllum				
Chorangaree—Travancore	29	11	·475	
Cæsalpinea Sapan (Sappan)	60	14	·974	Used for dyeing, and sometimes by the turner
Coombool—Travancore	31	14	·510	
Cotoor. *see* Castanea				
Coturnba—Ceylon	23	5	·373	Occasionally used in housebuilding in Ceylon, but not esteemed
Cou-moo—Tavoy	..		..	Used in boat and housebuilding
Cusroo. *see* Quercus				
Cynometra polyandra—India	52	10	·842	
Cynometra ——? (Maingga)—Martaban	48	7	·775	A small tree
Dalbergia lanceolaria (Neddoon, Nedun, Nander-wood)—Ceylon	45	7	·727	Used and valued for housebuilding in Ceylon
Dalbergia latifolia (East India ebony)—India	66	8	1·064	
Debool—Ceylon	38	3	·615	
Dheyri. *see* Taxus				
Diospyrus melanoxylon (black ebony)	61	2	·978	Used for turnery work and for inlaying
Diospyrus racemosa—India	34	11	·555	
Diospyrus ——? (Ryamucha, Choomulloo)—Martaban	50	3	·803	Used in housebuilding
Dipterocarpus ——? (Kunneanphew)—Tavoy	25	3	·403	Grows to a great size; is used for beams and planks
Domba—Ceylon	33	3	·531	Used for the outriggers of canoes
Dombeya melanoxylon (St. Helena ebony)—St. Helena	71	9	1·145	
East India ebony. *see* Dalbergia				
East India rosewood—India	..		..	
East India teak. *see* Tectona				
Ehretia lævis—Botanic garden, Calcutta	..		..	
Ekebergia ——? (Jiyakohi)—Gualpara	39	1	·625	
Eleocarpus serratus? (Weraloo)—Ceylon	33	8	·536	
Eriobotrya japonica (Loaquat)—India	46	11	·747	

WOODS OF ASIA—*continued.*

NAME AND PLACE OF GROWTH.	Weight per Cub. Ft.		Specific Grav.	REMARKS.
	lb.	oz.		
Eugenia malacoensis (Jamboo)—Ceylon	30	4	·484	
" " " Ceylon	30	14	·494	
Excœcaria?—Tavoy	..		..	
Fagræa fragrans (Annah-beng)—Martaban	52	8	·840	Timber large, compact, and very hard
Ficus ——? (Thubboo)—Tavoy	21	0	·336	Used in house carpentry
Gadeboo—Ceylon	21	3	·339	Used for making charcoal for gunpowder
Galloopah—Travancore	53	0	·848	
Garcinia ——? (Pullowa)—Tavoy	45	8	·728	A large tree, used for posts
Garcinia ——? (Purrah wah) "	45	8	·728	A strong, durable wood
Ghese. *see* Quercus				
Gmelina arborea—India	32	3	·515	
" "	32	6	·518	
Go-na—Ceylon	24	8	·392	
Gordonia? (Kaza)—Martaban	37	10	·602	Large timber; used for ordinary building purposes
Guacua—India	41	14	·670	
Guava. *see* Psidium				
Gundruey—India	34	15	·559	With an odour resembling aniseed
Heretiera ——? (Soondree)—India	57	15	·927	Used in shipbuilding
" " "	49	15	·799	
Hibiscus macrophyllus—Tavoy	27	13	·445	A middle-sized tree, used for common building purposes
" " "	28	0	·448	
Hibiscus?—Tavoy	..		..	Used for common building purposes; bark made into cordage
Hopea floribunda (Tantheya)—Tavoy	27	11	·443	A very large tree
Hopea odorata (Tengaun, Thaengong)—Martaban	38	0	,608	Canoes are made of this tree; it produces a valuable resin
" " " Tenasserim Coast	40	12	·652	Used in boatbuilding, grows to a large size, and is abundant
Hune—Burma	..		..	
Indian saul. *see* Shorea				
Indian wood	45	6	·726	
Iron wood. *see* Metrosideros				
Jack wood. *see* Artocarpus				
Jamboo. *see* Eugenia				
Jeea. *see* Cedrela				
Jeeah—India	36	11	·587	
Jiyakohi. *see* Ekebergia				
Juglans pterococca—India	39	14	·638	
Juniperus excelsa (Cedar of Himalaya)—India	34	7	·551	An excellent light wood
Kaantha—Tavoy	..		..	Small but valuable timber
Kain-tha-phogee. *see* Symplocos				
Kaunzo-kurro—Tavoy	43	0	·688	Used in boatbuilding
Kayzal. *see* Laurus				
Kaza. *see* Careya				
Kaza. *see* Gordonia				
Keahnaun—Tavoy	..		..	
Keaunan. *see* Xylocarpus				
Keaza-Perroun—Tavoy	..		..	Used in housebuilding
Keetha. *see* Syndesmis				
Keoun-lae. *see* Rottlera				
Kombo. *see* Careya				
Kuddoot-alain—Tavoy	53	3	·851	Grows to a great size; used in housebuilding
Kuddoot-nee—Tavoy	34	0	·554	An inferior wood; used in boatbuilding
" "	34	3	·547	
Kuenmounee. *see* Lagerstrœmia				
Kullowa. *see* Laurus				
Kuneenee. *see* Sterculia				
Kunna. *see* Pierardia				
Kunneen-phew. *see* Dipterocarpus				
Kunneen keunkee. *see* Bignonia				
Kunneen keunia. *see* Symplocos				
Kurrowa. *see* Laurus				
Kuzzoo. *see* Pierardia				
Lagertsrœmia reginæ—India	46	8	·744	
Lagerstrœmia ——? (Kuenmounee, Peema)—Tavoy	37	9	·601	
Laurus camphora? (Camphor-wood)—China	35	14	·574	A wood emitting an agreeable aromatic odour
Laurus ——? (Kayzal)—Tavoy	43	3	·691	Used in house carpentry
Laurus ——? (Kullowa, Kurrowa)—Tavoy	30	0	·480	Produces the sassafras bark and camphor wood of Martaban
" " "	30	0	·480	
Laurus ——? (Lumpatch, Chasepoo)—Nepal	34	0	·544	Used in carpenters' work, and for beams
Laurus ——? (Panatha)—Tavoy	43	0	·688	Used in house carpentry
Laurus ——? (Sassafras)—India	32	12	·524	
Laurus ——? (Thuggoo)—Tavoy	..		..	Used for oars and rudders
Lolsi. *see* Taxus				
Loquat. *see* Eriobotrya				
Lumpatch. *see* Laurus				
Malkay. *see* Murraya				
Maingga. *see* Cynometra				
Makoo-shingali. *see* Castanea				
Manga Chapui—Manilla	41	15	·671	Used in shipbuilding
Maroothee—Travancore	37	7	·599	
Maunthaen or Sassafras—Tavoy	36	10	·586	Used in making house furniture
Maymaka—India	51	12	·828	Used for timber of junks
May-rang—Tavoy	48	9	·777	Said to be very durable; used for posts of houses
Megeongee "	38	9	·617	Very large, used in housebuilding
Melia Azadirachta—India	46	1	·739	
Metrosideros vera (iron wood)—China	53	0	·848	Used for anchors by the Chinese

WOODS OF ASIA—*continued.*

NAME AND PLACE OF GROWTH.	Weight per Cub. Ft.		Specific Grav.	REMARKS.
	lb.	oz.		
Mimosa odoratissima—India	45	6	·726	
Mimosa polystachya—Calcutta	32	0	·512	
Mimusops Elengi—Tavoy	46	0	·736	A slow-growing tree
Moluvé or Moloba—Manilla	51	8	·819	Used in shipbuilding
Moonga Vallah—Travancore	38	5	·618	
Mootoocorandy ,,	38	13	·621	
Morinda citrifolia—Botanic garden Calcutta	28	10	·458	The root yields a red dye
Morung Saul. *see* Shorea				
Munhacadamboo—Travancore	38	15	·623	
Murraya ——? (Maikay)	60	13	·973	A strong tough wood
Myrsine capitellata—Nepal	21	11	·347	Said to be compact and hard
Nander wood. *see* Dalbergia				
Nar, or sacred wood—Ceylon	55	0	·880	Used by the natives for building temples and royal palaces; an excellent wood
Neddoon. *see* Dalbergia				
Nedun. *see* Dalbergia				
Neerovalum—Travancore	24	5	·389	
Nellee—Ceylon	34	8	·552	
Nelty, or Nelly—Travancore	42	5	·677	
Nerium Tinctorium—India	39	14	·638	
Nun Poungoo—Travancore	56	15	·911	
Odina Wodier—India	41	0	·656	
Osyris peltata (Phaoun)—Tavoy	29	10	·474	
,, ,, India	30	8	·488	
Pah-doubh	60	0	·960	
Palaepean. *see* Sapotea				
Palah—Travancore	14	9	·230	
Palai—Borneo	23	13	·381	Used in the construction of canoes
Palm—India	57	9	·921	
Palmist ,,	62	7	·929	The wood of one of the palms used for marqueterie work
Panacha—Travancore	44	14	·718	
Panatha. *see* Laurus				
Peema. *see* Lagerstrœmia				
Pen-lay-oun	32	0	·512	Affords good crooked timber
Pen-lay-peen—Tavoy	..		..	
Peroomarum—Travancore	27	14	·446	
Phaoun. *see* Osyris				
Pienmahne—Tavoy	..		..	
Pieumah-pue ,,	..		..	
Pierardia? (Kunna, Kusso)—Tavoy	37	12	·604	
Pinus dammara—Tavoy	39	0	·627	
Pinus longifolia—Nepal	..		..	Excellent timber
Pinus Webbiana ,,	21	0	·336	
Poma. *see* Cedrela				
Poomaram—Travancore	29	8	·472	
Poomdroo ,,	28	15	·463	
Poonah ,,	40	13	·653	
Poovem ,,	50	15	·815	
Popeeah. *see* Acacia				
Pothiree—Travancore	35	4	·564	
Premma hircina (Chikagambhari) —Gualpara	43	0	·691	A strong odour like that emitted by the musk-rat, is given out; used for musical instruments
Psidium pomiferum (Guava)—Travancore)	44	8	·704	
Pterocarpus santalinus (Rea Sandus)—India	46	14	·750	
Pterocarpus ? (Thoun-kheea)—Martaban	51	9	·826	
Pterospermum indicum (Amboyna)—East Indian islands	39	10	·634	Much used for ornamental work
Pullowa. *see* Garcinia				
Purrah-wah. *see* ditto				
Pusseen-zwa. *see* Ternstrœmia				
Pynyathe. *see* Artocarpus				
Quercus Amherstiana (Tirbbae, Ryakle)—Martaban	57	10	·922	Used for coarse furniture
Quercus fenestrata—India	47	0	·752	
Quercus lanceafolia ,,	41	10	·666	
Quercus lappacea ,,	51	4	·820	
Quercus semecarpifolia (Ghese, Cusroo)—Nepal	22	0	·352	Wood light, from a large tree
Red sanders. *see* Pterocarpus				
Regal wood—Thibet	54	6	·870	Very beautiful; much prized; used by persons of high rank only
Rhizophora decandra—India	46	0	·736	
Rottlera? (Keoun-lae)—Tavoy	37	9	·601	Large tree; wood used for rudders
Ryakle. *see* Quercus				
Ryamucha. *see* Diospyrus				
Sacred wood. *see* Nar				
Saint Helena ebony. *see* Dombeya				
Sandoricum —? (Thittoo)—Tavoy	28	6	·454	Used for furniture
Santalum album—India	47	13	·765	
Sapan. *see* Cæsalpina				
Sapbew. *see* Xanthophyllum				
Sapotea? (Palaepean)—Tavoy	41	0	·656	Very large tree; used in building
Sassafras. *see* Laurus				
Satin wood. *see* Swietenia				
Scytalia longan—India	44	8	·712	
Scytalia trijuga ,,	60	0	·960	
Scytalia ——? ,,	39	6	·630	
Shorea robusta (Indian saul)	52	10	·842	Strong and durable; in great repute for shipbuilding
,, (Morung saul)—Nepal	43	14	·702	
,, ,, ,,	45	14	·734	Used in India where strength and durability are required
Sonneratia? (Thaumma)—Tavoy	42	0	·672	A small tree
Soondree. *see* Heretiera				
Sophora robusta—India	42	4	·676	
Sterculia? (Kuneensee)—Tavoy	..		..	Of very large dimensions

WOODS OF ASIA—*continued.*

NAME AND PLACE OF GROWTH.	Weight per Cub. Ft.		Specific Grav.	REMARKS.
	lb.	oz.		
Swietenia chloroxylon (Satinwood, Booroota)—Ceylon	51	0	·816	Used for furniture, &c.
Swietenia febrifuga—India	54	14	·378	
Symplocos floribunda—Nepal	..		..	A large tree
Symplocos? (Kain-tha-phogee)—Tavoy	34	7	·551	Affords good crooked timber
Symplocos? (Kunneen-keunkee, Kunneen-keunla)—Tavoy	34	4	·548	Used for beams, posts, &c.
Syndesma tavoyana (Keetha)—Tavoy	..		..	Used in housebuilding
Taaka. *see* Tectona				
Talia-oon. *see* Carapa				
Tanabang. *see* Artocarpus				
Tantheya—Tavoy	44	0	·704	
,, *see* Hopea				
Tathee. *see* Bignonia				
Taxus virgata (Dheyri, Loisi)—Nepal	..		..	Grows to a large size; the timber strong and good
Teak. *see* Tectona				
Tectona grandis (Teak, Taaka, Tekka)—Ceylon	47	8	·755	One of the best of the Ceylon woods
,, ,, Travancore	42	8	·680	Strong and durable; much valued for shipbuilding
,, ,, East Indian teak)—Malabar coast	37	14	·606	The best kind of teak
,, ,, Moulmein	31	9	·505	
,, ,, ,,	32	1	·513	Not so good as the Malabar
Tekka. *see* Tectona				
Tengaun. *see* Hopea				
Terminalia catappa—Botanic Garden, Calcutta	30	0	·480	A noble ornamental tree; wood very good
Terminalia chebula—India	42	10	·682	
Terminalia citrana ,,	60	2	·962	Very heavy and compact
Terminalia ——? (Thuphauga)—Tavoy	50	5	·805	
Ternstrœmia ——? (Puzzeen-zwa) —Tavoy	36	7	·783	A rather large tree; used for posts and rafters
Tetranthera nitida—India	34	4	·548	
Tentha—Tavoy	54	0	·864	
Thaengong. *see* Hopea				
Thallaroo—Travancore	44	0	·704	
Thambuvoo—Travancore	55	6	·886	
Thau-baun-po—Tavoy	..		..	An inferior light wood
Thau-baun-thau-lay—Tavoy	..		..	A strong durable wood, but does not saw kindly
Thaumma. *see* Sonneratia				
Thittoo. *see* Sandoricum				
Thoun-Kheea. *see* Pterocarpus				
Thoun-mynga—Tavoy	48	0	·768	Used in housebuilding
Thubboo. *see* Ficus				
Thuggainnee. *see* Bignonia				
Thuggoo. *see* Laurus				
Thuphanga. *see* Terminalia				
Thurappe. *see* Calophyllum				
Thymboo—Tavoy	17	7	·279	Strong and durable light wood
Thymboo, Thau-baun-po—Tavoy	17	3	·275	Strong durable light wood, used in boatbuilding
Tirbbae. *see* Quercus				
Toon. *see* Cedrela				
Town-pine—Tavoy	28	13	·461	Used in boatbuilding; esteemed
Town-suggah ,,	..		..	
Tunga. *see* Cedrela				
Tungnusi. *see* Chincbona				
Une—Tavoy	..		..	Affords good crooked timber, for boatbuilding
Vallathorashel—Travancore	22	1	·353	
Vanava—Manilla	42	11	·683	Used in shipbuilding
Vaneemooringa—Travancore	40	10	·650	
Vateria lanceæfolia—India	53	15	·863	
Vavoolagoo—Travancore	29	4	·468	
Velilagoo ,,	28	8	·456	
Velty, or Vetty ,,	40	11	·657	
Venga ,,	47	1	·753	
Vinnee ,,	15	8	·248	
Vinny marum ,,	11	3	·179	
Vyashanthak ,,	41	0	·656	
Weraloo. *see* Eleocarpus				
White dammar lout—India	..		..	
Xanthophyllum ——? (Saphew, Choo muna)—Martaban	33	10	·538	
Xylocarpus ——? (Keannan)—Tavoy	46	9	·745	Used for furniture and in house building
Zeethee. *see* Zizyphus				
Zizyphus ——? (Zeethee)—India	35	11	·571	
———? —Travancore	..		..	Very light and soft, forming a good substitute for cork to the entomologist
———? —India	46	0	·736	
———? —Travancore	27	14	·446	
———? ,,	44	6	·710	
———? —Arracan	33	9	·537	
———? —India	43	5	·693	
———? ,,	45	4	·724	
———? ,,	50	5	·805	
———? ,,	70	1	1·121	
———? ,,	38	12	·620	
———? ,,	32	9	·521	
———? ,,	45	14	·734	
———? ,,	48	9	·777	
———? ,,	63	5	1·013	
———? ,,	38	14	·622	
———? ,,	37	5	·597	
———? —Tavoy	..		..	Used in housebuilding
———? —India	41	0	·656	

WOODS OF AFRICA.

Name and place of growth.	Weight per Cub. Ft.		Specific Grav.	Remarks, and what used for.
	lb.	oz.		
African oak—Sierra Leone	51	7	·823	The best quality
" "	50	7	·807	Excellent for shipbuilding
"	50	0	·800	Sometimes called Silver oak
" West Coast of Africa	43	11	·699	
African teak	54	5	·869	Shipbuilding; another term for African oak
Bar (Baphia nitida)	36	7	·583	Dyeing and turning
Cam "	34	13	·577	Dyeing and turning
Cam wood " Lion Hills	..		..	Dyeing
Columbice—Madagascar	53	1	·849	
Fernando Po wood—Fernando Po	30	1	·481	Shipbuilding
" " "	45	14	·734	"
Red Sanger wood	61	0	·976	Heavy and compact

WOODS OF NORTH AMERICA.

Name and place of growth.	Weight per Cub. Ft.		Specific Grav.	Remarks, and what used for.
	lb.	oz.		
Ash, American (Fraxinus)	35	10	·570	Tough, elastic, much used
Ash, white—Upper Canada	30	14	·494	
Balsam (Picea balsamea)—Upper Canada	19	0	·304	Carpentry
Bass wood (Tilia)—Upp. Canada	25	0	·400	Even grain, like common limewood
Beech, white (Fagus americana)—U.S.	42	2	·674	
Beech (Fagus ferruginea)—Upper Canada	36	9	·585	Dry carpentry; the wood has more rufous tint than common beech
Birch, black (Betula nigra)	35	7	·567	Shipbuilding in Canada and Nova Scotia, but not a durable wood
Birch (Betula ——?) — Upp. Can.	30	11	·491	An inferior wood
Box elder, ash-leaved maple (Acer Negundo)—U. S.	24	0	·384	
Butter nut (Juglans cinerea)—Upper Canada	23	8	·376	
Butter wood	28	12	·460	Shipbuilding
Button wood, sycamore (Platanus occidentalis)—United States	26	8	·424	Much used for making bedsteads
Cedar (Larix ——?)—Upp Canada	18	6	·294	
Cedar, red or pencil (Juniperus bermudiana)—Bermuda	34	15	·559	Shipbuilding and for making pencils
Cedar, red (Juniperus virginiana)—United States	26	10	·426	For making pencils, but not so good as the junip. bermudiana
Cherry wood (Prunus ——?)—Upper Canada	29	15	·479	
Cherry, wild (Cerasus virginiana) United States	32	3	·515	
Chestnut (Castanea vesca)—U.S.	25	4	·404	
Coffee tree (Gymnocladus canadensis)—U.S.	40	7	·647	Hard, compact, strong, tough
Cypress (Cupressus disticha)—United States	22	13	·365	Grows to an immense size
Dogwood (Cornus florida)—U.S.	47	4	·756	Hard, close-grained strong
Elm (Ulmus americana)—Upper Canada	36	11	·587	
Elm, american rock	36	3	·579	Shipbuilding
Elm, rock	37	10	·602	"
Elm, swamp	33	10	·538	" preferred to English elm
Elm, white	34	5	·549	By wheelwrights
Elm, red (Ulmus fulva)—U.S.	42	8	·680	
" " "	31	2	·498	
Gum tree, sour, or black (Nyssa multiflora)—U. S.	40	6	·646	
Hack-berry (Celtis crassifolia)—U.S.	38	6	·614	Tough, elastic
Hackmatack (Larix americana)	37	9	·601	
" " "	36	2	·578	Esteemed in British N. America for shipbuilding
Hazel, wych, or Quebec rock elm Ulmus?—Canada	34	2	·546	Shipbuilding
" " "	43	11	·699	
" " "	51	6	·822	
Hemlock (Abies canadensis)—United States	23	0	·368	
Hemlock spruce—Upper Canada	23	0	·368	Common carpentry
Hickory (Carya amara)—U.S.	..		..	
Hickory, pignut (Carya porcina)—U.S.	49	8	·792	Stronger and better than any other kind of hickory
Hickory, shell-bark (Carya sulcata)—U.S.	43	2	·690	
Hickory?	47	8	·760	
Hickory (Juglans alba)—Upper Canada	48	2	·770	
Honey locust (Gleditschia triacanthus—U.S.	40	6	·646	Very hard, splits with great facility
Iron wood (Ostrya virginica)—U.S.	48	11	·779	
Judas tree, or red bud (Cercis canadensis)—U.S.	33	7	·535	Close-grained, compact
Locust (Robinia pseud-acacia)—U.S.	45	8	·728	Shipbuilding occasionally, chiefly for treenails
" " "	41	11	·667	
Maple, soft (Acer eriocarpum)—Upp. Canada	36	14	·590	
Maple, red, (Acer rubrum)—U.S.	38	5	·613	
Maple, sugar (Acer saccharinum)—U.S.	38	6	·614	
" " "	39	6	·630	
Maple, bird's eye—Upp. Canada	40	15	·655	Ornamental work by carpenters and joiners
Maple, curly—Upp. Canada	36	10	·586	Common carpentry
Maple, var. bird's eye	36	0	·576	Ornamental work; a peculiar growth of the tree
Maple, hard—Upp. Canada	39	10	·634	

WOODS OF NORTH AMERICA—*continued.*

Name, and place of growth.	Weight per Cub. Ft.		Specific Grav.	Remarks, and what used for.
	lb.	oz.		
Mulberry, red (Morus rubra)—U.S	35	1	·561	
Oak (Quercus alba)—Upp. Canada	47	14	·766	
Oak, white—U.S.	40	1	·641	
Oak, white—Upp. Canada	44	4	·708	Shipbuilding
Oak, Quebec—Canada	33	11	·539	Shipbuilding, but not durable
" "	45	5	·725	Specimen of an inferior quality
"	39	5	·629	Shipbuilding, but not in repute
Oak, Quebec white—Canada	53	12	·860	Shipbuilding
" " "	54	6	·870	"
Oak, red (Quercus rubra)—U.S.	32	2	·514	
Oak, black (Quer. tinctoria)—U.S.	34	14	·558	
Oak, live (Quercus virens)—U.S.	56	4	·900	Heaviest and hardest of the oaks
" " "	51	11	·827	
Pawpaw (Uvaria triloba)—U.S.	22	7	·359	
Persimon (Diospyrus virginiana)—U.S.	44	6	·710	Hard, close-grained
Pine, yellow (Pinus mitis)	23	8	·376	Carpentry work
Pine, Amer. yellow "	22	15	·367	"
Pine, red (Pinus resinosa)—U.S.	28	7	·455	Carpentry; strong
Pine, Amer. red "	26	11	·427	Carpentry
Pine, pitch (Pinus rigida)—South Carolina	32	0	·512	Strong and durable
" "	42	2	·674	Much used in shipbuilding
Pine, Virginia "	34	6	·550	
Pine?—Upper Canada	22	8	·360	Same purposes as common deal
Poplar, yellow (Liriodendron tulipifera)—U.S.	24	3	·387	
Poplar (Populus ——?)—Upp. Canada	20	11	·331	
" " "	19	4	·318	Light, inferior wood
Red bud. *see* Judas tree				
Sassafras (officinale)—U.S.	37	4	·596	From a young tree
Spruce, white (Abies alba)	23	13	·381	
Sycamore. *see* Button wood				
Tamarack (Larix americana)—Upper Canada	23	15	·383	Good for shipbuilding purposes
Treenail (Robinia pseud-acacia)—Upp. Canada	41	8	·664	Treenails in shipbuilding
Walnut, white—U.S.	30	5	·485	From a young tree
Walnut, black (Juglans nigra)—U.S.	28	15	·463	Strong, tough, not liable to split
" " Upper Canada	28	11	·459	

WOODS OF THE WEST INDIES.

Name, and place of growth.	Weight per Cub. Ft.		Specific Grav.	Remarks, and what used for.
Batuta	54	11	·875	Heavy, compact
Braziletto (Cæsalpinia brasiliensis)—Jamaica	51	3	·819	Dyeing and turning
Broad leaf (Terminalia latifolia)——Jamaica	35	0	·560	
Bully tree, bastard (Bumelia salicifolia)—Jamaica	51	9	·825	
Bully tree, black—Jamaica	52	12	·844	
Calabash (Crescentia cucurbitina)—Jamaica	35	0	·560	Rather soft, tough, durable
Cedar (Cedrela odorata)—Jamaica	23	8	·376	Largely used in Jamaica for flooring, doors, &c.
Cedar, bastard (Bubroma guazuma)—Jamaica	41	1	·657	Tough, not durable
Cedar, common—Santa Martha	38	11	·619	Common carpentry
Cocus (Amerimnum ebenus?)—	66	6	1·062	Turning
Cœurbaril (Hymenæa cœurbaril)	60	14	·974	Ornamental furniture
Dogwood (Piscidia erythrina?)—Jamaica	54	13	·877	Hard, durable
Fig, red—Jamaica	25	9	·409	
Fig, white (Ficus ——?)—Jamaica	30	7	·487	Useless, except for fuel
Hard wood—Trinidad	63	8	1·016	Shipbuilding
" St. Lucia	36	15	·591	Shipbuilding
Hogplum (Spondias graveolens)—Jamaica	25	11	·411	Soft, valueless
Horseflesh, or Mangrove—Jamaica	45	15	·735	Sometimes in shipbuilding
Lignum vitæ (Guiacum officinale)	71	8	1·144	Machinery, and turning
Logwood (Hæmatoxylon campechianum)	..		..	Dyeing, occasionally in turning
Mahoe, blue (Hibiscus tiliaceus)—Jamaica	36	8	·584	Remarkable for toughness
Mahogany, Bay—Honduras	26	8	·424	Furniture and shipbuilding, called "Common southern"
" " "	25	13	·413	Shipbuilding, called "Common southern"
" " "	42	11	·683	Shipbuilding, called "Superior northern"
" " "	31	11	·507	Shipbuilding, and called "Good northern"
" " "	36	2	·576	Shipbuilding, called "Common northern"
Mahogany, Cuba	46	11	·747	Exterior of the butt of a log
" "	49	10	·794	Exterior of the top of a log
Mahogany, Honduras—Honduras	26	8	·424	Outside of the butt of a log, quality inferior
" " "	39	6	·630	" " "
" " "	26	2	·418	Interior of the butt of a log, quality inferior
" " "	35	13	·573	Interior of the butt of a log, quality good
" " "	34	11	·555	Exterior of the butt of a log, quality good
" " "	44	1	·705	Interior of the top of a log
" " "	36	9	·585	Exterior of the top of a log

WOODS OF THE WEST INDIES—*continued*

NAME, AND PLACE OF GROWTH.	Weight per Cub. Ft.		Specific Grav.	REMARKS, AND WHAT USED FOR.
	lb.	oz.		
Mahogany, Spanish—Cuba	48	6	·764	Much used for furniture
Mangrove. *see* Horseflesh				
Muss wood—Jamaica	36	6	·582	
Orange, wild—Jamaica	53	14	·862	Hard and durable, but not a true Citrus
Pimento (Eugenia pimenta)—Jamaica	60	3	·963	Hard, tough, durable
Potato wood—Jamaica	29	8	·472	
Prickly yellow (Xanthoxylum clava-Herculis)—Trinidad	35	2	·562	
Sabicu—Cuba	57	5	·917	Excellent for beams and planking in ships
„ „	64	9	1·033	Shipbuilding, much approved in the government yards
Seaside Grape (Coccoloba uvifera)—Jamaica	51	9	·825	Hard, tough, durable
Shad bark—Jamaica	41	4	·660	
Timber sweetwood (Laurus ——?) Jamaica	44	11	·715	
Trinidad Mangrove—Trinidad	61	15	·991	Very hard, firm, close-grained
Tropic birch (Bursera gummifera)—Jamaica	22	15	·367	Used for burning lime; soft, and not durable
Turkey wood (Andira inermis)—Cuba	45	15	·735	Strong, durable
Vallatab—Trinidad	58	12	·940	Shipbuilding
Yellow Mast—Trinidad	56	5	·901	Hard, but rather brittle
——————? „	56	2	·898	
——————? „	37	11	·603	
——————? „	67	3	1·075	

WOODS OF SOUTH AMERICA.

Acapu—Para	56	8	·904	The best wood of the country for standing exposure to the weather; much used in house carpentry
Brazil (Cæsalpina echinata)	58	13	·941	Dyeing and turning
Brazilian hard wood	58	9	·937	Shipbuilding
Brazilian oak—Brazil	51	4	·820	Shipbuilding
Bullet wood—Demarara	58	0	·928	
Cedrela ? (Cearo)—Para	29	3	·467	
Demerara wood—Demerara	23	13	·381	Shipbuilding
Greenheart (Laurus chloroxylon)—Guiana	51	15	·831	Excellent for shipbuilding; and acknowledged by Lloyd's to be one of the eight first-rate
„ „ Brazil	56	5	·901	Shipbuilding
„ „ Guiana	61	13	·989	„
Itanba—Para	54	2	·862	A fine hard wood
King wood—Brazil	43	11	·699	Turning and ornamental furniture
Limoeiro preto—Brazil	..		..	Shipbuilding
Macácaubá—Para	43	13	·701	Hard, handsome; used for furniture
Massaranduba—Para	69	4	1·018	Hard, of good quality
Morra (Mora excelsa)—Demerara	55	12	·892	Valuable for shipbuilding; acknowledged by Lloyd's as first-rate
„ „ „	57	15	·927	Sometimes called Demerara locust
„ „ Guiana	62	13	1·005	Shipbuilding; strong, durable
„ „ „	60	13	·973	„ „
Pao amarella—Para	55	2	·882	Fine yellow, similar to Canary wood
Pao d'arco—Para	54	1	·865	Used by the Indians for bows; is much used in machinery
Piquia—Para	43	15	·703	Very tough; for water-wheels and timbers for boats
Rosewood, or Jacaranda (Mimosa)—Brazil	44	14	·718	Much used for ornamental furniture
Santa Maria	37	8	·600	Occasionally in shipbuilding
Satin-wood	55	5	·885	Shipbuilding
South American hard wood, or Santa Maria-wood—Brazil	47	14	·764	„
South American hard wood, or Sucapura	53	4	·852	„
Stink-wood—Brazil	52	11	·843	Has a very unpleasant smell
Ytu—Para	83	8	1·336	Remarkably heavy and tough
Ytu—Brazil	32	9	·521	For making sugar-boxes
Ytu—Carthagena	25	0	·400	Boxes and common carpentry

WOODS OF AUSTRALIA.

Beef wood	56	12	·908	Ornamental furniture
Black gum, Borkee	56	11	·907	Hard, compact
Blue gum (Eucalyptus piperita)	57	4	·916	Shipbuilding; strong, durable
Box	59	1	·945	
Cedar	34	6	·550	
Findersia Australis	32	5	·517	
Gum wood (Eucalyptus resinifera)	52	9	·841	Shipbuilding
Huon pine (Dacrydium Franklinii)—Van Diemen's Land	25	2	·402	
Iron bark	65	9	1·049	Very hard, compact
Lemon	30	14	·494	
Mahogany	60	13	·973	
Myrtle	36	11	·587	
New South Wales cedar	29	4	·468	Joinery and furniture
New South Wales hard wood	54	9	·873	Shipbuilding
Remor	39	1	·625	
Stringy bark (Eucalyptus ——?)	49	4	·788	Shipbuilding; good for treenails
Swan River mahogany	43	8	·696	Shipbuilding; strong, durable
Trydee	44	13	·717	
———?—Moreton Bay	61	1	·961	

WOODS OF NEW ZEALAND.

NAME, AND PLACE OF GROWTH	Weight per Cub. Ft.		Specific Grav.	REMARKS AND WHAT USED FOR
Ake	40	4	·644	
Ake Ake, or Mohowrangs	63	3	1·011	
Boriele Pureele (Ephialtes ——?)				
Cowdie (Dammara Australis)	33	11	·539	
Fagus	33	3	·531	
Kahikatea (Dacrydium taxifolium)	31	1	·497	
Karigatta, or Manook	57	9	·921	
Káttár				
Kikiteah (Dacrydium taxifolium)	22	13	·365	
Kowdie (Dammara Australis)	35	9	·569	
Mero	48	4	·772	
Mora, or Maire	34	5	·549	
N. Zealand pine (Dammara Austr.)	25	3	·403	Much valued for masts and spars
„ „	26	13	·429	The best quality
Pohutukana	52	2	·834	
Purine	52	5	·837	
Rawa Rawa ?	51	7	·823	
Rewarewa	53	15	·683	Good quality, hard, compact
Rimu	34	6	·560	
Rowai	43	13	·701	
Tanekaha	36	7	·583	
Tangi	33	14	·542	
Tariedy	35	12	·572	
Totara (Podocarpus totarra)	39	5	·629	
Towha	35	4	·564	
Touwai	43	6	·674	

REGISTER OF NEW PATENTS.

ROLLING AND PRESSING MACHINERY.

PETER ARMAND LE COMTE DE FONTAINEMOREAU, of 4, South-street, Finsbury, patent agent, for *certain improvements in lithographic, typographic, and other printing presses, which improvements are also applicable, with certain modifications, to extracting saccharine, oleaginous, and other matters, and to compressing in general.* (A communication.)—Patent dated January 24, 1852.

Claims.—1. The arrangement of apparatus for obtaining impressions from lithographic stones; 2. the modification of the aforesaid apparatus for obtaining impressions from typographic plates; 3. the apparatus for extracting saccharine, oily, and other similar substances; 4. the application of the said apparatus to compressing in general.

First. The damping of the stone may be effected by two different machines. The first of these consists of a thin copper box, wider at the bottom than at the top, and open at the top and bottom parts, but closed at the sides; the lower part is filled with sponge and woollen rags, containing a certain quantity of water in suspension. These sponges and rags are covered over with buckskin, and the whole rests upon a piece of woollen cloth, having the shape of a bag, and fixed at the bottom of the box; this apparatus, when placed across the working parts of the machine, extends the full width of the stone, and damps it all over as it passes underneath. The supply of moisture to the apparatus is rendered constant and equal by the reservoir, from which it escapes in drops through taps, being so constructed and disposed as to be capable of very nice regulation. The next means of obtaining an impression consists in a roller composed of two hollow cylinders, fitted one within the other, the internal one being of cast-iron and the external one of copper; the two cylinders are perforated with a number of small holes, and are retained in their proper relative positions by means of several adjusting screws. By turning one of the cylinders, the size of the apertures will be widened or narrowed, and thus the flow of water with which the interior of the cylinder is filled may be regulated. This cylinder is supplied from a reservoir through copper pipes, passing through the stuffing-boxes, which are fixed to the roller at its extremities; the roller is surrounded with woollen cloth covered with buckskin, and also with a thick woollen stuff. This sponge roller is placed across the machine so that every part may successively come in contact with it. The roller also has a motion communicated inversely, so that it would derive from the friction of the stone its reciprocating motion if it were free; by that means the surface of the stone is thoroughly cleansed, and the particles of dust are deposited on a brush placed above it. As soon as the stone has passed under either of these machines, it is sufficiently damp to receive the ink, which is communicated by two rollers covered with leather. These rollers, denominated respectively transmitting and inking, are surmounted by a rubber surmounted by two other rollers, serving to equalise the flow of ink upon its surface. The rubber is fed by the transmitting roller, which is supplied by the inking roller, against which rests the bottom of the ink box, which may be brought more or less near to it, and by this means the supply of ink is regulated. The ink roller is worked by a system of bevil wheels, which receive their motion through a crank, which also communicates a to-and-fro motion to the table upon which the stone rests; this table can be raised or lowered at will by means of an adjusting screw. The stone moistened and inked, as before described, is ready to transmit the drawing or letters to paper; the necessary pressure to be given to the paper for this purpose is effected by means of a rubber of hard wood, the bottom part of which is in the form of a prism fixed within cast-iron cheeks, which serve to hold it firmly. This rubber has at its extremities two pivots resting in a bearing adapted to two circular plates, at the circumference of which plates are set the pivots of sixteen small rollers turning freely on their axes. These two plates are fixed upon a wrought-iron axis retained in the two bearings of the machine by means of spiral springs, which only admit of a slight vertical motion. The whole thus forms a single roller opened at the bottom, which contains the rubber moveable in one direction and compressed in the other. It is retained in an oblique direction by a spring which presses upon the upper part, and thus leaves a space free for the passage of the stone to be inked. At the moment when the pressure of the rubber is required, it is forced into its perpendicular position by a cam, and remains so as long as the pressure lasts, and when it ceases is again restored to its oblique position by the effect of the spring. The cam just mentioned is fixed on one of the two cog-wheels fixed upon the same axis as the before-mentioned plates, but outside of them, and united by a segment passing outside the before-mentioned small rollers without touching them. The pincers are set upon one of the borders of the segment, which take the paper between them; they are fixed at a certain distance upon two axes, and thus form two rows corresponding with each other. One of these axis presses them against the leather which surrounds the roller, and passes over the small rollers; the other row of pincers seizes the sheet by placing itself upon the first row. The leather is thin, and stretched all over the circumference of the roller from one extremity of the segment to the other; two cog-wheels are adjusted at the two ends of the roller, and turn freely upon their axes. Whilst the stone passes to the inking rollers they are immoveable, and retained by a rod; when the stone returns, this rod is put in motion by two eccentrics, and takes into the cog-wheels, and allows of a complete revolution, by which a sheet is printed. The rubber, which is an essential appendage to the rollers, retains its oblique position until the paper is near the stone, when the cam before mentioned puts the paper in a perpendicular position, and thus presses the leather upon which the paper is set against the stone. This leather, drawn by the rack-work and segment, is kept upon the stone during the pressure of the rubber, which ceases as soon as the stone has reached the proper height. The motion of the pincers is regulated by two eccentrics placed outside and kept in their position by two rods, which transmit to them a partial rotary motion; and, by letting fall the eccentrics corresponding with the axis of the pincers in their entering parts, these pincers are held tight by springs, which force them towards the centre of the roller.

Secondly.—The cylinder containing the before-mentioned rubber can likewise be constructed in the following manner, which affords the advantage of enabling it to be used instead of the pressing cylinders in typographic printing presses. The cylinder described in the former system, as formed of small rollers, consists in this case of cast-iron, formed hollow, polished outside, and opened at the bottom. This opening is of the same size as that occupied by the small rollers in the first-mentioned system. Within this opening is fixed the rubber in the manner previously described, the pincers and the leather acting also in a similar manner. When it is desired to change the friction roller for the pressing cylinders it is merely necessary to take away the rubber, to substitute woollen cloth or felt for the leather surrounding the cylinder, to fix the cog wheels at the two ends of the cylinder by means of screws, and to remove the bolt screw, which prevents the axis of the cylinder from moving upon itself. The pincers, as also the other parts of the mechanism, which are so constructed as to be serviceable in either case, remain, except the sponge roller, which must be suppressed, the types requiring no damping. The process to which the paper is subjected is as follows:—The sheets, after having been damped, are laid in heaps upon the inclined plane at the top of the machine; thence they are taken one by one and presented to the pincers, which conduct them, with the leather, between the stone and the rubber. After receiving the impression they are conducted between rollers formed of small discs fixed upon two superposed axes; there the sheets are left, and the rollers convey them to an inclined plane abutting the table, where another person receives them, and again places them in heaps. The machine is set at work by means of a fly wheel, upon the axis of which is a pulley, which puts in motion another pulley of a larger character, fitted upon an axle, at the other end of which is a crank, by means of which a to-and-fro motion is communicated to the table, and thereby to the stone, as before mentioned.

Thirdly.—The apparatus for the extraction of saccharine, oily, and other matters, consists of a number of plates of iron or steel, forming the links of two endless chains, which pass between a series of five or more rollers, which receive the matters to be pressed, which, when consisting of beet-root, turnips, and other similar matters, have to be previously reduced to a pulp; but if of oleaginous seeds, are reduced to flour. The five pairs of rollers are so arranged that every successive pair has a larger space left between them than between the preceding pair. These rollers turn upon wrought-iron axes, and communicate motion to one another by means of cast-iron cog-wheels, the strength of which is to be proportioned to the required pressure. The plates of the lower endless chain differ from those of the upper ones, the former having a flange on each side, running in the direction of the length of the chain, and also a great number of conical holes with which the bottom of the chain is perforated, through which the liquid escapes, and falls into a receiver placed under the machine, the flanges of which prevent the substance to be pressed from escaping through the sides. The lower plates run upon small rollers, which rest upon the frame; the plates already mentioned are covered with thin plates of sheet iron, pierced also with conical holes; these plates are covered with a thick and strong woollen cloth, upon which is spread the pulp, flour, or other substance to be pressed, which, falling from the rasp or mill (this fall being regulated by any suitable means), forms a thick and even coating upon the plates of the lower chain, which begin to be pressed when it reaches the first pair of rollers. The upper chain, formed also of plain strong steel or sheet iron plates, and also linked together like the lower ones, is lowered upon the substance so arranged and adjusted between the flanges above-mentioned. After passing between the last pair of rollers the plates or chains again separate, and the lower ones let fall the residue, deprived of its juice or oil, into a receiver placed for that purpose behind the machine; the woollen stuff with which the plates of the lower chain are covered facilitating the disengagement of the residue without further aid. As regards the general purposes of compression, it is evident that after having removed the cylinders, stone, types, rubber, &c., it can then be accomplished with the greatest facility, either by the printing machine, by a horizontal to-and-fro motion, or by a circular movement, by means of the expressing machine replacing the hollow plates by ordinary flat ones, or by any other way.

ARTIFICIAL FUEL.

WILLIAM PIDDING, of the Strand, for *improvements in the manufacture, preparation, and combination of materials or substances for the production of fuel, and for other useful purposes to which natural coal can be applied.*—Patent dated January 24, 1852.

Claims.—1. The various modes of treating, preparing, and combining the substances specified, and the product or products thereof—such product, or products forming a new and useful species of fuel; 2. The sole use of the combinations described of certain substances with coke, producing by such combinations a material or substance applicable to many useful and ornamental purposes.

The first part of this patent relates to the manufacture of artificial fuel out of small coal, the refuse of the pit's mouth, anthracite, turf charcoal, the roots of trees, of plants, and other carboniferous materials, by the following methods:—The materials employed are first compressed together and then saturated with a solution of saltpetre; the whole mass is then burnt, and then broken into pieces of such a size as to admit of their easy re-combination by means of pressure (that of the steam hammer being preferable). Another method consists in forcing into the pores of the materials fatty, resinous, or bituminous substances, and then pressing them into a box-shaped mould, having a cover to fit it exactly, and in which the mass is baked.

The second part of the invention consists in reducing charcoal, coal, or coke to powder, and then forcing it by compression into the pores of the coke. The mass is then submitted to carbonisation and afterwards pulverised. It is re-carbonised after it has been compressed into moulds of the shape of the article required to be produced. This composition may be applied to the production of various articles of common use, as picture frames, book covers, sounding boards for piano-fortes, culinary utensils, &c., and building materials.

The patentee does not claim the particular form of the mould described in his specification, as it may be modified to whatever shape required. Nor does he claim the materials separately, but the several combinations described.

FURNACES.

Joseph Jones, of Bilston, Stafford, furnace builder, for *an improvement or improvements in furnaces used in the manufacture of iron.*—Patent dated January 24, 1852.

Claims.—1. The use of water or other liquid or solution, applied in troughs fixed near the flue jamb-plates, bridge jamb-plates, and back wall-plates of single, puddling, boiling, or heating furnaces, and also in a tank or tanks under the bottom plate of such furnaces, for the purpose of cooling and preserving the inside plates of the same. [The water passes through a supply-pipe down to a trough fixed at the back of the flue jamb-plates; the water from these passes into a trough placed between the flue bridge-plates, and thence into a trough placed over the back wall-plates; it then passes down into a tank placed under the bottom-plate. A trough at the back of the bridge jamb-plates is supplied in the same manner, the water passing into a trough between the fire bridge-plates, thence into a trough near the back wall-plates, and lastly into the tank below.]

2. The use of water or other liquid or solution applied in troughs near the flue jamb-plates, bridge jamb-plates, and partitions of double puddling furnaces, for the purpose of cooling and preserving the inside plates of the same.

3. The use of the flue for carrying off the heated air, sparks, and products of combustion, from a refinery furnace.

4. The economisation of the heat from a refinery furnace, by passing the heated air from the same through the flues of, or around a steam-boiler.

4. The use of water or other liquid or solution, applied in a trough or troughs to the doors of furnaces used in the manufacture of iron for the purpose of cooling and preserving the same. [The iron casing of the door is filled with water, supplied through a slot by a flexible pipe, and passes out through another slot, the circulation being by this means kept up.]

6. The use of water or other liquid or solution, conveyed in a trough or troughs into slide dampers employed in the flues of furnaces used in the manufacture of iron, for the purpose of cooling and preserving the same.

ELECTRIC TELEGRAPHS.

Edward Highton, of Clarence-villa, Regent's-park, civil engineer, for *improvements in electric telegraphs.*—Patent dated January 29, 1852.

The improvements comprehended in this patent are—

First—An improved arrangement of keys for telegraphic purposes, which are so arranged that one spring only is employed in lieu of two, as usual. For this purpose the spring is placed between two keys, each of which is furnished with two studs. The spring, which is connected with the battery, presses upwards against a stud, and to which stud are fastened the telegraph wires. The method of working the machine is as follows: On the key being pressed down, one of its studs touches the spring, and the other the stud against which the spring presses, which is connected with the wire, and thus a current is sent along it. By touching the other key a current is sent in the opposite direction.

Second.—Two arrangements of alarums for telegraphic purposes.

Third.—The preparation of paper or fabrics to receive impressions from the telegraph by the ordinary liquids or materials in use for the purpose of rendering paper or fabrics capable of a change of colour when acted upon by acids susceptible of assuming one colour when acted upon by a positive current of electricity, and another colour when acted upon by a negative current. The electric current is spread over the fabric by the points, and the combination of the two colours is used to make a code of signals.

Fourth.—A method of more completely insulating telegraphic wires, by suspending them on arms placed obliquely to the supporting posts, instead of vertically or horizontally.

Fifth.—The use of power derived from the hydraulic ram for tightening the wires between the supporting posts.

Sixth.—Another method of tightening the wires, by bringing them into zigzag lines between the posts.

Seventh.—A method of suspending telegraphic wires and insulating them at the point of support. The wires, after being coated with varnish for about two feet of their length from each side of the supporting post, are bound round with varnished silk, and are finally inclosed in a coating of gutta-percha of the thickness of half-an-inch. The wires are suspended from the post by means of hook-shaped clamps of galvanised iron.

Eighth.—The more perfect insulation of the wires by means of the use of a band of galvanised iron round the supporting post above each wire, which band is connected with the earth by means of a wire. The electric fluid escaping from the wires passes on to the band, and from thence by the wire into the earth. It is thus prevented from in any way affecting the other wires.

SCREW PROPELLERS.

Joseph Haythorne Reed, of the Harrow-road, for *improvements in propelling vessels.*—Patent dated January 31, 1852.

Claims.—1. The vertical axes as a substitute for the horizontal ones of paddle and screw propellers as hitherto used; 2. The plane paddles as a substitute for the circular or other paddles and screw; 3. The valve principle of planes moving in one direction only, as applicable to paddles generally for the purposes of propulsion; 4. The general construction and combination of parts shown for the better propulsion of ships and other vessels.

This invention is upon the principle of the screw ordinarily used for the purpose of propulsion. At the stern of the vessel are placed two frames attached to vertical axes, and which are divided into two or more parts by rods running throughout their lengths, and to which rods are hung floats of the same length as the frames. The axes of these frames being made hollow, other axes fitted with catches are placed within them. These catches are capable of being turned from side to side and prevent the floats moving but in one direction. By bringing the catches to bear on the opposite side of the floats in the frames (which is to be effected by turning the external axes), their action will be reversed, as, if the frame turns in a direction contrary to that of the catch it closes of itself, owing to the resistance of the water, and if turned in the direction of the water it is closed by the catch.

PROPELLING VESSELS.

Alexandre Hediard, of Rue Tait Bout, Paris, for *improvements in propelling and navigating ships, boats, and vessels by steam and other motive power.*—Patent dated January 31, 1852.

Claims.—1. The construction of an apparatus in which the external water received by an ingress orifice is projected through an egress orifice of smaller dimensions, against the outer water in any required direction, for the propulsion and navigation of ships, boats, and vessels; 2. Regulating the volume and velocity of the projected jet of water by means of plates of various dimensions adapted to the egress orifice.

For the purpose of effecting this object a circular pump is placed in the vessel to which this species of motive power is intended to be applied, and which is connected with a cylinder, the bottom of which opens to the external water by means of an elbowed pipe, the bend being towards the stern of the vessel. In a line with this aperture, and towards the fore part of the vessel, is another orifice opening from the external water directly into the circular pump. The working of this machine is as follows:—The external water, assisted by atmospheric pressure, enters the last-mentioned opening, and is forced by the pump into the cylinder, which it leaves by the elbowed tube, and by the velocity with which it does so forces on the vessel. The velocity of the water may be regulated by means of heads (with suitable apertures) being affixed to the tube under the cylinder, and capable of being screwed on and off as may be deemed requisite.

TURNTABLES AND STEAM BOILERS.

WILLIAM BECKETT JOHNSON, of Manchester, manager for Messrs. Ormerod and Son, engineers and ironfounders, for *improvements in railways, and in apparatus for generating steam.*—Patent dated February 9, 1852.

Claims.—1. The construction of the framework of turntable tops of wrought-iron bars, bent or made in the form of sectors of a circle, and bolted or riveted, or otherwise connected together. [The wheel is made out of four pieces of iron bent into a triangular shape, having the angles more curved: these are united together by means of an iron band, after the manner of a wheel-tyre, being placed round the whole. Two iron bars are then placed across the whole at equal distances from the sides, and which are riveted to the rest. The rails upon which the carriage rests are fixed to the table by means of the ordinary chair.]

2. The application of two or more furnaces or chambers applied to a steam-boiler in such manner that the products of combustion proceeding from them shall meet each other in opposite directions. [In this case the boilers are placed one on each side of a space in the centre of the engine. The gases produced by the combustion of the fuel pass into a space at the backs of the respective boilers, and from thence through pipes passing through the boiler into the before-mentioned space, from whence they are carried into the chimney.]

3. The application of tubes to stationary boilers in such manner that the products of combustion shall return through them to the front or firing end of the boiler. [The fire-box is placed in the centre of the boiler, and through the boiler passes several pipes. The gases are carried from the fire-box through these pipes to a space at the other end of the boiler, from whence they return by means of a cavity passing underneath the fire-box to the spot from whence they were derived.]

4. A mode of fitting tubes into the tube-plates of boilers, by causing their ends to be expanded, or forced into cavities or enlarged diameters formed in the ordinary tube-holes of the tube-plates. [The metal tube being placed in the hole in which it is intended to be fixed, and the edge of which hole is grooved for the purpose, an expanding mandril is placed within the tube, which being worked, causes the metal to spread into the grooves. The outer edges are then beaten flat.

RAILWAY CARRIAGE SPRINGS.

GEORGE SPENCER, of Lacy-terrace, Islington, engineer, for *improvements in the springs of railway carriages, trucks, and wagons.* —Patent dated February 3, 1852.

The improvements described in this patent consist in the construction of buffer, draw, and bearing springs for railway purposes out of india-rubber vulcanised.

Claims.—1. The use of a confining cylinder or case, made of wrought-iron or other material when used for railway carriage buffer, bearing, and draw springs. [Above the axle-rest is placed a kind of cylinder inclosing a series of rings composed of vulcanised india-rubber. The rod of the piston contained in the cylinder presses upon the axle-rest, and thus forms a new kind of spring. In the construction of buffers the same means are employed, with the exception that the cylinders are placed horizontally instead of vertically.]

2. The use of rings of vulcanised india-rubber, or other suitable elastic material, of certain forms shown, when used for railway carriage buffer, draw, and bearing springs.

3. The combination of rings of vulcanised india-rubber, of various densities or sizes, so as to regulate the resisting power of the springs when used for railway carriage buffer, draw, and bearing springs.

4. The use of any combination of the rings described with a confining case or cylinder, when used for railway carriage buffer, draw, and bearing springs.

MOTIVE POWER.

CHRISTIAN SCHIELE, of Oldham, machinist, for *certain improvements in obtaining and applying motive power.*—Patent dated February 12, 1852.

The improvements claimed and described in this patent are as follow:—

First. Certain arrangements of machinery for obtaining motive power by the action of steam, water, or other fluid on a species of turbine or rotary cone-wheel, and for transmitting the motion therefrom. In the interior of a cylinder are placed two cones joined to each other at their respective bases. Inside these is placed a fan-wheel horizontally. The steam or other motive power entering the lower cone forces round the wheel, and by that means produces the required motion.

Secondly. A species of piston governor, or speed regulator for steam-engines and other machinery, wherein the unbalanced pressure on the two sides of a piston in a detached cylinder is made to adjust the throttle-valve, or passage for the actuating medium.

Thirdly. A means of transmitting power along ranges of pipes or fluid ducts, and of transmitting motion therefrom, and regulating or governing the same.

Fourthly. A mode of working the expansion-valves of steam-engines by means of an adjustable pendulum-action for varying the "cut-off."

GAS BURNERS.

PETER ARMAND LE COMTE DE FONTAINEMOREAU, of 4, South-place, Finsbury, for *certain improvements in gas-burners.* (A communication.)—Patent dated February 23, 1852.

Claims.—1. The construction of gas-burners divided into compartments, and provided with internal tubes for regulating the supply and combustion of gas.

2. The supplying air to gas-burners through orifices in the chimney, the said burners being covered with a metal cloth; and the adaptation of tubes, in lieu of the ordinary orifices, for the passage of gas, by which joint arrangements the vacillation of the flame is avoided.

The gas reaches the burner through a pipe divided into two branches, and adapted to the bottom part of the burner, as is usually the case. The gas is conducted into a chamber through pipes; when it has arrived in sufficient abundance to fill the chamber, it descends by a tube into a lower chamber, from which it ascends through a tube into another compartment; and from a third chamber it egresses into the point of combustion through holes perforated circularly in the upper part of the burner. The third chamber forms a kind of a reservoir, into which the gas slowly introduces itself, after losing, by the circuit which it has been compelled to perform, the impulsive force which the difference of pressure, produced by a variety of causes, might have given to it. By that means the extinction of a large number of burners on a sudden pressure will not produce any effect on this burner. The dimensions of the chambers and the diameter of the pipes may be varied at discretion, according to the elevation of light required. The patentee can, at option, apply on the tube an inverted capsule, set on a ring soldered to the tube. When this capsule is employed, it is provided with a lateral opening, which allows the gas contained in the second chamber to introduce itself into the tube: the dimensions of the capsule vary according to the intensity of the light required. He also provides a vertical section of a gas-burner, in which the current of air is supplied through orifices made in the glass, and is forced to pass through a metallic cloth, and the gas is made to egress from the burner by the place of consumption through tubes adapted to the top of the burner.

Another improvement relates to the prevention of the vacillation of the light in gas-burners placed in passages and in places exposed to strong currents of air. To obviate these inconveniences, the burner is constructed on the same system as that hereinbefore mentioned in reference to the compartments, the current of gas arriving in the burner with this difference, that the current of air in the apparatus is entirely suppressed, and the gallery usually placed on the burners for supporting the chimney-glass is entirely closed instead of being opened. The glass used for the burner has a lateral opening cut at about three lines above the base of the point of combustion; and to prevent the air from striking directly against the flame, the upper part of the burner is provided with a metallic cloth at about one-third inch from the flame, being supported by hooks or claws fixed to the gallery. All the burners are made with a worm, so as to enable the upper envelope to be removed to clean all the tubes and change the capsule, if unemployed, for one of a different size. The chamber can also be increased or lessened in size; but for that purpose the burner must be constructed of two parts, attached by means of a screw-worm, which will serve to vary the dimensions of the chamber. The burners, as well as all the compartments, may be constructed of metal, porcelain, or any other suitable material. These improvements are applicable to all kinds of burners by merely fixing the tubes of the different burners on a cylinder provided with the chambers and tubes of the same invention.

ON ECCLESIASTICAL ARCHITECTURE.

By Edmund Sharpe, M.A.

[*Read before the Archæological Institute, at Newcastle-upon-Tyne.*]

Church architecture is separated into two principal divisions—one in which the circular arch only is employed, and the other in which the pointed arch is alone employed; and that is so simple and so much of a leading division at the same time, that we can have no hesitation in adopting it. The architecture of buildings in which the circular arch obtains is usually denominated the Romanesque, while that which is characterised by the pointed arch is commonly called the Gothic. It is, however, necessary to bear in mind that these two classes exclude a very large number of buildings in existence at a period before the circular arch was altogether abandoned, and when it was used in conjunction with the pointed arch. For the ecclesiastical edifices erected in the intermediate period between Saxon and Norman times, during which both the pointed and circular arch had been used, no term is so applicable as that of "Transition." On the other hand, as regards the buildings of the Gothic period, when the pointed arch was used, no division is so convenient as that suggested by the principal changes in form through which the window passed during that period. For half-a-century after the disappearance of the circular arch, the window appeared under a form which, from its general resemblance to a lancet, caused the application of that term to all the windows of that period. Out of the practice of combining a number of lancets into one arch, and of decorating the intervening spaces between the heads of the arch, the beautiful invention of tracery took its rise; and for nearly three-quarters of a century after its introduction tracery is found characterising every form of window in which the circle is most conspicuous. This gave rise to the expression "Geometrical period," at the close of which the curve called the "O. G." had begun to make its way into the tracery of windows, and to impart to it a grace and an ease which it had not previously possessed. The term Curvilinear might, therefore, be applied to the tracery and all the details of the windows of that period. In the latter part of the Curvilinear period, a horizontal bar or transept made its appearance in the windows. Vertical lines also commenced to make their way into the tracery; in fact, a new principle began to pervade the whole of the building—this is the straight line which overran the entire part of the structure. We shall, therefore, call that the Rectilinear period of Gothic architecture. This divided Gothic architecture into six portions—namely, the Norman period, which prevailed from 1006 to 1145; the Transition period, from 1145 to 1190; the Lancet period, from 1190 to 1244; the Geometrical period, from 1244 to 1315; the Curvilinear period, from 1315 to 1360; and the Rectilinear period, from 1360 to 1450.

The architectural remains of the Saxon period are all undoubtedly of very great interest, but are altogether of such a detached, fragmentary character, that it is utterly impossible to reconstruct two interior or exterior compartments which can be used to represent correctly the main idea of a Saxon building. With regard to the Norman period, its characteristics are very apparent at the first glance. The proportions of the building are massive; for instance, a circular mass, sometimes a cluster of heavy shafts, is seen resting on piers which were scored and ornamented with a series of zigzag lines. The blind story is usually very large, while the clerestory consists generally of a triple arcade, the centre compartment of which is the largest. The circular arch prevails every way.—The next is the Transitional period, in which the proportions of the building are considerably lightened; the piers especially being very much less substantial and massive. Certain of the arches have the pointed, while others maintain the circular form. The employment of the circular and pointed arch simultaneously in the same building is the characteristic of this period, examples of which are to be found in the choir of Ripon Minster. The capitals of the piers are also of a much lighter description. There is, likewise, another very peculiar mark of that period—indeed, it is the most characteristic of it—which consists of a small volute, to be found in the corners of the capitals, with the curl turned upwards instead of downwards. It was called, therefore, the Transitional volute. We have no nobler examples of the Norman period than are to be found in the nave and other portions of Durham Cathedral. In Carlisle Cathedral we have only the remnant of the nave, but it is a very interesting example indeed, although sadly encumbered with pews and by being cut into two parts by a floor. Of the Transitional period we have a tolerable example in Brinkburn Priory, Northumberland, in the Galilee of Durham Cathedral, and in the door of the Castle, in which the Transitional volute is seen in every capital of the building. In St. Andrew's Church, Newcastle-upon-Tyne, we have also some interesting remains of the transitional period. In Darlington Church, which is reputed to have been built by Bishop Pudsey, we have the style in a very advanced state—so much so, that the architecture of that church has always been called in modern times "Early English," though erroneously. The chapel of the Bishop of Durham's palace, at Bishop Aukland, likewise contains very interesting specimens of the Transitional period.—In the Lancet period the piers are seen broken into slender and detached shafts, and all the foliage decorating the capital is of a conventional rather than of a natural character, consisting mostly of a series of stiff leaves growing out of the stems. We have also the lancet form of window prevailing everywhere throughout the building. We have some beautiful examples of this period at Durham, in the priory church of Hexham, and in the west front and nave of Lanercost Priory.—In the Geometrical period the circle prevails everywhere, while the ornaments taken from the vegetable kingdom are of a much more natural kind than in the former era.—In the Curvilinear period we find the sinuous form obtains in every direction, not only in the windows, but in the panelling of the walls, examples of which are to be found in the choir of Ely Cathedral.—In the next, or Rectilinear period, we have the characteristics of straight lines, while the blind story disappears altogether, examples of which are to be found in the nave of Winchester Cathedral. There is also a peculiar feature in the form of the arch, which is flattened, and descends from four different centres. This characteristic is also prevalent in the window.

THOMAS GRAINGER, Esq., C.E.

It is with extreme regret that we have to record the death of this gentleman, under circumstances of so very painful a character. He was engaged in numerous large undertakings, embracing many engineering difficulties, which have been overcome by works of remarkable magnitude. In the tunnel which extends for 1000 yards under the streets through the new town of Edinburgh, almost insurmountable obstacles arising from the running sand, and the proximity of fine ranges of street houses, have been successfully overcome. And while the 44-arch viaduct on the Edinburgh and Glasgow Railway was once the largest of his works, it has been exceeded in magnitude by several of his works in England; and, besides the magnificent model of his proposed Central Station for the junction of all the lines at Leeds, we have admired the models of many of his spacious iron arches.

Mr. Grainger had, during the last two years, enjoyed a relaxation of the arduous bodily exertion which his extensive business required of him during the railway mania; but amid the anxiety of his many responsible consultations and arbitrations, he was a valuable President to the Royal Scottish Society of Arts, and is well known to have largely increased the number of members of that popular scientific body, and he had the distinguished honour of being appointed to the chair a second year. He was also a member of the Royal Society of Edinburgh, the Institution of Civil Engineers, the British Association, &c.

NEW MODE OF SHIP BUILDING

L. Arman, Ship Builder, of Bordeaux, Inventor.*

From time immemorial, timber appears to have been the material almost exclusively employed in the construction of ships and other floating bodies of capacity; and so long as vessels were constructed of those proportions which long experience had proved to be best adapted for sailing purposes, it was not found necessary to resort to any other material; but since the introduction of steam for the propulsion of vessels, it has been thought advisable to make a considerable variation in the old proportions generally assigned to sailing vessels; that is to say, the length of steam-vessels has, with great advantage for speed, been most materially increased, to the extent of one-half, or more, as compared with the breadth and depth.

Unfortunately this addition to the length of vessels has necessitated a great increase in the scantling of the material (timber) employed in the construction, thereby greatly augmenting the weight and displacement of the vessel, and to a great extent nullifying the advantages indisputably obtained by the fine lines produced by the additional length; and it should be remarked that the great increase of weight in the material is required, not only as regards the mere strength of cohesion of the parts lengthways, but is requisite in order to obtain adequate rigidity and stiffness, which are so important in all steamers expected to have great speed.

The deficiencies of the ordinary description of timber, to meet the requirements of the new order of long fast steamers, very soon became apparent; and a substitute offering the required properties was eagerly sought for. The search was not long, for it was soon discovered that the material *iron* possessed the requisite qualities in an eminent degree; and *iron* has therefore been most extensively and successfully employed in the construction of the fastest and most splendid steam-vessels now in existence.

But attention was early drawn to the fact, that iron steam-vessels, when employed in warm climates, very soon become foul on the surface; an incrustation of weeds and shells is speedily formed, and very seriously retards the speed of the vessel; moreover the material itself is liable to very rapid deterioration, of which there are many well-authenticated cases; in iron vessels that have been employed for only a few years within the tropics, on examination, the iron outside plating or skin exposed to the action of the water, as well as the iron frames, has been found very extensively changed in character, being converted into a sort of plumbago, easily cut with a knife, without any strength or tenacity, and creating alarm of sudden destruction and disaster: many endeavours have been made to remedy these evils, but it is feared with only partial success.

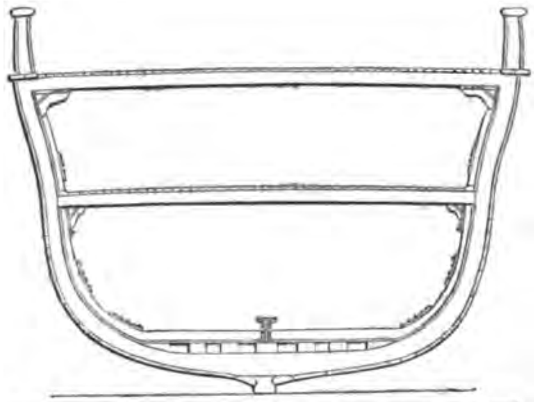
Besides these very important objections to the use of *iron* as a material for shipbuilding, there is another so paramount and so unanswerable that the Lords of the Admiralty had at one time determined to put a stop, as far as they could, to the building of vessels with that material altogether; iron vessels having been proved by different experiments carried on at Portsmouth, by order of the Board, unfit for war purposes, all packets intended to carry the mail, or take contracts for that service under government, were ordered to be timber-built vessels, that they might be added to the naval forces of the nation, should they at any time be required.

To obviate the foregoing serious objections, no plan has hitherto been thought of; and the employment of heavy timber-built vessels is still continued in England, France, and the United States. But in almost every case, where great speed is an indispensable consideration, iron is still resorted to, notwithstanding the very serious evils attending the use of that material, as it is generally employed.

Messrs. L. Arman and Co., shipbuilders, of Bordeaux, have brought forward a plan for the construction of long sharp steam-vessels, in which they extensively employ iron, in combination with timber. The plan unites the two modes of building; that is to say, the outside part of the vessel in contact with the water, and exposed to the weather, is a timber-built vessel, while internally it is an iron vessel. For instance, in a vessel built on this plan, a framing of timber of the usual form, but of considerably reduced scantling, is prepared; on the outside of this timber-frame the wood planking is secured in the common manner, copper-fastened and coppered, as may be judged advisable; inside the timber-framing is introduced a second framing of iron, the ribs of which are formed of iron, rolled in a shape like the letter Z. The iron ribs are not placed vertically, but diagonally, about two or three feet apart, crossing the first framing at an angle of about 45°, and bolted to the timber-frame at every crossing, something similar to the plate-iron riders frequently adopted in timber-built ships. The lower ends of these iron ribs are continued forward or aft, so as to connect them with, and form a part of, an iron kelson, introduced for that purpose. Iron shelf-pieces, clamps, beams, &c. &c., are also used as in iron-built ships; so that in fact the inside is to all intents an iron vessel. Longitudinal plate-iron strakes are riveted or bolted to the inner surface of these iron ribs at different heights, dividing equally or nearly so, the distance between the under part of the beams of the main-deck and the floor timbers, leaving thereby spaces or interstices which fully expose to view both the iron and wood framings, as also the inside of the wood planking.

To prevent any portion of cargo finding its way into these interstices, they may be covered over with moveable or sliding panels, composed either of wood or iron.

Fig. 1.—Vertical Section.



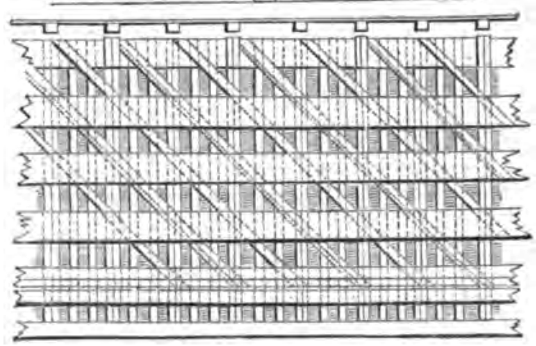


Fig. 2.—Interior View of one Side.

In the year 1851, Messrs. L. Arman and Co., built on this plan a steamer of one hundred and twenty horse-power, the *General Castilla*, which it is stated so completely fulfilled the high expectations entertained of Mr. L. Arman's new mode of building, that the French government appointed a commission to examine this new construction, and report thereon: and M. Sabattier, a naval engineer, expresses himself in these words, addressed to M. de Chasseloup-Laubat, Minister of the Naval Department:—

"The hull of this vessel [*General Castilla*] is lighter than that of any of the mail-packets of one hundred and twenty horse-power, having the same dimensions; and Mr. Arman has certainly succeeded by his combination of wood and iron framings in making it much more rigid and solid.

"The draught, here annexed, will explain clearly the system adopted by this gentleman; and a few explanations of the mode of construction of the said vessel will show all the advantages of his plan.

"The timbers of packets for one hundred and twenty horse-power are, for the floors, moulded $6\frac{1}{2}$ inches, and $8\frac{5}{8}$ sided; and 4×6 inches at the gunwale. Mr. Arman has reduced the

* We refer our readers to Mr. Jordan's patent for building vessels of iron and wood, reported in the *Journal*, Vol. XIV. (1850) p. 89. We suspect some portion of Mr. Arman's plan will be found an infringement upon that patent.—Ed. C.E. & A. *Journal*.

scantling of these frames to $4\frac{3}{4}$ inches, from the floor-timber to the gunwale. The distance between the timbers is $6\frac{1}{4}$ inches, and he introduces alternately a pair of ribs, and then two single ribs. When his timber-frame is formed, he brings in his filling-in pieces for the bottom, bolts the frame with the keel; and substitutes for the wooden kelson an iron kelson of 13 inches high, and nearly half-an-inch thick.

"This kelson is fastened to the timbers by rag-bolts, and to the filling-in pieces by fore-lock bolts. Then beginning about midships, and proceeding fore and aft, he crosses this timber framing by a second framing of $2\frac{3}{4}$ double angle-iron, riveted back to back, in the shape of the letter Z, extending from the under part of the deck to the iron kelson, to which it is fastened, and forming the sides of the iron kelson aforesaid. These iron ribs are fastened to one or two galvanised iron bolts on each timber, which they cross at an angle of about 45°, and clinched on the outside. These iron ribs are 4 ft. 7 in. apart, and between and parallel to them, a light wooden piece $2\frac{3}{4} \times 5\frac{7}{8}$ is made fast on each of the timbers. Iron shelf-pieces and clamps are substituted for those of wood, and fastened to the framing as done in iron vessels. The beams are of iron in the engine-room, and of wood towards each end.

"The engine-room is separated from the other parts of the vessel by iron bulkheads, fastened to the timber-frame by angle iron. The stiffness of the vessel is also increased in this part by four iron riders extending from the main-beams to the iron-bearers; establishing thereby a connection between the different parts, and giving to the whole a great solidity. The engine and boiler bearers are of plate and angle-iron; fastened on the timber-framing, with bolts clinched outside, previously to the fastening on of the outside planking.

"When these framings are properly fastened, as well as the engine-bearers and the iron-riders above mentioned, they proceed with the outside planking, wales, &c., which are copper-bolted on the timber-framing only, the bolts being clinched inside as usual. When the outside planking is securely fastened, and the whole has been well painted, three longitudinal strakes of plate iron are riveted on the inside surface of the iron ribs, dividing equally, or nearly so, the distance between the shelf-pieces and the lower floor-heads. Interstices are left between these plate-iron strakes, which fully expose to view the double framing, which may be kept in order and painted, so as to last longer than usual. This important point constitutes one of the greatest advantages of Mr. Arman's plan. The engines are perfectly steady on the iron-bearers, and during our trials at sea not the smallest vibration or play could be discovered in any part of this double-framed vessel. We may therefore say that this plan of building combines all the rigidity and solidity of iron-built vessels, with all the advantages of timber-built ships. Repairs of all sorts will present less difficulties than usual; and should it be necessary at any time to remove any of the iron ribs, coach-screws may then be advantageously used in refixing them.

"In conclusion, we may say that sea-going vessels built according to Mr. Arman's plan are lighter and stronger, though not dearer, than those built according to the old system. It is therefore most important to the French navy that a trial should be made, and that one of the vessels that are ordered should be built on this plan."

THE SUPPLY OF WATER IN PARIS.

Paris is divided into two distinct zones for the distribution of water. All the lower portion, that is to say, four-fifths of Paris, might be supplied by the water of the Canal de l'Ourcq, arriving naturally from its own weight, without the aid of machines and the expense of fuel. This is the first zone. The other portion, less important as to extent, cannot receive the water except by artificial means. On the left bank it comprises the Montagne St. Genevieve and the neighbouring quarters, which are supplied by the waters of Arcueil, the well of Grenelle, and the forcing-pump of Notre Dame; on the right bank, the second zone forms the line running parallel to the *octroi* wall. These are the richest and best built quarters of the capital, yet they are the worst supplied with water from the Seine. The forcing-pump at Chaillot gives a very insufficient supply. Wanting the means of action, either on account of the small number of its pipes or of their small size, the city of Paris cannot utilise the mass of water which it has a right to expect from the Canal de l'Ourcq. In fact, according to the agreements entered into in 1848 and in 1851 between the company having the concession of the canal and the administration, 5000 inches of water may be taken as it may be required by the engineers, at 25 mètres above the level of the Seine, and in all seasons of the year, to be used by the public fountains, or any other mode of distribution in the interior of Paris. Out of these 5000 inches scarcely more than from 2400 to 2500 inches have been used during the greatest heats of summer, in consequence of the insufficiency of the means of distribution which we have just enumerated. In consequence of the inconveniences which every day arise from this sad state of things, in the simultaneous service of the fountains at the corners of streets, the watering and the public fountains, the city had decided on utilising all the water it can draw from the Canal de l'Ourcq. For this purpose the three reservoirs of the left bank—Vaugirard, Racine, and St. Victor—the supply of which, in consequence of the narrowness of the pipes, is not sufficient for those populous quarters, will be united to the aqueduct by large pipes of 50 centimètres. Thanks to this system, the reservoirs will be always full, and in a state to supply uninterruptedly the accessory pipes which convey the water into the different streets of Paris. As to the right bank, a reservoir capable of containing 1800 mètres of water, will be made at Chaillot, and new pipes will supply all those parts in which the distribution has been hitherto insufficient. As far as regards the second zone of Paris, a part lower than the level of the Canal de l'Ourcq, and which is supplied by the waters of the Seine, the new machines at Chaillot will convey to it 1400 or 1500 inches of water instead of from 400 to 500, which are now distributed by the old machines. The works for the execution of these improvements will entail an expense of 2,800,000f.:—viz., distribution of the water of the Ourcq, 1,300,000f.; distribution of the water of the Seine, 1,500,000f. In adopting this vast system in principle, and in devoting to it a first outlay of 300,000f. on the budget of 1852, the city has comprehended that it would be a productive expense, and that the sacrifice which it was obliged to make would not be onorous for its budget. In fact, after providing for the service of the fountains at the corners of the streets, the watering and the monumental fountains, the city now derives from the sale of its water a revenue of nearly 1,200,000f. This is a revenue which is every day increasing, and which will be still further increased by the ameliorations we have just spoken of. The receipts for the sale of water in 1830 were 575,641f.; 1840, 845,571f.; 1848, 1,065,683.f; 1851, 1,187,368f. The amount of the receipts every year increases; out of 35,000 houses, 6000 at the most have taken concessions, and this number will certainly augment as soon as the city can offer water to the proprietors of houses in every quarter. These are useful expenses; they will turn to the profit of the finances of the city, and to the comfort of the inhabitants; they will complete with the new system of sewers now in use, an *ensemble* of desirable improvements.—*Journal des Débats.*

INSTITUTION OF CIVIL ENGINEERS.

Award of Premiums—*Session*, 1851-52.

The Council of this Institution have awarded the following premiums for papers read during the last session:—

1. A Telford Medal, in silver, to Captain Mark Huish, Assoc. Inst. C.E., for his paper "On Railway Accidents." (See *Journal, ante* p. 159, 198.)

2. A Telford Medal, in silver, to Braithwaite Poole, Assoc. Inst. C.E., for his paper "On the Economy of Railways." (See *Journal, ante* p. 159, 198.)

3. A Telford Medal, in silver, to Colonel Samuel Colt (U.S.), Assoc. Inst. C.E., for his paper "On the Application of Machinery to the Manufacture of Rotating Chambered-breech Fire-arms, and the peculiarities of those Arms." (See *Journal*, Vol. XIV. p. 611, 629.)

4. A Telford Medal, in silver, to Frederick Richard Window, Assoc. Inst. C.E., for his paper "On the Electric Telegraph, and the principal improvements in its construction." (See *Journal, ante* p. 116.)

5. A Telford Medal, in silver, to Charles Coles Adley, for his paper entitled "The History, Theory, and Practice of the Electric Telegraph." (See *Journal, ante* p. 117.)

6. A Telford Medal, in silver, to Eugene Bourdon (Paris), for his "Description of a new Metallic Manometer, and other Instruments for measuring Pressures and Temperatures." (See *Journal*, Vol. XIV. p. 608.)

7. A Telford Medal, in silver, to Pierre Hippolyte Boutigny (d'Evreux), for his "Description of a new Diaphragm Steam Generator." (See *Journal, ante* p. 118.)

8. A Telford Medal, in silver, to George Frederick White, Assoc. Inst.

C.E., for his "Observations on Artificial or Portland Cement." (See *Journal, ante* p. 198.)

9. A Council Premium of Books to John Baldry Redman, M. Inst. C.E., for his paper "On the Alluvial Formations, and the Local Changes, of the South-Eastern Coast of England, from the Thames to Portland." (See *Journal*, Vol. XIV. p. 656; Vol. XV. p. 38.)

10. A Council Premium of Books to William Thomas Doyne, Assoc. Inst. C.E., and to Professor William Bindon Blood, for their paper entitled "An Investigation of the Strains upon the Diagonals of Lattice Beams, with the resulting Formulae." (See *Journal*, Vol. XIV. p. 596.)

11. A Council Premium of Books to George Donaldson, Assoc. Inst. C.E., for his paper "On the Drainage and Sewerage of the Town of Richmond, Surrey." (See *Journal, ante* p. 158.)

12. A Council Premium of Books to Professor Christopher Bagot Lane, Assoc. Inst. C.E., for his "Account of the Works on the Birmingham Extension of the Birmingham and Oxford Junction Railway." (See *Journal*, Vol. XIV. p. 640.)

13. A Council Premium of Books to William Bridges Adams, for his paper "On the Construction and Duration of the Permanent Way of Railways in Europe, and the modifications most suitable to Egypt, India, &c." (See *Journal, ante* p. 77.)

Subjects for Premiums—*Session*, 1852-53.

The Council invite communications on the following, as well as other subjects, for Premiums; and which are to be forwarded to the Institution prior to January 30, 1853:—

1. On the principles upon which the works for the improvement of river navigation should be conducted, and the effects of the works upon the drainage and irrigation of the district.

2. The construction, improvement, and maintenance of natural or artificial harbours and docks, with the forms and action of large sluices for clearing away deposits by the use of backwater, or by directing the natural currents.

3. The selection of sites for the construction of docks on the course of tidal streams, with reference to the communication with railways and with inland navigation.

4. The selection of sites for, and the principles of, the construction of breakwaters and of harbours of refuge; illustrated by examples of existing works.

5. The forms and construction of piers, moles, or breakwaters (whether solid or on arches), sea-walls and shore defences; illustrated by examples of known constructions, such as the Cobb Wall at Lyme Regis, &c.

6. The best system of forming artificial foundations, showing the ratio of pressure to surface, and the soil best calculated to sustain heavy structures; illustrated by the best examples in modern practice, and by accounts of the failures of large works.

7. The relative value of various kinds of natural stones available in Great Britain, for the purposes of construction; with experiments on the law of increase of the crushing force of short blocks of stone, with their diameters.

8. On brick and tile making, and the capability of introducing new forms for engineering and architectural purposes. With the processes most useful to emigrants and settlers.

9. The laws of the strength of cast and wrought iron, under the various conditions of tensile, compressive, transverse, tortional, impulsive, and other strains; with examples illustrative of the co-efficients employed by eminent practical authorities in the construction of works.

10. The construction of girder-bridges, whether of trussed timber or wooden lattice; of cast-iron, trussed or plain, or combined with wrought-iron, in simple or compound triangulation; of wrought-iron lattice-work; or of plate-iron riveted sides with cellular top and bottom.

11. The construction of suspension-bridges with rigid platforms, and the modes of anchoring the stay-chains.

12. The comparative advantages of iron and wood, or of both materials combined, for the construction of steam-vessels, with drawings and descriptions; the methods for preventing corrosion; and details of the arrangements for the compasses in iron ships.

13. On the changes that have been introduced, within the last fifteen years, in the lines of ships and steam-vessels; and an examination of the effects produced by the new law of measurement for tonnage.

14. An examination of the circumstances which appear to limit the maintenance of higher speeds than are now attained by steam-ships in deep sea navigation; and an inquiry into the causes which have hitherto prevented the asserted high speeds of steam navigation on the American rivers from being arrived at in England.

15. The best method of external condensation, so as to permit the employment of salt or of hard water, and furnishing pure water for the boiler; with a description of various systems of evaporating, refrigerating, &c.

16. The results of the use of tubular boilers, and of steam at an increased pressure for marine and other engines, noticing particularly the difference in weight and speed in proportion to the horse-power and the tonnage; with details of the most successful means for avoiding smoke in furnaces of all descriptions.

17. The best methods of reducing the temperature of the engine and boiler room of steam-vessels, and of preventing the danger arising from the over-heating of the base of the funnel.

18. The relative efficiency of the screw-propeller and the paddle-wheels, when applied to vessels of identical form, tonnage, and steam-power, independent of the use of sails.

19. The results of the application of steam-power and screw-propellers to the conveyance of coal, as compared with the system of sailing-vessels.

20. The arrangement and distribution of the workshops at the principal repairing station of a railway, for the repairs and maintenance of the locomotives, passenger, and other carriages, &c.

21. The construction of locomotive engines, specially adapted for steep inclines; with accounts of experiments demonstrating the comparative value of large and small engines, under various circumstances.

22. Improvements in the construction of railway-carriages and wagons, with a view to the reduction of the gross weight of passenger-trains. Also of railway-wheels, axles, bearings, and breaks; treating particularly their ascertained duration and their relative friction.

23. The results of a series of observations on the flow of water from the ground, in any large districts, with accurately recorded rain-gauge registries, in the same locality, for a period of not less than twelve months.

24. The conveyance and distribution of water for the supply of towns; the sources from whence it may be derived, noticing the relative permeability of different rocks and soils, and their actual capacity for retaining and delivering water; a description of the different modes of collecting and filtering; and an account of the advantages or disadvantages of the high-service constant supply system, with notices of the best forms of large valves, and of the best methods of jointing pipes of large diameter to resist considerable pressure, and the precautions to be observed in laying the mains through mining districts, where the ground is liable to sink.

25. The comparative duty performed by the various descriptions of steam-engines for raising water, for the supply of towns, or for the drainage of mines; noticing the depth and length of the underground workings, the height of the surface above the sea, the geological formation, the contiguity of streams, &c.

26. The drainage and sewerage of large towns; exemplified by accounts of the systems at present pursued, with regard to the level and position of the outfall, the form and dimensions of the sewers, the prevention of emanations from them, the disposal of the sewage, whether in a liquid or solid form, and of the arrangements for connecting the house drains with the public sewers.

27. On warming and ventilating buildings.

28. The precautions adopted for guarding against accidents by fire-damp in mines.

29. The results of contrivances for facilitating the driving of tunnels, or drifts in rock.

30. Descriptions of the various kinds of machinery in use in the principal shipping ports, for the shipment of coal; noticing particularly those in which the greatest expedition is combined with the least amount of breakage of the coal; and also accounts of the means of unshipping, and measuring or weighing the coal on its arrival in port.

31. Descriptions of the ovens, and of the best processes used in Great Britain, and on the Continent, in the manufacture of coke for railway and other purposes; with the comparative values of the products.

32. Improvements in the system of lighting by gas; the results of the use of clay retorts—of large ovens (for producing a better quality of coke)—of exhausters, condensers, and modes of purifying, and the precautions for the economical distribution of gas.

33. A mathematical or geometrical demonstration of the advantages of flat sails for ships, over those of different degrees of curvature, when exposed to direct and slanting winds; with practical examples.

34. On the application of machinery, combined with mechanical power, and the means of transporting manure and produce on large farms and agricultural establishments; and on improvements in the plan of the works and buildings, and the 'plant' employed.

35. The most effective arrangement and form of centrifugal and reciprocating blowing apparatus.

36. The chemical analysis, and the application to economic purposes, of the gases generated in iron blast furnaces.

37. An investigation of the causes of "red" and of "cold-shortness" in malleable iron, and other chemical characteristics which affect the physical properties of cast or of wrought iron.

38. Description of cast or wrought iron cranes, scaffolding, and machinery, employed in large works, in stone quarries, hoists, or lifts on quays, in warehouses, &c., especially where either steam or water is used as a motive power.

39. The various systems of preserving timber from decay, and from the attacks of marine insects or the white ant.

40. On the improvements which may be effected in the buildings, machinery, and apparatus for producing sugar from the cane in the plantations and sugar-works of the British colonies, and the comparison

with beet-root, with regard to quantity, quality, and economy of manufacture.

41. Description of the machinery adapted for the preparation of Indian cotton.

42. Improvements in flax machinery, and in the processes for preparing the flax for manipulation.

43. Notice of the principal self-acting tools employed in the manufacture of engines and machines; also of moulding machines and wood-working machines; and the effect of their introduction.

44. On the best system of remedying the inconvenience resulting from the present want of uniformity between the weights, measures, and coins of the different countries of Europe.

45. The construction of lighthouses; their machinery and lighting apparatus; with notices of the methods in use for distinguishing the different lights.

46. Memoirs and accounts of the works and inventions of any of the following engineers: Sir Hugh Middleton, Arthur Woolf, Jonathan Hornblower, Richard Trevithick, William Murdoch (of Soho), and Alexander Nimmo.

THE NEW BILLINGSGATE MARKET.

The extensive alterations and improvements for the enlargement of the great city fish market, long known as Billingsgate, are proceeding rapidly towards completion. Apparently there has been some delay in the prosecution of the works ordered by the Court of Common Council to be carried into execution in July 1852. Since that period, however, several unforeseen obstacles to the plan of the city architect have had to be overcome, with reference more especially to the drainage of the enlarged market. These difficulties being now overcome, and the whole of the works being near completion, perhaps an authentic sketch of the improvements involved in the outlay agreed to (independently of the erection of the building) for sanitary and ventilating purposes, viz. 1840*l.*, may prove interesting. There will be an abundant supply of water, pumped in the first instance from the river through an iron filter (similar to that used by Messrs. Calvert and Co., the brewers, of Thames-street). This filter will be sunk below low-water mark, and a sufficient supply of water, of a pure quality, will be obtained for the use of the salesmen. Independently of this a sufficiency will be furnished for thoroughly cleansing the surface, flushing all drains, and keeping constant streams running in the waterclosets and urinals at all times when requisite. The surface drains, both in the upper and lower markets, are so constructed that they will carry off the filth and water from cleansing the fish, &c., and will have a constant and plentiful flow of water through them to assist in its removal, and to keep them perfectly sweet. Instead of providing a cistern for the reception of the filtered water from the cylinder fixed in the bed of the river, the water is pumped up to the same height as the cistern would have been placed, and arrangements are made so that it may discharge itself in the form of a fountain in the upper market, the fountain not having cost more than a cistern would have done. As a great quantity of water is used in the lower or shell-fish market, which is considerably below the level of high water, it has been found to be necessary to pump out the drainage, hydraulic machines for this purpose having been provided. The drainage by pumps has these advantages—that it prevents the necessity of a large cesspool for the accumulation of filth and foul water from the lower market closets and urinals, and that the drainage can be carried out to below low-water mark, and kept constantly discharging in small quantities under water, instead of running away over the surface of the mud, emitting the most unpleasant odours, which during the existence of the old market were so frequently and so justly complained of. The market being inclosed on three sides, and the lower market having only the well-holes for the admission of light and air, it has been thought advisable to provide means for ventilation, as it appeared that such works might be done in connection with the drainage and works at a trifling increase of expense. This is accomplished by a ventilating disc, which it is believed will prove at all times necessary in the lower market, and highly beneficial to both in producing a current of air in close or sultry weather. The river front of the market, with the shell-fish and upper market, is nearly completed, and the Thames-street front is rapidly proceeding, the stone pillars for the support of the intended superstructure being erected. It is expected that the entire area will be opened for business purposes simultaneously during the autumn.—*Globe.*

LIST OF NEW PATENTS

GRANTED IN ENGLAND FROM JULY 22, TO AUGUST 26, 1852.

Six Months allowed for Enrolment unless otherwise expressed.

Henry Bessemer, of Baxter House, Old St. Pancras-road, Middlesex, for improvements in the manufacture, refining, and treating sugar,—part of which improvements are applicable for evaporating other fluids.—July 24.

Henry Wickens, of Carlton-chambers, Regent-street, Westminster, gentleman, for improvements in obtaining motive power. (A communication.)—July 31.

Samuel Starkey, of Clapton, Middlesex, gentleman, for improvements in machinery for washing minerals, and separating them from other substances.—July 31.

John Gerald Potter, of Over Darwen, Lancaster, carpet manufacturer, and Matthew Smith, of the same place, manager, for certain improvements in the manufacture of carpets, rugs, and other similar fabrics.—July 31.

William Edward Newton, of Chancery-lane, Middlesex, civil engineer, for improvements in the construction of wheels for carriages. (A communication.)—July 31.

William Ackroyd, of Birkenshaw, near Leeds, for improvements in the manufacture of yarns and fabrics when cotton, wool, and silk are employed.—July 31.

William Hetherington, of Handsworth, near Birmingham, gentleman, for improved machinery for stamping or shaping metals. (A communication.)—August 3.

Alfred Vincent Newton, of Chancery-lane, for improvements in the manufacture of metallic fences, which improvements are also applicable to the manufacture of verandahs, to truss frames for bridges, and to other analagous manufactures. (A communication.)—August 7.

Roger Hind, of Warrington, engineer, for certain improvements in the construction of machinery or apparatus applicable to weighing-machines, weigh-bridges, railway turn-tables, cranes, and other similar apparatus.—August 7.

Alexander Mills Dix, of Salford, Lancaster, brewer, for certain improvements in artificial illumination, and in the apparatus connected therewith, which improvements are also applicable to heating and other similar purposes.—August 7.

Richard Archibald Brooman, of Fleet-street, patent agent, for improvements in the manufacture of manure. (A communication.)—August 10.

Edward Joseph Hughes, of Manchester, for improvements in machinery or apparatus for spinning and weaving cotton, wool, and other fibrous substances, and also in machinery or apparatus for stitching either plain or ornamentally.—August 10.

Robert Weare, of Plumstead-common, Kent, electrical engineer, for improvements in galvanic batteries.—August 12.

Melchior Colson, of Finsbury-square, Middlesex, civil engineer, for certain improvements in the construction of vehicles.—August 12.

Daniel Adamson and Leonard Cooper, of Newton-wood Iron-works, near Hyde, Cheshire, for certain improvements in the construction of steam-engines and steam-boilers, also in the method of using and rarefying steam, part of which improvements are applicable to marine, locomotive and other boilers, and marine architecture in general, as well as in cisterns, tanks, and articles of a like nature.—August 12.

Richard Laming, of Millwall, Middlesex, chemist for improvements in the manufacture and the burning of gas, in the treatment of residual products of such manufacture, and of the distillation of coal, or similar substances, and of the coaking of coal.—August 12.

Nathaniel Jones Amies, of Manchester, manufacturer, for certain improvements in the manufacture of braid, and in the machinery or apparatus connected therewith.—August 12.

Francois Bernard Bekaert, of Cecil-street, Strand, for improvements in the manufacture of zinc white. (A communication.)—August 12.

James Lowe, of Charlotte-place, Upper Grange-road, Bermondsey, mechanic, and Thomas Eyre Wych, of George-street, Mansion-house, London, gentleman, for improvements in propelling vessels.—August 19.

William Palmer, of Sutton-street, Clerkenwell, Middlesex, manufacturer, for improvements in the manufacture of candles and candle-lamps, and in packing candles and night-lights.—August 19.

Thomas Hunt, of Leman-street, Goodman's-fields, Middlesex, gun-maker, for improvements in fire-arms.—August 19.

Henry Rawson, of Leicester, for improvements in preparing and straightening wool and other fibrous materials.—August 19.

Henry Spencer, of Rochdale, Lancaster, manager, for certain improvements in machinery or apparetus for preparing, spinning, and weaving cotton and other fibrous substances.—August 19.

Charles Butler Clough, of Tyddyn Mold, Flint, gentleman, for certain improvements in machinery or apparatus applicable to the purposes of brushing and cleaning.—August 19.

Pierre Armand Lecomte de Fontainemoreau, of South-street, Finsbury, Middlesex, patent agent, for certain improvements in cutting schistus for slates. (A communication.)—August 19.

Samuel Nichols, of Coldham-street, Nottingham, mechanic, John Livesey, of New Lenton, in the same county, draughtsman, and Edward Wroughton, of New Lenton, in the county aforesaid, mechanic, for improvements in the manufacture of textile fabrics, and in machinery for producing such fabrics.—August 19.

Henry Needham Scrope Shrapnel, of Gosport, for improvements in ordnance and fire-arms, cartridges, and ammunition or projectiles, and the mode of making up or preparing the same.—August 23.

Frederick Dam, of Brussels, chemist, for improvements in preventing incrustation in boilers.—August 23.

Josiah George Jennings, of Great Charlotte-street, Blackfriars-road, brass-founder, for improvements in water-closets, in traps and valves, and in pumps.—August 23.

Julius Roberts, of Portsmouth, lieutenant in the Royal Marine Artillery, for improvements in the mariners' compass.—August 23.

Auguste Edouard Loradoux Bellford, of Castle-street, Holborn, for improvements in the machinery and apparatus for printing fabrics and other surfaces. (A communication.)—August 29.

Paul Joseph Poggioli, of Paris, France, gentleman, for an improved medical compound.—August 26.

George Twigg, of Birmingham, button-manufacturer, for certain improvements in the manufacture of buttons and other dress-fastenings, and in the machinery and apparatus to be used therein.—August 26.

Charles Cowper, of Southampton-buildings, Chancery-lane, Middlesex, for improvements in the application of iron to building purposes. (A communication.)—August 26.

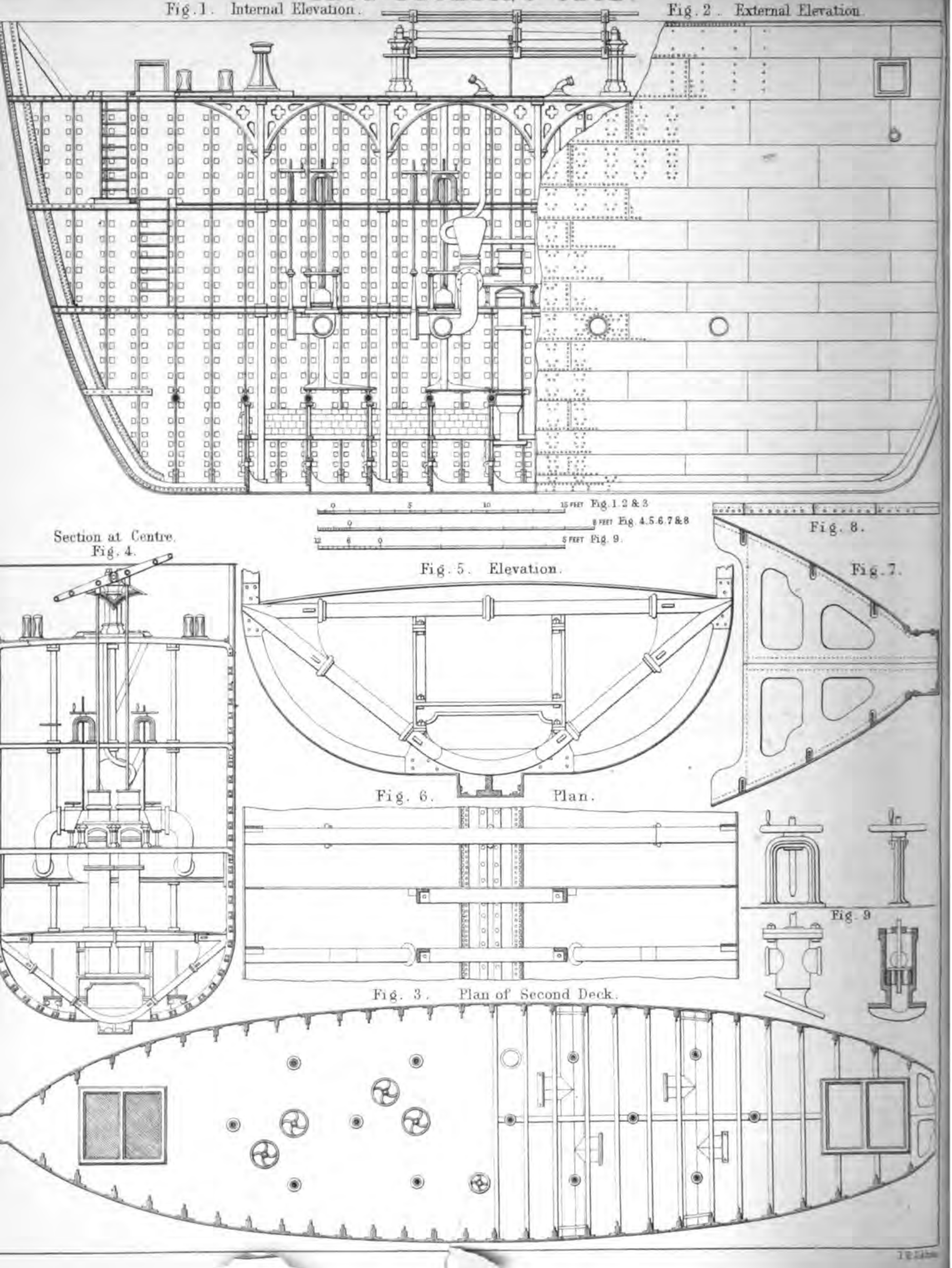
John Fish, of Oswaldtwistle, Lancaster, for certain improvements in looms for weaving.—August 26.

Andrew Crosse, of Broomfield, Somerset, Esq., for improvements in the extraction of metals from their ores.—August 26.

Pierre Amable de Saint Simon Sicard, chemist, of Paris, for improvements in enabling persons to remain under water and in noxious vapours.—August 26.

James Lawrence, of Colnbrook, Middlesex, brewer, for improvements in brewing apparatus.—August 26.

IRON FLOATING GATE.



AMERICAN DOCKS.—No. II.*

(*With an Engraving, Plate* XXXIV.)

In our first notice of General Stuart's work we alluded to the floating-gate or caisson, which, as it is rather novel in its details and applications, we have thought may interest our readers. Works of the kind have been executed in this country at Sheerness and Woolwich, and Mr. Brunel also has one in progress at Bristol: General Stuart's impression is that his is the first constructed entirely of metal.

This floating-gate at the New York Navy Yard is in addition to the turning-gates, and is an iron vessel, with keel and stems made to fit the grooves in the masonry at the entrance of the dock. By floating the vessel over the grooves after a ship has entered the dock, and by admitting water into the vessel, it settles into these grooves, and forms a barrier against the sea. It is removed from its place by pumping out water sufficient to float the vessel clear of these grooves, which are curved, and therefore wider at the surface line than at the bottom line. The grooves are cut in masonry, 26 inches in width and 12 inches deep from the top to the bottom of the side walls, and in the floor. The floating-gate is used in case the turning-gates require repair, or to relieve the strain on them by dividing the pressure of the water.

The outer dimensions of the caisson are 50 feet at the keel and 68 ft. 8 in. at the rail. At the first or upper deck it is 67 feet long; at the second, 65 feet; at the third, 61 ft. 3 in.; and at the fourth deck, or at the top of the truss-bracing, 57 ft. 2 in. The beam at midship section is 16 feet, and at the keel 7 feet.

The material used for the keel and stems is plate of ¾-inch iron, 2 feet wide, and 9 inches deep. The frame is made of vertical ribs of iron, bent to the form of the vessel, covered with boiler-iron, and stiffened by angle-iron deck-beams and cast-iron tubes. At the keel the bottom plates are 24 inches wide and ¾-inch thick, and the stems are of the same size. The sides of the keel are formed by bending the garboard streaks at right angles to the bottom plate, and those of the stems by a continuation of the side streaks, of which there are sixteen in number, made of boiler-plate, 9 feet long by 2 feet wide. The first six of these, from the keel, are ⅝-inch thick; the next four ½-inch; the next three, ⅜-inch; and the next two, for bulwarks, are ¼-inch thick, with a lining of $\frac{3}{16}$-inch iron, from upper-deck to rail. They are all secured together by ¾, ⅝, and ½ inch rivets, at 2½ inches from the centres. The ribs of the frame are composed of wrought-iron, thus: first futlock, or to the second deck, 6 by 1 inch; second futlock, or to the upper deck, 5 by 1 inch; and from main deck to rail, angle-iron, 2½ by 3 inches, and by ½-inch. The pieces of each rib are welded together, and butt at the centre of the keel, in castings provided for the purpose, and secured by rivets 1 inch diameter. There are thirty-one ribs on each side of the vessel, moulded to conform to sections, 2 feet apart, as shown in Plate XXXIV. fig. 1. The knees to which the sheathing is secured are of wrought-iron, each limb being 4 by 4 inches in width, and fastened to the ribs, one knee on each side of each rib, secured by two 1-inch rivets, as seen in fig. 1.

The cast-iron truss-braces are 5 inches outer diameter and 3 inches bore, through each of which passes a 2½-inch bar of wrought-iron, which is secured to the sides and keel-plates by keys passing through them and the bar.

The kentledge-table is so arranged that a passage-way of 2½ feet high is left between that and the keel, for the purpose of repairs and painting, a very necessary arrangement in such a construction. This table is 5 feet wide, and on it is now placed, says General Stuart, 211,295 lb. of cast-iron kentledge, formed with sockets and pins to fit one into the other, and so to prevent it from shifting, which might upset the caisson, and cause serious trouble. The top of the truss-beams is moulded to 4 inches high in the centre, with provision for laying on a deck if needed. The truss-braces and beams commence at frame No. 1, alternately to frame No. 11, at which they terminate with cast-iron transom-plates, running into the stem at each end of the vessel. There are likewise two cast-iron transom-plates at the stems under each deck.

The beams and decks are all composed of wrought-iron. The former are of angle-iron, 3½ by 3 inches, riveted to the frame at each rib by six ¾-inch rivets. The decks have lapped joints, with the exception of the main deck, which is butted, and has a crown of 3 inches. The decks are all riveted to the limbs of the beams by ½-inch rivets, and the rivets of the main deck have counter-sunk heads. Each deck is supported by five cast-iron columns in the centre, of 4-inch bore, communicating from the keel to the main deck.

The filling-tubes, four in number, are of cast-iron, 17 inches diameter, and 14 inches bore, extending through the whole width of the vessel, riveted to the sheathing, and secured with keys to the ribs. Each filling-tube is provided with two valves for the purpose of passing the water through the caisson into the chamber of the dock when the ship is floated out, and likewise into the inside of the caisson, when required, by four branch valves from the same tubes. These last valves are only used when the vessel is being put into place on the grooves, and are of composition metal, cast in halves, planed and fitted together, and bolted through the chambers and flanges of the tubes, which are made in two lengths. The valves are worked by means of shafts and wheels bearing handles, as shown in fig. 1. To one of the tubes is connected a discharge-pipe, having two double-action pumps, each of the following dimensions: 16 inches bore, 14 inches length of stroke, worked like a common fire-engine, by breaks and levers placed upon the main deck, as shown in fig. 2. These pumps are placed on the third deck, and from them suction-pipes extend to within 12 inches of the keel. In addition, a 4-inch bilge-pump is used to take the water out of the inside of the keel, and from below the kentledge-table when required. There are likewise what are called two Kingston valves, worked like the other valves, at the bottom of the vessel, through which it can be emptied, when the chamber of the dock is free of water, without using the hand-pumps.

There are two capstans of cast-iron on the main deck for warping the vessel, and cast-iron heads to secure her when afloat. From the main deck there are connected with the pumps two pipes of 3 inch bore, to be used for washing out the caisson and chamber of the dock, and in case of a fire in the neighbourhood or on board of a ship when in the dock for repairs.

A lining of india-rubber, 8 inches wide, and 1 inch thick, weighing about 979 lb., was fastened to the outer surface of the keel and stems, with countersunk screws, before the caisson was launched, to prevent as far as possible the leakage of water between the vessel and the masonry of the dock. This, says the General, answered the proposed purpose very well, until it became torn by repeated use of the caisson during the past year. Oak or yellow-pine plank is to be used instead, arranged like the buffer-timbers of the turning-gates.

The contract for the floating gate was made in August 1849, the iron keel laid in October of that year, and the vessel launched on the 1st of January, 1850, the day the contract expired. The whole of this complicated and massive structure was built in the short space of seventy-two days. The weight of metal and ballast is about 320 tons, and the total cost 79,419 dollars, or about 18,000*l*.

The description of Plate XXXIV. is as follows:—

Fig. 1, shows an internal elevation of the caisson, with its general arrangements for operating it; including the capstans, pump-brakes, frame, bulwarks, main deck, second and third decks and their supports, stairways leading to them, valve-gear, pump chambers and pipes, truss bracing, ribs, angle-irons, knees, stems, and kentledge-table and ballast.

Fig. 2, shows an external elevation of the caisson, with the side and stem plates, openings of filling-tubes, hawse-holes, ring-bolts, &c.

Fig. 3, shows a plan of the second deck, with the ribs, columns, and ties to support the upper-deck, and wheels for working the filling-tubes' valves, and on the right are seen the filling-tubes on the third deck, the hatchway, transom-plate, and stem.

Fig. 4, is a cross section of the caisson, decks, frame-pumps, filling-tubes, valves, wheel, truss-bracing, and keel.

Fig. 5 and 6, are an enlarged view of the truss-bracing, filling-tubes, and kentledge-table in plan and section.

Fig. 7 and 8 are enlarged views of the transom-plates in plan and section.

Fig 9, shows the Kingston-valves, and hand-wheel gear for operating them.

* 'The Naval Dry Docks of the United States.' By Charles B. Stuart, Engineer-in-Chief of the United States Navy. Twenty-four Steel Engravings. New York: Norton. London: Weale. 1852.

NECESSITY OF AN ARCHITECTURAL EDUCATION ON THE PART OF THE PUBLIC.

By Owen Jones, F.R.I.B.A.

[*Exhibition Lecture delivered at the Society of Arts, London.*]

In all times but our own all ornamentation resulted from architecture; in the present age we have no guiding principle in its design or unity in its application: the architect has abandoned to inferior hands that which was his especial province. The education of our architects must undergo some change before we can hope that architecture and its attendant arts shall faithfully represent the wants, feelings, and faculties of our time; this result can never be effectually obtained till a much higher amount of art-knowledge exists in us as a nation.

How is any change for the better to be brought about? It is certain that the production of a national style must be, as it ever has been, a work of slow development; yet, if never attempted, the problem never can be solved.

It seems to me—now that we have so many schools devoted to the improvement of design as applied to manufactures, and that a movement in this direction, aided by this Society, is receiving a fresh impulse—that if the government were to undertake to gather together all the records of the past, and would disseminate that knowledge with correct principles for making use of it, a vast stride would be made in the right direction.

The system of architectural education followed in France is very superior to that pursued in this country. Here the young architect is apprenticed to an architect in practice as to a trade, and is engaged for five or seven years on the works of his master; he gains thereby a good knowledge of construction and of the business of an architect, but has but little opportunity of studying architecture as a fine art. In France, on the contrary, besides the drawing-schools which exist in every town, where the young may obtain much elementary knowledge, there are in Paris many studios where professors devote their time to the instruction of a large number of pupils, making them thoroughly acquainted with the works of every period, and giving them a thorough knowledge both of architecture as a fine art and of construction in theory.

The pupils of these various studios are mostly attendants at the Architectural Academy, where they once a-month produce designs in competition for a given subject, and they are assisted in the formation of these by their professor. One consequence resulting from this system is, that we see in France at any given period a much greater unity in the character of their works; and there is not that disorder and waste of forces which we see in this country, where each architect is pulling in a different direction.

Works executed in France have a family resemblance not to be found in those of this country; the influence of the professor is much more felt, and schools of architecture are thereby formed, much as were the ancient schools of painting.

All these architectural students do not become architects; those who do so, when they have finished their studies, become clerks of the works under government architects, where they learn the practice of their profession, and ultimately practise on their own account. Many of those who have not been sufficiently advanced, or want government influence to be so placed, turn to other professions connected with architecture—become decorators and designers for manufacturers. It is this cause which gives to the designs of France the superiority they have. Mostly all their designers have had an architectural education. I do not mean to say that the French have made much more progress towards the formation of a national style than we have; what they have done is, that, at any one period, they have carried out the reproduction of any extinct style with much more unity. The fashion, as long as it lasted, has been general; and we do not see in France, as we see here every day, the building of one style of architecture, the decorations of another, and the furniture of a third, with every variety of age and period. However, it is the kind of education as pursued in France which I think it would be useful if our government could be prevailed upon to foster. The Schools of Design have not hitherto produced any marked improvement in the designs of our manufacturers, and have been conducted as if it were the intention only to make painters. The study of the human figure has been carried to excess, and much labour wasted upon it; useful as it is for refining the taste and teaching accurate observation, yet it is a roundabout way of learning to draw for the designer for manufactures. I may here remind you that the Eastern nations, who appear to excel all others in their works of ornamentation, are forbidden by their creed to make any representation of the human figure; and it is probably to this cause that we may attribute their excellence in ornament.

I cannot but feel that if the education of the government schools were made more architectural, much real benefit would result to this country; besides that the study of architectural forms must be the best preparation for the designer of ornament, they would do more good in helping to make architects than painters, to whom individuality is less of an evil. Architects should be educated in masses, because it is their duty to give expression to common wants and common feelings. The opposite system has been in use in this country, and has most assuredly failed. The knowledge we have acquired of the works of past ages has been procured by individual efforts, but, unfortunately, with but small results. Each has been tempted to exaggerate the importance of the style of his predilection, and which he undertook to illustrate. That a little knowledge is a dangerous thing has proved most true in architecture and its attendant arts.

As each new architectural publication appears, it immediately generates a mania for that particular style. When Stuart and Revett returned from Athens, and published their work on Greece, it generated a mania for Greek architecture, from which we are barely yet recovered. Taylor and Cresy did as much for the architecture of Rome. The travels of Belzoni and his successors produced the Egyptian Hall, and even Egyptian-faced railway tunnels. The celebrated French work on the architecture of Tuscany, and Letarouilly's 'Modern Rome,' have more recently inspired us with a desire for Italian palaces. The works of the elder Pugin and Britton, with a host of followers, have flooded the country with Gothic buildings; with which, notwithstanding the learning and research they exhibit, I must frankly avow I have but little sympathy. I admire and appreciate the Gothic buildings, which were the expression of the feelings of the age in which they were created; but I mourn over the loss which this age has suffered, and still continues to suffer, by so many fine minds devoting all their talents to the reproduction of a galvanised corpse.

Instead of exhausting themselves in the vain attempt, who will dare say that had these same men of genius, as they certainly are, directed their steps forward instead of backward, architecture would not have made some progress towards becoming, as it is its office, the true expression of the wants, the faculties, and the sentiments of the age in which we live? Could the new wants to be supplied, the new materials at command, the new sentiments to be expressed, find no echo to their admonitions? Alas! iron has been forged in vain,—the teachings of science disregarded,—the voice of the poet has fallen upon ears like those of the deaf adder, which move not, charm the musician never so wisely.

More than this; instead of new materials and processes suggesting to the artist new forms, more in harmony with them, he has moulded them to his own will, and made them so to speak, accomplices of his crime. The tracery of Gothic windows, generated by the mason's art, have been reproduced in cast-iron; the Doric columns of Greek temples, which owe their peculiar form and bulk to the necessities of stone, have been but a hollow iron sham.

We have gone on from bad to worse: from the Gothic mania we fell into the Elizabethan—a malady fortunately of shorter duration; for we then even worshipped not only a dead body, but a corrupt one.

We have had an Italian mania without an Italian sky; and we are even now threatened with the importation of a Renaissance mania from France. It would be most unfortunate if the attention which has been directed to the peculiar beauties of the East Indian collection of the Great Exhibition should result in an Indian mania; but if this disease, like measles, must come, the sooner it comes and goes the better. What we want to be convinced of is, that there is good mixed with evil in all these styles; and I trust, when each has strutted its brief hour on the stage, recording for posterity the prevailng affectation of the day, we shall. We want to be convinced that all these styles do but express the same eternal truth, but in a different language; let us retain the ideas, but discard the language in which they are expressed, and endeavour to employ our own for the same purpose. We have no more business to clothe ourselves in mediæval garments than to shut ourselves in cloisters and talk Latin; to wrap ourselves in Indian robes and to sit all day on divans, leading a life of voluptuous contemplation.

After the expression of so much heresy, I must beg to say the fault does not at all lie with the architectural profession, to which I esteem it an honour to belong. The fault lies with the public; the public must educate themselves on this question. Architects, unfortunately, can but obey their clients: this one will have an Elizabethan mansion; this clergyman can admit no other than a mediæval church; this club of gentlemen must be accommodated in an Italian palace; this mechanics' institute committee must be located in a Greek temple, for there alone wisdom can be found or philosophy taught; this railway director has a fancy for Moorish tunnels or Doric termini; this company, again, an Egyptian suspension-bridge—the happy union of the alpha and the omega of science; the retired merchant must spend his surplus in Chinese follies and pagodas. And, to wind up the list of these melancholy reproductions, I will cite the worst I ever saw, though fortunately not an English one. We have here a client, who requiring a steam-engine for the purposes of irrigation for his garden, caused the architect to build an engine-house in fac-simile of one of the beautiful mosque tombs of the caliphs of Cairo. The minaret was the chimney-shaft. Nothing was omitted; even the beautiful galleries, which you all know were used for the purpose of calling the Moslem to his prayers, here surrounded a chimney without a means of access.

I again repeat, the fault lies with the public; an ignorant public will make complaisant and indolent architects. Manufacturers, again, will always tell you, in answer to a reproach for the bad designs they produce, that they are only what the public require, and will have: let us trust that this excuse will no longer avail them. The Great Exhibition has opened the eyes of the British public to our deficiencies in art; although they were unable to suggest better things, they were found quite able to appreciate them when put before them. There must be on the part of manufacturers, architects, artists, and all who in any way minister to the wants and luxuries of life, a long pull, and a strong pull, and a pull altogether; they have one and all, like dramatic authors, written down to the taste of the audience, instead of trying to elevate it. The public, on the other hand, must do their part, and exercise a little pressure from without.

I know that I shall be told that the production of a new style of architecture is not so easy a matter; that it has never been the work of any one man, or set of men, but rather something in the like of a revelation; for which, probably we may be told to wait. Much of what I have said here this evening will be set down as the ravings of folly. Some will say, architecture is a thing of five orders, discovered and perfected once for all, beyond which we cannot go, and all that is left us is an adaptation of it to our own wants; others will tell you that a Christian people should have no other than Christian architecture, and will tell us to go back to the thirteenth century in search of architecture, and that beyond this there is no salvation; but I answer that this architecture is dead and gone; it has passed through its several periods of faith, prosperity and decay; and had it not been so, the Reformation, which separated the tie which ever existed between religion and art, gave to Christian architecture its death-blow.

To show how new styles are really formed, I will here give you an instance of the progression of an architectural idea. Here is the ornament known as the egg-and-tongue moulding, so common in Roman architecture, which we produce over and over again to such an extent that there is hardly a building or house erected where it is not used externally and internally. Let us see what the Arabs did with it; let us see if they were content to consider it as perfection, and to set themselves down before it with folded arms to worship it.

When the Mahometan religion and civilisation rose with such astonishing rapidity in the East, the Arabs, in their early mosques, made use of the materials which they found ready to their hands in the ruins of old Roman buildings, or buildings which they purposely destroyed; they took columns with their Corinthian capitals, &c., and adapted them to the arrangement required for their own temples. In their subsequent works they did not, as we should have done, continue to copy and reproduce the models which were at first so convenient to them; but, applying to them their own peculiar feelings, they gradually departed from the original model, to such an extent at last, that but for the intermediate steps we should be unable to discover the least analogy between them. Yet by this process the capitals of their columns can be traced back to the Corinthian order which they, in the first instance, found so abundantly for their use.

In the instance before us, who, at first sight, could see any connection between the egg-and-tongue moulding and the ceiling of the hall of the Two Sisters of the Alhambra? Yet, by placing side by side the intermediate stages, we may be as certain of the process by which they arrived at it as if we saw them at work before our eyes. Here is a cornice very common on the earlier buildings of the Arabs. You will see that it resembles in all respects the egg-and-tongue moulding, save that what is here round in the Arabian cornice is straight. Some fresh mind at work upon it saw an opportunity for fresh beauty in doubling it, as you see here another in tripling it; then there must have burst upon some other that this muitiplication of a simple element was a mine of wealth to them. We now see this principle developing itself in the formation of pendentives, and the filling up of niche-heads and doorways. It was reserved for the Moors to carry this principle to its utmost limit; and we see in the Alhambra capitals of columns, arches over large openings, and ultimately the ceilings of their halls, were covered with the stalactite roofs, which are not more remarkable for their elegance and beauty than for their scientific construction.

This model before you is a portion of the ceiling of the hall of the Two Sisters; it is composed of 5000 pieces, being combinations of the same seven, based upon three primary forms—a right-angled triangle, being the half of a square; a parallelogram, having one of its sides equal to the hypothenuse, and the other to one of the sides of the angle; and an isosceles triangle, also with sides equal to the sides of the right angle; so that as these seven pieces occupy the same space on plan, but are different in elevation and section, they may be used indifferently one against the other, and the most astounding varieties can be produced: in fact, they are infinite, like the combinations of the seven notes of the musical scale.

Similar progression may be seen in every architecture. Many of the types of Greek architecture may be seen in Egypt. The flutes on the Doric column were first simply corners cut off in the piers of the rock-cut temples of Egypt. They then became eight-sided, and so on, till some one must have suggested making the sides curve inwards; and lo! we have the flutes. A rude type of the honeysuckle ornament, so prevalent in Greek architecture, is seen on the Assyrian monuments discovered by Dr. Layard and M. Botta; in fact, any one so disposed will find numberless instances of these progressions: but I have said enough to show that architecture, till now, has ever been progressive. What has been done in past ages may be done in this, if our minds are only so directed.

We have all the works of the past, as I said before, for our inheritance. We may use the principles and knowledge derivable from them, but may not parody the results of these principles. From the works of Egypt we may learn how to symbolise; from those of Greece we may learn purity of form and grace of outline; from the Arabs and Indians, perfection of form, harmony of colouring, and more especially the conventionality of natural forms; from the Moors, in addition, the great powers of geometrical combinations, and the immense value of the repetition of the most simple elements, as producing grandeur and richness; and when fully impressed with this knowledge, have we not before us the whole range of Nature's works, furnishing us suggestions of endless variety? See what the Egyptians did with the lotus, the Greeks with the honeysuckle, the Romans with the acanthus, the mediæval artists with the trefoil, the maple, the vine, ivy, and oak. Have the plants and flowers of every clime been gathered together in vain for the architect? can they furnish him no hint for the development of new conventional forms?

There is but little hope that any but a slight modification can take place in the art of the present generation, but it is the bounden duty of all to help in the elevation of the future. We have movements going on around us to promote the knowledge, improve the morals, and preserve the health of our race. Philosophers measure the innermost recesses of the vault of heaven, or descend into the bowels of the earth for knowledge, which they disseminate by cheap literature to the homes of the humblest. Free trade supplies food and raiment to all. The railway movement quadruples the power of locomotion. The sanitary movement seeks not only to prolong life, but to render that life a blessing rather than a curse. The movement in favour of the drainage and irrigation of the soil now dawning, promises so far to increase the productiveness of the country by pouring on it the waste of towns, that what are now the luxuries only of the few will hereafter be daily supplied to the many. Shall we, then, be content to supply only the material and intellectual wants of man, neglecting that far happier portion of his nature, the sentiments? Shall there be no movement in favour of bringing art-knowledge within the reach of all? I would strongly urge that there could be no more noble result springing out of the Great Exhibition than this; no more noble task for this Society, which brought about the Great Exhibition, to set itself than this.

Every town should have its art-museum, every village its drawing-school; every parent should educate himself in art, as far as he can, and cause his children to be educated still further: it is as necessary for the refinement and the happiness of mankind to develope the innate poetry of his nature by the cultivation of the eye as to develope his intellect by giving him the power of reading and writing. Do not say this is visionary or impossible; every movement now successful was once so regarded, was once but the philanthropic yearnings of the few.

The government may, and ought, to assist in developing this movement; it should help with no niggard hand: a few thousands spent in forming art-museums, accessible to all, would save many thousands more from being spent in building gaols.

Although the evil passions lurking in the breast of man can never be eradicated, yet they may be subdued and charmed to slumber by the cultivation of his higher mental and sentient powers. Give a people healthy pleasures, and the tendency to crime must be diminished. As a first step in the development of this movement I would preserve the Crystal Palace. When I reflect that at the very moment when the Ruler of France decrees—That, seeing the city of Paris has no permanent building worthy of public exhibitions and national *fêtes*, therefore let there be one on the plan of the Crystal Palace of London; when I reflect that we who have it are about to destroy it, I am perfectly astounded at the apathy of the British public which allows it.

It is to me a melancholy sign of the little feeling which exists for art in this country, and that there are so many educated people found to ask, What would be the use of keeping it where it is? Why, sirs, I assert that were the building simply to remain as it is, a vast covered area, where the people of every class might daily intermingle, it would have a civilising influence over the present generation, which would be worth the paltry sum required to purchase it many times over.

There is no country in the world where the manners of the peer and the peasant so nearly approach as in Spain, and we find there every town and almost every village has its *paseo* or promenade, its *alameda* or elm-grove, where daily, just before sunset, all classes freely mingle together, enjoying the refreshing evening breeze, their hearts dilated by the contemplation of nature's noblest works. Their churches, again, are their art-museums; on their marble pavements the duchess and the grisette kneel side by side. Who can doubt the influence of these facts in forming those refined artistic instincts so universal in a people who are very deficient in acquired knowledge?

There is no doubt whatever that the free mixing of the several classes which took place last year in the Great Exhibition has produced a feeling of higher appreciation of each other, both with the great and the humble; the great have a higher respect for the humble, the humble look with much less of envy on the great. Were the opportunity for this continued, the impression would become permanent instead of being transitory, or worse.

This civilising influence, I say, would result from the empty building; but when we imagine, in addition, its vast nave, adorned with a complete history of civilisation recorded in sculpture from the earliest times to the present, with casts of the statues of our great men which now adorn our squares and public places, invisible from London smoke; when we imagine the plants of every region, however distant, climbing each column and spanning each girder; the sides of the buildings set apart for the formation of collections, recording man's conquests over nature, where hundreds daily may be taught to see with the mind as well as the eye, an education as necessary to the governors as to the governed; were such a scheme carried out nobly and lovingly, the success of the Great Exhibition would be, in comparison, failure itself.

To effect this, and in further developing the movement in favour of bringing art-knowledge within the reach of all, the government may do much, but the public must do more; it must depend for success on the co-operation of all.

It is a movement that may not be delayed; we must be up and stirring, if we would not that England, in the midst of her material greatness, become a byword and a reproach amongst nations.

PROMOTION OF ARTISTIC EDUCATION AMONG THE WORKING CLASSES.

One of the greatest impediments to the development of artistic composition by architects is the want of competent assistance from workmen. In exact proportion to the desire and capability of the architect to exhibit artistic excellence is the difficulty he finds to carry his designs into execution. Great as may be his acquirements, fertile as he may be in composition, and assiduous as he may be in the discharge of his duties, it is impossible that he can fully design every detail, if such detail is to receive its due artistic treatment. Even in a small structure it is undesirable and impossible for the architect to be the sole designer and only artist employed; and in a large building the attempt is at once acknowledged to be hopeless. In the paucity of adequate assistance from workmen, from the fear to intrust to rude hands the treatment of parts, the architect is led to rely on mechanical reproduction, and to design patterns which can be put into the hands of the manufacturer and supplied by the cwt. or yard run. Hence the want of earnestness and lifelikeness in our modern edifices as compared with those of antiquity; hence the appearance of poverty of execution in the works of our greatest masters, or the impression that the structure is unfinished.

It is from the cause we have exhibited our efforts for the promotion of originality in art are paralysed, for while we stimulate the architect to exertion, he only moves forward to encounter serious obstacles. We can, it is true, urge the architect to exertion, but we cannot insure him, from an untrained population, adequate instruments for achieving his designs. We have never concealed from our readers the necessity of obtaining a remedy for this state of affairs, and of placing architecture as all other arts, on the only true and living groundwork—that of the sympathy and co-operation of the mass of the population. Whatever may be the thought elsewhere as to the desirability of confining any branch of education to a select class, nowhere can we so well appreciate the false economy of it as in the department of art. A population uneducated in art deprives the artist not only of efficient assistance, but of patronage; and what is still dearer, the moral appreciation of his exertions. Those who will work for cognoscenti, or for exclusive patrons, must narrow the sphere of their conceptions, because they narrow the means of execution; and in no respect, perhaps, does the true artist more sensibly feel the decline of art among us than in its low condition among the working classes. Every relic of antiquity shows us not only that the artist of old was more of a workman than now, but that every workman was more of an artist.

It is under these convictions that we again bring this subject before the architectural profession, feeling assured that there is such a degree of earnestness awakened as will enlist the co-operation of every member in the promotion of any practicable and well-intentioned measure. If heretofore this co-operation has been less manifest, it is because there has been no adequate encouragement for the exertion of the architect. Schools of design were, it is true, founded some years ago, but on such narrow principles that they promised to do as little for the architect as in reality they have performed. These schools turn out their scores of pupils; but what the architect wants is instruction for his tens of thousands of masons, carpenters, smiths, and workmen—and this the schools of design could never afford. We dwell upon this neither as an exculpation for the architects, nor as an inculpation of the schools of design, but for the simple explanation of the state of the case. The schools of design have undoubtedly done good in many branches of ornamentation, and have greatly promoted the views of the architects; but they must not lead us away from the more comprehensive question—that of the artistic training of the mass of the population. In our early volumes we advocated this, for already fifteen years ago the inadequacy of the schools of design was felt, and a movement was begun in the formation of the Society for Promoting Practical Design, which, although it effected only partial good then, at any rate kept the true principles alive. In that society Haydon and Sir Martin Shee, Mr. Wyse, Mr. Ewart, Sir Robert Peel, and Mr. Labouchere, endeavoured to correct the narrow policy of the government, to carry out the views of the parliamentary committee, and extend artistic instruction among the population. In its short-lived career the society succeeded in reducing the fees of the government schools from 10*l.* a-year to 6*d.* a-week; in opening the study of the figure and the higher departments of instruction to the working man; in removing the obstacles to the free development of artistic instruction; and in giving the example of the first female-school. The committee also republished and circulated extensively the same evidence of Mr. Dyce and others as to the state of foreign schools and the means of rivalling them, as is now, after so many years, brought before the public by the Department of Practical Art. In the success achieved with such small means by the society, the new department has the best ground for its exertion, and the best assurance that its labours will not fall to the ground.

The School of Design was certainly an important step, but for nearly fifteen years the cause remained without progress. The next step, and which is likely to be attended with still greater benefit, is that taken this year in the establishment of the Department of Practical Art. If we correctly understand the objects of this new organisation, they are of a twofold nature—first, the promotion of the direct practical application of the arts to manufactures; and next, the extension of elementary artistic instruction among the body of the population.

The department has under its charge the metropolitan schools of design, and twenty provincial schools, the Trustees' School at Edinburgh not being reckoned. All these schools are now for males and females; but the most extensive organisation is in London, where, besides the high school at Somerset-house, there is a special school at Marlborough-house for the principles and practice of ornamental art and the study and practice of special processes of manufacture. There are likewise special classes of instruction for silk patterns, painting on porcelain, wood-engraving, and chromo-lithography. There is a class for architectural details and practical construction, under Mr. C. J. Richardson. The Department is now taking measures for co-operating with the mechanics' institutions, each of which has its drawing class, and which train students for the schools of design.

New rules have been promulgated to encourage the formation of elementary schools for drawing and modelling, which contemplate a government guarantee for a fixed period towards the payment of the master's salary, until such time as the scholars' fees shall be sufficient to afford a remuneration.

A very useful measure is the introduction of an official drawing-master, to give weekly lessons in each public school in a town, at the charge of 5*l.* yearly for each school.

It is however requisite to give a further stimulus to instruction in the common schools; and this we should propose to effect economically by a system of inspection and rewards. The twenty schools of design, or of ornamental art as now called, would furnish in their masters inspectors for the National (English and Irish), and British and Foreign Schools already under the Board of Education, and a small additional fee would meet this system of inspection in the first instance. A further sum should be appropriated in sums of 5*l.* each for the reward of those masters of the inspected schools who should have proved themselves most efficient. Such a sum would be adequate inducement to stimulate the exertions of numerous members of the now increasing class of public schoolmasters.

We should observe, that the Department of Practical Art has fallen into the old practice of publishing and recommending elementary books, by their own parties. The less the Department has to do with publication the better we are convinced it will be for itself and for art. Indeed, we can already trace the effect of mannerism in the tone already adopted. Thus we see the artificial Geometrical system patronised by one member, and the Oriental or Alhambric scheme of colouring by Mr. Owen Jones. No course can be adopted so sure to create prejudice against the Department, because many in the sphere of art entertain strong objections to the inculcation of the geometry of the square and circle as a vehicle for the study of nature and natural mechanics; and Mr. Owen Jones's theories have been already the subject of controversy. The Department has quite enough to do practically without engaging in bookselling, and in jobbing the books of its members to the exclusion of the productions of others. Messrs. Longman will always be willing enough to publish the works of Mr. Dyce, Mr. Redgrave, and Mr. Owen Jones, without the adventitious qualification of a government monopoly.

Besides the schools, the Department has a museum of ornamental art at Marlborough-house, formed by donations and a treasury grant of 5000*l.*, for the purchase of articles from the Great Exhibition. This museum is in its infancy, and must soon obtain a greater extension, while it will exercise a material influence on other museums which have objects of kindred interest, and lead to their re-organisation with a view to special objects of study. Such are the Museum of Practical Geology, that of Economic Botany, the Soane Museum, the Egyptian, Etruscan, and Roman departments of the British Museum, the Tower Museum, the United Service Museum, Asiatic Museum, and the incipient Museum of Economic Botany just opened by the Royal Botanic Society. There are likewise objects at St. James's, Windsor, and Hampton Court, which will acquire a new interest as examples of ornamental art.

The Marlborough-house Museum contains many well-chosen objects, and the catalogue is one of a useful character, giving a greater value to the collection. Each article catalogued is accompanied with its price, and observations on its artistic or manufacturing qualities. Although we may dissent from some of the theoretic views enunciated, we are bound to acknowledge that these observations are calculated to be of use to the student by exciting habits of reflection.

One division of the Museum is that devoted to examples of works on false principles—a museum, in fact, of morbid anatomy, and therefore the more valuable. In engineering, few things are considered of more practical value than an accurate acquaintance with failures, with a view to ascertaining their causes and avoiding their recurrence. The public will grieve to find many favourites in this limbo, but we cannot pity any of the culprits after having seen them. The formation of such a class was a task of some hazard, but it seems on the whole to have been well carried out.

In the collection of casts and drawings, our professional readers will be glad to be informed there is a copious selection from the Renaissance style. Who knows but in time we shall have the elements of the so-often-wished Architectural Museum?

The library is only just begun, and intended for the students; but we hope the managers will use it with liberality. It will be well worth their while to give up a room to it, and make it at least as accessible as the British and Soane Museums, and gratuitous. It will not be long before they receive donations and government grants more than compensating for any presumed loss. The opening of this library will react beneficially on the two libraries already named, and likewise on the Royal Academy and Institute of British Architects.

The Annual Exhibition of the works of students of all the schools is now an established institution: and here, again, we have the opportunity of adverting to a wider field which each effort is certain to obtain, thereby greatly extending the influence of the individual example. A short time ago, ornamental art had no field of display, but now there is not only Marlborough House, but the Architectural Exhibition and the Society of Arts, besides many provincial exhibitions.

It will be seen, from what we have already stated, that a movement is in progress, which must have a very great influence on art, and necessarily on architecture. The period has arrived when the architect must consider what part he shall have in this course of progress, or whether, awaiting the fruits, he shall resign active participation in the preliminary labour to other artists. If he do so, his own profession must lose an opportunity for distinction, and his own art will fail in obtaining a proper degree of advantage from the system of instruction carried out. It will be, as heretofore: the objects of the architect will be slighted or slurred over, and the more clamorous applicants will monopolise attention. Manufacturers will contend for the workmen, and painters arrogate to themselves the management, and architects, as in so many cases, be deprived of their fair claims. On the other hand, by judicious and liberal co-operation in the metropolis and the provinces, not only may general results of interest to the profession be secured, but special classes like that under Mr. Richardson, be formed on a more extensive scale.

BRITISH ASSOCIATION.

Selections from Papers read at the Meeting held at Belfast, September, 1852.

INTRODUCTORY OBSERVATIONS OF JAMES WALKER, ESQ., C.E., PRESIDENT MECHANICAL SECTION.*

I HAD not been told, until I came here yesterday afternoon, that it was expected that the Presidents of the departments of this Association were to introduce the business by addresses; indeed, I have been, as respects attendances, so very unworthy a member, that I suppose the honour of being selected to the chair of this very important department is due greatly, or chiefly, to my connection with Belfast, as Consulting Engineer to the Harbour, which professional employment I have filled ever since the great improvements were designed and executed. I believe Mr. Smith, the respected and talented Resident Engineer, and under whose immediate direction the works have been executed, intends to present a paper on the subject, when some observations may present themselves.

I have said that the Mechanical department is important, so far as regards the useful and practical purposes of life in an improved society; I believe I might have said the most important, for they are all dependent upon it, and improve as machinery improves. The time has long passed when machinery, supplanting manual labour, was a subject for alarm, unless it be with those whom machinery has not yet reached, and who, perhaps, entertain the almost equally reasonable fear of witchcraft. I do not say that there are no cases in which mechanical improvements have not caused temporary injury to individuals, nor can it be said that the belief in witchcraft has not prevented crime; but, in general, the one is about as reasonable as the other, and superstition has, perhaps, as many arguments in its favour. It is useful until reason supplants it, and so hard labour is useful until mechanical inventions are brought to light, and no longer. Take this town as an illustration—but for the employment of machinery for the manufacture of its staple article, it never would have reached its present thriving state and great and increasing population; and its active and industrious inhabitants do not want to be told, that if they allow the machinery of other towns, as applicable to the manufacture of linen, to get ahead of them, the sun of their glory shall have set. See, again, the effects of mechanical knowledge in lessening the resistance of water to the passage of ships, by improving their form, and, more recently, by the application of the steam-engine as a propelling power upon ships and railways, and consider how universal their effects are felt, in administering to our convenience and comfort, as printing, that greatest of all enemies to ignorance and superstition, does to our mental improvement and happiness. But not only are books, and better clothes, and long journeys, cheapened, and brought within our reach, by machinery, and the produce of all parts of the world, as it were, brought to our doors, and the fuel we use supplied to us by means of canals and railways, at one-tenth or one-thousandth of the expense they would otherwise be,—but as machinery gets to be more and more applied to the improving and draining of land, or the growing and preparing of corn, rice, and other grains, the great staff of life, bread, in all its forms, becomes cheaper and more abundant. Not only does the same ground produce a greater crop, but it produces it with a less quantity or expense of labour, and therefore enables each individual to exchange his labour for a greater quantity of food. If I am asked how machinery effects this, I would refer to the vast variety of machines shown at agricultural meetings, and the number in the yard of every good farmer,—to the winnowing-machine, the thrashing-machine; the application of steam to this, and also to grinding, in lieu of a precarious water-power; and last, but not least, the canals and railways for conveying the corn to market, contrasted with the roads scarcely passable in winter, along which the farmer's horses had to drag a small load, adding materially to the cost. The operation of these causes in cheapening the corn and the produce of the soil generally does not appear to me to be alluded to so much as they deserved. I consider the present low prices of many of the necessaries of life to be the effect of them, and that to apply machinery still more to agriculture is the most natural and unobjectionable means of meeting the cheapening effects of the free importation of corn from other countries. Linen, as respects the growth of flax, and its conversion into cloth, is a manufacture; and so also is bread as respects the growth of corn, and its conversion into bread. Now, Belfast is not afraid of a free-trade in linen—its improved machinery enables it to defy the world; it imports foreign flax at a cost, and is able to make linen, if they will take it, cheaper than the country which grows it can make it at all.

But for improved machinery, again, as applied to the sciences—take the most sublime of them all, astronomy—Lord Rosse could not have brought down the wonders of the heavens to our senses by his great telescope, if he had not been a mechanic as well as an astronomer; and Mr. Craig, whose great telescope I have seen, could not probably have brought his ideas into practice as respects the formation of the great tube, and the mode of fixing and adjusting it, without the assistance of the engineer's gravatt.

I shall conclude these remarks with one involving the interests of capitalists, in respect to the effect of the late discoveries and importation of gold reducing the real value of their nominal property, money and money rents, to show how much mechanical science may come in to relieve them.

That the greater abundance of gold, and the lesser labour in procuring it, must have the effect of cheapening the article, cannot be doubted; but the same principle applies to every other article, including, as I have before shown, corn; and if we progress with machinery and the other means of cheapening all articles, this may still enable as large a weight of corn and other articles to be exchanged for the same weight of gold as before the late golden discoveries—their relative value may remain the same as before. It is to that we may ascribe the little effect which the importations of gold, and prospects of greater abundance, have had upon the markets. One day of rain during harvest produces more effect on the price of corn than all the fear of being overwhelmed with gold has done. Consider, also, that there are a hundred, or perhaps a thousand times the number of men employed in cheapening corn by machinery, draining, and digging, to one digger of gold.

After this hurried address, which has extended beyond my intentions, it will not be expected or wished that I should go into a description of recent scientifical inventions; but I cannot close without noticing, in general terms, the electric telegraph, by which communications are made at the rate of six times round the earth in one second of time, and how mechanical appliances have been adopted to make this practical and useful by land, and more by water. The knowledge of the operations of this—what it is that passes along the wires at this enormous rate—is beyond our reach at present: we only know that something, a property—matter—actually does so, but for the knowledge of what it is we must refer to the Author of Nature, the great source of all science.

* For the report of Mr. Walker's Address we are indebted to the *Northern Whig*.

MECHANICAL PROCESS FOR COOLING AIR.

Remarks on the Mechanical Process for Cooling Air, proposed by Professor C. Piazza Smyth. By W. J. MACQUORN RANKINE, C.E.

IT has been proposed by Prof. Piazza Smyth, for the purpose of cooling air for the ventilation of buildings in tropical climates, to make use of the well-known property which air possesses, in common with all other elastic substances, of causing heat to disappear by its expansion. The air is to be first forced, by a compressing pump, into one end of a refrigerator, consisting of a long tube, or a series of tubes, surrounded by water. The heat developed by the compression being given out by conduction to the water, and the air restored to its original temperature, it is to be allowed to escape from the other end of the refrigerator into the building to be ventilated, where, by its expansion, it will become cooled to an extent depending on the extent to which it was originally heated by compression.

The machinery which Prof. Smyth proposes to employ having been described to this Section at a former meeting, and also in the *C.E. & A. Journal* for 1850 (Vol. XIII. p. 299), it is not my intention to enter into details respecting it. My object in this paper is to show the method of calculating the power necessary to work the machinery; and especially, the saving of power which may be obtained by means of an improvement recently proposed by Prof. Smyth. This improvement consists in adding, at the escape end of the refrigerator, a second cylinder, in which the air during its expansion works a piston, before being distributed through the building. The effect of this addition is at once to save and employ in assisting the compression of the air, the mechanical power developed during its expansion, and to prevent the partial re-heating of the air by friction, which might take place if it were allowed to escape without working a piston, in consequence of the violence of the blast. The saving of power is in fact so great, that the friction of the machinery becomes the principal part of the resistance to be overcome, instead of being, as before, secondary to the compressive power.

The formulæ which I shall use are not minutely correct in theory, for they treat air as a perfect gas, and assume the laws of its action with respect to heat and elasticity to be more simple than they actually are; but they are sufficiently near the truth for practical purposes.

Let T denote temperature in degrees of Fahrenheit, measured from the ordinary zero; then what is called Absolute Temperature is given by the formula

$$t = \mathrm{T} + 462°.$$

Let t_1 denote the original absolute temperature of the atmosphere; t_0 that to which the cooled air is to be ultimately brought; t_2 that to which the air must in the first instance be heated by the compression: these three temperatures are related by the proportion $t_0 : t_1 :: t_1 : t_2$; or by the equation

$$\frac{t_2}{t_1} = \frac{t_1}{t_0} \quad . \quad . \quad . \quad . \quad . \quad (1.)$$

Let p_1 be the pressure of the external atmosphere; p_2 the pressure in the refrigerator: these pressures are connected by the equation

$$\frac{p_2}{p_1} = \left(\frac{t_1}{t_0}\right)^n \quad . \quad . \quad . \quad . \quad (2.)$$

The value of the index n, as nearly as we can at present ascertain it, is $n = 3\frac{1}{2}$.

Let v denote the volume of one pound avoirdupois of air at the pressure p and absolute temperature t; v^1 its volume at any other pressure p^1 and absolute temperature t^1: then

$$v : v^1 :: \frac{t}{p} : \frac{t^1}{p^1},$$

$$\text{or,} \qquad \frac{v^1}{v} = \frac{t^1}{t} \cdot \frac{p}{p^1} \quad . \quad . \quad . \quad . \quad (3.)$$

For the ordinary temperature 60° Fah. (that is, the absolute temperature 522° Fah.) and the pressure of one atmosphere, the bulk of one pound avoirdupois of air is about 13·085 cubic feet. Hence

$$v = 13{\cdot}085 \text{ cub. ft.} \times \frac{t}{522 \times \text{pressure in atmospheres}} \quad (4.)$$

These formulæ will serve to calculate the volumes and pressures assumed by the air in different parts of its course.

It is obvious that the expansion-cylinder ought to be smaller than the compression-cylinder in the ratio of the original and final absolute-temperatures of the air, $t_1 : t_0$.

The mechanical power consumed in raising, by compression or friction alone, the temperature of one pound of air by one degree of Fahrenheit, is about 130 foot-pounds, which is also the power given out by the same mass of air in expanding till its temperature falls by one degree of Fahrenheit. The corresponding amount of power, for so much air as fills one cubic foot at 60° Fah. and one atmosphere of pressure, is obviously almost exactly 10 foot-pounds. Consequently, the power consumed in the compression cylinder, in raising the air from t_1 to t_2, is

$$10 \text{ ft.-lb.} \times (t_2 - t_1) = 10 \text{ ft. lb.} \times \frac{t_1}{t_0}(t_1 - t_0)^* \quad . \quad (5)$$

for each cubic foot, measured at 60° Fah. and one atmosphere, exclusive of friction of machinery.

This formed the basis of my previous calculations, when I stated that one horse power working for one hour would lower the temperature of 9000 cubic feet of air by 20° Fah., in round numbers. But if we now take into account the power saved in the expansion-cylinder, which is, for the same quantity of air, 10 ft.-lb. $\times\ (t_1 - t_0)$, we find the net amount of power, exclusive of friction of machinery, to be

$$10 \text{ ft.-lb.} \times (t_1 - t_0)\left(\frac{t_1}{t_0} - 1\right) \quad . \quad . \quad . \quad (6)$$

* It may here be observed, that this formula gives, though by a more simple process, the same numerical results which would have been obtained by using the formula which expresses the power required directly in terms of the pressures and volumes successively assumed by the air—viz.

$$p_2 v_2 - p_1 v_1 + \int_{v_2}^{v_1} p\,dv = \int_{p_1}^{p_2} v\,dp.$$

per cubic foot, measured as above; a quantity so small, in all practical cases, that friction becomes by far the most important part of the resistance to be overcome.

It is almost impossible to estimate what this friction will be, until the machine is actually in operation; but to fix the ideas and illustrate the subject, I shall take the amount, which is not improbable, 2 ft.-lb. $\times\ (t_1 - t_0)$* per cubic foot of air; giving finally,

$$\left\{2 + 10\left(\frac{t_1}{t_0} - 1\right)\right\}(t_1 - t_0) \text{ ft.-lb.} \quad . \quad . \quad (7)$$

for the power required, per cubic foot of air, measured at 60°, and one atmosphere. For example, let the air be at 90°, and let it be required to cool it down to 60°: then, $t_1 = 552°$; $t_0 = 522°$, and the power required is,

$$\left\{2 + \left(10 \times \frac{30}{522}\right)\right\} \times 30$$

= 77 ft.-lb. per cubic foot of air, or about 25,700 cubic feet of air per real horse-power per hour.

In this example, the absolute temperature at which the air must enter the refrigerator is found by the proportion $t_0 : t_1 :: t_1 : t_2$; or

	522° : 552° :: 552° : 583°·7
From which result subtracting . .	462°·2
This temperature, as usually measured, is found to be . .	121°·7 Fah.

So that the air must, in the first instance, be heated by 31°·7, in order that it may ultimately be cooled by 30°. The difference, 1°·7, corresponds to 17 ft.-lb. per cubic foot of air, spent in causing transfer of heat, which, with 60 ft.-lb. allowed for friction, makes up the 77 ft.-lb. already stated.

The ratio of the initial and final absolute temperatures of the air is

$$\frac{t_1}{t_0} = 1{\cdot}058.$$

This must also be the ratio of the size of compression-cylinder to that of the expansion-cylinder.

The ratio of the pressure in the refrigerator to that of the atmosphere is found by equation 2 to be

$$\frac{p_2}{p_1} = \left(\frac{t_1}{t_0}\right)^n = \left(1{\cdot}058\right)^{3\frac{1}{2}} = 1{\cdot}216\,;$$

so that, if the pressure of the atmosphere is that of 30 inches of mercury, that in the refrigerator should be 36·48 inches.

By means of the formula 3, the condensation of the volume of the air in the compression-cylinder, as well as its dilatation in the expansion-cylinder, is found to be in the following proportion:—

$$\frac{v_2}{v_1} = \frac{t_2 p_1}{t_1 p_2} = 0{\cdot}87 = \frac{1}{1{\cdot}15} \text{ nearly.}$$

In passing through the refrigerator, the air undergoes a contraction in the ratio $\frac{1}{1{\cdot}058}$, which is also the ratio of the volumes of the air at the beginning and end of the entire operation.

With respect to the pressure in the refrigerator p_2, it may be observed, that the calculation of the precise amount is liable to some uncertainty, owing to the exact value of the index n not being perfectly known. In practice, therefore, it will probably answer best, after having constructed the two cylinders according to the proportions already laid down, to determine the proper pressure in the refrigerator experimentally, by gradually increasing the load on a safety-valve until the desired effect on the temperature of the air is produced.

Professor Smyth's method of cooling air has been lately found, in a mine in South Wales, to answer well even with imperfect machinery.

* This estimate is one-fifth of the power produced in the expansive cylinder. It is somewhat larger, therefore, in proportion, than the friction of the Cornish Engine at Old Ford, which is about one-seventh of the total effect.

STRAINS IN LATTICE GIRDERS.

On the Calculation of Strains in Lattice Girders, with practical deductions therefrom. By James Barton, C.E.

Mr. Barton showed that, notwithstanding the large and valuable investigations of late years into the theory and form of wrought-iron girders for large bridges, yet the nature, intensity, and directions of the strains in the vertical web or portion of the beam which separates the top and bottom were comparatively neglected, or conclusions drawn without correct theory; and having shown the great amount of material used in this portion of girders, and therefore the economic importance of the investigation, he proceeded to explain the mode in which he had arrived at accurate results as to these strains in the case of lattice-beams. Having investigated the subject in connection with some large bridges he has lately erected on the Belfast Junction Railway, and for the design for the Boyne viaduct, the calculations for which, and working out of the detail, had been intrusted to him by Sir J. Macneill and the directors of the company, the results showed the high importance of a separate consideration of the effects of a passing and of a constant weight; and, by diagrams, were shown the maxima strains of compression or tension to which each bar and each portion of the top and bottom is subjected in ordinary bridges from both of the above causes. The paper went on to compare the relative values of single systems of bracing with the lattice, and to consider the true angle of economic bracing; also, how far the calculations are effected by riveting together the bars at their intersections. The paper further proceeded to the practical application, and to the details of construction, explaining some improvements introduced by the author, both as to the mode of construction of the compression-bars, which are by him made to form lattice-beams; as, also, in the connection of plates, by means of which he proposes to rivet plates which have to bear tension with but very slight loss of their sectional area.

Mr. Fairbairn, of Manchester, observed that the subject was important; that the only difference between tubular and lattice bridges was in the sides, and that he considered having them solid gave them additional stiffness. He did not see why it should be better to have the sides open instead of being made of plates. He adopted tubular-bridges believing them to be the best, but if shown that a lattice-bridge is better he would adopt it. He did not comprehend how, in Mr. Barton's experiments, the tubular beams had not borne more than they appeared to have done, and thought they must have been peculiarly constructed.

Mr. W. Coates, of Belfast, stated that he had constructed the experimental girders exactly as directed by Mr. Barton, and the weight, span, and depth of beam being equal, the lattice bore slightly more than the tubular. He also stated, in answer to the President, that he could construct lattice-girders at from 10 to 20 per cent. less cost than tubular girders.

Mr. Fairbairn assented to Mr. Coates's statement, and also to the facility of repair afforded by the lattice system.

Mr. Barton, in reply, showed that when the sides of a beam are made of solid plates, theory demonstrates that there is a loss of iron, as there is unnecessary material there which would be more effective in the top and bottom. He accounted for the fact of the tubular and lattice beams, in his experiments, not bearing as much for their weight as in Mr. Fairbairn's experiments, by the fact that the beams were, in his experiments, of uniform section throughout, being made so for convenience; this circumstance not affecting the comparison, he expressed how valuable he felt Mr. Fairbairn's experiments to have been, and the importance of what had been done in tubular-bridges, but that he conceived that theory showed that advantages were to be obtained, of considerable importance, by bracing for the sides, which would meet more directly and economically the strains induced.

TELEGRAPH TIME SIGNALS.

On Telegraph Time Signals. By Charles V. Walker, Engineer and Superintendent of Electric Telegraphs to the South-Eastern Railway Company.

Mr. Walker stated that his object was to explain the arrangements that have been completed, as far as his part in them extends, for promoting the scheme of transmitting Greenwich mean time throughout the whole kingdom. He then detailed the proceedings between himself and the Astronomer Royal on this subject, and the schemes suggested. On the 5th of August the first time-signal passed; and on August 19th the clock at Greenwich, which originates the signals, having been brought to time, and the adjustment elsewhere having been completed, the regular transmission of signals commenced; in the first instance to Dover at noon, and at 4 P.M. Mr. Walker described the apparatus constructed by Mr. Shepherd, and erected at the London terminus, by which the connections are made. And, incidental to this, it is to be understood that in the Galvanic-room at the Royal Observatory is a set of ordinary sand-acid batteries: one battery termination is connected with the earth by means of the gas-pipes; and the other with a spring contained in Mr. Shepherd's electro-magnetic clock. The Greenwich London wire also terminates in the same clock; and the connections are such that, at the last second of the last minute of each hour, this line-wire and the battery-wire are placed in contact for an instant; and, consequently, if the circuit is completed at the other end of the wire, whether at London, Dover, Rochester, the Strand, Lothbury, or elsewhere, a signal will pass every hour; and, when the circuit is left open, no signal will pass. To accomplish this, a train of wheels is connected with the rod of Mr. Carter's turret-clock, now erected over the South-Eastern Terminus. Sets of springs are placed near at hand to some of the wheels; the springs are all tipped with platinum, and are respectively connected with the several wires concerned in the scheme; and, according as the contacts between the several springs are varied, so is the time-signal led to its destination. Mr. Walker then explained an ingenious contrivance by which, at the completion of the circuit at Greenwich, a voltaic current of instantaneous duration passes from Greenwich to Dover, and causes one sharp deflection of the galvanometer needle of the usual electric telegraph. The clerks at the several stations, should they overlook the general order to cease working, and to be on the watch, are reminded that the time is nearly due by finding that the telegraph circuit is broken; which happens during the two minutes that the spring is lifted by the pin off the earth-wire at London. The clerks watch the signal, and make note of the error of their local clock. The time-signal will, at set times, be allowed to pass automatically to Hastings, to Deal, and to Ramsgate, by turning them on the main line by the usual telegraphic turn-plates now in use at junction stations. The signal will be transmitted to intermediate stations by hand, which can be done correctly to a fraction of a second. The clerk will watch for the signal while he holds in his hand the handle of a group, or a branch instrument; he will move his hand as he sees the signal, and a simultaneous signal will pass along the group.

GRAPHITE BATTERIES.

On the subject of Graphite Batteries. By Charles V. Walker, C.E.

After referring to the unfitness of copper, and the too great cost of the superior metals for the purpose of batteries, he said he had early sought a substitute for both purposes. The corrosion or graphite collected in old gas-retorts seemed to promise all that he desired. He selected some fine blocks, and cut them into plates 4 inches long, 2 inches wide, and ¾-inch thick. He selected 12 plates, and connected them with well-amalgamated zinc-plates by copper slips. They were placed in a 12-cell trough, filled up with sand, and charged with dilute sulphuric acid (1 acid + 15 water) in the usual way, and connected them with the telegraph instrument in his study, which was in connection with a fellow instrument at the Tonbridge station, and forming a circuit of about a mile and a-half. He left them now to do the ordinary work with that instrument, and they were put to a stringent test, for they would in this case have a minimum of working and a maximum of waiting; that is, the instrument was used only in the morning or at night, when he was at home, and was rarely used during the rest of the day. He made notes of all the attention paid to the battery, and the rule he observed was not to add liquid to the battery until the clerks at the station complained that the signals were bad, and required improvement. The diary commenced April 5, 1849, and ended February 4, 1851, during which period the battery was only twenty-one times supplied with water and occasionally acid. The powers of the battery fell at very irregular intervals; in some instances the causes of this difference were not apparent, and were not inquired into; but for the most part, they were due to the variations in the *bona fide* evaporation, due either to the temperature of the weather or to the artificial temperature of the apartment. Throughout this period the sand was left undisturbed, and the acid water was added at the rate of a tea-spoonful to each cell. The ordinary copper-zinc battery would have required several times cleansing and re-amalgamating during this period of nearly two years; and the zinc would have required renewal. The results of further experiments were then stated, and during the same period

London station has been working with the copper-zinc sand batteries, which have been changed six times in the interval. More work is done by these—and they are not therefore comparable in all conditions. But a similar set of copper-zinc batteries used at Tonbridge, for the signals of the branch-lines, have been once cleansed and twice changed during the same period; and are at this date again exhausted, and undergoing purification. They have less work than the graphite set have had.

SUBMARINE ELECTRIC TELEGRAPHS.

On Electric Telegraphic Signals by Land and Sea. By F. C. Bakewell.

The author, in this paper, endeavoured to show that the system generally pursued in the insulation of wires is radically defective. In his opinion, confirmed by experiments, the points of attachment to the posts which are now the only parts attempted to be insulated, are not of so much importance as the exposure of the rest of the wires; which in damp weather transmit the electricity from each other through the nearest circuit. He is of opinion that there is an unnecessary waste of labour and money in endeavouring to prevent the escape of the electricity from a few feet of wire, whilst the electric force is escaping, without any attempt at hindrance, from miles of surface. Another question mooted by Mr. Bakewell referred to submarine operations. He contends, that to use thin copper wire instead of thick iron—as is common in all the submarine telegraphs hitherto laid down—is the reverse of what ought to be the practice. Iron conducts electricity with much less facility than copper, hence the preference of the latter; because a less surface being required to conduct the electric fluid, it has been assumed that the insulation could be better effected. If, however, as much electricity escape from a small exposed surface of copper as from a large exposed surface of iron, in the ratio of their respective conducting powers, there would be no object gained in adopting copper wire for such a purpose, while the liability to injury is prodigiously increased. The plan of an economical telegraph with a single wire is a favourite one of Mr. Bakewell. He estimates such a submarine telegraphic communication at the rate of 30*l.* a-mile, and that by the means of improved instruments, such as his copying telegraph, it might do the work of five or six wires, as at present commonly used. Since last year he said he had been enabled to increase the rapidity of transmission by the copying telegraph to three hundred letters per minute, and as yet he saw no limit to the rapidity attainable by the copying process. But, taking three hundred letters per minute as the limit, at that rate it would transmit a greater number of messages in a day than are now sent between all parts of the kingdom. The total number of messages transmitted by the Electric Telegraph Company last half-year, between all their stations, was 85,913—being about 500 in a day. Such a means of communication, therefore, would amply suffice for the present telegraphic wants of Ireland. One of the peculiarities of the copying telegraph is the means it affords of maintaining the secresy of correspondence by transmitting the messages invisibly. Mr. Bakewell concluded his paper by exhibiting a specimen on which the writing had been impressed invisibly, and by washing it over with a solution of prussiate of potass he rendered it legible.

TELEGRAPHIC COMMUNICATION.

On Telegraphic Communication between Great Britain and Ireland, by the Mull of Cantyre. By W. J. Macquorn Rankine, C.E., F.R.S.E., and John Thomson, C.E.

Although we are well aware that the project of connecting Britain with Ireland by a submarine electric telegraph between Tor Point and the Mull of Cantyre, has occurred to others besides ourselves, yet, as we conceive that so appropriate an occasion as that of the meeting of the British Association at Belfast ought not to be allowed to pass without bringing this scheme before the public, we shall, as briefly as possible, describe its leading peculiarities and advantages, in the hope that when these become extensively known, this useful and important line of communication may meet with the support which it deserves, and may ultimately be executed.

The strait between Tor Point and the Mull of Cantyre is the narrowest part of the channel between Great Britain and Ireland, being only 12½ miles wide, or 9 miles less than the strait between Donaghadee and Portpatrick. The depth at each side increases very rapidly from the shore, the line of 50 fathoms' soundings being within 3000 yards of the coast. The situation of the proposed line of telegraph in this strait is such, that the event of a vessel anchoring across it may be looked upon as an almost impossible occurrence.

Two alternative lines of telegraphic communication from Glasgow to the Mull of Cantyre are laid down on the map: one passing through Dumbarton, and crossing three arms of the sea—viz., the Gareloch, Loch Loug, and Loch Fyne, on its way to the peninsula of Cantyre. This line would require the construction, between Glasgow and the Mull of Cantyre, of 5½ miles of submarine telegraph across narrow arms of the sea, and 92 miles of land telegraph, commencing at Glasgow; but as a telegraphic communication as far as Dumbarton, a distance of 14 miles, may be considered necessary for local purposes, the length of land telegraph in Scotland specially required for this line may be reduced to 78 miles.

The other line laid down on the map extends from Glasgow, through Paisley and Greenock, to a point called "the Cloch," opposite Dunoon. At this point it crosses the Firth of Clyde, which is here 2 miles wide, proceeds by land to Loch Fyne, which it crosses at a strait 3 miles wide. Its course along the southern portion of the peninsula of Cantyre is the same with that of the former line. This line would require the construction, in Scotland, of 5 miles of submarine telegraph across the Firth of Clyde and Loch Fyne, and 87 miles of land telegraph, commencing at Glasgow; but as a telegraphic communication from Glasgow to Greenock, a distance of 22 miles, is requisite for purposes connected with the latter town, the length of land telegraph in Scotland specially required for this line may be reduced to 65 miles. Thus the line from Greenock is the shorter by half-a-mile of submarine telegraph and 13 miles of land telegraph; but its submarine portions are somewhat more exposed than those of the line from Dumbarton.

The line of land telegraph from Tor Point to Belfast, through Cushendall, Glenarm, Larne, and Carrickfergus, would be 48 miles in length; but as a line of telegraph from Belfast to Larne, a distance of 20 miles, may be considered necessary for local purposes, the length of land telegraph in Ireland specially required for this scheme may be reduced to 28 miles. The extent of the entire line of telegraphic communication between Britain and Ireland by the Mull of Cantyre may be thus summed up:—

	Route from Dumbarton.		Route from Greenock.	
Submarine telegraph across the Channel..	13 miles.			13 miles.
Submarine telegraph across narrow inlets..	5½			5
Total submarine telegraph	18½			18
Land telegraph in Scotland........	78		65	
Land telegraph in Ireland	28		28	
		106		93
Total land telegraph..........		124½		111

The advantages possessed by this line of telegraphic communication are the following:—1. The line of submarine telegraph across the Channel is the shortest that can be found, by 9 miles; 2. It is also the safest, for there is no risk of its being disturbed by ships' anchors; 3. The additional 5 or 5½ miles submarine telegraph required to cross inlets are in small detached portions, which can be laid at a moderate expense, and in which the effects of any accidents which may happen may be easily detected and repaired; 4. Independently of its advantages in a national point of view, this line of telegraph possesses the important local advantage of presenting the most direct line of communication from Belfast, and the north of Ireland generally, to the ports on the Clyde.

The most important advantage, however, of the proposed line of communication is its security; and we conceive that this advantage, independently of local and economical considerations, would be sufficient to warrant its execution, even were the lines of telegraph from Portpatrick and Holyhead in full operation.

On a new Flax-Dressing Machine. By Matthew Whyttla, Auckland, New Zealand.—The distinctive feature of this machine is that it acts transversely instead of longitudinally on the fibre.

MALLEABLE IRON GIRDERS.

On the Form of Iron for Malleable-Iron Beams or Girders. By T. Murray Gladstone, C.E.

For fireproof building, the necessity for using metal beams is obvious. Careful experiments have been made so as to determine the value of their power and the strongest proportions of section on which to make those of cast-iron. These have been extensively adopted for viaducts, bridges, mills, and warehouses. Although, however, the greatest care may have been taken by previous proof, they have been found frequently very unsafe, and have given way when loaded far below the test to which they had been subjected. While the positive strength of cast-iron under compression has been easily and safely fixed, when its tensive action has been tried, it has been found very variable and most uncertain, especially in large castings. Its crystalline brittleness forms a chief objection, and its deflective property so small and doubtful, that it is now considered very unsafe without an enormous margin beyond what might and had been considered due test. From these causes, it has been extensively superseded by wrought or malleable iron, especially wherever any vibration from friction or sudden impact has to be met; also, wherever any extent of tensive pressure on its fibres has to be brought into action. Consequently, in heavier engines—indeed, in an infinite variety of ways—it is avoided; although, in many cases, from the peculiar form, size, or proportions rendering it difficult in manufacture, and increasing the cost, wrought-iron is now used, and has been found safe and equal to every occasion.

It is on the application of wrought-iron beams or girders I propose to make some remarks by contrasting their powers and properties with those of cast-iron; to show what form of iron I conceive best adapted for such use, and to state, as a manufacturer, what may be expected as the capabilities of iron-work to produce the same beyond previous efforts, as to meet the increased requirements of the times. Of the experiments and the facts taken, therefore, with reference to the adoption of wrought-iron, of which to construct those immense beams, the Britannia-bridge, with many others, are familiar to the members; and therefore it is not needful for me further to refer to them than as showing the vast advantage and full proof of the power of wrought-iron so distributed, contrasted with any cast-iron girders.

It is found, that by converting iron from a cast into a malleable state, the adhesion of the fibres of the metal under tension, becomes increased from 7 to 27, and indeed much beyond that when the best quality of material is manufactured. At the same time it is stated that the compressive strength is somewhat reduced. In this latter assumption I do not altogether concur, from a permanent feature in the experiments not being sufficiently taken into account—namely, that in experimenting with wrought-iron, as a given extension from pressure is necessary before you obtain even a medium value of the resistance, a modicum of deflection must take place to bring into play each of the fibres; consequently, not like as in a rigid cast beam, where the full action of compression acts at once, some allowance must be made for the change from the first position, in calculating the compressive forces.

Assuming generally that the increased strength of tensive power of wrought compared with cast iron is 27 to 7, it at once reduces the six-fold area of the bottom web of the iron beam, and nearly reduces to one-half the required sectional area throughout, yet retaining an equal strength for every purpose. In many cases this increase of strength, enabling to reduce the weight, will fully compensate for the difference in price, so that up to this point the market and effective value of both may be said to be equal. The wrought-iron beam, however, possesses this material advantage, and that is, it will always give good warning before the point of danger is reached, and this mainly from its vastly-increased deflective power—indeed, before its maximum is reached, a great deflection can safely take place; therefore, both for life and property, its advantage is most conspicuous.

With regard to the best form for carrying the greatest weights with the least metal, I have come to the conclusion, from actual experiment on a large scale, that the double T section is the best, provided the flanges are sufficient to prevent lateral action from the load. I have experimented on bars 8 inches deep, 4-inch flange, and $\frac{3}{4}$-inch thick, both in webs and flanges. Of these, with two beams 10 feet apart, and 10 feet between the supports, and a load resting all within 2 feet from and on the centre, the deflection from 21 tons was only $\frac{3}{8}$-inch, and when removed the beams returned back to their original position. With two such beams having $18\frac{1}{2}$ feet span, and the load within a radius of 3 feet of the centre, the deflection is only $1\frac{3}{8}$ inch, which load so placed is more than equal to 20 tons distributed over the whole surface. This difference shows clearly the effect of extended span with the same iron, from which I deduce, that for the effective resistance, while the proportion should be half the breadth of flange for the depth of the beam, the depth should be at least $\frac{1}{13}$th of the span.

At the Belfast Iron Works the members can see one of these experiments with its load upon it, at the present time; also iron of the section shown, in bars of 26 feet long, and weighing nearly half-a-ton, so that it will be seen the mills are now constructed so as to roll iron almost any dimensions which may be required, and such bars, from the breadth of the flanges, have never before been attempted in the three kingdoms. When I had the honour, some four years ago, to read a paper at the Society of Arts, on a means of constructing bridges without any centering, of such proportions of iron, no ironmaker would attempt to produce such a proportion of material, while now I have accomplished it, and would have no hesitation in making them much larger if required. I have not a doubt for warehouses, mills, public buildings, and bridges, its value will now become extensively applied and appreciated. It must be seen that the section here given differs materially from that which is the ordinary double T-iron, which I conceive to be very defective, from the insignificant breadth of their flanges, as they do not sufficiently prevent lateral action, while a proportion of flange which determines an equal-sided triangle from the centre or neutral axis, will be found fully to provide for every difficulty.

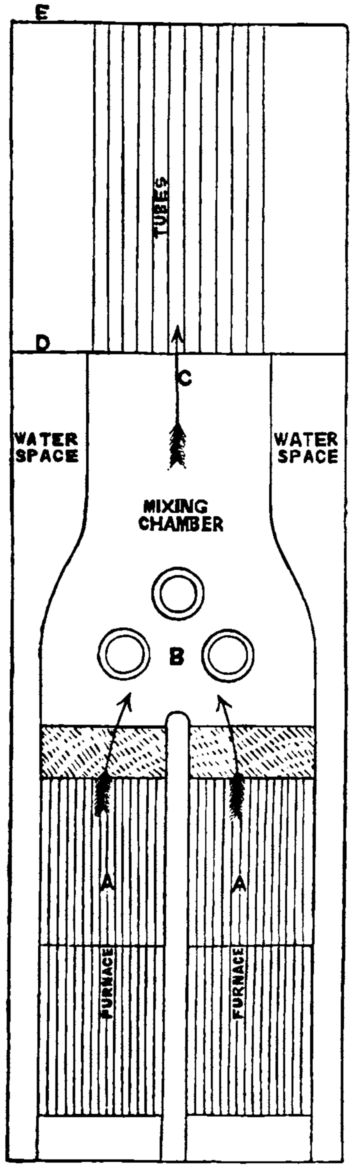
As these bars are rolled solid throughout, on comparison I have found they will bear nearly one-third more than any made beams of equal sectional area—that is, with a beam of which the centre rib is of plate-iron and the flanges of angle-iron, and riveted thereto, and so distributed as to make the double T form. This is easily accounted for, as you necessarily weaken the whole by its being requisite to introduce riveting, while a due and equal resistance is offered from all parts by the solidly-rolled bar.

It would be too long to go into the details of calculations bearing upon this subject, the experiments upon which of a Fairbairn, a Rennie, with many other eminent men, have been extensively and minutely given, and form the best guides on the subject. The given points herein are new features upon the question, particularly the relative proportions of the flanges, which I have briefly brought before this section of the Society in order to have its merits discussed and considered as fully as possible.

TUBULAR BOILERS.

On a New Tubular Boiler. By W. Fairbairn, C.E.

It is now upwards of fourteen or fifteen years since Mr. Fairbairn first introduced the cylindrical boiler with double flues and double furnaces, which, up to the present time, has been successful and in general use. Repeated attempts have been made to improve this construction; but it has yet to be proved whether the alterations recently introduced are substantially improvements on the original boiler, with the double furnaces and alternate firing. The new boiler, as now constructing by Messrs. William Fairbairn and Sons, consists of two furnaces, the same as the double-flue boiler; but with this difference (as shown in the annexed diagram) that the cylindrical flues A, A, each 2 ft. 8 in. diameter, which contain the grate bars, are united at B, 8 feet from the front of the boiler, into a circular flue C, 3 ft. 10 in. in diameter, which forms the mixing chamber, and where the heated currents of combustion from each furnace unite. This chamber, 8 feet long, terminates in a disc plate D, which, with a similar plate E, at the extreme end of the boiler, receives from 104 to 110 3-inch tubes, also 8 feet long, similar in every respect to the tubes used in marine boilers and the locomotive. These tubes are contained in a boiler 7 feet in diameter, and from the thinness of the metal become the absorbents of the surplus heat escaping from the mixing chamber and the furnaces. On this principle of rapid conduction, the whole of the heat, excepting only what is necessary to maintain the draught, is transmitted into the boiler; and he period the economy of entirely dispensing with brickwork and flues, an important desideratum in those constructions.



The heating surfaces in the improved boiler, as compared with the old one, are as follows:—

			feet.
New Tubular Boiler.			feet.
Heating surfaces	in two furnaces		128
Do.	do.	in mixing chamber	80
Do.	do.	in vertical tubes	28
Do.	do.	in 104 3-inch tubes	670
		Total	906
Old Double-Flue Boiler.			
Heating surfaces	in two furnaces		110
Do.	do.	in two internal flues	270
Do.	do.	exterior surface in brick flues	240
		Total	620

which gives a ratio in favour of the improved boiler of about 6 to 9.

In the construction of the improved boiler just described, it must be observed, that in "gathering" or forming the plates as they pass from the two circular furnaces into the cylindrical chamber, an ellipse is formed, and in order to render this part of equal strength, and increase the vaporative power of the boiler, three vertical tubes, 6 inches diameter at the bottom and 9 inches at the top, are firmly riveted through the transverse diameter of the ellipse, thus imparting the required strength to that part, which, if not attended to, would contain the elements of destruction whenever the boiler should happen to be severely pressed. The flat ends are points of construction which require equally careful attention, and there is no plan so well adapted for such a purpose as gussets radiating from the centre of the boiler, securely riveted by angle-iron to the external circumference, and by having them divided at not more than 12 inches on the circumference. The required uniformity of strength, assuming the end plates to be one-half thicker than the shell of the boiler, will be as nearly as possible obtained.

Mr. Fairbairn said he did not as yet know what amount of fuel would be consumed by the new boiler, as there was no calculation on that part of the subject; but he was certain that its generative powers were very great, and that it was perfectly secure, although of course it was exceedingly necessary that the several parts of the boiler should have uniform strength. It was on the same construction as the boilers of the locomotives: and a good boiler was calculated to last for twenty-seven years, and in every respect it was superior to those at present in use.

THE MINIE RIFLE.

Remarks on the Minié Rifle. By W. Fairbairn, C.E.

In attempting to describe the new rifle-gun and its results, as compared with that formerly in use, I must approach the subject not so much in the light of a question involving considerations of great military importance, but as one more immediately connected with practical science. I have, therefore, ventured to bring it before the Section, under the conviction that any improvement by which we are enabled to advance the interests of the public, and the advancement of mechanical science, must be interesting to the meeting.

Before alluding to the effects produced by this new construction, I may be permitted to allude to the improvements which have taken place, and great facilities which are now afforded for the construction of muskets and every other description of fire-arms. Until of late years, all the gun-barrels for the army, and other descriptions, had to be welded upon mandrils, some of them formed by a bar of iron rolled upon the mandril in a spiral direction, and then welded by repeated beatings from the muzzle to the breech. Others were differently constructed, by welding the bars longitudinally, in the line of the barrel, and not in the spiral direction adopted in the former process. Now the whole is welded at one heat, and that through a series of grooves in the iron rollers, specially adapted for the purpose. This, with the other improvements introduced by Mr. Lovel, the government officer at the head of the Small Arms Department, has rendered the manufacture of rifles and other arms a matter of much greater certainty and of security than at any former period.

Admitting the advantages peculiar to this manufacture, it does not, however, affect the principle of the rifle itself, in which there is no alteration, but in every respect similar, even to the spiral grooves, which I believe are not altered, but are the same as in the old rifle. This being the case, it has been a question of much interest to know wherein consists the great difference in the practice with the new rifle, as compared with that of the old one. It is not in the gun, and must, therefore, be in the ball, or that part of the charge which generates the projectile force. But, in fact, the improvement consists entirely in the form of the ball, which is made conical, with a hollow recess at the base, into which a metallic plug is thrust by the discharge. The plug is so constructed as when driven into the ball, it compresses the outer edges against the sides of the barrel, and, at the same time, forces a portion of the lead, from its ductibility, to enter the groove, and to give the ball, when discharged, that revolving motion which carries with such unerring certainty to the mark. In the practice which I witnessed, with one of those rifles, on the marshes at Woolwich, the following results were obtained:—Out of twelve rounds, at a distance of 700 yards, as near as I can remember only one bullet missed the target, and the remaining eleven rounds were scattered within distances of about six inches to four feet from the bull's eye. At 800 yards three shots missed the target, and the remaining nine went through the boards, two inches thick, and lodged themselves in the mounds behind, at a distance of about twenty yards. The same results were obtained from a distance of 900 yards, and at 1000 yards there were very few of the bullets but what entered the target.

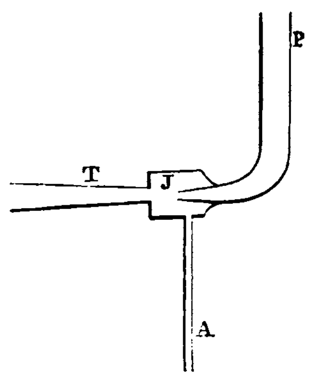
In these experiments I have to remind you that the end of the rifle was supported upon a triangular standard, and the greatest precision was observed in fixing the sight, all of which are proved by Mr. Lovel at Enfield Lock, and graduated to a scale in the ratio of the distance varying from 100 to 1000 yards, which latter may be considered the range of this destructive instrument.

Mould for Conical Bullets.—Mr. Woodhouse then read a short paper on the mould for casting conical bullets, which, in connection with the previous paper, was the subject of a short conversation, in which Mr. J. G. M'Gill, the Chairman, Mr. Fairbairn, and others took part.

THE JET PUMP.

On the Jet Pump. By James Thomson, C.E.

The purpose for which this instrument is designed is to clear the water out of the pits of submerged water-wheels, when access to them is required for inspection or repairs. For this special purpose it was likely to prove very useful, though there were very few other cases in which it could not be employed with advantage. Mr. Thomson then proceeded to describe the pump, the principle of which will be seen in the accompanying engraving. P, represents the pipe conducting a fall of water from any height; it terminates in a jet J, inserted into a small chamber which admits the pipe A, from the well whence the water is to be drawn. T, is a conical tube inserted into the chamber opposite the jet, and through which the discharge takes place. When the pump is in action, the horizontal force of the fluid draws up the water from the well, and the action continues as long as the water flows down the conduit-pipe P. The height that water can be raised in this manner is, of course, limited by the pressure of the atmosphere. In the course of his remarks, Mr. Thomson said the action of the jet-pump depended on two principles. One of these is the same as that of steam-blast used in locomotive engines, and in the ventilation of mines. The other is one which was known to the ancient Romans, and has been used sometimes by them for drawing off more water from the public pipes than they paid for. The pump was first tried at the mill of Messrs. Herdman and Co., Belfast, when it was found most successful.



At the conclusion of Mr. Thomson's paper a conversation as to its merits ensued, in which Dr. Robinson and several other gentlemen took part, which resulted in an entire conviction as to the great simplicity and usefulness of the pump.

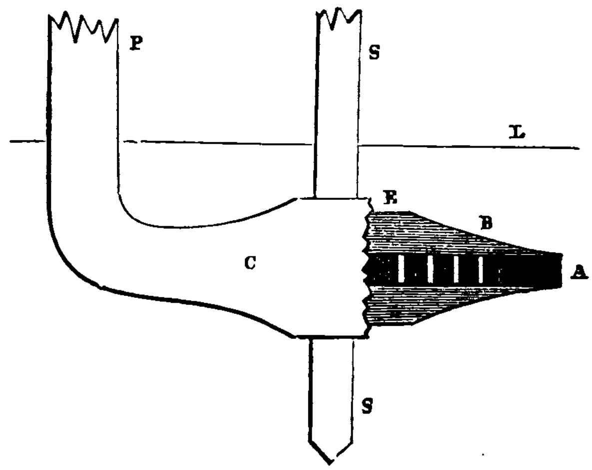
VORTEX WATER-WHEEL.

On a new form of Vortex Water-Wheel. By J. Thomson, C.E.

This wheel, Mr. Thomson observed, is a new variety of the general class of water-wheels called turbines. In this machine the moving wheel is placed within a chamber of a nearly circular form. The water is injected into the chamber tangentially at the circumference, and thus it receives a rapid motion of rotation. Retaining this motion it passes onwards towards the centre, where alone it is free to make its exit. The wheel which is placed within the chamber, and which almost entirely fills it, is divided by thin partitions into a great number of radiating passages. Through these passages the water must flow on its course towards the centre, and in doing so it imparts its own rotatory motion to the wheel. The whirlpool of water acting within the wheel-chamber being one principal feature of this turbine, leads to the name vortex as a suitable designation for the machine as a whole. For some time past there have been several of these new turbines in course of construction and erection. The one first completed and brought into action for practical use was for a new beetling-mill of Messrs. C. Hunter and Co., of Dunadry, near Antrim. It was constructed in Glasgow, and on being brought across the channel and erected at its destination, its first trial was made on the day before Chrismas last. This trial proved completely successful, and the subsequent performance of the machine has been highly satisfactory.

Mr. Thomson explained that the velocity of the circumference is made the same as the velocity of the entering water, and thus there is no impact between the water and the wheel; but, on the contrary, the water enters the radiating conduits of the wheel gently, that is to say, with scarcely any motion in relation to their mouths. In order to attain the equalisation of these velocities it is necessary that the circumference of the wheel should move with the velocity which a heavy body would attain in falling through a vertical space equal to half the vertical fall of the water, or, in other words, with the velocity *due* to half the fall; and that the orifices through which the water is injected into the wheel-chamber should be conjointly of such area that when all the water required is flowing through them, it also may have a velocity due to half the fall. Thus one-half only of the fall is employed in producing velocity in the water; and, therefore, the other half still remains acting on the water within the wheel-chamber at the circumference of the wheel in the condition of fluid pressure. Now, with the velocity already assigned to the wheel, it is found that this fluid pressure is exactly that which is requisite to overcome the centrifugal force of the water in the wheel, and to bring the water to a state of rest at its exit, the mechanical work due to both halves of the fall being transferred to the wheel during the combined action of the moving water and the moving wheel.

Fig. 1.—Elevation and Section.



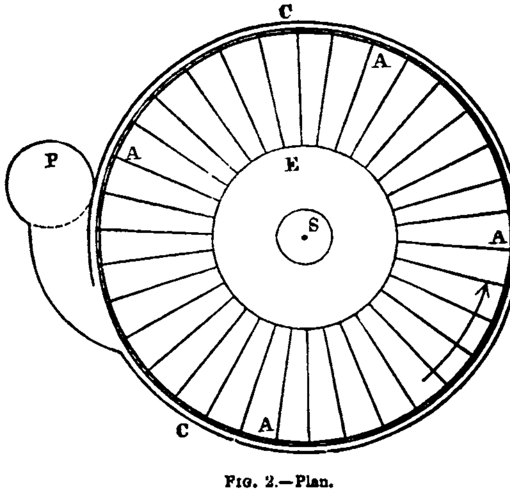


Fig. 2.—Plan.

Fig. 1 is an elevation and section, and fig. 2 a plan of this machine. B, is the body of the wheel, which is broad in the centre, and tapers off to the circumference, having a space A, of about 3 inches for the entrance of the water; E, is the central aperture for the discharge of the water, which flows out above and below; P, is the conduit-pipe through which the water is injected against the sides of the radiating passages A, A, A; C, represents a portion of the outer case; and S, is the vertical shaft, fixed to the wheel, and revolves with it. The wheel is worked a few inches below the level, L, of the water.

PERMANENT WAY OF RAILWAYS.

On the Permanent Way of Railways. By JAMES BARTON, C.E.

TRANSIT by rail has now become so prominent an item in the list of those matters which every-day use and enjoyment has caused us to consider nearly in the light of necessaries, that, though almost wholly a practical subject, it may not be uninteresting to consider how this rail, over which we are accustomed to pass so rapidly, is best constructed so as to form a secure road, and what recent practical improvements have been made in it, or in other parts of that which is ordinarily termed the permanent way or superstructure of the railway; and, in doing so, I may be permitted briefly to notice the steps by which we have arrived at our present practical knowledge on this subject. The first attempt at a railway ever made in Great Britain appears to have been at Newcastle, for the conveyance of coal-wagons, and was merely pieces of timber laid longitudinally for the wagon-wheels; and such are described as existing in the year 1676. For nearly one hundred years after this, little advance was made. The railway had, however, become a cross-sleeper road, with longitudinal timber rails fastened by wooden pins. The system of communication by canals being about this period developed, seems to have decreased the anxiety for further improvements in railways. The next important step was the cast-iron tram-plate instead of the wooden rail; and was used, about the year 1768, by the Colebrookdale Company, and, a few years later, at the Sheffield Collieries. These trams were, of course, of simple construction, but were from that time gradually improved. The first use of stone blocks to secure them seems to have been about 1797, at Newcastle; and for about twenty-five years after this the details of connections and forms of rail were the subject of a great number of improvements, the great difficulty being the securing of the joint of these short cast-iron rails on the stone blocks. Amongst the important modifications at this period were the form of edge or double-headed rail, as it is termed—that which increased in depth between the points of support, according to the results of the theory of girders; also, the securing the rails by different forms of cast-iron chairs.

The first wrought-iron rails ever used are supposed to have been at Newcastle, by Mr. Nixon, the rails being square bars, 2 feet long. But the first wrought-iron rail, properly so called, can hardly be placed much before Birkenshaw's patent, in 1820. His rails were very similar to some of the present edge-rails, except that they were made to increase in depth between the sleepers, the mode of managing which was very ingenious. These rails were from 12 to 15 feet in length, and secured by a cast-iron chair. They were, after a time, lapped at the joints, and other ways were devised for improving the connections, as also the section. The rail adopted by Mr. Stephenson, for the Liverpool and Manchester Railway (the first, as we may say, of the present system of railways), was of a section something similar to this, and rested upon large stone blocks, being secured thereto by cast-iron chairs and keys.

As railway travelling now became very much increased in its speed from anything heretofore attempted, the effect of the working upon the weak parts of the permanent way became much more manifest, and the difficulties of keeping the fastening in the blocks secure, and the concussion, when the road was subjected to the violent blows of the wheels of a train passing over a loosened or bad joint, became so serious a defect, that engineers were forced to go back to the timber road, as giving a soft material to meet the concussions, and so to adopt, in fact, a temporary substructure to prevent the evils of an imperfect superstructure.

In 1835, Professor Barlow, at the instance of the London and Birmingham Railway Company, instituted a series of experiments on rails, and came to the important conclusion, that the parallel rail, that is one whose section was uniform throughout, is equally strong for the work it has to do, and has many practical points of superiority when compared with the description of rail which increased in depth between the supports. Since that time almost all engineers have had their rails made parallel. The edge-rail, though giving theoretically the maximum strength for a given quantity of iron, admitted of modifications without seriously affecting its theoretic value; and of these, the most important was that which divided the vertical web into two, and attached to the bottom of each one-half of the lower flange, thus forming the bridge-rail, which has been very extensively used by Mr. Brunel, Sir John Macneill, and many others.

There are a variety of models in which timber is applied as sleepers—longitudinally under the rail, across at intervals, and a combination of these two; and the relative merits of each plan have been advocated by some of the most eminent engineers. The cross-sleeper road is, however, generally admitted to be the cheapest, and is contended for as having other advantages, practically, by Sir J. Macneill, and others who have adopted it. Both have their important defects, with which it is now my present duty to deal. The rail-joint in both is imperfect, and the timber *sub*-structure is constantly decaying, and requires a large annual cost for its renewal.

Those whose professional duties have brought the subject of permanent way prominently before them have been lately giving much consideration to the further improvement, and several patents have been lately taken out for improvements of which I would bring under the notice of the Section two or three which appear to me the most important. These improvements all consist in the application of cast or wrought iron to endeavour to meet the two grand defects above-named—the bad joint and the decaying sleeper. The first improvement I would take the liberty of bringing under your notice is that of Sir John Macneill's, who has patented a cast-iron sleeper which is applicable to the bridge-rail only; it is secured by riveting to the flange of the rail, and at intervals secured in gauge by transverse bars, upon which the opposite sleepers are cast, and which secures the important advantage of the bevel to the rail top by which it is caused to coincide with our conical wheels. Of this description an experimental length has been laid, for about two years, on the Belfast Junction Railway, and is now being adopted to a certain extent by the Drogheda Railway Company, where the sleepers have become decayed, their rails being of the bridge form and being quite sound—likely to last a great number of years. I shall have occasion to refer to it again, in reference to experiments which I made to test the value of the different improvements. The next is a cast-iron sleeper, applicable to the edge, or double-headed rail, patented in 1849 by Mr. P. Barlow. This sleeper has been laid already in parts of the South-Eastern Railway and on the Ashford and Hastings line in England, and on the Londonderry and Enniskillen Railway in Ireland. It gives a large bearing surface, is easily laid and repaired, and enables a light rail to be used with advantage, the distances of bearing points being less than in the ordinary cross-sleeper road. I have laid for experiment 100 yards of this description of road also, on the main line of the Belfast Junction Railway; and besides the observation of its action for the last year and a half, I have also tried experiments and calculated its strength and cost, &c. There is also a patent for an improvement of the joint of the edge-rail when secured to wooden sleepers, which has been patented by Mr. Samuels, and which consists in fishing, as it is termed, the joint with bars of wrought-iron riveted or bolted through the vertical web of the rail, these fishes lying in the hollow between the upper and lower flanges. This has a good effect so far as it goes, and is a considerable improvement to an edge-rail upon timber-sleeper roads. There is another cast-iron sleeper applicable to the bridge-rail just devised by Mr. Godwin, which I have not as yet had opportunity of examining. The last improvement I shall draw your attention to is Mr. W. H. Barlow's broad-flanged rail, which is distinguished most materially from the other improvements, inasmuch as it casts away the sleeper altogether, gives up the cast-iron also, and proposes a bearing surface of wrought iron, and that wrought iron the rail itself: it is, in fact, making the rail its own base, and doing away with all substructure. I annex drawings of this description of rail, of which I laid down an experimental length, as for the other kinds, and tried upon it, also, experiments, &c. The form of this rail is that known as the bridge, but it is rolled so wide and thin at its flanges that it gives, according to weight, 11, 12, or 13 inches of width of bearing surface; the connections being formed by a chair of wrought iron whose external form exactly coincides with inside of the rail, to which as a joint cover, both are riveted; the cross-ties being angle-irons secured by the same rivets, and being curved or bent to give the bevel correctly, as in the case of Sir John Macneill's.

It will, perhaps, be interesting, before considering what advantages these different roads may offer, to allude to a point on which considerable difference of opinion has been expressed, namely, whether or not it is safe to rivet together the rails of a railway, that is to say, whether the effect of expansion and contraction will not be such as to render such a course impossible to be permanent. Directly opposite opinions have been given on this point, and practical proofs offered by both sides. Professor Barlow reported to the London and Birmingham Railway Company that it was quite inadvisable, and his opinion has been followed in practice very generally ever since. It would appear to me that the matter is a simple one, dependent on the amount of expansion, and the strength of the iron, for if a bar of iron be held secure at the ends, and cooled down, the contraction by cooling is prevented by the extension which the induced strain upon the fibres caused by holding it firmly produces. Now, if the length to which we may extend the iron, without injury to its elasticity, be as great as the contraction caused by cooling, the heating and cooling may be repeated constantly without injury. The case of a jointed bar requires that the joint-cover and rivets shall be able to bear the above strain; the amount of this strain is simply arrived at, for, let us take the extreme range of our temperature at about 75°, the contraction of a bar riveted at that temperature will be $\frac{1}{2000}$th of its length, the contraction being about $\frac{1}{150000}$th for each degree of Fahrenheit: but the strain to lengthen a bar $\frac{1}{2000}$th of its length is five tons to every sectional incb, or one ton per inch to each $\frac{1}{10000}$ of the length. How, then, is it that rails are said to have lifted, and to have gone out of line by expansion? Very simply, because the rail was secured in cold weather, and the effect of expansion was not to injure the iron, but to cause flexure, the rail in this case acting as a pillar, and its strength depending on the laws of pillars—say the cube of its least dimension—instead of directly on its section as in the case of extension. It is, therefore, I submit, perfectly safe that a properly secured road be laid without expansion openings; but important that, if so, it be finally riveted up at a high temperature, so that there will be but little expansive action, and so the induced strain be almost entirely a tensile one, arising from contraction. I should note also that there is a considerable difference between the expansion of rails raised on a non-conductor like timber, and those either riveted to a cast-iron sleeper, imbedded in the ballast, or, as in Mr. Barlow's case, the rail itself deeply imbedded. This is supposed to decrease the effect of temperature one-third or one-half.

The constant hammer-like sound of the wheels of a train passing over each joint is necessarily familiar to all; this is caused by the one rail sinking below the other, and necessitating a stroke of the tyre, as it mounts or depresses the higher rail; the noise, and its effects upon the carriages and engines, is almost wholly got over in most of the above systems of our road, and we approach more nearly to a continuous rail.

We have, too, a permanent structure, one which will last for a long series of years, and when worn out will be renewed at a cost of about 2*l*. per ton, as the rails will merely have to be re-rolled and the waste supplied. I annex herewith a copy of the experiments which I made to determine the mode of permanent way which I would recommend to the Dublin and Belfast Junction Railway: the object of the experiment was to ascertain the relative strength of the cast-iron sleepers, and wrought-iron road against fracture and other displacement; and I have tested these by the fall of a ram, weighing 13 cwt., let fall upon the rail from different heights. This may represent the effect upon a rail in case of an obstruction, over which the engine-wheel passes and drops upon the line again, or in case of other accident. I have found by this test, that I had, in almost all the descriptions of cast-iron sleepers, as great a strength as in the rail itself, between the timber-sleepers, which is the total useful strength of a timber road in practice. And in Mr. W. H. Barlow's rail, weighing 90lb. per yard, I had, as might be expected, considerably more strength than in any other kind. Again, I tried a series of experiments by a number of blows, caused by a slight fall of the same ram, which might represent the effect of trains passing a bad joint, and noted how long it took to depress the part of the rail so struck, so that it should require packing. These last experiments, however, did not elicit any important difference as to maintenance between the roads, and were insufficient data to determine cost of maintaining, inasmuch as the great difference in different roads is the difference of time between opening out a sleeper road to get at it for repair, and the simple clearing the gravel off the castings. In this latter respect Sir John Macneill's sleeper and the flange rail of Mr. W. H. Barlow were most economical.

The effect upon a train of properly riveting an even joint is, that the joint becomes wholly imperceptible to the passer; but, to attain this perfection, the rails must be manufactured with great accuracy as to being perfectly straight, and identically similar in the end section. This is difficult in such a large rail as Mr. Barlow's, but is gradually being accomplished by the manufacturers, amongst whom Messrs. Crutwell and Allies, of South Wales, have taken considerable trouble and gone to expense, and succeeded to a large extent. After a careful consideration of the question, the rail which I finally recommended to the companies for which I was acting was the broad flange rail, of a section slightly modified from those before laid. Nor did I do so lightly, as I was thereby proposing the adoption of a rail at that time not laid on any line except on a small length on the Midland Railway, in England, by the inventor, and my professional brethren in this country expressed many doubts. I have, however, now most confidence in expressing a favourable opinion, being fortified by those lately expressed by a number of our most eminent engineers in both countries. The great economy of this road is its most striking feature. The estimates given below are either from my own knowledge, or, when they refer to maintenance for a term of years, are taken from actual tenders made to me for the work; and we see from them that, in comparison with a timber road, the first cost of the flange railroad is less by about 360*l*. per mile, and a constant annual saving of about 56*l*. per mile; and the cast-iron sleepers would show an increased first cost of about 160*l*., but a decreased annual cost of about 50*l*. per mile per annum—and these are immense savings on long lines:—

Description of road.	Cost of materials for a double line for one mile, and for laying same	Cost of ballasting per mile of double line.—Average.	Cost of renewal from the decay and wear of materials of permanent way, for double line per mile per annum.
	£	£	£
Cross-sleeper timber road and bridge-rail, 80 lb. to the yard	2900	800	80
Cast-iron sleepers for either the bridge or edge rail, Sir John Macneill's or Mr. Barlow's	3260	600*	30
Broad, flanged rail, Mr. Barlow's	2740	600	24

* The iron roads require five or six inches less of ballast in consequence of the depth of wooden sleepers, and this decreased quantity gives the same depth under the sleeper.

Some of these iron roads have been objected to for a sensation of hardness which they seem to produce in passing over them, but that this is a matter principally caused by the peculiar sound which is produced, and is not of any consequence practically, appears to me to be proved by a variety of considerations; and, amongst others, that the reality of any increased vibration which might be supposed to be the cause is rendered doubtful by the results of experiments upon smoothing tried by Mr. Barlow, by a machine he has arranged, which he terms a salograph, which magnifies and marks on paper, to a large scale, every inequality in a road over which it passes, when properly connected with the carriage framing. I have now had laid by order of the Belfast Junction Railway Company seven miles of the flange rail, and rails are preparing for delivery for twelve more to make a second line of rails for a portion of their line. Mr. Hemans, I am informed, has lately adopted it also for the second line of the Galway Extension.

VENTILATION OF COAL MINES.

On the Evolution of Gas in Wallsend Colliery. By Prof. Phillips.

This is one of the very numerous coal-mines which have been rendered remarkable for the frequent explosion of the inflammable gas with which they are filled, and the awful loss of life which has, in so many cases, been the consequence. The coal is arranged in perpendicular layers, between which the gases exist in a highly compressed state. In order to detach these layers with the least possible danger, it is usual to cut through them endways, by which means the gases are allowed to make their escape at once from a considerable portion of the coal. A district of this colliery, covering about 50 acres, was effectually

FIRE BRICK GAS RETORTS.

Fig. 1. Front Elevation.

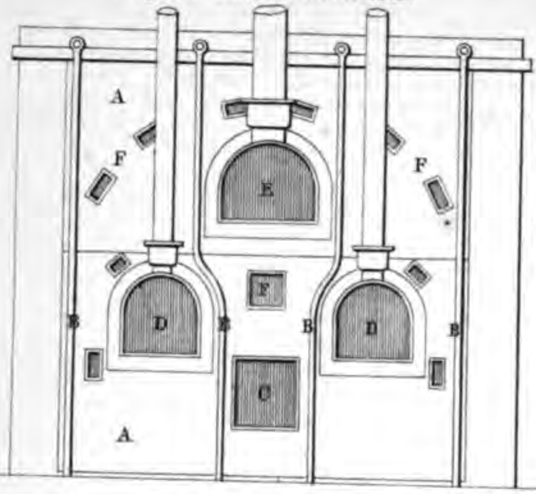


Fig. 3. Details of Arch Bricks.

1/8th size.

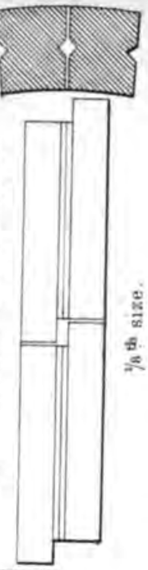


Fig. 2. Transverse Section.

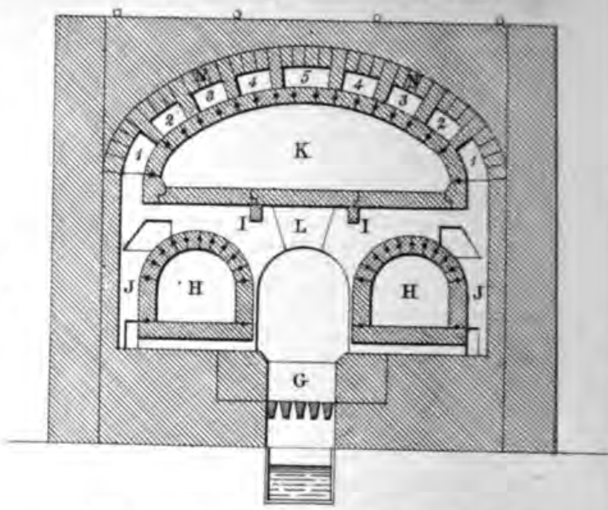


Fig. 4. Plan at top of Upper Retorts.

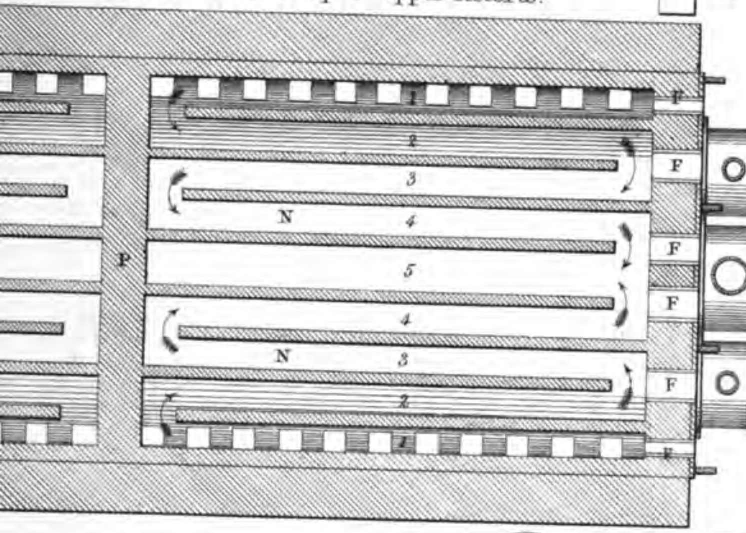
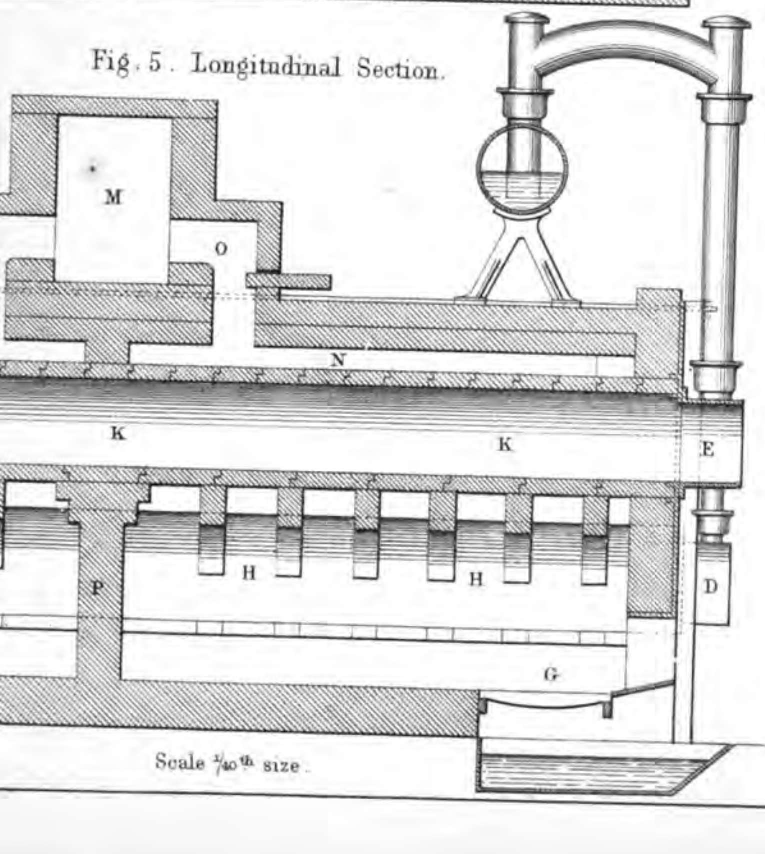
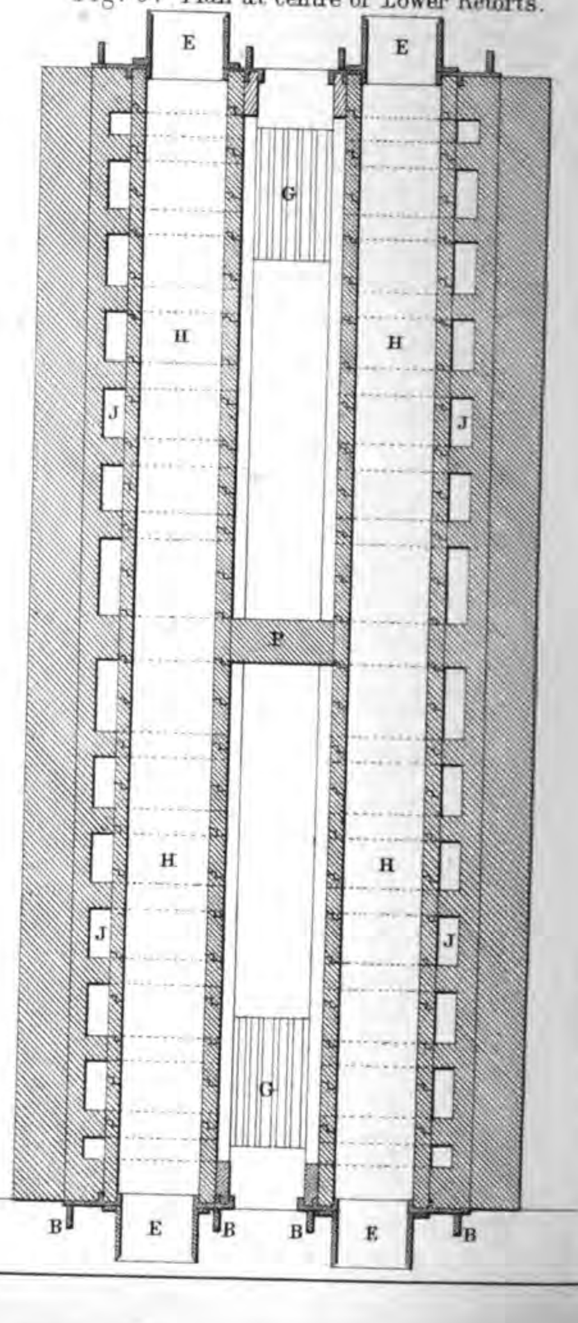


Fig. 5. Longitudinal Section.



Scale 1/40th size.

Fig. 6. Plan at centre of Lower Retorts.



walled up in consequence of the immense discharge of gas that was continually taking place. A pipe was led from this inclosed portion up through the mine and for 40 feet above the surface, and from this pipe there has been a constant discharge of gas for the last eighteen years. This gas has been inflamed, and in the roughest and most stormy weather it has burned without intermission; and were it as rich in carbon as ordinary carburretted hydrogen, it would illuminate the country for miles round. Two water-gauges were fixed to the pipe, one at the surface of the earth, and the other at the bottom of the mine—the results were, that whilst the pressure in the mine was only $\frac{3}{16}$-inch on an average, that at the top of the pit was upwards of 4 inches. It was observed hy Prof. Daniels, in his researches at the Royal Society, that the water barometer indicated the change of pressure an hour earlier than the other. From practice in these mines it is seen that discharges of fire-damp, depending on atmospheric pressure, take place before being indicated by the barometer, and that, as an indicator, that instrument cannot be relied on.

NEW PATENT LAW.

On the New Patent Law, with its bearing on the interests of Inventions and Manufactures. By T. Webster.

Mr. Webster contrasted the facilities which the new law afforded in the several stages in the application for patents, with the cumbrous expensiveness or duplicated processes which characterised the former system, by which collusive speculation for the mere purpose of making profit by registering patents was encouraged, while real invention was retarded. He pointed out the pernicious effects of the *caveat* system, by which persons who might be able to introduce actual improvement could be prevented by any parties who entered a *caveat*, while another of the evils of the proceedings was the enormous fees. He showed the cheapness and other advantages of the new system, by which those abuses were repressed, and greater protection afforded to the invention by the visitation of all the costs upon persons who entered groundless opposition to the patent, while the administration of the law being confided to the Commissioners, the public were relieved of trouble and responsibility. He advised inventors to assert their rights, and see that the law-officers did their duty. The establishment of an office for filing specifications, and the provision for having copies of them in the principal towns, were also valuable improvements.

FIRE BRICK GAS RETORTS.

By John E. Clift, of Birmingham.

[*Paper read at the Institution of Mechanical Engineers.*]

(*With an Engraving, Plate* XXXV.)

The object of this paper is to describe a plan for constructing gas retorts, which the writer has had in use several years at the works under his management, and has also adopted at various other towns; and the only apology he has to offer for bringing it before the meeting is, the request of the Council of the Institution to furnish the practical results of the working of the plan. The first great desideratum in a gas-generating retort is on all hands acknowledged to be *surface*, a large surface, upon which may be spread a thin layer of coal; this was early shown by Mr. Clegg, in his invention of the revolving-web retort, the only difficulty in working which was the destructible nature of the material of which it was composed. The second condition required is, that this large surface shall be *economically heated.* A strong opinion existed for a long time against the use of fire-clay for retorts, in consequence of the inferior heat-conducting properties of that material compared with iron; but experience has proved that as large a quantity of gas can be generated, with a given weight of fuel, with fire-clay retorts as with iron. This may be accounted for partly by the fire-clay losing less of its heat on being exposed to the air whilst charging, and on the cold charge of coal being first thrown in; or in other words, that the greater mass of fire-clay acts as a reservoir of heat, and does not become so readily exhausted when a large demand is made upon it, but on the contrary maintains a greater uniformity of temperature throughout the process; this is easily demonstrated by observing the small quantity of gas made from an iron retort during the first hour after charging compared with a fire-clay one. It is also partly accounted for by the iron retorts, as they are generally set, being so covered and shielded with fire-bricks to preserve them from destruction, as to partake as much of the character of clay retorts as of iron.

The following table, which is the average of a number of experiments, gives the quantities of gas generated, as indicated by the meter, from iron and clay retorts, during each half-hour of the charge, from the same quantity and quality of coal :—

IRON RETORTS.				BRICK RETORTS.			
1	half-hour	250	cubic feet.	1	half-hour	480	cubic feet.
2	,,	630	,,	2	,,	1800	,,
3	,,	1340	,,	3	,,	2000	,,
4	,,	2300	,,	4	,,	2000	,,
5	,,	2600	,,	5	,,	2300	,,
6	,,	2640	,,	6	,,	2300	,,
7	,,	2600	,,	7	,,	2460	,,
8	,,	2600	,,	8	,,	2400	,,
9	,,	1700	,,	9	,,	2000	,,
10	,,	1630	,,	10	,,	1630	,,
11	,,	1790	,,	11	,,	860	,,
12	,,	700	,,	12	,,	550	,,
	Total	20,780			Total	20,780	

The third requisite in a retort is *durability*. The proper way to measure this element is to divide the quantity of gas made, by the cost of the retorts and ovens, and the repairs during the time they are worked; this will be shown presently by a comparison from the actual working of iron and clay retorts.

The retorts to be described in the present paper are composed entirely of fire-bricks, with cast-iron front plates to attach the mouth-pieces to, and to bind the brickwork together, and they are made of any length, width, or height. They are generally constructed in sets of three, as shown in fig. 1, Plate XXXV., which is a front elevation. AA, are the front plates of cast-iron, $1\frac{1}{4}$ inch thick. BB, are the wrought-iron stays, $4 \times 1\frac{1}{4}$ inches, fastened at the bottom by cramps built into the brickwork, and at the top by tension bars, connected to similar stays on the opposite side. C, is the furnace-door. DD, two retort mouth-pieces, 15×15 inches. E, a large retort mouth-piece. F, sight-holes for examining the flues and cleaning dust from the external surface of the retorts.

Fig. 2 is a transverse section; G, is the furnace; HH, are the two lower retorts, 15 inches wide, 15 inches high, and 20 feet long, with a mouth-piece at each end. The fire-bricks forming the bottoms and sides of the retort are 16 inches long and 3 inches thick, the arch-bricks forming the top are 9 inches long by $3\frac{1}{2}$ inches deep. Each brick is rebated 1 inch deep in the transverse joints, and grooved in the longitudinal joints, as shown by the enlarged drawing, fig. 3; these grooves are filled with stiff fire-clay when they are put together, which burns into a hard tongue $\frac{1}{4}$-inch thick as it becomes heated; the object of these tongues is two-fold,—they offer a resistance to the leakage of the gas by breaking the joint, and they tie together the arch of the retort.

K, is the large upper retort, 5 ft. 3 in. wide, and 20 feet long, open for charging at both ends; the bricks are similar to those forming the small lower retorts; L, is a cross arch 5 inches thick, spanning the furnace flat on the top, which covers the underside of the transverse joints of the bottom of the large retort; the longitudinal joints are covered by small arched bricks, marked I. J, are the side flues; N, the longitudinal flues, shown more fully in fig. 4, which is a plan of the top of the upper retort, showing the course of these flues. In rising from the furnace the heat passes partly underneath and partly over the small retorts into the first flue, No. 1, moving to the back of the oven, then crosses the division and returns to the front along the 2nd flue, then to the back along the 3rd flue, and to the front along the 4th, when it meets with the heat which has gone through a similar course on the opposite side, and passes along the middle flue, No. 5, into the main flue M, as shown in the longitudinal section, fig. 5. By this arrangement the heat passes over 50 feet length of surface of retort from the time it leaves the furnace until it reaches the main flue.

Fig. 5, is a longitudinal section through the upper retort K, showing the opening into the main flue M, and the damper O, by which the draught is regulated. In this figure the position of the cross arches L, that carry the large retort is shown; covering the joints in the bottom of the retort; also the centre wall P, which divides the two furnaces and flues, and carries the main flue.

Fig 6, is a plan of the lower retorts, showing the two furnaces GG, with the centre division-wall P, the side flues II, and the floor of the lower retorts HH.

It will be seen by the plans figs. 4 and 6, that the sight-holes FF are so arranged as to command a view of the whole longitudinal and side flues, by which means the condition of the retorts may at all times be observed, and any defects detected.

With regard to the durability, the writer may observe that twelve sets of the retorts were put up by him in 1842, and worked constantly, with the exception of short periods, up to 1849, when they were taken down for the alteration of the works, and they were found then in good condition, and were fit for working several years longer with slight repairs. The writer also put up twelve sets of these retorts in 1844, and they continue in regular work now, and are in good condition; the cost of repairs of the retorts, ovens, and furnaces during the eight years they have worked has not exceeded twenty shillings per annum for each set. The writer accounts for the durability and economy of retorts constructed on this plan—firstly, by their being composed of a great number of pieces, instead of only one; so that when their temperature is altered, either by the carelessness of the stokers, or in letting down the heat to throw the retort out of work, each joint opens a little, equal to the contraction of a nine-inch brick, and prevents any portion of the retort cracking. In the same way, in getting up the heat (which is a time when a great number of clay retorts made in one piece are destroyed), if one portion of the retort becomes heated more than another, the joints accommodate the expansion; or, if the brickwork is in a very green state, and the expansion from the moisture is great, the screws of the tension rods may be eased, which will allow the whole mass of brickwork to swell, but as soon as the moisture is expelled it will sink back into its place, and be as perfect as when first built. When a set of these retorts is first put to work, either new or after being let down for any purpose, it leaks through the joints for about twenty-four hours, gradually stopping; and after that time, if the heat be good, it will have become quite sound, and permanently gas-tight, under a pressure equal to 10 or 12 inches head of water.

From a sufficiently long experience, the writer has proved that brick retorts built upon this plan will wear for ten years, with the outlay of twenty shillings per annum for repairs, and that iron retorts will not last more than 1½ year, under the most favourable circumstances. Then, to show their comparative economy, take a number, say 20 sets or beds of Iron Retorts, and 20 beds of Brick Retorts, each bed being capable of making 20,000 cubic feet of gas in 24 hours; and to make the calculations as correct as possible, let the cost and repairs of each be estimated, and the quantity of gas they will make, during a period of 10 years, in order to ascertain the cost of the gas produced from each plan per 10,000 cubic feet.

Iron Retorts.

	£	s.	d.	£	s.	d.
First cost of 20 beds of Iron Retorts:—						
Bricks, clay, and labour for arches.. ..				367	0	0
100 Cast-Iron Retorts, 18 cwt. each, 90 tons, @ £6				540	0	0
Fire bricks, shields, quarries, &c., for setting				150	0	0
Labour for setting, 60s. each				60	0	0
				1117	0	0
Cost of renewing 20 beds of iron retorts:—						
100 iron retorts, 90 tons, @ £6	540	0	0			
Bricks and clay	150	0	0			
Labour, taking down and resetting ..	80	0	0			
	770	0	0			
Less by old burnt iron, 50 tons, @ 25s £62 10 0						
Less by one-third of bricks, which may be used again 50 0 0						
	112	10	0			
	657	10	0			
This sum will be multiplied by 6½, the number of times they will be renewed in 10 years, which will give..				4270	10	0
Making the total expense of Iron Retorts.				£5387	10	0

Brick Retorts.

	£	s.	d.	£	s.	d.
First cost of 20 beds of Brick Retorts:—						
Bricks, clay and labour, for arches.. ..				367	0	0
Iron for front plates and brick stays, 21 tons, @ £6				126	0	0
Pattern and other bricks and clay for retorts..				180	0	0
Labour for building retorts				110	0	0
				783	0	0
Cost of repairs for 10 years, at 20s. per bed per annum..	100	0	0			
Less value of old front plates, &c., 20 tons, @ 25s.	25	0	0			
				75	0	0
Making the total expense of Brick Retorts				£858	0	0

Now, as the quantity of gas that each of the two descriptions of retorts is estimated to generate is the same for ten years—namely 1460 million cubic feet, it follows that the gas from the cast-iron retorts cost 9*d.* per 10,000 cubic feet, and that from the fire-brick retorts 1⅓*d.* per 10,000 cubic feet, for the item of retorts and ovens; showing an economy of 84 per cent. in the improved fire-brick retorts.

Mr. Clift, in answer to questions, replied that a defect in fire-brick retorts could be easily repaired at any time, without stopping the working of the retorts; the surface of the retorts could be thoroughly examined through the different sight-holes, and any defective joint detected by the appearance of a gas-flame, and a single brick could be taken out of any part when required, and removed by proper tools through the sight-holes, which were made large enough for a brick to pass, and another brick was set in its place with fire-clay, without occasion to let down the heat of the retort. When a brick-retort was pulled down, it was found that the carbon deposited from the gas filled up any crack or fracture by the carbon adhering to the rough surface of the brick, and collecting upon it, from the indestructible nature of the brick. But a crack in a cast-iron retort continued getting worse, and became constantly more open, on account of the surface of the iron perishing in the sides of the crack, which prevented it from getting closed up by a deposit of carbon as in the brick retorts. When a cast-iron retort was once cracked it was done for, and must be thrown away, requiring the whole oven to be opened out and rebuilt, and causing a serious delay to the work, as well as expense. And he observed that the plan of constructing the retorts of double the usual length, with a mouth-piece at each end, he had only in use for about a year, but he found it a decided improvement, and had since adopted it in all new works. The other retorts became scurfed up with a large accumulation of carbon, particularly at the back ends, where the scurf became several inches thick and very hard, and the retorts had to be stopped work and the heat let down, usually every eight months, for the purpose of clearing out this scurf, and getting it detached by the contraction in cooling. But, in the long retorts, open at both ends, there was no back for the scurf to accumulate, and the current of air through the retort every time that both ends were opened, caused the scurf to scale off, and it was much easier to detach, and conseqently it was found that they would work much longer before requiring to be let down. Also the centre portion of the oven, which is the hottest part, and most valuable for making gas, was lost before by the blank ends of the retorts, but is now made available, as there is only a single brick wall dividing the flues, and by this means the heating surface and contents of the retorts are increased, without any increase in the size or expense. Another advantage is found in preventing the injury and shaking of the joints that was caused in drawing the coke from the retort, by the heavy rake being driven againt the back of the retort.

Proposed Submarine Telegraph.—A scheme has been proposed for a transatlantic telegraph to take the line from the northern coast of Scotland through the Orkney, Shetland, and Ferroe Islands; thence to Iceland, Greenland, and Labrador, whence they would easily communicate with Quebec, and also with the 27,177 miles of electric telegraph already in operation with the United States.

SUPPLY OF WATER IN TOWNS.*

By Michael Scott, C.E.

Mr. Scott having been appointed to report on the supply of water in the town of Swansea, drew up the document now before us; and the authorities feeling it very desirable that the improvements proposed should be popularly known among the inhabitants, requested Mr. Scott to publish his report for circulation. In this document he has endeavoured to lay the whole facts of the case before the parties interested, and although much is only of local importance, and beyond the scope of professional men at a distance, there are some points of a more general nature, which our readers may think worthy of their attention. Thus, Mr. Scott has given all the arguments for and against that much-debated question, constant or intermittent supply; and as they are by him succinctly stated, we think it worth while to reproduce them:—

"*Nature of the Supply.*—There can hardly be two opinions respecting the requirements, either as affecting the consumers or the supplying body, seeing that *in cases where the full benefits are to be realised*, continuous supply under pressure is better than a supply on the intermittent principle. But, whilst this may be readily conceded, I must be permitted to add that much misconception has prevailed respecting the relative advantages of the two systems; and, for this reason, I propose to enter somewhat into detail, for the purpose of pointing out their distinctive peculiarities, with which experience has made me familiar. As a consumer's question, the principal advantage anticipated from the introduction of continuous (or constant) supply is, that house-cisterns and butts would no longer be required, and therefore that not only would the cost of the internal fittings, original and annual, be diminished, but that the water would be obtained for use in a more pure and desirable state. With reference to these anticipations, I would observe that, in the case of the poorer class of houses, they would be realised, but with regard to the dwellings of the middle and upper classes, the amount of benefit would not be so great. For, assuming that there could be no object in wishing for an ample supply unless it were intended to make extensive use of it, I must conclude that water-closets, baths, and other conveniences, would be generally introduced, and that water would be laid on to every floor, so as to be everywhere and always available, under pressure.

"Now, it appears to me, that when many persons picture to themselves the enjoyment which such perfect arrangements would afford them, they forget to reckon the cost; or, rather, basing their anticipations upon the erroneous statements which have appeared from time to time upon this subject, they believe that their visions can be realised without any additional outlay whatever, or probably at a diminished rate of charge. Let us look more closely into the matter. Suppose the case of a town which has hitherto been supplied upon the intermittent system, but in which the inhabitants are now to obtain water under continuous high-pressure. The old cisterns, formerly required, would be dismantled, except such as could be adapted to serve the water-closets and baths; for, with respect to the former, I have never met with any description which operated satisfactorily without a cistern; and, with regard to the latter, particularly shower-baths, it would be rather disagreeable to stand shivering in the cold, between every pull, waiting until the small supply pipe furnished the quantity for another discharge; while even with the plunge-bath considerable time would frequently elapse before the body of water required could be delivered, because the pressure may be diminished if water is being drawn off below.† Secondly, it should be noticed that in the great majority of cases, the lead pipes would not be capable of sustaining the increased pressure, chiefly on account of their being too light and thin, but partly from the defective system of manufacture practised until recently.‡ For, even assuming that the elevation of the source from which the supply was formerly delivered remained unaltered, the chances are that the pressure due to that elevation never was placed upon the pipes, because, in the intermittent system, all the tenants in the district under service would be drawing at once, some below and some above, and thus numerous taps would be open during the time the water was turned on; but on the constant system, the case is very different, for if not in the daytime, at all events during the night, every pipe would be subjected to very nearly the total pressure due to the head. Besides this, the concussions to which the lead pipes are subject in the lower parts of the houses, on shutting the taps is generally very much greater under constant supply than under the intermittent system; because in the former the pressure is derived direct from the mains, and in the latter it is only that due to the height of the cistern in the house.

"It ought also to be borne in mind, that to take full advantage of the new supply, additional apparatus, such as sinks, pipes, &c., must be provided, not to mention baths and water-closets, which have been supposed to exist in each house. Now all this work will obviously be of an expensive character, having to be calculated not to sustain a limited pressure for a few hours every other day, but a constant and very high pressure.* For, be it remembered, the supply is to be available at all times on the upper floors, and to sustain this condition will, of necessity, involve a very high pressure, seeing that parties may be drawing water below at the same moment that it is required above.

"The alterations in the structural arrangements to be effected at the cost of the house-owner or tenant will, therefore include—First, either the adaptation of the old cisterns, or, what in most cases will be the cheaper plan, the erection of new ones; secondly, the renewal and extension of the leaden communication and service pipes; thirdly, the fixing of the new taps, sinks, and similar apparatus; and, fourthly, supposing them not to be already provided, the erection of baths, water-closets, and other conveniences, with all the accompaniments of overflows, soil-pipes, &c. Nor will the expense end here; for the continuousness of the supply, combined with the increased pressure, renders it necessary to keep the taps in much better condition; and experience shows that the requisite repairs are costly, especially if the water contains sand or other matter, which, by attrition, expedites the decay of the moving parts. Indeed, I have known cases in which it was found cheaper to provide cisterns, into which the water was delivered in the first instance, and from which the various taps were fed, the pressure upon them being thereby reduced.

"Of course, in the case of the introduction of water for the first time, where no works existed previously, part of what has just been stated would not apply; but I have thought it right to mention these facts, because many large towns are supplied on the intermittent system, and to this Swansea is not an exception.

"It here occurs to me to be necessary to guard against misapprehension, or a misconstruction of the foregoing remarks; for I wish it to be observed, that I am not arguing that the intermittent system is equal, much less superior, to the constant system *per se*; but I have been endeavouring to show that such comforts as water-closets and baths are not necessarily a part of the constant, any more than of the intermittent system, and therefore that their enjoyment must involve expense in any case.

"Still, considered as a consumer's question, I would now allude to some advantages attached to constant supply, which do not involve a *per contra*, in the form of increased outlay, &c.

"In the dwellings of the poor, where no apparatus is generally provided beyond a single tap, constant supply confers a great benefit, by substituting one service reservoir, or one very large cistern, for numerous small ones or butts; and the former being placed under competent management, the arrangement is better and cheaper, besides affording infinitely less opportunity for the defilement or deterioration of the water. Moreover, a sufficient quantity is rendered available at all times, which is seldom the result on the intermittent system.

"The same effect follows in the case of the supplies required by manufactories, such as breweries, where constant supply saves the expense of large vessels, and reduces the dimensions and the cost of pipes, cocks, and similar fittings,—affords facilities for feeding boilers and filling them up when cold, without

* Report on the Supply of Water to the Town of Swansea. By Michael Scott, C.E. London: W. Clowes and Sons. 1852.

† Perhaps the best evidence of the necessity for cisterns, arising from the difficulty of sustaining the pressure in the upper floors of high houses, is to be found at Glasgow, where, with great capabilities on the part of the waterworks, cisterns are always provided, in order to prevent disappointment in this particular.

‡ The method of forming leaden tube, at no distant period, was by the drawbench, whereby any minute pore in the original casting was elongated into a split, dividing the pipe in the direction of its length; and it is only within these few years that the more perfect plan has been pursued of forcing solid lead through a die by hydraulic pressure.

* I do not mean that the risk of bursting the pipe is augmented by the pressure being constant, but that the risk of injury to the house and furniture, if the pipe does burst, is much increased; for although stop-cocks may be provided to shut off the water in the event of an accident, still, from long disuse, they are seldom in working condition.

pumps, &c. The large tanks heretofore employed in such establishments were no doubt useful for measuring the quantity taken, and determining the charge made for the supply; but Mr. Siemen's beautiful invention bids fair to attain this object in a less expensive manner, by providing a very perfect water-meter, a desideratum long felt.

"Amongst the more recent applications of water wherein constant supply (under pressure, of course) possesses great superiority, I may advert to the washing of railway carriages, as originally proposed and carried into effect by the writer, and which will no doubt be more extensively adopted when more generally known.

"For supplying shipping, including filling casks and tanks, washing decks and holds, filling new vessels to test their tightness, &c., water always obtainable under pressure is very valuable, inasmuch as smaller hose may be used, fewer men employed, and less time occupied in each operation, all of which contribute towards saving money and promoting convenience; and, as illustrating one point only, I may state that as water is generally the last thing taken on board prior to sailing, amidst much hurry and bustle, without very considerable facilities vessels frequently lose the tide, as it is called, or find the dock-gates shut before they can get out, which is a very serious matter, especially in the case of emigrant vessels, as it will probably involve a delay of twenty-four hours.

"Hitherto we have considered the subject of constant supply as a consumer's question; but there is another aspect in which it ought to be viewed—namely, as affecting the supplying body, and to them there are several advantages, the most prominent of which I will notice. The first is, that fewer men are required to attend to complaints of non-supply, and as turncocks in connection with the service for domestic and trading purposes: for in the case of constant supply, the tenants have only to help themselves, whereas, with intermittent service, the water has to be turned on to different districts, at different periods of the day, and the turncock requires to see that the tenants are supplied before he shuts off the water again. The second point is, that, with constant supply, many of the pipes may be smaller, if cisterns are provided for water-closets and baths, because these receptacles become filled during the night; but if no cisterns were provided, and if the inhabitants were to avail themselves fully of the water for bathing, &c., the difference in the dimensions of the pipeage would not be great, inasmuch as the demand for water being general at certain periods of the day, the quantity passing through the pipes requires to be correspondingly large, if the pressure is sustained so as to reach the upper floors of the houses. Thirdly, with constant supply under high pressure, that waste of water is saved which arises, under the intermittent system, from the poorer class of consumers throwing away the surplus quantity they may have stored in various vessels from one water day to another; and when pipes are carried *into* each house, the very force of the water tends to prevent the inhabitants from permitting it to run to waste; but, on the other hand, with outside or stand pipes, and even inside, unless taps of a superior kind be provided and kept in good condition, the waste from them may be, and frequently is, enormous, especially in the case of ball-cocks supplying cisterns provided with overflows. Fourthly, the constant pressure system has this advantage, as respects the landlords of weekly property, who may be considered as the supplying body, that it, in a great measure, prevents the tenants from abstracting the fittings, as is not unfrequently done under the intermittent system, thus furnishing the landlords with a reason for objecting to supply the necessary apparatus. Fifthly, a fertile source of annoyance under the intermittent system—namely the contamination of the water by gas drawn into the pipes by the vacuum formed when the supply is shut off and the pipes emptied, is avoided under constant supply; because however saturated the ground may be with gas, it can find no entrance into the mains when they are kept always full. Sixthly, the strain upon the service-pipes is not so great on the constant system as on the intermittent system; for, on the former, it is more nearly that due to the simple pressure, whereas, on the latter, concussions frequently arise, in consequence of the sudden admission of water into pipes either partially or completely empty, although this effect is modified by the use of cocks, which open gradually. Seventhly, the oxidation of the iron of which the pipes are composed, arising from the action of the oxygen of the atmosphere, is considerably less when they are constantly charged.

"On the other hand, the intermittent system affords greater facilities for repairs to the service and communication pipes, and, in addition, it is free from the following disadvantage, which is of a serious nature. In many cases, especially when the supply is given by means of stand-pipes, it is hardly practicable to recover the water rents from many of those served, because so long as one pays, the supplying body is precluded from cutting off the water from others who may wish to avoid so doing. But this cannot occur to such an extent with intermittent service, because not only is the presence of the turncock a check, but as the water is left on only long enough to serve those who do pay, there is no time for those who do not to obtain a supply.

"For sanitary purposes, such as washing courts and paths, and watering streets, all of which are more cheaply and effectually done by a jet of water than by any other means, pressure is indispensable; and the same remarks apply to the cleansing of slaughter-houses, markets, &c.

"As I have paid some attention to this subject, the present opportunity may be taken to point out some of the principal advantages of the system of watering streets by jet, as compared with the old method of water-carts; and, as a ready means of doing so, I shall quote in substance from a report made by me some years ago, merely varying it according to the suggestions of recent experience.

"The objections to the use of water-carts are, the valuable space they occupy in crowded thoroughfares, either when being filled or when in motion, and the slowness of their operation. The jet system, on the contrary, offers little interruption to the traffic, and is infinitely more effective, because the streets may be much more thoroughly drenched at one operation, without a corresponding loss of time, But these are minor advantages, when compared with the facility which is afforded by this system for washing, not only the streets, but also the paths, courts, and narrow passages, where no cart could enter, although it is in such passages that the detergent process is more particularly required: and, as an important collateral benefit arising from the jet system, I may mention that there would be a large number of men trained to use the branches and hose, who would form a valuable body in the event of fire.

"There is one question, however, which may naturally arise, and which deserves attention—viz., Why is watering by jet not more generally practised in towns where an ample supply under pressure may be had? I conceive that, one, it might almost be said *the* reason, is, beause there has been no means of controlling the extent or force of the jet; for, if the water flowed with great velocity, then, although it enabled the operator to sweep or include a large area of street, still he could not water the part near himself, except in one of two ways—by allowing the jet to rise perpendicularly and so descend with great force, or by directing it downwards—either of which would disintegrate the surface of the street, at all events, if laid in macadam. I shall now explain the method which I adopted for overcoming this difficulty, without diminishing the force of the water required to give the necessary range. It consists of a branch furnished with a small wheel, which, on being turned, shuts or opens a valve inside the pipe, and thereby regulates the stream of water; and the valve being nearly in equilibrium is quite easily moved, whatever pressure of water there may be in the main. Here, then, we have all that is required to remove the only objection worthy of notice to the jet system. The water can be made to fall 100 feet off, or drop gently at one's feet. It can be made to flow with full force, or be shut off entirely in a moment; in fact, it is so perfectly under control, that neither danger nor annoyance need be apprehended.

"Lastly, for the extinction of fire, great pressure is essential, if the water is to be applied without the intervention of a fire-engine. Water has for a long period been applied direct from the mains for this purpose (I remember it being so used many years ago in Glasgow), and the only improvement more recently effected consists in the employment of greater pressure, which confers the following advantages:—First, it enables the operator to reach the upper portions of the building on fire, and frequently this cannot be the case with limited pressure, because the intense heat of the burning mass prevents a very near approach to it; secondly, great pressure gives power sufficient to break the glass in the windows, otherwise a dangerous operation, and yet often a most necessary one, for the admission of water into the interior of the building; thirdly, pressure and quantity are, to a certain extent, convertible terms; and as it has been found that to insure the efficiency of water applied direct from the mains, comparatively very large pipes are required, even with considerable pressure, it follows that, with the ordinary service-pipes laid for domestic supply, either very great pressure must be used, or it will not be possible to dispense with fire-engines; since a much smaller quantity would be discharged through a single jet and length of hose than would flow into the engine-tub at the level of the street. In the case of a fire on ship-board, in the dock or harbour, where the usual course of scuttling the vessel is expedited by pouring in water from above, high pressure, as increasing the quantity, is most important."

VENTILATION OF THE HOUSES OF PARLIAMENT.

Analysis of the Evidence given before the Select Committee appointed to Consider the Ventilation and Lighting of the House and its Appendages.

GURNEY (G.)—The atmosphere of the House, in its mechanical condition, is in a state of considerable disturbance, a state of aërial commotion. He has gone through the chambers below, he has gone through the House, and he has also gone through the chambers above; he finds that the air is all in a state of commotion, from the time it enters to the time it escapes. It (the air) is forced in below by a large fan, by which much disturbance is given to the air; it next passes into the first chamber through certain openings prepared for the purpose. In these passages it takes an increasing velocity, and that increased velocity produces a second disturbance; the air is set into a state of retrograde currents, eddies, and cross impulse from one side of the room to the other. The air now goes into a third chamber, in which these disturbances are still increased. In the second chamber the air is warmed; part of it is heated by tubes, or iron cylinders, filled with hot water; this produces a difference in the specific weight of the air, coming in different parts; and here the natural brattice is formed, which is another disturbing force.* When the air comes into the house it meets with another series of disturbances. The House is in a state of *minus* pressure, or partial exhaustion as compared with the atmosphere outside; the pneumatic balance between the external air and the internal air is broken by the air of the House being at a higher temperature. The principle of ventilation which witness had laid down is, that a sufficient quantity of air should be extracted, under control, for the requirements of the House, and arrangements so made that that quantity shall be supplied by an insensible movement under nature's law. Under this plan the same simple system of drawing in the air from the roof of the building, and admitting it at the floor, might be made to afford a perfect ventilation, even if the air is prepared and warmed before it is permitted to enter. Under witness's system, supposing the temperature of the House to be fifty or sixty degrees, and the external temperature to be thirty-two degrees, if either doors or windows were opened there would be no current of air; the disturbance would be so small it would be scarcely perceptible. The current of cold air which comes into the building on the opening of the doors arises from the state of exhaustion of the House itself; the House itself being in a state of partial exhaustion, or *minus* pressure. One of the radical evils is, that the accesses of air in the present House of Commons are too small; evils arising from the difficulty which the air has to pass through the strangulated channels prepared for it, and the twists and turns given to it before it can get to the House. The process of respiration constantly alters the composition of the air. The laws of diffusion of gases soon produce an equal division of any effluvium that may happen to be floating in a room. But in the present condition of mechanical disturbance of the House, there is no disturbance from the laws of diffusion. Evidence shows that it is partially decomposed, one of its conditions being that of air over-heated, heated above ninety degrees. Air is so vitiated by over-heating as to have a great effect upon the animal constitution. Another cause of the unpleasant condition of the air is, that by the partially-exhausted state of the House, it is vitiated from foreign and unprepared sources. A further cause arises from the wet iron surface over which the air is made to pass over the floors, having been previously over-heated by dry iron cockles. The air should never be heated up to a high degree in order to be pulled down again. When the two doors going into the House of Commons are opened, there is more air passes than is sufficient to ventilate five such houses. Objects to forced ventilation as contra-distinguished from natural ventilation. Ventilation should be as simple as possible: the vitiated air should be simply drawn off, nature will do the rest. Witness has had the Court of Common Pleas and the Court of Exchequer under his control for the purposes of ventilation. The mode of ventilating the Court of Exchequer is downwards. The vitiated air is drawn away by a steam-jet placed in a chimney opening into and very near the floor of the Court. The air comes into a chamber below the floor, and it is drawn out by a steam-jet, and sent into the open atmosphere. This steam-jet is under the management and control of the man in the charge, who opens or shuts the stop-cock more or less as he requires power; he has the power of producing any amount of draught he pleases. The air comes in from above unrestricted and unthrottled from the external air; the chilliness is taken from it in cold weather as it passes, so that the pneumatic balance between the court and the external atmosphere is preserved. Baron Parke sometimes likes the windows open, which are about two-thirds of the distance between the floor and the roof, and we find no inconvenience from this opening; the cold air does not come in through the windows, as might be supposed, in sufficient quantity to make an unpleasant draught. During frost his lordship will sometimes have the windows open, when the temperature inside is not above 60 degrees. The height of the building is about 30 feet. At the time fresh air is coming in, the vitiated air is drawn out by the jet. More or less power from the jet is turned on and off according to the requirements of the court; and fixed in accordance to the pressure-gauge connected with the anemometer provided for the purpose. In addition to the escape at the floor there is a little escape provided through the lanthorn by a small self-acting Venetian valve; this small escapage is to take off a certain gas which is formed from respiration, and which is much lighter than the atmosphere. In summer the air is cooled by what is called "the spray-jet." It is an invention of Mr. Cayley's the barrister, the son of the member for North Riding, which we had recourse to within the last twelve months. Water is driven by a compressed jet of air, or high-pressure steam, one tube acting within another, like the oxy-hydrogen blow-pipe, into spray, which cools air very rapidly. When we find by the hygrometer that the air is taking up too much water, so that the hygrometer shows a break below 5 degrees, air is then passed through the same battery or apparatus, which battery becomes reversed in its action by being filled with cold water instead of hot; instead of being filled with steam, it is then filled with water at a lower temperature than the atmosphere. If ice-water is employed the cooling power is very rapid; or freezing mixtures so rapid that you may bring the air down below 40 degrees, and it falls out at the bottom between the leaves of the apparatus. The spray-jet is placed in the Court at the inlet of the air. The difference in principle between witness's system and that adopted by Dr. Reid is, instead of a furnace drawing off the air, either downwards or upwards, a steam-jet is used as the tractive power, and instead of using tubes filled either with hot water or steam, as adopted by Dr. Reid and Sir Charles Barry, witness adopts parallelograms, which apparatus are called "warming batteries;" called so on account of being in form like the galvanic battery. The difference between Sir C. Barry's principle and the one adopted in the courts of law is, that in the latter there is one power only, which is an extracting power. Sir C. Barry has a fanner for injection, so that he may keep up by the force of injection, and at the same time by a simultaneous action which is going on above, an exact balance in the House of Lords is preserved; the balance is adjusted by these powers. The air in Sir C. Barry's system at the House of Lords comes in at a high level and goes out at a high level. In the system witness has adopted it comes in at a high level, but goes out at a low level. Witness has the means of sending it out also at a high level, but if that is done the Court is not so comfortable. The present mode of lighting

* A brattice is a plate of air at rest between two moving currents, one up and one down; horizontally it seldom exists, but vertically it does. These currents are produced by the difference in weight of two equal columns of air, occasioned by different temperatures, the heavier column descending, and the lighter column ascending. The plate of air between those two columns is called "the natural brattice;" this is a term given by Mr. Gurney in 1849, when first discovered existing in a coal-pit up-cast, and has been adopted since as a term; persons at all acquainted with colliery ventilation will understand it. In a coal-mine shaft there is often a division of it from top to bottom by a partition of wood; one side forms the up-cast and the other the down-cast column; this is called a brattice-pit. The cold air goes down the one side, and the warm air goes up the other in this brattice-pit; but when the air forms of itself into two columns, it is called "the natural brattice," namely, the quiescent plate of air between those two currents.

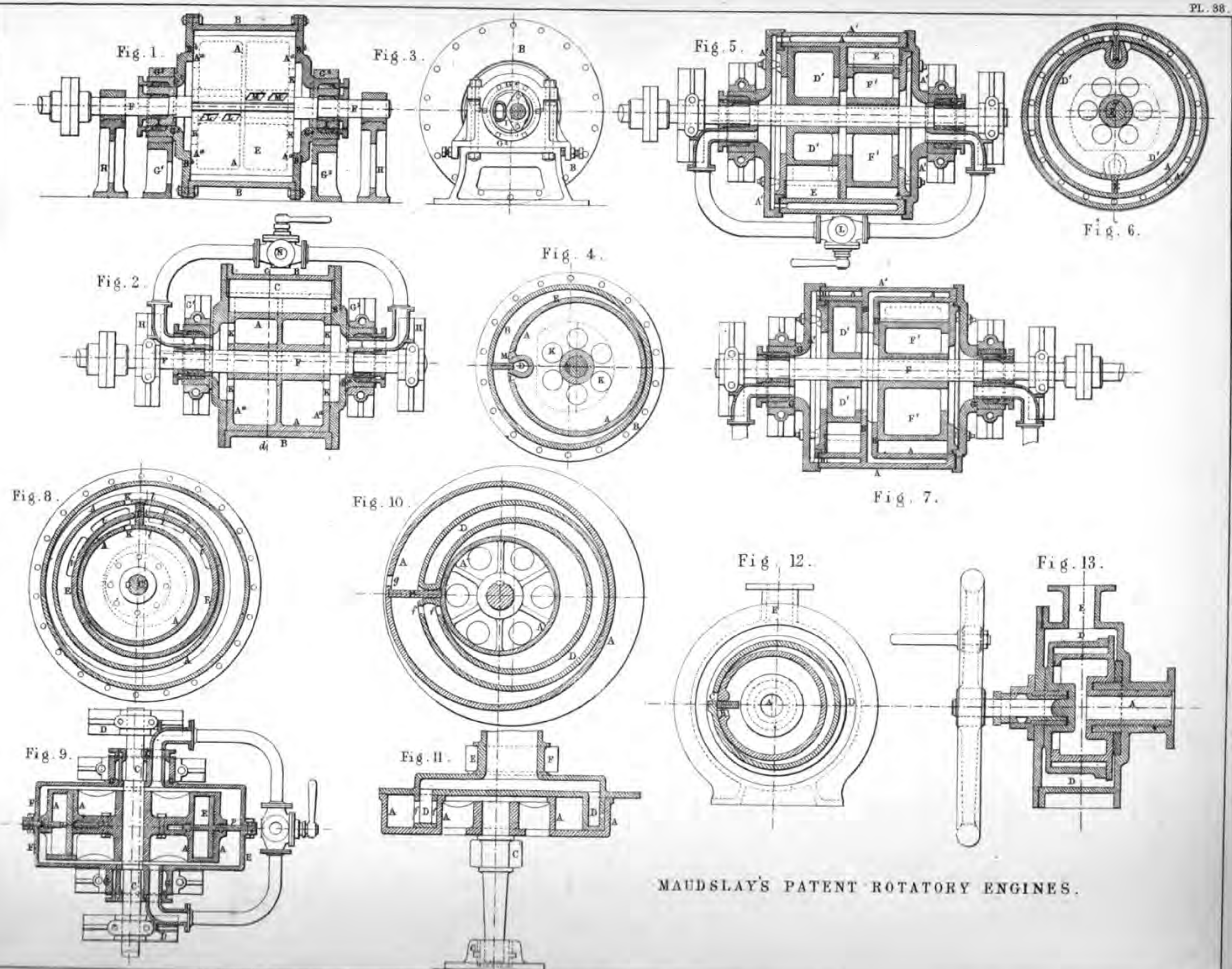
the House tends to make the air oppressive; this was not the case in the old House, as the lamps were insulated. The present areas for the access of air to the House are not sufficient. Would prefer the clock-tower as the source from which to draw the supply of air. Witness does not reject the vaults as a means of obtaining air. A portion of the air now enters the House through the hair-cloth carpet; this very much hinders its ingress into the House, and must have the effect of carrying with it particles of dust. Witness does not know practically of any process to cure air of its impurities. Chloride of lime is used to correct smells; the chlorine partly acts on the hydrosulpherets, but it seems to act on the principle of one smell overpowering another. Does not think that any chemical change is effected by it of the atmosphere. There is an effect produced by electricity or galvanism, and on oxygen of the air, called ozone. It is said there was none of it in the atmosphere when the cholera was here. A process has been adopted for relieving the air of impurity in a large manufactory on the other side of the water, where the escape of smell was so great as to be an annoyance to the whole neighbourhood. By driving the impurities, by means of a steam-jet, through a fire at a white heat, it burns the air and the offensive particles which were floating about in it. Witness considers that in the whole of the building, generally speaking, there is the foundation of everything that can be required except for crowded committee-rooms on special occasions: there is a good deal of artificial ventilation in many of the rooms which is not required. The principal evil in the committee-rooms arises from the great extent of glass surface, which should be removed. The cooling influence of the glass occasions a plate of cold air to fall, which is not prevented by the arrangement made against it. The glass cools the air in contact with it very rapidly, and it falls as a plate or sheet of cold air. Attempts have been made to warm that sheet of air from below the windows, but the warm air is overpowered by the falling sheet of cold. These windows are very high, and there is an unusual quantity of glass. Witness would not recommend double windows; first, because they would be very expensive, and would interfere with the architectural arrangement of the building; secondly, double glass would only get rid of one half the mischief. If a simple transparent blind or curtain which drew upwards instead of downwards (so as not to interrupt the light above the principal part of the window) was properly arranged, the stream of cold air falling from the glass might be warmed *in situ* by the present warming apparatus. The intervening air then would be warmed, and the evil now produced by the falling cold sheet of air would be removed. Those curtains would go a little more than half-way, which would be sufficient even in the coldest weather; there is no occasion to draw them up so far as this in warm weather; a plain white curtain would be sufficient for the experiment, and even for practical purposes. He thinks the warm air from a triple steam-coil, or from those now fixed, would remove the evil. Has found that the cold glass of the window brings a current of cold air down at the rate of above a foot a second, from 60 to 80 feet a minute: it being a sensible and disagreeable fall; it runs along the floor. The principal evil is from the cold glass; there is an incast through the windows; there is a leakage always found about windows, however well made; does not think that that intake of air is of so much consequence as the cold sheet of air which falls from the cooling influence of the glass; the air that comes through the window-leakage will go horizontally, or nearly so, into the room; but the air that witness refers to is the cold sheet that falls from being cooled by the glass surface. Persons could not look out when the blind was drawn up; if this is an object, a double glass frame might be put up occasionally part of the way. If another glass is put inside instead of the curtain, persons might look through it, and the same effect would be produced by warming the air between the two casements as between the curtain and the window; without this warming between, glass alone would only remove one-half of the evil. The term "sheet" and the term "plate" mean that vertical plate of air next in contact with the window. The descending particles of air call after them other particles, which fall in with the current; the whole increases as it descends, and forms a large descending-plate of air; when it touches the bottom it runs along the floor into the room. That sheet having come down is supplied by another sheet, which is equally cooled against the glass, and comes down, and so continually follow. Thinks that the inconvenience which is felt in the rooms arises principally from the difference of temperature between the internal and external air, and not from the pressure of air arising from the wind; unless the latter blows strongly from the east does not think it of much consequence. With double windows one-half the evil is got rid of, and no more; but when you pass warm air between double windows, you get rid of the whole; you effectually get rid of it. It is converted into a mixing-chamber. You have a portion of warm air, and a portion of cold; the air is cooled by the atmosphere without, through the glass; if you have warm air between the two frames of glass you have a plate of warm air insulating the external air entirely. The principle has been introduced into some hot-houses with great advantage. As regards the special coil, placing the pipes vertically is a far better arrangement than placing them horizontally. All the inlets and outlets appear to be under proper regulation, though they are not exactly upon the system witness would have recommended; witness's plan would have been to extract from below, and allow the air to come in from the upper parts of the windows. It is far more desirable to ventilate by the single action, as adopted in the Court of Exchequer, but it is one which cannot well be now introduced into the House of Commons. Is of opinion that it is not worth while to upset the present system of ventilation, and go to a great expense to upset the building. The libraries are comfortable, with the exception of the cold windows. The great defect of the air of the House, compared with that of the libraries, committee-rooms, and lobbies, may be attributed to its being partially over-heated, and partially to impurities being drawn into the House from sources which are contaminated. The difference between the Houses consists in one being warmed by means of a horizontal pipe, and the other a vertical; partly to the different sources from which the air is extracted, and partially to the greater over-heating in the case of the House of Commons, compared with the House of Lords. In the one case there are horizontal pipes and in the other vertical ones: there is a partial vacuum in the one case, by which air is drawn in from uncontemplated sources; in the other the balance is very nearly preserved. When witness made experiments in the House of Commons with his differential barometer, he found the air in the House in a rarefied state, which he attributes to the vacuum draught upon the air from the shaft, where the furnace was. The apertures for the ingress of air are deficient. Carbonic acid expired from the lungs will fall in a still atmosphere, though not if the atmosphere is disturbed; therefore it offers no opposing force. The downward system of ventilation favours the immediate escape of carbonic acid and the sebacic formations; they are both heavier, and both naturally tend to go immediately out in escapage, if drawn from below. The skin, as well as the lungs, gives out carbonic acid; it lies at a low level. The nitrogen which leaves in combination with the breath is very nearly of the same weight as the atmosphere, so that it does not interfere with the escape, whether it goes up or down; all physiological facts, connected with the subject, are in favour of the downward system of ventilation. There is always an ascending and descending current near a wall; if the wall is at a lower temperature than the room, there is a descending current next it which is very sensible: if the wall is warmer, there is an ascending current next it, so that these currents interfere to mix the air; the oppression alluded to is a matter of temperature. In a theatre the upper part is the hottest, and the lower part is the most unhealthy. In the Lyceum Theatre the temperature, on one occasion, was 84° above the level of the boxes, 70° in the middle, and at the bottom about 60°. The difficulty in breathing would be in the rare atmosphere above. The advantages of a downward system, as compared to an upward current in ventilation, are chiefly as to the products of combustion being heavier, the inconvenience of dust rising from an upward current, and as to the most serious practical objection of all, the incoming jets of air. The latter is one which cannot be got over; it is inseparably connected with pneumatic laws of air entering below for ventilation; that air, where it enters, must produce a series of disturbances highly objectionable to the feet and legs, if in sufficient quantities for proper ventilation. Formerly it was thought that a draught of air was "a draught," and nothing more, going straight ahead in a given direction; but on the investigation connected with the rationale of the steam-jet, it was apparent that the secondary currents arising from the primary motion were of more importance than the first as respecting this question; for instance, it was manifest the air first passed in a given direction drew after it air that fell in its wake, which formed a series of currents of more consequence than the first. These would all take place near the floor, or near the source of the air entering, wherever it might be; if the entry of air were through the floor these series of currents would all happen in that locality, and therefore they would fall upon the person, and be very inconvenient. Another reason is, the emanations from the skin and sebacic glands. A dog follows his master for miles in the country entirely by the falling of this effluvia, even in stormy weather. This in the dog is a natural power; there is something which has fallen to a low level from the person, it is this which produces what is commonly called scent. Witness prefers that the lights of the House should be reflected through glass, not only on account of its intercepting the rays of the heat, but on account of insulating the lights entirely from the House, and also on account of its facility in colouring the rays to soften them; by colouring the glass very slightly you get a tempered quality of light, which is more agreeable than a pure white light. If you colour the reflecting surfaces you diminish their reflecting power; the expense of light is materially increased; you are obliged to have a larger quantity of initial light to produce the same effect. It is better to deal with reflected rays by coloured media. It would be better to put a glass shade under the light, ranging with the ceiling; it is a matter of taste whether it be of coloured or figured glass. If it was a very slightly coloured yellow or orange the light would be more agreeable. The late Sir Robert Peel suggested that coloured water should be placed between two plain layers of glass, for the purpose of colouring the rays; the coloured water, he conceived, would have two useful properties: in the first place, it would cut off the direct rays of heat, would insulate the burner; and secondly, it would produce a tempered light. That experiment was tried and approved of; there not being much loss of light. Proposes to bring the drop light down into the body of the House, to avoid the shade under the galleries. Sir David Brewster proposed that under the edge or cornice of the galleries a refracting medium should be placed, which should change the angles of light, and send them under the gallery: in the experiment it succeeded. Those refractors got their light from above. A portion of the light falling perpendicularly, would, by these refractors, be turned out of that direction and thrown under the gallery. The refractor is placed immediately under the outer edge of the gallery. The present light is rather too white; light a little coloured is far more agreeable than pure white; this can be carried out when it is reflected through glass. The up current is assisted when the lamps are lit. The introduction of lights inside the House is objectionable. Reflection from a metallic surface, and transmitting that light through glass into the House, is the best mode of lighting. The loss by reflection is, from the surface of a mirror, only one-ninth; from the surface of a polished reflector, as used by the Trinity House, it is scarcely so much; when reflected, if in a true parabola, there is no loss. Radiated light loses as the square of its distance, but not reflected light; this depends on the angle of reflection. On one occasion, a light placed at Purfleet, 11 miles away from Blackwall, threw a visible shadow of a stick held against a white board at Blackwall. If the reflecting surface is imperfect, there may be great loss either by material or from angles; but if the reflecting surface is very good there is no great loss. The loss in radiation of light arises from the fact that it has to illuminate a space increasing as the squares; but if reflected from a true parabola the rays pass in one direction parallel to each other; the loss through the atmosphere by floating particles of opaque bodies is the only source of loss in such case. He would have more lights for two reasons; first, that it would be more agreeable in appearance; and, secondly, that it would make up in quantity of illuminated surface what is now produced by intensity. The intensity is now too strong to be pleasing; if you made it up in quantity, the light on the ceiling would be more agreeable; it would not be so offensive to the eye. The amount of expense of a smaller number of large, or a greater number of small lights, would be very nearly the same. It would only be the first cost of the burners; there would be very little difference in the expense of the nightly consumption. Proposed that a small mask catoptric light should hang from each of the present pendents, of which there are ten, and that the roof should also be lighted on the present system, with certain modifications. Witness conceives it possible, by increasing the amount of light, to get a sufficient amount of illumination for the House generally, by making the ceiling a reflector; but there would then be more light in the galleries than in the body of the House; this would have an unpleasant appearance. A pleasing effect would be produced by having the surface, that is the roof and ceiling of the House, of an agreeable reflecting colour. There is nothing to prevent the present House being lighted perfectly well, exactly as the old House was lighted, by adding to the present light in the roof a couple of chandeliers fitted with catoptric masks; this would light those portion of the roof which are now in shadow. He proposes to illuminate the whole of the panels in the central part of the roof. Would propose the "Atmospheric Bude Light," with concentric burners, as used in the old House. He would place small masked lights concealed under the gallery, so as to illuminate under it, and to illuminate the members who sit below, and also the back panels. It would be necessary to make it a masked light, because a naked light would be offensive to their eyes, and possibly seen from the House; a masked light, shedding its radiance over the whole of the panel-ceiling of the gallery, would not be seen; it would diffuse itself generally, and would be agreeable to the eyes. As the quantity of light required under the galleries is small, spring wax-lights may be used, properly placed and made for the purpose; they must be made to burn for twelve hours, and constructed to be fitted to the catoptric mask. Witness had them in the old House constructed for that purpose, with a large quantity of wax in proportion to their length; they were placed in a spring-socket, so that the flame was always at the same level, like the flame of a carriage-lamp. They used to burn twelve or fourteen hours. He proposes to illuminate the gallery by placing a light between, behind, or in a line with the pillars, so as to reflect against the ceiling below the front of the gallery. Taking out the present panels and substituting glass would in no way affect the hearing; which would be the case if the panels were left open. The result of experiments which witness has made with respect to the colour most suitable for the reflection of light, shows that silver reflectors are the best. The most powerful reflection is from white surfaces; the least powerful is from brown or black; you find them follow nearly in the same order of colour from white to black; the whiter the surface the more light is reflected. Gold is practically good; experiments were made with gilded reflectors; the light was good, and produced a very agreeable tint upon the countenance; persons looked very well, particularly when it was a deep gilding. The quantity of light reflected from a gilded surface in proportion to the quantity of light that would be reflected from a white surface, was less; he measured it by a good photometer: thinks the loss was in the ratio of one upon five, about a fifth upon the gilded surface, was lost. Would not recommend gilding as a matter of economy of light, but as a matter of effect; in many cases it might be used with advantage. Would recommend highly-polished silver reflectors: they are used in all the lighthouses; the object is to reflect the light as effectively and profitably as possible. It has been found that there is less light lost from silver reflectors, properly burnished and properly curved, than from any other surface, even from a mirror: if the reflector gets dull, the power of reflection is considerably reduced. If the panels were dead silvered in the same way as if gilded, you would get a quantity of light from it greater than you get from rough white painted surfaces; ordinary white surfaces are a series of white points or facets; dead silvering would be much the same thing. So that a system of silvering might be applied instead of gilding, which would answer decorative purposes, and at the same time give a very good reflected light. By a little mixture of light blue (if introduced with taste) the effect might be very pleasing.

Arnott (Neil, M.D.)—There cannot be a perfect system of warming and ventilating in a building having separate rooms, if there is a deficiency in respect to any one of the following particulars:—First, means of moving through the building steadily the definite quantity of pure air known to be required; secondly, means of duly distributing this air to the different rooms and compartments; thirdly, means of properly diffusing the air in each room; fourthly, fit means of discharging the vitiated air from the room; fifthly, means of giving to the air the fit temperature; and, lastly, means of giving the fit moisture. The more the apparatus is rendered self-regulating, or independent of the constant watching and interference of attendants, the better it is likely to be both as to performance and economy. Even the learned have understood that the air we breathe is as much a material substance as the water we drink or the food we eat, and may be mingled with poisons as these may be. A hundred years ago nobody on earth knew that there was such a substance in nature as oxygen, now called also vital air, which is one of the elements of our atmosphere, but which constitutes also four-fifths by weight of the whole substance of the ocean, and nearly one-third by weight of the solids forming the crust of the earth. In respiration the oxygen which enters the lungs takes from the blood there some carbon, and returns as carbonic acid gas, which cannot safely be breathed again, and therefore has to be removed by ventilation. The natural ventilation of persons is produced by the warmth of their breath and the wind. The poisonous hot breath being lighter than the surrounding air, is buoyed up, and the wind carries it away. Walls and roofs of houses, however, by preventing these natural movements, soon made men aware of the necessity of ventilation; therefore, even of old, when crowds had to meet, they did so in the open air. Smaller numbers found that they could meet under cover, and yet breath comfortably for a while if they had open doors and windows. Then appeared more spacious houses, and particularly with large space above, as in cathedrals; then openings for air were formed in buildings below and above. The history of the attempts to ventilate the Engish Houses of Parliament during the last 100 years is curiously instructive, both as proving that the art of ventilation is a very new art, and as showing the steps by which the art has advanced. For a long while the only means of ventilation in the House of Commons were four openings made, by order of Sir Christopher Wren, in the ceiling of the House, of a foot square each; short tubes were placed by him over these openings, to make them draw more strongly; then fires were lighted in connection with the tubes, still further to increase the effect. Another adviser, Dr. Desaguliers, for the purpose of extracting the foul air from the roof, introduced a fan-wheel over the ceiling of the house, which, although answering better than anything which had preceded, was still very unsatisfactory. Then, about thirty years ago, Sir Humphrey Davy being consulted, caused two iron tubes, of one foot diameter, to be made as channels for vitiated air, leading from the ceiling through the roof, and in their course passing through fires to heat the air in them. But this scheme also signally failed, owing to the smallness of the tubes and the weakness of the fire. Not long after happened the destruction of the Houses by conflagration. In the temporary House of Commons which succeeded, Dr. Reid had the merit of exhibiting for the first time an air-moving mechanism equal to the demand. It was his great heated chimney, 100 feet high, and with internal area of nearly 100 square feet. Its performance gave great satisfaction. In the present new Houses, similar gigantic chimneys again appear; and, in addition, there are gigantic fan-wheels, moved by steam-engines and powerful steam-jets, familiar now to the public eye in the chimneys of engines on railways. Those enumerated can be used to produce the one or the other of two effects, which have been distinguished by the names of the plenum and the vacuum movements; the first blowing pure air into the House, so as to force an equal quantity of foul air out; the second, extracting foul air from the House, and so drawing in (to use a popular phrase) an equal quantity of fresh air. The plenum is the more simple of the two, and has considerable advantages. A plenum, produced in another way, is already familiar to the public, in the shape of a gasometer, as seen working in great perfection at all the common gas-works, distributing over a great town one kind of air from a central station, with uniform force, and with certainty, to all the houses, from garrets to cellars, of the town. The gasometer is a simple mechanical means of moving air, without fail, upon the plenum principle. Considering that it can be made to act with any desired steady force, that it is cheap, and easily managed, and is always by its visible movement declaring accurately the amount of work done by it, we may wonder that it has so lately been introduced as a ventilating agent. Some of the advantages of a plenum used in ventilation are, that it makes impossible the entrance into the place so supplied with air, of smells from drains, or of smoke, and lessens or prevents altogether the leakage of gas from pipes. That will depend, of course, upon the pressure of the air in the room, as compared with the pressure of the gas in the pipe. A plenum always lessens the chance of leakage, and, if strong, might prevent it altogether. With a plenum in a room all crevices are made outlets instead of inlets; cold air cannot come in; if any door is open the air flows out. The vacuum again has the disadvantage of favouring the entrance of all these impurities into the house; every crevice with it becomes an inlet ready to admit smoke, or gas, or smells from the kitchen, or any other source of impurity. Mechanical power enough exists in both Houses to move the air through with the required force; but, owing to the complexity of the arrangements, increased attention and intelligence will be required in the attendants, and the chance of irregularities greater. Considers the apparatus already completed, or in progress, may be made to work very well. Is in favour of the single system of the plenum movement, it being so simple. At present the distribution is made by having channels to every room, and every channel with its simple valve or door, which has to be more or less opened or shut, as found necessary, by attendants always watching. Instead of the simple doors or sluices, which, if left in any fixed position, allow very different quantities of air to pass, as the moving force or resistances vary, he advises self-acting regulating valves, of a kind which, when adjusted to any known degree maintain, notwithstanding any accidental change of forces, a uniform current or supply until a new adjustment be made. There are at present sufficient means of distribution, but only with hand regulation. The present channels are sufficient for the distribution of the air, either by vacuum or plenum. The apparatus at York Hospital is on the self-regulating principle: the water which enters for the general purposes of the hospital, in falling from a high cistern to lower ones, furnishes the power for moving this machine; it acts on a small water-engine, which keeps up the motion of the air-pump night and day without cessation; the number of strokes is determined by a cock in the descending pipe. Thinks by this apparatus one pint and a quarter of water, descending from a height of 60 feet, injects 250 cubic feet of air at every double stroke of the pump, and eight strokes in the minute give the required quantity of 2000 cubic feet of air in a minute. The engineers to the Board of Health made an estimate that it would cost about one shilling a day for the whole expenses of the apparatus, the working power (even if the water flowed to waste), and the superintendence. The air enters the wards by chinks round the skirting-board in sheets as thin as the blade of a knife, and so mingles at once completely with the air of the room; it passes away by the openings near the roof, and as, when diluted, it is not so hot as the breath of the parties in the room, the breath rises and escapes first. Dr. Arnott stated what the diffusing power is, and also what he considers to be the difference between distribution and diffusion. The distribution is made to the separate apartments of the House; the diffusion is the sending of the air equably over any single apartment. If there were a crowd assembled on a field, in the wind, the people on the windward side would have pure air, those to leeward would inhale the breath of others near them. As the smoke of London accumulates to leeward on a windy day, and the air is pure to windward, so it is with the breath of a crowd. If there were no means of ventilating a room but by open doors and windows, some of the company would have too much and others too little. The idea of perfect ventilation for a crowd is suggested by seeing birds on a tree, where the air enters below and passes up between them, and no one is taking air from another. The pierced floor of the House of Commons exhibits a like result: the air is diffused by entering an apartment under the floor of the House, and then rises through narrow apertures equally to every person. The difficulty connected with this matter is, when the quantity of air passing is considerable, to convert the sharp jets which traverse the apertures under the impulse of the ventilation movement, into a diffused slow-moving mass of air like what may rise among the branches of a tree in a calm; a sensible draught or current of air in a room is unpleasant, and unless the air be properly warmed is dangerous. Various means of slackening and diffusing air-currents are known, such as the great multiplication of the openings, diffusing covers placed over these, the hair carpet—and such are adopted in both Houses; but he doubts, from the complaints made, whether with the completeness required. Considers there are at present sufficient means for diffusion. If he had to arrange the ventilation of the House of Commons with its present means, or any means, he would bring the air in from the floor; although the downward current from the ceiling would more directly prevent the rising of dust from the carpet, and any sensible draughts among the feet. The bringing of air in at the ceiling is a less natural mode, as in all temperate climates the air which we breath ascends to pass away; and if an artificial ventilating current descend only as fast as the hot breath tends to rise through it, that breath will accumulate round the mouths of persons there, and may be breathed again. Then, because cooler heavy air above cannot repose quietly or evenly on warm lighter air beneath, more than water can rest on oil, the pure air will descend irregularly in some parts, and the hot breath will rise irregularly in others, and the desired uniform downward movement will be prevented. Still, notwithstanding the objection stated, if the speed of the descending air be rendered considerable, and if the expense of sending the much larger quantity of air required through the House be not regarded, it is possible to ventilate very fairly by a downward current. Preference to be given to the mode of ventilating from below; the pierced floor of the House nearly answers this purpose. There is risk of its carrying up dust, and the following are among precautions used in regard to this: daily cleaning the carpets; having the parts of the floor most trodden upon left solid or unpierced, so that no air can pass through; or if pierced, having separate air-channels underneath them, by which a downward movement of the air can be there established, while the upward movement goes on elsewhere; and lastly, on the principle of road-watering, it has been proposed to keep the gangways or portions of the carpet on which persons chiefly tread, moistened a little by threads absorbing water from below, as for the wet bulb of the common hygrometer. The air should be let in over the whole floor, except where the principal gangways are, and also from some perpendicular surfaces about the steps of the floor and benches. An upward ventilation would be imperfect if no part of the carpet were used, but at the gangways there might be a down-draught through the carpet; bringing the air in at the ceiling is an unnatural mode. It is of great consequence that all the air which enters should be sifted, by passing through wire-gauze, to prevent the entrance of dirt. There could be no difficulty in carrying into effect the plan of creating a plenum in the House by having to force the air through the carpet. Objects to the ventilating current descending from the roof. There are difficulties in the way of lighting the House in the event of ventilation coming from the roof; the over-heating of the upper portion of the House can be better overcome by the ascending system. In case of the introduction of warm air from the roof, it is doubtful whether the members would derive any benefit from it whatever. Does not approve of the system of ventilation in the House of Lords. Proposes a simple mode for discharging the vitiated air where it tends to accumulate, by discharging it at the roof through the vitiated air-channels towards the up-cast shafts, moving chiefly under the influence of a plenum impulse from below, aided by the action of the simple chimney-shaft, through which it escapes to the atmosphere. Sees no difficulty in adopting the system of the plenum movement only in the ventilation of the House of Commons. With a perfect system of ventilation there would be no need of pumping or forcing out the vitiated air. The discharging apertures for the vitiated air in the House of Commons are sufficient for the adoption of any system of ventilation. The greater density of the atmosphere within the House by witness's plenum system would be very little, not sufficient sensibly to affect the respiration. One system of ventilation would answer for the whole of the House of Commons buildings, as well as the House itself. Necessary for the person charged with the ventilation of the Houses of Parliament to have complete control of the means necessary for accomplishing it. Objects to the present system of giving to the House the fit degree of temperature by means of steam. The distribution of the machinery and pipes for warming the House is good, and might be applied in the carrying out of witness's system. In answer to a question, What is the best mode of supplying moisture to the air of the House? he said the importance of the moisture in air he need not speak of; persons knew that a north-east wind in spring is very dry and cold, and that coming upon the body it absorbs the moisture from both external and internal surfaces, and occasions great discomfort. A south-west wind is the opposite in these particulars, being warm and moist. Hence, in cold and dry winds it had been deemed important for persons in weak health, and even for persons in strong health, as precaution, that a due proportion of moisture should be added to the air: common means have been to hang up wet cloths in the place, or to let a jet of steam pass in. The simplest mode for large buildings he believes to be that of jetting steam from a pipe with branches placed in the channel by which the air enters. The steam should be uniformly diffused. It is easy to let more or less enter as may be desired, by turning the steam-cock; the hygrometer would show always what quantity of moisture was in the air. All air which is warmed from a low to a high temperature is thereby made capable of dissolving a larger quantity of moisture to make it like the ordinary atmospheric air. The healthiest state of the atmosphere in respect of moisture is, with a difference of about 8 degrees of temperature between the wet bulb and the dry of the hygrometer. He would apply steam for moistening the air only in winter; in summer using evaporating surfaces or the cold water jet; artificial rain has been made to fall into a channel by which the pure air was entering a building; this cools the air, and if the air be dry moistens it. He passed into the gallery when the lamps were burning, and found the heat from them very oppressive there. The lamps when lighted up in the House, already warm enough, become like a blazing fire lighted in a summer apartment. In this committee-room lately, an honourable member reported some experiments which he had made on the difference of temperature in different distances from the lamps in the upper part of the House, according perfectly with what witness observed. Light from above is the most natural light to us; for the sun sheds his light from above; but where light is united with much heat, as in the sunbeam, or in the illumination of the mass of gas-lamps in the House of Commons, a screen becomes necessary. In nature, the hair of the head even of the naked savage, defends him from the sun; among civilised people we see the turban answering this purpose; the hat, the umbrella, the parasol, and so forth; frequently, persons exposed to the hot sun with the head uncovered are affected with head-ache, *coup de soleil*, palsy, &c.; the lower animals seek the shade of trees. Now, the intense heat upon the heads of members sitting in the gallery of the House of Commons is oppressive, and not without danger; it seems essential, therefore, if the House is to be lighted chiefly from the top, which probably is the best mode, that there should be some screen to give protection. It happens conveniently that the substance of glass, although allowing the heat of the sun to pass with the light (as proved by the action of a burning-glass), arrests the radiant heat of ordinary combustion; this is familiar to us in the instance of a glass screen standing before a drawing-room fire: a person sits on the distant side of the screen and feels nothing of the radiant heat of the fire; the glass itself becomes heated just as a sheet of iron would be, and then, as a new centre diffuses the heat which falls upon it in all directions, instead of letting it pass on to the person screened. Lamp-glasses themselves being near the flame may become almost red hot, but a sheet of glass at a greater distance remains comparatively cool. If the lamps in the House of Commons were raised so near the ceiling as that a floor of glass could be placed beneath them, separating them in fact from the House altogether, and causing them to be supplied with air from above, nearly the whole light of the lamps would enter and descend into the House, with very little of the heat. It had been proposed for the late House of Commons, by Dr. Reid, to place the lamps outside altogether, above the ceiling and on the outside of the windows. Side-lights might be placed where the painted windows now are. Considers a system of lighting by wax candles exceedingly inferior, for many reasons, to gas-lighting well managed. The system of gas-lighting for the House, with a false glass roof and the lights above it, would be sufficient for lighting the House of Commons. Until the late House of Commons existed, there never was in the world a room in which 500 or more persons could sit with comfort for 10 hours in the day, and day after day; it was a perfect novelty in regard to the science of ventilation.

Clark (William, C.E., Assoc. King's College)—Has applied Mr. Gurney's system of ventilation at the Court at Hull. At the time he was engaged there he found that the upward system of ventilation had been adopted; air was admitted from the exterior, which came into contact with hot-water pipes. The stench in the court was very great indeed, owing principally to the peculiarity of the persons who attend. He re-established the downward ventilation by erecting an air-shaft, which is connected with the building by channels passing under the floors; a series of steam-jets are placed in the shafts, which, when in action, exhaust the air from the building. Air is admitted at a high level: the result is, the air enters the court through the windows near to the ceiling, the openings being properly regulated. The velocity with which the external air comes in is not found to be at all objectionable. The air within the building is warmed by steam-pipes, placed round the interior above the floor, by the front of the seats, and round the gangways of the court. This artificial means of warming is used only when there are a few persons in the court, or when a number suddenly leave. Does not imagine that persons breathing retain a certain portion of the foul air around them for a length of time, but thinks the extent to which the exhaled gases ascend is very much less than is generally supposed. When it is considered that one of the most abundant impurities, carbonic acid, is as heavy at 250° as pure air is at 60°, that the specific gravity of the combined gases is as great at the temperature of 68° or 70° as the pure atmosphere is at 60°, and when a person breathing upon a thermometer, in an atmosphere of 60°, and at a distance of 12 inches from the mouth, cannot raise the thermometer so high, then it must become apparent that these gases do not ascend so far as is generally supposed; at all events, they can only ascend while they retain their temperature; but inasmuch as the temperature becomes diluted by mixing with other atmosphere, they have a tendency to obey the law of gravity, some being heavier, others lighter, particularly in a crowded assembly, who being perfectly still, caused but a very slight mechanical disturbance of the air. They would start at about 94°; 98° is the temperature of the body. Has been engaged to ventilate the assize courts at York upon the same principle, where he has introduced a heating battery as the means of raising the temperature; and is about to introduce the same at the courts in the neighbourhood of Beverley.

Daukes (Samuel Whitfield, Architect)—Objects to the principle of ventilation adopted by Sir Charles Barry in the House of Lords and the committee-rooms, and to the manner in which it is developed. In the system of ventilation adopted by witness, the object has been to approximate as nearly as possible to the principles of natural ventilation. In natural ventilation, air, rendered warm by radiation from the earth's surface, ascends, its place being immediately supplied by air of a lower temperature. In artificial warming and ventilation the object is to maintain an agreeable temperature of pure air, about 63°, upon the same natural principle, fresh air of modified temperature continually entering at the low level to supply the place of the vitiated air which is escaping at the high level or ceiling of the room. For the House of Commons the air should be introduced through channels beneath the floor, entering the House at places where it would not be inconvenient to any person sitting or standing. The mode of warming the air would be by a machine formed of a series of flat vertical vessels (full of heated water), inclosed in a chamber, the cold fresh air entering beneath them, and having passed between them, and become warm in its passage, it is discharged into a flue, and thence into the House. In each of these flat vessels the water circulates; and it is not by conduction, but by the water circulating in each vessel, that the surface becomes of the temperature required to warm the air sufficiently to enter the room, according to the state of the external atmosphere. The vitiated air escapes from the ceiling in channels provided for that purpose, communicating with an external shaft. Witness does not propose to use any tractive power at all, but considers the natural upward passage of the vitiated and hotter air to be adequate to produce a sufficient and constantly recurring supply of fresh air into the building. It is impossible successfully to apply a forced ventilation to the Houses of Parliament. The system of ventilation in the Colney Hatch Asylum is by the vacuum principle, and performs satisfactorily. The principle of ventilation adopted in the House of Commons is at present incomplete; the supply of fresh air is not adequate to the requirements of the House, and consequently there is not an escape of the vitiated air. The variety of temperature in the House is in consequence of the air being unequally discharged into the chamber from which the ventilators which feed the House with air open; some portion of the cold air enters at some ventilators, while at others the air is escaping. The admission of fresh air is stifled by the perforated floor being covered with a carpet; there would be plenty of fresh air passing through if the carpet were removed. Witness does not consider that when the works are completed, and the whole principle in force, that the ventilation will be satisfactory. The gas-lamps would have no prejudicial effect in an upward-current ventilation. The ventilation of Exeter Hall is natural ventilation, and acts successfully. The artificial system of ventilation adopted by witness, which has been found successful in the several buildings in which employed, is exceedingly simple in construction, and easy of regulation; it is what is called Mr. Price's plan. The diffusion of air under witness's system is under complete control. Witness prefers the tractive power of ventilation only to the forcing power, or the union of the two. The present apparatus for the ventilation of the House of Commons is not applicable to what witness considers a complete system. Is of opinion that where there is a current of air passing through a vault a very disagreeable close smell will be discoverable in the air. The mode which witness should adopt for improving the warming and ventilation of the House of Commons would be this: he would adopt the plan, as in the House of Lords, of covering the whole floor over with lead, and the carpet exactly as in the House of Lords; then calculate the quantity of air that would be necessary to pass through the House thoroughly to warm and ventilate it, and have a sufficient number of openings where it would not be inconvenient to any of the members sitting, and admit the air in those parts through ventilators; then there would be a very gentle radiation from the floor itself, and the admission of air through the ventilators provided for it would be sufficient to sustain ample ventilation in the House, and warmth too. The warm air would naturally pass off, but if it required it he would apply a proper contrivance to rarefy the air in the extracting-shaft. The system of warming proposed by witness would be perfectly under command, so that it could be raised or lowered at pleasure. Witness does not agree with Mr. Gurney that by his system the barometric balance could be preserved to such a nicety that a window might be opened without any rush of cold air being felt. Proposes to moisten the air, after it has passed over the plates, by evaporation: he places the water for evaporation in the warm-air flue, in a shallow pan, and allows it gradually to moisten the air. The mode adopted by Dr. Reid to diffuse the cold and fresh air is quite inadequate to its purpose. At present the air is stifled in its very first discharge by the carpet covering the whole of the orifices in the floor. Would confine the uprise of tempered air to certain portions of the House, instead of making the entire floor a channel for the uprise of fresh air. Placing ventilators for the admission of air on the risers of the steps in the gangways to the seats, would be the best position, as there would be little or no inconvenience felt therefrom. The centre of the House would be a very good position for the admission of moderately warmed air. The present lighting of the House is not injurious to any contrivance for ventilation on the ascending principle. Witness would admit the air at a temperature a few degrees lower than that at which it would be desirable to maintain it in the House. Seven apparatuses are required for the ventilation of the Colney Hatch Asylum, from the enormous extent of the building. Witness does not give Exeter Hall as at all a perfect specimen of the application of his principle, but merely to show what little assistance to natural ventilation is required. The double system of letting the air enter the floor, and drawing it out at the floor must operate very much against the ventilation. There are no channels now existing from the roof of the House of Commons to conduct the vitiated air into the upper air-shaft. Witness sees no great objection to the admission of air above the heads of the persons occupying the building, if it were necessary. Witness is in favour of ventilating the House of Commons or any building of the kind, from or near the floor, relying upon natural means of ventilation, with the assistance of an extracting-shaft, with a rarefier in it in case of need. The apparatus now in use would not be sufficient to effect a complete system of ventilation according to witness's ideas. The pipes are not at all equal as a warming medium to the flat vertical vessels. Would substitute for those pipes flat plates with hot water. One apparatus would take the whole range of the committee-rooms; its dimensions would be a matter of calculation as to the surface required. Witness's apparatus would be much better regulated and under control. The temperature of the pipes of each of these apparatuses, heated by steam, is obliged to be maintained at 212°; while the water will circulate at much lower temperatures, according to the temperature of the room. He would dispense with the steam-engine, the boilers, and the fan. Would use the air-courses connected with the Victoria Tower by constructing an inner independent flue through the vaults on purpose for the cold air, and equal in dimensions to the quantity of air which would be required to be discharged in the various rooms. He would not allow the cold-air flue to come in contact with the adjoining walls. He would case the present vaults, or rather form an independent flue; would case them with brick.

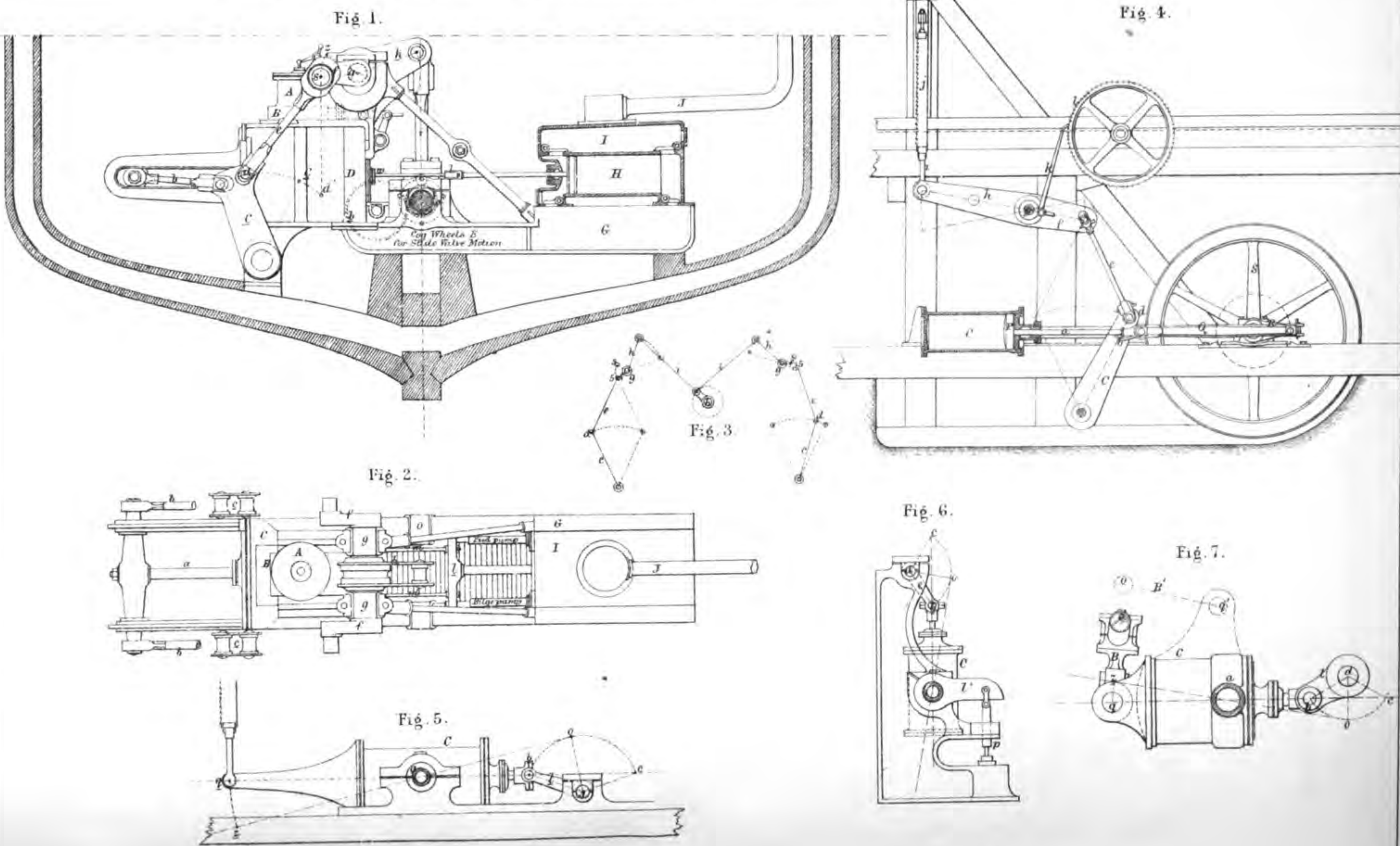
(To be continued.)



MAUDSLAY'S PATENT ROTATORY ENGINES.

COWPER'S PATENT FOR MULTIPLYING MOTION.

Fig. 1. Fig. 2. Fig. 3. Fig. 4. Fig. 5. Fig. 6. Fig. 7.



REGISTER OF NEW PATENTS.

ROTATORY ENGINES.

(*With an Engraving, Plate* XXXVI.)

JOSEPH MAUDSLAY, of the firm of Maudslay, Sons, and Field, of Lambeth, Surrey, engineers, for *improvements in steam-engines, which are also applicable, wholly or in part, to pumps and other motive machines.*—Patent dated January 26, 1852.

Claims.—1. For improvements in obtaining motion in steam-engines by means of two cylinders revolving on independent centres, the one within the other, and in such relative orbits that the lesser cylinder shall, during each revolution, come throughout its entire length in contact with the larger cylinder; 2. For the application of the said improved modes of construction to pumps and other motive machines.

The invention relates to that class of engines commonly called rotatory engines: it consists of an improved arrangement of parts represented in figs. 1, 2, 3, and 4, Plate XXXVI., fig. 1 being a longitudinal section of an engine constructed according to said arrangement; fig. 2, a plan thereof in section; fig. 3, an end view; and fig. 4, a cross-section on the line *c d*. A, B, are two cylinders of different diameters, the lesser of which is designed to revolve within the larger one, but eccentrically in regard to it; so that the outside of the smaller cylinder shall, throughout its entire length and circumference, come in contact with the inside of the larger one as they revolve together, but only a portion or line lengthways of the cylinder being in contact at the same moment. C, is a piston-plate, which projects from the inside of the larger cylinder, and as that cylinder revolves, moves in and out of a recess D, formed in the side of the inner cylinder A. The ends A^a, and B^b, of both the cylinders are turned truly, and fit exactly the one into the other. The larger one has a hollow trunnion formed on each end, and the two trunnions revolve on fixed bearings G^1, G^2, which are provided with set screws for exactly adjusting the position of the cylinders in relation to each other. F, is a spindle or axis, which carries the smaller cylinder A, passing right through the centre of it, and also through the hollow trunnions G^3, G^4, and resting at its extremities in the bearings H, H. The two sets of bearings G^1, G^2, and H, H, are parallel to, but not in the same line with one another, and the hollows of the trunnions of the large cylinder are of such size as to allow the axle of the smaller one to pass clear through them in its eccentric position. I, I, are boxes which contain the packing for the axles, and also serve as passages for conveying the steam to and through the trunnions. K, K, are openings made in the end of the small cylinder, through which the steam is admitted into the interior of that cylinder. L, L, are passages for the admission of steam behind or on one side of the piston-plate; and M, M, are passages for the escape of the steam on the opposite side, or from in front of the plate. N, is a four-way cock for starting, stopping, regulating, and reversing the engine. The mode of operation of the engine is as follows: steam is passed through the hollow axis or trunnion G^4, at one end of the large cylinder into the interior space between the two cylinders, that is to say, into the space which, for the time being, is behind or on one side of the piston-plate; and this steam pressing against the piston-plate carries it round, and along with it both the larger cylinder to which it is attached, as also the smaller cylinder with which it is interlocked (by means of the piston-plate). As the two cylinders revolve together the piston gradually loses its effective area of propulsion, that is to say, the area of the piston exposed between the cylinder is gradually diminished until the point of contact between the two cylinders or dead point of each revolution is reached, over which point the engine is carried by the momentum of the parts in action. After the steam has thus performed its office, it passes off from the opposite side of the piston-plate through the hollow trunnion G^3, on the other end of the large cylinder, either into the atmosphere or into a condenser, according as the engine is worked as a condensing or a non-condensing engine.

A modification of the preceding arrangement is exhibited in figs. 5, and 6. Here the larger cylinder A, is made with an outer steam casing A^1, and fitted with false ends adjustable by set screws; and it is divided by a partition D, into two compartments, to each of which there is a separate piston-plate E, the two piston-plates being placed in opposite positions in regard to each other, so that a more uniform power may be obtained throughout each revolution. And instead also of one inner cylinder, two (D^1, and F^1) are here employed, one of which is keyed on to the spindle F, while the other is left loose upon it, and so at liberty to adapt itself to the varying position of the piston. In this modification the steam may be admitted at one trunnion, and be conveyed through the outer casing formed round the larger of the two cylinders into the space behind the piston-plate or plates, and conveyed thence through the smaller cylinder to the other trunnion; or the motion of the engine may be reversed by causing the steam to enter through the smaller cylinder, and pass away through the outer casing of the larger one. L, is a four-way starting and reversing cock.

Another modification is shown in fig. 7, which it will be proper to adopt when it is desired to work the engine on the continuous expansion principle. The outer and larger cylinder A is made, as in figs. 5 and 6, with an outer casing A^1, which is divided by partitions B, B, into two compartments of different sizes, each of which is provided with a separate piston-plate, the two piston-plates being placed in opposite positions to each other. In this arrangement also, as in figs. 5 and 6, there are two inner cylinders (D^1, and F^1) of different sizes, the larger one of which, F^1, is keyed fast to the spindle F, and the other left loose. The steam is admitted through the trunnion G, and apertures H, H, into the outer casing A^1, and thence into the space behind the piston-plate of the smaller compartment of the larger cylinder, from which it passes through the interior of the small cylinder D^1, into the outer casing A^1, when it enters the space behind the piston of the large compartment, where it acts on the piston by its expansive force, after which it is allowed to pass off through the interior of the inner cylinder F^1, and the trunnion G, either to the condenser or to the atmosphere.

A fourth modification is shown in figs. 8, and 9. A, is an annular cylinder, which is mounted on a spindle or axis C, which revolves in fixed bearings D, D. Within the annular space is a ring E, with a groove or opening cut in it, through which a piston-plate or plates B, passes, which piston-plate or plates is fixed to the outer and inner ring of the annular cylinder. The ring E, revolves on its own centre in bearings which are fixed eccentrically in regard to the other bearings D, D, so that as the one ring revolves within the other, the outside of the interior ring shall be brought in contact with the inside of the outer ring of the annular cylinder, whilst, at the same time, its interior is in contact with the outside of the smaller ring of the annular cylinder; thus forming two lines of contact between the annular cylinder and the internal ring. To allow of the insertion of the interior ring, the large one (A) is made in two halves, as shown. The smaller ring E, has a circular flange P, by means of which it is attached to the outer casings F, F, which are carried by hollow trunnions G, G. The piston-plate B, forms the barrier against which the steam acts, and through the medium of which motion is communicated from the annular cylinder to the interior ring, so that they shall revolve together, but each on its own centre. Steam is admitted, as in the arrangements previously described, through one of the trunnions and the holes K, K, to the back of the piston-plate, and escapes from before the piston-plate through the other trunnion and holes, shown by dotted lines at *l, l*. The steam passes from one side of the annular flange P, to the other through the holes *i, i*. Instead of the annular cylinder being fixed on a spindle, as in the arrangements just described, and the internal ring being carried by an outer casing with hollow trunnions, it may in some cases be found more advantageous to form the hollow trunnions on the former, and carry the latter on a circular flange or boss fixed on an axle passing eccentrically through the trunnions.

The different forms of steam-engines before described offer in common the following advantages: first, their great simplicity, lightness, and compactness, the working parts being in each case few in number, and these all in balance, or nearly so, and there being neither valves nor slides nor eccentrics required for the admission and emission of the steam; secondly, the directness of their action; and thirdly, the great velocity at which they are capable of being unintermittingly driven, and without noise or shock.

Instead of the piston-plate in the engine, represented in figs. 1, 2, 3, and 4, and its modification, being attached to the larger or outer cylinder, as before described, it may be attached to the smaller or inner cylinder, and made to work in a recess in the outer one. It is preferred to use cylinders, though cones or portions of cones, with the axles so placed as to bring the surfaces in contact, might be employed. So also, instead of the spindle of the smaller cylinder being employed as the driving-shaft, the motion may be taken from a toothed-wheel and gearing attached to the outer or larger cylinder.

Any other elastic or non-elastic fluid may be used for working these engines as well as steam. An arrangement which would be particularly suitable for being driven by water, is represented in figs. 10, and 11; A, is an annular cylinder, open at one end, which has a piston-plate P, fitted into it, and revolves on its centre in fixed bearings C, C; D, is an internal ring made hollow, to form a channel for conveying the water to the back of the piston-plate, and which has its centre or axis formed by a hollow trunnion revolving in the bearing E, which is fixed eccentrically to the bearings C, C. The annular cylinder has at top a circular flange or disc, which must be sufficiently large to allow for the change of position as the two parts revolve together. Water is admitted down the hollow trunnion, and through the passages *f*, *f*, into the space behind the piston, and it is allowed to escape from before the piston through the passages *g*, *g*, in the annular cylinder.

As pumps for raising or forcing water or other fluid, engines on any of the plans which have been described will be found especially useful, as, in consequence of the high velocity of which they are capable, and their continuous rotatory action, a small machine may suffice to discharge a large quantity of water or other fluid. An arrangement of the engine well adapted for pumping water is shown in figs. 12, and 13. The axis A, is made hollow, and the water admitted through it to the interior of the smaller cylinder, whence it passes through a passage B, into the space behind the piston-plate, from which space it is discharged through the passage C, in front of the piston-plate into the outer casing D, from which it is finally discharged through the delivery pipe E. As blowing machines, too, they will have the advantage of maintaining a great pressure of blast with a regular and easy motion.

MULTIPLYING MOTION IN STEAM ENGINES.

(*With an Engraving, Plate* XXXVII.)

Charles Cowper, of Southampton-buildings, Chancery-lane, Middlesex, patent agent, for *improvements in multiplying motion applicable to steam-engines, saw-mills, and other machinery in which an increase of velocity is required.* (A communication.)—Patent dated January 31, 1852.

Claims.—1. For multiplying motion in steam-engines, so as to obtain a complete revolution of a shaft from one stroke of the piston of the engine; 2. For multiplying the motion of the piston of a steam-engine, and regulating the same; 3. For multiplying the motion of steam-engines by the application of an oscillating-cylinder, in combination with a lever; 4. The particular applications of the invention to saw-mills, punching-presses, and engines for driving the screw-propeller; 5. The mode or modes of multiplying motion so as to obtain from a single stroke of any prime mover, four or eight strokes, or other greater number of strokes (such number being a power of the number two).

The invention relates to improvements in multiplying motion by means of a lever or levers, and a rod or rods, in such manner that each stroke of the piston of a steam-engine, or other reciprocating motion, is multiplied so as to produce two, four, or eight, or more strokes; and thus to be applicable for driving the screw-propeller of a steam-vessel, and also for driving vertical saw-frames, and other machinery in which an increase of velocity is required.

Fig. 1 is a transverse section of a portion of a steam-vessel, showing the mode of applying the invention to a steam-engine for driving a screw-propeller; fig. 2 is a plan of the engine. C, is the steam-cylinder, placed horizontally, and provided with a slide-valve B, and expansion-valve A, of any of the ordinary constructions. D, is the exhaust-pipe or passage, which is continued through the foundation-plate E, to the condenser G, on which is placed the double-acting air-pump H. I, is the hot well; and J, the hot water delivery-pipe. The air-pump H, is shown in section. It has passages leading to the bottom of the condenser, to enable it to remove the water from the condenser, or a separate pump may be employed for that purpose. *a*, is the piston-rod of the steam-cylinder, which is provided with a cross-head and two side-rods *b*, *b*, which are jointed to the levers *c*, *c*, which turn on pins or fulcra at their lower ends. Each of these levers carries a pin *d*, from which a connecting-rod *e*, proceeds to the pin *s*, of the crank or lever *f*, on the shaft *g*. On this shaft is another lever *h*, from which a connecting-rod *i*, proceeds to a crank on the shaft O, which drives the screw-propeller. *m*, *m*, are two additional piston-rods attached to the piston of the steam-cylinder C, and connected by the cross-head *l*, to the rod of the air-pump.

The action of the machinery is as follows: the lever *c*, works to and fro with the motion of the piston of the engine, and the pin *d*, moves in the arc shown by the dotted lines. When the piston is at the end of its stroke, the point *s*, is in its lowest position, as shown in fig. 1. When the piston has reached the middle of its stroke, the lever *c*, and rod *e*, are in a line with one another, and the pin *s*, is raised to its highest position *x*. As the piston proceeds and arrives at the end of its stroke, the point *s*, again descends to its first position, and thus the levers *f* and *h*, make two strokes for one stroke of the engine. The same effect is produced in the return-stroke of the piston, and the motion being communicated by the rod *i*, to the screw-shaft O, that shaft will make two revolutions for every double stroke of the piston. The slide-valve of the engine is worked by a crank or eccentric on a shaft, which is driven at half the velocity of the screw-shaft by means of toothed wheels. Two of these engines should be employed to drive cranks at right angles to each other, on the screw-shaft O; or the two engines may be arranged so as to drive the same crank as indicated by the diagram fig. 3, in which the various parts are indicated by the same letters as are employed for the corresponding parts in figs. 1 and 2. During a small portion of the centre of the stroke of the piston, its power over the lever *f*, is very great; but its motion at that part is regulated by the resistance of the air-pump, as well as by the inertia of the moving parts. When necessary the motion may be rendered still more regular by the application of a fly-wheel, as shown in fig. 4.

Fig. 4 is a side view, partly in section, of a steam-engine applied to work a saw-mill according to the invention. C, is the steam-cylinder; P, is the piston, and *a*, the piston-rod; *b*, is a side-rod connecting the piston-rod end to the lever *c*, which turns on a fulcrum at its lower end; *d*, is a pin on the upper end of the lever, which is connected by a rod *e*, to the short end *f*, of a lever or beam, turning upon a pin, *g*; the long end *h*, of this lever gives motion to a vertical saw *j*, by means of the rod *i*; *k*, is a paul jointed to the beam *f h*, and driving the ratchet-wheel *l*, which advances the timber or other material to the saw in the ordinary manner. The piston-rod *a*, is connected by the connecting-rod Q, to the crank R, of the fly-wheel S, which serves to regulate the motion of the whole. This arrangement may be used to produce a rotary-motion by applying a connecting-rod and crank-shaft, in lieu of the rod *i*, and saw *j*.

In all these figures it will be seen that the motion communicated to the lever *f*, is much greater than it would be if the pin *d*, moved in a straight line, as it would do if the rod *e*, were connected directly to the cross-head or end of the piston-rod. This is a point of great importance, and is owing to the application of the lever *c*, in combination with the rod *e*. The motion may be still more increased by communicating the motion of the piston to the lever *c*, at a point nearer to its fulcrum than the point *d*, as in fig. 4.

Figs. 5, 6, and 7, show three applications of the invention to oscillating-engines. In these cases the cylinder and its piston-rod are caused to act in lieu of the lever *f*, and rod *e*, in the previous figures. C, is the steam-cylinder oscillating upon the trunnion *a*. The end of the piston-rod *b*, is jointed to the lever *e*, which turns on the fulcrum *d*, and moves in the arc shown by dotted lines. The points *b*, *o*, *c*, indicate the extreme positions of the end of the piston-rod. The cylinder is thus caused to make two oscillations for each single stroke of the piston, and this multiplied motion is applicable to various machinery. Thus in fig. 5, its application to a saw-mill is shown, the saw being driven by an arm *q*, attached to the cylinder. The stroke of the saw is from *q*, to *z*, and this motion may be increased or diminished by lengthening or shortening the arm *q*. Fig. 6, shows the application of an oscillating-engine, according to the invention, to a punching-press: *l*, is a lever attached to the trunnion of the engine, and giving motion to the punch *p*. In fig. 7, is shown the application of an oscillating-engine for obtaining a rapid rotary-motion, suitable for driving a screw-propeller. The arm *q*, is fixed to the cylinder C, and is connected by the rod B, to a crank on the shaft O, which is thus caused to make to make two revolutions for every double stroke of the piston. The length of the stroke of the arm is from q, to r. In lieu of attaching the arm q, to the end of the cylinder, it may be placed in any other convenient position, as shown by the dotted lines, in which q', is the arm; B', the connecting-rod; and O', the crank.

In all these arrangements of oscilliating-engines, when the power to be communicated is considerable, it is advisable to employ guides for the piston-rod, which guides are fixed to the cylinder or cylinder-cover, and serve to prevent the bending of the piston-rod by the lateral strain upon it.

In lieu of taking off the motion from the oscillating-cylinder, it may be taken from the lever e. Thus, in fig. 7, the crank-shaft may be placed below the fulcrum d, of the lever e, and may receive its motion from a connecting-rod jointed to the lever e; or intermediate levers, or beams like those marked f, and h, in figs. 1, 2, 3, 4, and may be employed to increase or vary the length of stroke.

In the sawing and punching machines hereinbefore described, the parts are so arranged that the steam may be expanded in the steam-cylinder with great advantage, as the greatest pressure of the steam is employed to produce the downward or effective motion of the saw or punch, while the reverse motion is produced by the expansion of the steam. The motion of the piston in either of the arrangements may be regulated by a fly-wheel, in a similar manner to that already described with reference to fig. 4. In figs. 5 and 6, the motion of the piston may be arrested at each end of the stroke, by means of springs of steel, or other suitable material, or by arranging the slide-valve of the engine so as to close the exhaust-passage and confine a portion of steam in the end of the cylinder, which portion of steam then serves as a spring or cushion to check the motion of the piston, and prevent it from striking the end of the cylinder.

When it is required to multiply the motion four times in lieu of twice, it is effected by first doubling the motion in the manner hereinbefore described, and then again doubling the motion in a similar manner. Thus, if a rod be jointed to the end of the lever f, in fig. 4, and placed in a horizontal position, when the lever f, is horizontal; and if the opposite end of this rod be connected to a vertical lever, this last lever will make four strokes for each single stroke of the steam-piston. In a similar manner the motion may be again doubled, and so on as many times as may be required.

The various modes of multiplying motion hereinbefore described, may be employed for driving other descriptions of machinery, which require a multiplication of motions, as well as those hereinbefore mentioned.

CAST METAL PIPES AND RETORTS.

Edward Moseley Perkins, of Mark-lane, for *improvements in the manufacture of cast-metal pipes, retorts, or other hollow castings.*—Patent dated March 8, 1852.

Claim.—The mode described of making core-barrels used in the manufacture of cast-metal pipes, retorts, or other hollow castings.

This improvement consists in the construction of hollow core-barrels to be used in the manufacture of cast-metal pipes, retorts, &c., in three sections. These sections are fastened to metal shafts capable of being moved outwards by means of a screw passing through their axis. This enables the outer sections to be contracted or expanded at pleasure, thus facilitating their withdrawal from the mould.

ELECTRIC TELEGRAPH APPARATUS.

William Smith, of Park-street, Grosvenor-square, civil engineer, and Archibald Smith, of Princes-street, Leicester-square, for *certain improvements in electric and electro-magnetic apparatus, and in the machinery for and method of making and laying down submarine, submerged, and other such lines.*—Patent dated March 8, 1852.

Claims.—1. A mode of insulating suspending wires at the points of support. [Upon an upright post are placed as many boxes of earthenware, or any other non-conducting material as there are wires, having two "dead-eyes," one on each side. In each of these "dead-eyes" is inserted a piece of galvanised wire; they are then filled with some non-conducting material, and their covers placed tight upon them, in order to exclude damp or the atmosphere, and thus entirely insulate them. At the extremity of each wire is fastened the conducting wire, and by this means thorough insulation is effected. To prevent the possibility of the current being broken, a thin band of copper covers the wire from one point of insulation to the other.]

2. Certain arrangements of machinery for making telegraphic cables.

3. The setting up of such or analagous machinery on board steam or other vessels whereby telegraphic wires may be manufactured and submerged simultaneously. [The wires to form the rope are placed upon as many wheels as there are intended to be strands to the cable. The wheels are then made to revolve simultaneously with another wheel, which, revolving transversely, receives the wires upon its circumference, and performs the operation of twisting. Also, simultaneously with all these revolves a wheel, upon which the core of the cable is wound, and which, by its revolution, gives off the wire intended for this purpose. The cable thus completed may be payed out at the stern, and fixed in the manner usually pursued with respect to submarine telegraphs.]

4. A mode of testing the conducting power of telegraphic wires as they are made into cables.

DECORATIVE PAINTING.

William Froggatt, house and decorative painter, for *a certain improvement or improvements in decorative painting, which improvement or improvements are applicable to rooms, halls, carriages, furniture, and other purposes to which decorative painting has or may be applied.*—Patent dated March 30, 1852.

The method employed by the patentee for effecting this object is as follows:—White zinc or lead is ground into spirits of turpentine, which is allowed to evaporate by drying; after this copal varnish is mixed with it to reduce it to a consistency necessary to facilitate the object of the artist. The mixture is then laid on to the object to which it is intended to be applied, after which it is left to dry; more varnish is added, and also after each coating, until, at the last coating, it is one almost entirely of varnish. This is the method employed to produce a white ground; various other colours may be produced by employing the different pigments, in all cases mixed with white lead until the required tint is produced.

REPAIRING A SHIP'S BOTTOM WHILE AFLOAT.

The following communication on the above subject, appeared in the *Boston* (U. S.) *Daily Transcript*, of August 12th:—

"Sir—In your paper of this morning, I have read an article named under the following head, viz., 'Repairing a ship's bottom while afloat,' to which I wish to call the attention of our oldest ship-carpenters, that they may join with me in claiming the invention for an American. The piece it is said is copied from the London *Civil Engineer and Architect's Journal*, which contains an account of replacing a defective sheet of copper on the bow of an English man-of-war, five feet below light-water line. The article goes on to explain how the work was accomplished—viz., on the principle of the cofferdam invented by a shipwright in the British service. More than twenty-five years have passed away since the *Delaware* ship-of-the-line, then in *this* Navy Yard, had a *plank* in her bottom under the larboard bow, so much destroyed by the 'marine worm' that the water forced itself through—under '*light-water line*' seven or eight feet; the defective plank was removed, a new piece fitted, and over all coppered secure. Charles D. Broadie, Esq., late Naval Constructor, invented the cofferdam-box, a description of which is given precisely in the London papers. The box was known and spoken of as 'Broadie's Box.' The Commissioners of the Navy made Mr. Broadie a handsome present, and the fact was published in all the newspapers of that time. Mr. Broadie rests in peace, and a friend wishes to do him justice.

"*Navy Yard, Gosport, U.S.* J. J."

"*August* 11*th*, 1852.

ON THE CONVERTIBILITY OF PHYSICAL POWERS.

By W. J. Macquorn Rankine, C.E., F.R.S.E.

It is much to be desired that practical men were more generally acquainted than they yet appear to be, with a principle which has long been conjectured to be true, but which has only within the last few years been proved experimentally, that all the different forms of physical energy, whether chemical action, light, heat, electricity, magnetism, or visible motion and mechanical power, are convertible into each other; and that although physical energy may be converted from one form to another, or transferred from one portion of matter to another, its whole amount in the Universe is unchangeable. This principle may be justly considered as the foundation of the whole of the physical sciences. It embraces, as a particular case, the principle of the conservation of *vis-viva*, which is the foundation of that physical science which treats of visible motion and ordinary mechanical power. In its general form, it is obviously of paramount practical importance in the working of all machines which act by the transformation of one kind of physical energy into another, such as steam-engines and air-engines, which transform heat into expansive power and visible motion. In such engines, the gross mechanical power given out is the exact equivalent of the heat which disappears in the working; that is to say, the difference between the quantities of heat possessed by the expansive material, whether steam or air, or any other substance, on entering and on leaving the cylinder or other working part of the machine, allowance being made for the waste of heat by conduction and radiation.

The mechanical value of heat has been very accurately determined by Mr. Joule, by means of experiments on the production of heat by friction. He has found that so much heat as is capable of raising the temperature of one pound of liquid water by one degree of Fahrenheit, is equivalent to so much mechanical power as is capable of lifting a weight of one pound to a height of 772 feet. Consequently, for every 772 foot-pounds of power given out by a steam or air engine, so much heat must disappear during the expansion of the steam or air as is capable of heating one pound of liquid water by one degree of temperature on Fahrenheit's scale. I have tested this principle by several comparisons with the actual performance of steam-engines, and found it to be corroborated in every instance.

The knowledge of the law of the convertibility of physical energy is the only safeguard against a tendency which has manifested itself in the minds of many ingenious persons, to devise machines which shall produce power out of nothing; a tendency from which some men of high scientific reputation were not wholly free, before this law became a matter of experimental demonstration as well as of reasoning and conjecture. It was, indeed, a necessary consequence of the hypothesis of a *fluid* of heat, or *caloric*, that the visible mechanical power of engines acting by the agency of heat must be produced out of nothing.

A striking instance of the fallacious conclusions to which this hypothesis leads, is found in a passage of the description, in the *New York Tribune*, of Capt. Ericsson's Air Engine, or "Caloric Engine" as it is called. The writer, after describing an apparatus called a "Regenerator," for saving as much as possible of the heat which would otherwise escape with the waste air of this engine, makes this remark, "The power of the steam-engine depends upon the heat employed to produce steam within its boilers; but that heat, amounting to about 1200 degrees, is entirely lost by condensation the moment it has once exerted its force upon the piston. If, instead of being so lost, all the heat used in creating the steam employed could, at the moment of condensation, be re-conveyed to the furnace, there again to aid in producing steam in the boilers, but a very little fuel would be necessary; none, in fact, except just enough to supply the heat lost by radiation."

So that, if radiation and other waste of heat could be prevented, the engine having been once set in motion, would go on for ever producing power and overcoming resistance, without any fresh supply of heat—a conclusion opposed to common sense; and yet the legitimate consequence of the hypothesis that heat is a substance, and therefore inconvertible.

The principle of the convertibility of heat with mechanical power reconciles, in a very simple and obvious manner, two results of experiment which appear, from the reports of a recent meeting of the Institution of Mechanical Engineers, to have been considered at variance with each other.

Early in 1850 it was predicted independently, and almost simultaneously, by M. Clausius, in Germany, and by myself in Britain, in papers published respectively in 'Poggendorff's Annalen,' and in the 'Transactions of the Royal Society of Edinburgh,' that it would be found that when saturated steam, or any other vapour, gives out mechanical power by expansion, the heat converted into mechanical power by the expansion is greater than that supplied by the reduction of temperature corresponding to the reduction of pressure, so that a portion of vapour must be liquefied to supply enough of heat to expand the rest.

Professor William Thomson, of Glasgow, to whom this conclusion was communicated before its publication, was at first struck with its apparent inconsistency with the fact of the dryness of high-pressure steam which has escaped from a jet; but he almost immediately suggested the explanation, that when vapour escapes from a jet into the atmosphere, or into a receiver, the whole of the mechanical power developed by its expansion, instead of being applied to the moving of a load, is immediately re-converted into heat by the mutual friction of the particles of vapour; so that the vapour ultimately possesses all the heat which it originally had, and is therefore *super-heated* by an amount equal to the difference between the quantities called the total heats of evaporation at the original and final temperatures.

That this is a true explanation has since been shown by the experiments of Mr. Joule and Professor Thomson, on the temperatures at different parts of a jet of air rushing from a receiver into which it had been compressed. On first rushing from the orifice it was found that the temperature of the air fell suddenly by an amount depending on the expansion; but at a distance from the orifice sufficiently great to allow the great velocity and agitation of the air to subside, it was found to have very nearly, though not exactly, received its original temperature; showing that the mechanical power at first produced at the expense of heat by the expansion, had been re-converted into heat by the friction which had caused the agitation of the air to subside. Had the air, on the contrary, been made to raise a loaded piston, it would have been permanently cooled by the expansion, to an extent equivalent to the work performed.

Now, it has been concluded by Mr. Daniel K. Clarke, from the results of an extensive series of experiments on locomotive engines, described in the *Civil Engineer and Architect's Journal* for September, 1852, that during the expansive working of steam a portion becomes liquefied, unless it is supplied with heat from without. Mr. Clarke arrives at this conclusion from a comparison of the quantities of steam measured out by the cylinders of locomotive engines with the quantities of water actually consumed.

Mr. Charles W. Siemens, in a paper published in the same journal, states that Mr. Cowper, Mr. Marshall, and himself, had found steam which was allowed to expand by rushing from a jet into a tube connected with a condenser, to be super-heated, or at a higher temperature than necessary to prevent it from liquefying under the pressure applied.

At the meeting of the Institution of Mechanical Engineers, at which Mr. Clarke's paper was read, it seems to have been considered by some of the members present that his conclusions were at variance with the results of the experiments of Mr. Siemens, Mr. Cowper, and Mr. Marshall. It must be evident, however, from the explanation already given, that the results arrived at by Mr. D. K. Clarke and by Mr. C. W. Siemens, are not only consistent with each other, but are precisely what had been anticipated by reasoning from the principle of the mechanical convertibility of heat. In Mr. Clarke's experiments, the steam in expanding had performed work in driving an engine, and had lost an amount of heat equivalent to the work performed, in consequence of which a portion was liquefied. In Mr. Siemens's experiments, the steam had performed no work, and, consequently, lost no heat; and it was therefore super-heated by an amount equal to the difference between the total heats of evaporation at its original and final temperatures. This difference, as measured in degrees of temperature applied to liquid water, is, according to the experiments of Regnault, $0{\cdot}305 \times$ the difference between the two temperatures of the steam.

Although Mr. Clarke's experiments afford a general verification of the deduction from the mechanical theory of heat to which I have referred, it may be doubted whether the whole of the discrepancy between the quantity of water consumed, and the quantity computed from the bulk of steam in the cylinder, arose from liquefaction in the cylinder; for we know little of the bulk occupied by a given weight of steam under different circumstances except by conjecture; and from the analogy of the more easily condensible gases it may be inferred, that steam and other vapours near their point of condensation, especially when of great density, are affected by the force of cohesion to an extent which causes them to occupy much less bulk than they would do according to the laws of the perfectly gaseous condition.

It is true, as I have shown in a series of papers published in the 'Transactions of the Royal Society of Edinburgh,' Vol. XX., that formulæ, founded on the assumption that steam is a perfect gas, agree with the actual performances of expansive steam-engines; but this fact throws little light on the subject of the actual density of steam, for, according to a law discovered by Carnôt, reconciled with the mechanical theory of heat by Clausius and Thomson, and shown by me to be a consequence of the supposition that heat consists in a molecular oscillatory movement, the *proportion* of the heat employed in expanding an elastic substance which is converted into mechanical power by an engine, depends solely on the two temperatures at which the heat is supplied, and the unconverted portion of heat abstracted being greater as the former of those temperatures is higher and the latter lower; and is independent of the nature of the substance which works, and of the law of its expansion; so that, although an erroneous law of expansion may be assumed in calculating the power of the engine, it may still, by a compensation of errors arising from Carnôt's principle, lead to correct results in practice.

The knowledge of the density of steam at various pressures and temperatures, is now the most important desideratum, both in the theory of heat and in its practical application. M. Regnault long since announced that he was about to undertake a series of experiments on this subject, at the expense of the French government, but the results have not yet appeared. It is to be hoped that they may not be much longer delayed.

59, *St. Vincent Street, Glasgow,* W. J. M. Rankine.
September 23, 1852.

REPORT ON DESIGN AT THE GREAT EXHIBITION.

By Richard Redgrave, R.A.*

The desire evinced by the rudest, as well as the most civilised, nations for the decoration of their buildings, utensils, and clothing, almost raises ornament into a natural want, and must render its proper application of the utmost consequence to the manufacturer, since upon it the value of his manufactures in the various markets of the world greatly depends. It can hardly be possible, therefore, that any one should doubt, on the present occasion, the importance of a careful review of the union of design and ornament to manufacturing skill, since all that the inventive powers, the fancy, and the handicraft of man can do, has this year been gathered into one place, and the world been invited to consider and examine it. But, without some critical guidance, some judicial canons, or some careful separation of the meretricious from the beautiful, it is to be feared that the public taste will rather be vitiated than improved by an examination of the Exhibition, as it will readily be allowed that the mass of ornament applied to the works therein exhibited is of the former character, and from that very cause more likely to impose on the uninformed taste of the multitude than the simpler qualities of real excellence to impress us with a just sense of their worth. Such considerations were, doubtless, among the reasons which influenced the determination of the Royal Commissioners on this subject.

We have spoken of design and of ornamental decoration. These are two essentially different things, and it is highly necessary that they should, from the first, be considered as separate and distinct. "Design" has reference to the construction of any work both for use and beauty, and therefore includes its ornamentation also. "Ornament" is merely the decoration of a thing constructed.

Ornament is thus necessarily limited, for, so defined, it cannot be other than secondary, and must not usurp a principal place; if it do so, the object is no longer a work ornamented, but is degraded into a mere *ornament.* Now, the great tendency of the present time is to reverse this rule; indeed, it is impossible to examine the works of the Great Exhibition, without seeing how often utility and construction are made secondary to decoration. In fact, when commencing a design, designers are too apt to think of ornament before construction, and, as has been said in connection with the nobler art of architecture, rather to construct ornament than to ornament construction. This, on the slightest examination, will be found to be the leading error in the Exhibition, an error more or less apparent in every department of manufacture connected with ornament, which is apt to sicken us of decoration, and leads us to admire those objects of absolute utility (the machines and utensils of various kinds), where use is so paramount that ornament is repudiated, and fitness of purpose being the end sought, a noble simplicity is the result.

The primary consideration of construction is so necessary to pure design, that it almost follows that, whenever style and ornament are debased, construction will be found to have been first disregarded; and that those styles which are considered the purest, and the best period of those styles, are just those wherein constructive utility has been rightly understood and most thoroughly attended to. A dissertation upon difference of styles would be out of place in this Report, as well as an expressed preference for any particular one, since each, doubtless, contains some qualities of beauty or excellence which will justify its use when restrained and regulated by fixed principles. It may not, however, be improper to illustrate, by a few remarks, the opinion expressed above, since it involves important principles connected with a proper consideration of works coming within the scope of the Report.

To begin with the ecclesiastical architecture of the middle ages: when the style was purest, the construction was most scientific, the arches were best formed for resistance, the groining was elevated and simple, the ornament modest, and applied to the forms of construction only. As the style progressed with time, it departed from its primitive simplicity: it became more ornamental it is true, but at the sacrifice of some of its constructive truth: the use of the arch was partly obscured by its being placed under an horizontal arrangement, and supported by perpendicular mullions, and it was gradually flattened to the worst form for sustaining pressure. The groining, at first simple, became a most elaborate system of reticulation, by its numerous lines reducing the apparent height of the roof, to the entire loss of the sublime effect produced by its elevation and simple groining in the earlier period. At the same time the enormous pendants seemed ready to fall on the heads of the beholder, and to bring with them the flattened arch of which they were the key-stones. The exterior was everywhere decorated, effecting the ruin of the building by the dust and moss which this humid climate soon engendered. In its last period, decoration could be carried no further, and so Gothic architecture, which had grown into glory and beauty, from its just and scientific construction, was thrown aside when a florid ornamentation had taken the place of constructive truth. It was succeeded in this country by the Tudor style, a modification of the Renaissance. The Renaissance itself arose mainly from the study of Roman remains, and those often of the worst period of the Empire, when Greek science, skill, and pure taste had fallen before Roman magnificence and barbarism, and before modern discoveries had opened up the Athenian treasures of Greek art. It was introduced, however, by men of enlarged minds, most of them great constructive architects, and by them it was constructively adapted; they embodied in it many of the just principles of the ancient styles; and if the stream of tradition had brought down much rubbish as well as treasure, still the master-minds of the fifteenth century gradually separated them, and applied with unrivalled skill and a fertile fancy what was beautiful and good. It was, however, essentially pagan in all its details, and its ornament conveyed no symbolic truths to the hearts of men. In the hands of less skilful masters, it soon became decoration without a pervading spirit—ornament merely used as ornament, without propriety as without meaning; and thus, as the Tudor style, it succeeded in this country to the Gothic, that style dying out, partly from the causes above stated, and partly from the change of feeling consequent on the reformed opinions which then prevailed. This debased form of the Renaissance, in its decoration, had already cast off all constructive truth and consistency: much that was bad in the late style was retained and mixed with it; whatever was good was as certainly forgotten. Columns were reversed, the

* Reports by the Juries on the Subjects in the Thirty Classes into which the Great Exhibition was divided. London: Clowes & Sons. 1852.

heavy and broad part being upwards, the small part below; they swelled alternately into enormous bands, and were contracted into severing rings, and sometimes they stood upon balls, to give a further sense of insecurity. Terminal figures were introduced, which had the weight of their entablatures borne on baskets of imitative fruits or flowers. The covering-pediments were broken, contrary to all constructive application, or were placed successively one within another: entablatures were enlarged out of all proportion to the supporting columns; and the useful was superseded by the ornamental.

In France first, and afterwards in all the countries of Europe, the Renaissance was degraded into the style known as that of Louis Quatorze. In all that this style differed from the true Renaissance, it differed merely as arising out of decoration. As a style, it never had a commencement in construction, as the Gothic and Renaissance had, both of which were founded on an architectural basis; *this* sprang from the love of the Grand Monarque for magnificence and display. In it, all that was constructively true was disregarded utterly and systematically; thus, supports became curved and broken in line exactly where they require strength; bearing-rails were severed in the centre where the greatest bearing is; the union of horizontal and perpendicular forms was suppressed, styles and rails as far as possible hidden; veneers applied with the grain across the framing, and every effort of invention strained, not to decorate the due constructive truth of things, but utterly to hide and abolish construction altogether. The ruling principle of the style, as far as it can be said to have had one, was the avoidance of symmetry, and the search after variety by every possible means: for this reason, central forms had dissymmetrical sides, and the most unequal division of parts was the rule of composition. Nevertheless, for the purpose which called it forth, for mere magnificence and display, it was admirably adapted, being one of the most suitable styles for the display of gilding, and for brilliancy and sparkle in metal and ormolu work, showy and glittering beyond anything attainable in the simpler forms of the Renaissance or of classic antiquity. From these qualities it has long maintained its hold on the public taste; and its florid and gorgeous tinsel still prevails in three-fourths of the works of the Great Exhibition, notwithstanding its gross contempt of constructive principles.

The ornament of past ages is the *tradition* of the ornamentist, and tradition ever hands down to us things good and bad, both equally consecrated to most minds by the authority of time. But a moment's reflection will show how necessary it is to discriminate before receiving anything on such authority. A church or temple built in a rude age remains undisturbed by some happy chance; a villa or a theatre in a remote provincial town escapes the fatalities of accident or time; some tomb is opened, some overwhelmed city exhumed from the *débris* of ruin that had gathered over it. The ornamental details found therein are copied and illustrated by the notes of antiquarians, or published in the proceedings of learned societies, and are at once regarded as authorities for imitation, it being forgotten that they were perhaps the works of obscure provincial artists, of a barbarous age perchance, or of a people with whom *art*, no longer studied for its principles, had ceased to progress, or had rapidly declined.

Such traditional ornament, moreover, had or had not a local use—a consistent application to domestic, ecclesiastical, or funeral purposes—in fact, a local symbolism; but even if it had, this, mostly overlooked, is sure to be soon disregarded; and not only have we ornament of a degraded period, of a declining age, or by inferior artists, but to this must be added, that its symbolic life is totally extinct, and perhaps fortunately so, for when revived it is indiscriminately, for purposes totally at variance with its first application and original intent. Moreover, the ornament suited for one material is misapplied to a material different from that for which it was designed. Thus, ornament originally carved in stone, is used for metal or for wood, or, worse still, for carpets or for dresses. That which was intended to be carved in relief, is imitated as the inlay of a floor or the hanging of a wall, and senseless anomalies of all kinds speedily arise from undue reverence for, and indiscriminate use of, traditional ornament. That this is no forced view of things, a glance at the Exhibition will at once show, wherein are to be seen the sacred vessels of the church imitated for secular purposes; the funeral urns of the Greek revived as drinking-vessels for the table; the columns of temples turned into candlesticks, and sarcophagi into wine-coolers; while the decorations of ceilings are applied to carpets, and the carved frieze of an Ionic temple to a muslin curtain: all these errors arising from the indiscriminating use of those materials with which antiquity has supplied us.

Ornamentists may fairly be divided into two classes: the traditional, who superstitiously reverence the remains of past ages, and are wedded in practice to existing styles; and those who despise the past, and feel themselves at liberty to adopt from the abundant sources of nature a mode and manner for themselves, without regard to the works of their predecessors. The first class simply seek to follow where precedent leads, and to be able to claim the sanction of authority for their works. These, even when taste duly regulates their choice, are men of limited ideas and small progress. Those of the second class, who pay no deference to authority, who think that ornament is governed by no laws, and who see no principles by which they are to be guided, are little likely to raise the art to the level of past times, and still less to advance its aim and widen its scope. The true ornamentist would seem to be one who seeks out the *principles* on which the by-gone artists worked, and the rules by which they arrived at excellence, and, discarding mere imitation and reproduction of details, endeavours, by the application of new ideas and new matter, on *principles* which he believes to be sound, or which time and the assent of other minds has approved to be fundamental, to attain originality through fitness and truth. The antiquarian ornamentist, however, will always have a certain reputation, and justly, if he has the taste to select what is best from the great masters of past times. In any case, the critic must be bold who speaks against the authority of the fathers of the art; and praise is safe when great names are on the side of the critic. From this class of ornamentists we may at least demand purity of style, that marked eras should be kept distinct, and that the adopted ornament should be fitly applied to fabrics or manufactures of the like nature, and, as far as possible, for the like uses, as those for which the ornament was first designed.

From the labours of the second class of ornamentists, united to that constant search after novelty at any sacrifice of true taste for which manufacturers are so constantly urgent, there has arisen a new species of ornament of the most objectionable kind, which it is desirable at once to deprecate, on account of its complete departure from just taste and true principles. This may be called the *natural*, or merely imitative style, and it is seen in its worst development in some of the articles of form.

Thus, we have metal *imitations* of plants and flowers, with an attempt to make them a strict resemblance, forgetting that natural objects are rendered into ornament by subordinating the details of the general idea, and that the endeavour ought to be to seize the simplest expression of a thing rather than to imitate it. This is the case with fine art also: in *its* highest effort mere imitation is an error and an impertinence, and true ornamental art is even more opposed to the merely imitative treatment now so largely adopted. Let any one examine floral or foliated ornament produced in metal by electrotyping the natural object, whereby every venation and striation of the plant is reproduced, and compare it with a well and simply modelled treatment, where only the general features of the form are given, and all the minutest details purposely omitted; and if this latter has been done with a true sense of the characteristics of the plant, the meanness and littleness of the one mode will be perfectly evident, compared with the larger manner of the other. But this imitative style is carried much further: ormolu stems and leaves bear porcelain flowers, painted to imitate nature, and candles are made to rise out of tulips and China asters, while gas-jets rush forth from opal Arums. Stems, bearing flowers for various uses, arise from groups of metal leaves standing tiptoe on their points, and every constructive truth and just adaptation to use is disregarded for a senseless imitative naturalism. In the same way, and doubtless supported by great authority, past and present, enormous wreaths of flowers, fish, game, fruits, &c., imitated *à merveille*, dangle round sideboards, beds, and picture-frames. Glass is tortured out of its true quality to make it into the cup of a lily or an anemone; not that we may be supposed to drink nectar from the flower, but that novelty may catch those for whom good taste is not piquant enough, and chaste forms not sufficiently showy. In fabrics, where flatness would seem most essential, this imitative treatment is often carried to the greatest excess; and carpets are ornamented with water-lilies floating on their natural bed, with fruits and flowers poured forth in overwhelming abundance, in all the glory of their shades and hues; or we are startled by a lion at our hearth, or a leopard on our rug, his spotted coat imitated even to its relief, as well as to its colour, while palm-trees and landscapes are used as the ornaments of muslin curtains. Though far from saying that imitative ornament is not sometimes allowable, still it will at once be felt that the manner wants a determined regulation to exclude it in most of the above-mentioned cases from all works aspiring to be considered in just taste, and to leave it to be adopted by those only who think novelty better than chaste design, and show preferable to truth.

The constant search after novelty has just been alluded to as one of the sources of bad taste in modern ornament. Manufacturers are eager to obtain it at any sacrifice of truth and at any cost. The efforts of those past ages, when taste was most indisputable, appear to have been directed rather to the continually perfecting and refining their designs and inventions, than to creating new ones. Thus, in architecture, the robust simplicity and grandeur of the Doric order remained unchanged from age to age, architect after architect striving only to perfect its just proportions and the symmetry of its parts, rather than to add any novelty of feature or ornament, until, in the Parthenon, it seems to have arrived at the most perfect development that taste, science, and art could unitedly effect. Even among the more voluptuous inhabitants of Asia Minor, at least until the age when their artists became servants and panderers to the coarser magnificence of Rome, the details of ornamentation were few, and those universally received. The volute, the acanthus, the anthemion, the echinus, and a few frets and guilloches, seemed to pass the ordeal of criticism, not that they might be rejected for more novel treatments, but that the symmetry of their parts might be more justly balanced, the commoner curves rejected for those more varied, beautiful, and refined, and the true import given to their projections. Proportion and symmetry being thus sought after instead of novelty, their ornament has come down to us with authority like that of Scripture, rather than that of tradition, aud all the after efforts of artists, who have adopted and adapted it, have failed to improve its elegance, or add to its beauty. Even in the eastern nations we find the same usage prevail; and to this day Indian ornament is composed of the same forms as it was in the earliest known works; the principles that governed ornamental practice in those works seem still to be a tradition with the artist and the workman, and still to produce the same beautiful results, as is abundantly seen in the fabrics and tissues of the Indian department of the Great Exhibition. Now, however, our efforts are of an entirely different nature, and the hunger after novelty is quite insatiable; heaven and earth are racked for novel inventions, and happy is the man who lights upon something, however *outré*, that shall strike the vulgar mind, and obtain the "run of the season." Such patterns as often result from the caprice of accident as from any effort of thought—witness what is called the diorama pattern in cotton printing, which was very popular, yet was the result of an accidental folding of the stuff on the cylinder in printing. Accepted for the season, these fantasies no sooner pass away than the world wonders how it could ever have looked upon them with satisfaction, or tolerated for an instant such solecisms in taste, such strange incongruities, or gross absurdities.

The ornament of past ages was chiefly the offspring of handicraft labour, that of the present age is of the engine and the machine. This great difference in the mode of production causes a like difference in the results. In old times the artist was at once designer, ornamentist, and craftsman, and to him was indifferent the use of the pencil or the brush, of the hammer, the chisel, or the punch: his hand and his mind wrought together, not only in the design, but in every stage of its completion, and thus there entered a portion of that mind into every minute detail, and into every stage of finish, and many a beautiful afterthought was embodied by the hand of the "cunning artificer," many a grace added to the work by his mastery and skill. He worked, not to produce a rigid sameness, but as Nature works:—she produces nothing exactly similar to its fellow, in every turn of every stage of growth, in every flower, and in every leaf, adding a changing grace, a differing beauty; so he varied his labours with every feeling of his overflowing mind. But this is not possible with the stamp, the mould, the press, and the die, the ornamental agents of our days: after the type or model is made, all the products are rigidly the same, whence arises a sickening monotony, a tiresome sameness, unknown in the works of nature and peculiar to these artificial works of man: the varying mind has no share in their production, and man himself becomes only the servant of the machine.

Moreover, the old ornamentist worked generally from feelings of piety, from love of his labours, or from the desire of fame, motives hardly known to the artists of this class in our days, at least in this country. Who seeks fame from the ephemera of a season? Who loves a labour that is so soon to pass away? Who cares for a work that is not to be the child of his own hand, but to be produced in thousands by the aid of machinery? The toil of him of old times was spent upon the thing itself, and not upon a mere model for it: the chalice, the cup, the lock and key, the reliquary, were to be without repetition, and without rivals; he sought to give them their highest excellence, and, labouring from one of the feelings we have described, threw his whole soul into his work, so that it became a thing for future ages to look upon and to prize. Not that handicraft or art-workmanship is utterly excluded from our manufactures; it is only partially so, making more painfully evident how greatly ornamental art has suffered from its union with machinery. Wherever ornament is wholly effected by machinery, it is certainly the most degraded in style and execution; and the best workmanship and the best taste are to be found in those manufactures and fabrics wherein handicraft is entirely or partially the means of producing the ornament, as in china and glass, in works in the precious metals, carving, &c. This partly arises from the facilities which machinery gives to the manufacturer, enabling him to produce the florid and overloaded as cheaply as the simple forms, and thus to satisfy the larger market for the multitude, who desire quantity rather than quality, and value a thing the more the more it is ornamented. This state of modern manufacture, whereby ornament is multiplied without limit from a given model, by the machine or the mould, ought at least to awaken in the manufacturer a sense of the importance of the first design. One would think that what was to be produced by thousands and tens of thousands should at least be a work of beauty, and no pains be spared to insure its excellence. The cost of the first design or model must in such a case be a mere atom when divided among its myriad prototypes. It would seem strange, too, that any one could be found to throw away great expense upon dies and moulds, to carry out a design which in itself was hardly thought worth paying for. Yet, often in this country artists are paid little better than workmen, and a belief seems to prevail that knowledge, skill, and taste come by nature: the artist has often no interest in the result of his labours, his name is unknown, his pay is niggardly, and what there may be of beauty and excellence in his work is often spoiled by the alterations of the manufacturer, who makes no scruple of setting his own taste above that of the artist, and altering and changing his design at his sole pleasure. In France, and some parts of Germany, where taste has long been cultivated, and the value of ornamental design is better understood, these relations are better understood also; and in this country, if good taste is to prevail, the manufacturer must learn to appreciate more highly the value of the designer's labours, must seek to foster his talents and stimulate his *amour propre*. Society, also, must be prepared to contribute more largely than heretofore to public education in ornamental art, aud taste must be disseminated by every available means; for it is not only truth, but a truth that should be told, that, notwithstanding our skilful workmanship and our excellent manufacture of most fabrics, we are sadly behind in the design applied to them, and greatly indebted to foreign artists even for what little is good. Moreover, our greatest difficulty consists even less in the want of designers than of skilled art-workmen to carry out designs. A design for cotton-printing may be spoiled by the "putter-on," or for silk by him who prepares it for the loom. The sculptor may design a statuette, but there are few able to chase the bronze, or to retouch the clay, or to unite the parts when they come forth from the mould. Even where such are found, they are mostly men of slow minds, who enter little into the spirit of the artist's labours, and who work without feeling as without fire. We find plenty of chasers able to imitate the fur of animals, or the texture of draperies, but few who understand the bones and the anatomy of the parts, and fewer still who carry an artist's spirit into their works. In painting, also, the painter on glass and china is generally a mere copyist, or he works too entirely by rote, and without feeling. The lily and the rose which he paints are always the same lily and the same rose, a work of the hand and eye, in which the mind has no share. There are honourable exceptions, no doubt, but with the many art is a mere handicraft. In France, in Germany, in Bavaria, in Italy, this is not the case. There the artist often carries out his own design, and, where he does not, has always at hand a band of skilled art-workmen to embody his ideas, or to complete his labours. The beautiful works in metal, by Vechte, Wagner, and Weishaupt, the china paintings of Jacobber, Schilt, Ducluzeau, Haman, and a multitude of others, and the furniture carvings of Lienard, are choice examples of the above-stated truths; while the works in oxidised silver, such as seal and knife handles, paper-weights, cigar-cases, &c., exhibited by Rudolphi, with the bronzes of Méné, Pradier, and a host of other such works, show the skill, taste, and knowledge of the art-workmen of France. In France, moreover, there is a fitness and fancy pervading ornamentation; the ornament, especially where figures and animals are introduced, being specially adapted to the thing ornamented. In England, the ornament designed for one work is made to do duty for twenty others: one figure truly plays many parts, and is often used with an inconceivable want of fitness. But the English public, and the English manufacturers as a body, are hardly yet awake on the question of design: government has established schools of ornamental art in many of our large manufacturing towns, for the purpose of spreading genuine taste, and educating our workmen; but they are as yet a forced product, and have hardly anywhere, after ten years of struggle, won the warm support of the local manufacturer. Even in this great Exhibition, the question of *design* was nearly overlooked, and the works of the designer left without a place: his name was not necessarily coupled with the fabrics or manufactures his skill had designed or decorated, and his reward, therefore, was left to the good feeling of his employer. No special jury was named to unite with manufacturers in the various classes in judging of the taste and art displayed in the ornamentation of their fabrics; and that art which, as we have before said, is calculated, when excellent, to raise the reputation of a nation's manufactures, was left to the judgment of those too likely to consider, not its real excellence, but what an untaught multitude would purchase and would prize. In France, many large establishments have well-appointed schools attached for teaching drawing and modelling, and the rudiments of science connected with their manufactures. In Germany also, and in Italy, schools and institutions have long been in operation for the cultivation of taste in design; and it will be necessary for this country to enter seriously on the same course, if we are to maintain even our manufacturing reputation before the world.

In estimating the progress of this country in ornament and in art-workmanship, as compared with the continental nations, there is one circumstance that must enter largely into consideration. In France, Germany, Italy, and Belgium, in addition to schools for teaching ornamental art, royal and national manufactories have been established for many years. In these, no necessary expense is spared to bring to perfection the fabrics wrought in them, both as to the highest excellence of workmanship and materials, and to their embellishment by ornamental design. The best painters, sculptors, and designers, as well as men of the most scientific acquirements in botany, mineralogy, and chemistry, are among their professors; and the works being carried on at the public expense for the attainment of excellence, the cost of repeated failures is unheeded. In such establishments, a band of skilled workmen must of necessity be trained to the ultimate benefit of the private manufacturers, and those difficulties which science had found the means of overcoming, or those new processes and new materials which it had brought to light, be spread abroad for the common advantage of all. Moreover, the sight of excellence and of the products of skilled workmanship is one of the greatest stimulants to further exertion, since all art and all manufacture arrive at perfection by gradual advance on past labours. The workman who sees the results of the skill which has produced such works in china and porcelain as are exhibited in the Sèvres room or in the hall of the Zollverein, must feel this stimulus in no mean degree. When it is remembered what one single artist did in this country for the same manufacture, and how greatly Wedgwood and his workmen were indebted to Flaxman, we can well feel what influence a band of artists of like ability, exercising their talents to improve every department of the manufacture, and of these a continued succession, would be likely to exercise over the taste and skill of those in contact with them. Nor is this all: the excellence of one fabric awakens a desire for like excellence in others, and calls forth the same spirit of emulation. It surely cannot be doubted, therefore, that the continental nations, and more especially France, in this manufacture, and through it in many others, have been largely benefited by such institutions; besides the amount of national reputation obtained by them from the display of the choice works which are therein produced.

In these remarks it is not intended to plead for the desirableness of such establishments in our own country, but only to point them out as the means whereby other nations have attained to great excellence. It is no answer to such an argument—although it is indeed true—to say, that without these aids the *general* manufacture of such fabrics in Germany and France is behind our own; and that the private show of such works by Minton, Copeland, and others, is, both as to manufacture and design, superior to that of any private manufacturer of those countries. This may arise from various causes; but with the like advantages on our side, it may well be imagined that much greater excellence would have been attained: the want of skilled art-workmen being felt and acknowledged by these manufacturers as a great hindrance to the complete success of their manufacture. Moreover, it is but fair to remember that such royal and national establishments, by the beautiful works produced in them, have added largely to the number of rewards won by other nations in this peaceful contention, and have placed at some apparent disadvantage the manufacturers and workmen of our own country. Let us hope, however, that the time is coming when England will seize eagerly every proper means of improvement. Symptoms of it are already abroad; and there seems a likelihood that the Great Exhibition of the Industry of All Nations will be valuable to all in showing shortcomings as well as excellences; and to none will it be more so than to the British nation, if it awakens us to a knowledge of our deficiency in ornamental art, and to a hearty endeavour immediately to remedy it.

Decoration of Buildings.

The objects in the Exhibition which range under the above head belong to almost every known style of ornament, and are so various in their character and uses that it is hardly possible so to arrange them as to bring them under general criticism, or to define any principles which would be universally applicable to their design. They consist, first, of decorative treatments, exhibited as efforts of skill; secondly, of restorations of parts of buildings, and of ornamental constructive parts; and thirdly, of works intended to form integral parts of a building, but which are *manufactured* so as to be adventitiously applied. Properly speaking, the design for the decoration of any building, both externally and internally, is the province of its architect, since in this case decoration is essentially a part of architecture. If the principle insisted upon in the prefatory remarks to this Report, that ornament is the decoration of construction, be just, it will be apparent that it is hardly possible to judge of the one without the other. In works wherein the decorator makes his own sham construction in order to ornament it, as well as in those multiplied manufactured "parts," which form the staple *ornament* of a large class of *workmen* in this line, we may admire the skill of the execution, the cleverness of the details, the excellence of the manufacture, or the imitation of early works of acknowledged merit; but to appreciate "decoration," we must view it as a whole in the place for which it was specially designed, and in harmony with the building whose construction it ornaments. Moreover, it must mainly originate in local circumstances, and ought to have an individual significance. Here, however, the moment we enter upon the varied inspection, we become sensible how impracticable it is to lay down any general canon for works which differ almost as widely as the beginning and end of time. In other ages of the world, nations have been fortunate in so adapting design to prevailing wants, and in sympathy with existing feelings, as to produce a national style. But in the present day, men no longer attend to such considerations; they are wholly without such guiding principles, and consequently are totally without a characteristic style. They are satisfied with the indiscriminate reproduction of the architecture of Egypt, Greece, and Rome, or of Christendom in any, or all, its marked periods. Originality they have none. One man delights in a Gothic villa; another prefers the style of Italy: even India and China have their advocates, who never consider that climate and use should rule the choice, rather than fantasy and whim, and that there *must* be conditions arising from the present state of society, from fiscal regulations, modern habits, &c., which duly attended to, would, in addition to utility, be likely to result in novelty and beauty.

It is this merely imitative character of architecture which has so largely contributed to decorative *shams*, to the age of putty, papier-maché, and gutta-percha. These react upon architecture; and, from the cheapness with which such ornament can be applied, and its apparent excellence, the florid and the gaudy take the place of the simple and the true. A popular writer describes the wearer of cheap finery as having his jewellery "a size larger than anybody else;" and so it is with the cheap finery of imitative ornament: it is always "a size larger" than it should be—bolder, coarser, and more impudent than the true thing; it excites our contempt by its flasby tawdriness, so incongruous with the meanness and vulgarity it is intended to adorn.

From this *manufacture of ornament* arises all that mixture of styles, and that incongruity of parts, which, perhaps, is itself "the style" of this characterless age. Through it, also, the plasterer and the paperhanger too often usurp the place of the architect, to the certain dismissal of the mason and the wood-carver; and ornament, perchance in itself unobjectionable, is sure in such hands to be grossly misapplied.

The "designs" for architectural decorations exhibited are few in number, and are very open to the foregoing criticism.

Those on the foreign side are in the French department: they seem the very vagaries of a fantastic imagination, full of fancy, it must be owned, and skilfuly executed, but without the slightest sense of utility or of constructive truth. Everywhere ornament is in excess; the architectural construction obscured and overlaid with figures, fruits, flowers, &c., so that they seem more fitted for the scene of a theatre, than for any sober purpose of every-day life. Crowded together in such capricious abundance, the ornament can only be that of those cheap imitative manufactures we have above referred to. The "designs" on the English side consist of a few reproductions and adaptations of early styles, on which invention is as much wanting as in the others it is in excess. Of the works themselves exhibited in this section, the reasons already given will dispose of a large number, since it is impossible to view them otherwise than as specimens of skilful execution, or the reverse; thus, for example, what can justly be said of the ceiling exhibited by A. Montarari, of Milan? The room which is fitted up for its reception is badly lighted, and otherwise unsuitable, and the reverse of what is requisite for a library, for which the decoration is intended; but that matters little, since, under the best circumstances, it could be truly appreciated only in connection with an architectural reality. It may deserve praise for its extremely dexterous and skilful execution; but this is quite a separate thing from exhibiting any just principles on which it has been designed. It may be said, however, that as a ceiling, the decoration is too heavy, both in form and colour. This, which would be even more apparent in a lighter apartment, is a great error in a ceiling decoration, having the effect of depressing it, and diminishing the height of the room—a fault often seen in the richly gilt and massive ceilings of the continental palaces. It may, indeed, be laid down as a rule, that the decoration of a room should diminish in heaviness, in strength, and in gorgeousness as it passes into the ceiling. Then, again, as to the numerous ceiling decorations beneath the galleries on the English side: from the same causes it is only possible to speak of the skill of the decorative workman, since to judge of their local adaptation is out of the question; the light and graceful decorations being necessarily placed at the same height as the heavier and more richly treated ones, and of course their due adaptation judged of equally by that height, although, perhaps, the one may have been designed for a much lower ceiling than the other. The like difficulties, arising from causes before enumerated, prevent the proper considerations of the various specimens of wall-decorations. The principles, however, which are given under the head of Paper-hangings, eminently apply to such works.

The restoration of parts of existing buildings calls for little originality in the designer, since it almost wholly consists in the careful study of the decoration which remains, aided by a knowledge of the traditional ornament of the period. Such are the carefully-restored spandrel for Hereford Cathedral by N. J. Cottingham, part of the tomb of Queen Philippa by S. Cundy, and the wood-carving for the dining-room at East Sutton Place, designed by C. J. Richardson. In such works the taste of the designer is shown in excluding the coarser characteristics of the style, and making use of those only which, if less marked are also less extravagant, adopting its general spirit rather than copying its individuality. Thus in the sister art the unskilful portrait-painter seizes on the most salient characteristics of his sitter, and dwells upon all the individual defects of form and feature: the result is a likeness indeed, but a caricature even upon the homely original. The painter more skilled in his art avoids such coarse renderings, and under his hand even the plainest face is refined and generalised. In the same way a style becomes degraded. The decorators who adopt it overlook the spirit of its general idea, and exaggerate its peculiar characteristics, until at length it is likely to become a mere distorted caricature. Thus it was that the Renaissance degenerated into the Tudor, and the ornament of Louis XIV. was further degraded into the rococo and bizarre style which now goes by that name. A work, otherwise of much merit, may serve as a slight illustration of these remarks; it is the decoration, carved in walnut wood, for the end of a room, in the style of Francis I., exhibited by Messrs. Holland and Sons. This skilful work is detracted from, in a degree, by want of due selection; thus the large shell-forms, used in the blocking course above the cornice, are heavy and out of place in such a situation, and should not have been so used, however sanctioned by traditional authority. The ornament of the pilasters also, otherwise well designed and skilfully executed, ought in wood-carving to have been kept in lower relief, so as to have been within the surface of the pilaster itself, instead of projecting beyond, by which it is at once evident that the ornament is applied, and not, as it should be, carved from the solid wood.

Space will not permit, even if it were necessary, to speak of the numerous carved and other works in stone, wood, and marble, for decorative additions to buildings, exhibited in various parts of the Exhibition, since there is little which, from the original or peculiar application of design, calls for especial notice. The errors of such works will often be found to originate in the construction fitted for one material being applied to another; thus, that which ought to have been stone is wrought in wood, or wood treatments are carried out in stone or metal. The costly malachite decoration exhibited in the Russian Court may be noticed as an example of this mistake. Stone doors at all would seem to be an anomaly, but framed after the manner of wood still more so. In addition, the doors, which necessarily produce a sense of extreme weight, are hung to pilasters so narrow as to be quite disproportioned for their support.

It may not be amiss here to advert to the error arising from excess which these works illustrate. Thus, the malachite vases exhibited in this room are improperly supported on malachite pedestals, greatly detracting from the sense of rarity and richness which would result from having only the principal object made of the rare material, and its support in a baser one, while all the enrichment which would arise from contrast is lost also, and the eye is fatigued with the quantity and sameness of colours, which would have been refreshed had a marble of some homogeneous colour been used for the bases instead of the malachite.

Ornaments manufactured from plaster materials, such as gutta-percha, putty, carton-pierre, &c., have no doubt a substantial value in the Great Exhibition, commercially considered. As regards design, however, they are but dangerous subsidiaries, often doing greater injury, from the tasteless, misplaced, and false decoration arising from their use, than good, by ministering to decorative purposes. Apart from that monotonous multiplication of the same forms, necessarily resulting from the unvarying productions of the mould and the die, which has been before alluded to, there are other evils sure to accompany *manufactured* decorations such as those now under consideration. The great cheapness of the substitute, compared with the real material, inevitably leads to excess. Such ornament always seems added or applied, stuck on as it were, and can rarely be made to appear as a part of construction; it therefore constantly carries with it a sense of untruth, till the mind and eye, from habit, become satisfied with it, and at the same time deadened to what is really true and good. Moreover, decoration of such materials must necessarily be patchy and incomplete; when the parts to be ornamented are large, this evil is seen in its most exaggerated form; a florid and gaudy centre has perhaps to be united with coarse corners, either by other ornaments or by the repetition of the centre portion, and all sorts of expedients must be resorted to to "bring in" the parts so as to suit the architectural distribution of the apartment; it can indeed barely be possible that the quantities, or the geometrical arrangement in which the ornament has been originally constructed, will agree with the place to which it has to be adapted, and more or less of makeshift must be the result. One of the most important works in such materials is the centre compartment of a room in carton-pierre, by V. Cruchet, which, with all the excellences of the manufacture, exhibits many of its prominent defects, and may serve to illustrate the general faults of such materials. Thus it is decidedly over ornamented, and this is shown not only in the excess of ornament, but in the want of relative scale between the ornament and the constructive forms of the architecture, the former being far too large, as well as too redundant. Scale also seems to have been quite disregarded in the parts themselves, since the fruit and flowers, the birds and game, of one part, are different in size from those of another part. The style, again, is mixed, one part being two centuries earlier than the other. There is, besides, far more pains taken with the exact rendering of fur or a feather, than in perfecting the form of a moulding, or the shape of a panel—the architecture has, in the designer's mind, been subordinate to the ornament, and an ill-formed ellipse, or a coarse and unrefined moulding, appears of less importance to him than the mere imitation of the feathers of his birds, or the fur of the animals of which his ornament consists. Carry this treatment a little further, and it will result in having the game, the fruit, the foliage, and the flowers not only modelled to the exactest imitation, but the skill of the painter called in to add to its naturalism, and the whole painted with the colours of nature; thus decoration will be thought perfect only when it competes with those strange relieved pictures which are exhibited in frames in close juxtaposition with the work in question.

Of the artistic and skilful grouping, and of the merit of the modelling of the ornamental portions of this decoration of Cruchet's, there can be no question; but, as has been before said, even these excellences may merge into faults if they are too exclusively directed to mere imitation, and if the design to which they are applied has not the merit of a just perception of use and purpose. One great cause of evil in the use of the materials under consideration, consists in the false principle of their application to decorative purposes. It is found, for instance, that peculiar qualities, which are difficult of attainment and an effort of great skill in other materials, can easily be obtained by a new means; instead, therefore, of carefully studying its just adaptation to ornamental production, the effort is only to emulate in excess those peculiar qualities which are trials in the more intractable material. It too often happens, moreover, that the original works imitated were in false taste; and this becomes far more apparent in the copies, since the mind can no longer dwell on them with that admiration which is caused by a sense of difficulties overcome, and which compensated, in some degree, for the absence of good taste in the works they emulate: for instance, the exact imitation in wood or stone carving of the individual details rather than of the general character of objects used as ornament, extreme relief, under-cutting, lightness, thinness, and picturesqueness of the forms of foliage and flowers, whereby their natural growth is attempted in carving rather than a due ornamental disposition of their forms—all tending to excess and exaggeration, and to be avoided rather than copied. Another source of error consists in rendering what should be true constructive forms into mere ornament: thus pilasters, and even columns, consoles and trusses intended to support weight, are manufactured in these imitative materials, and introduced only to decorate, until all sense of utility and construction is lost, and ornament becomes the principal instead of the subordinate. Such materials, however, are capable, under proper control, of useful application to ornamental purposes, both from their ready adaptability to various surfaces and forms, and from the cleanness and sharpness with which they can be moulded, as is seen in the works of the Gutta Percha Company, Jackson and Son, Bielefield and Co., and others, as well as in the work above referred to. It is most desirable, therefore, that the errors to which a false application leads should be carefully pointed out, so as to bring these materials as much as possible within their duly limited use.

Some of the above criticisms will apply to terra-cotta also; but this material, partaking largely of reality, and allowing of being perfected by the hand after the first mechanical process of moulding, would, under fitting regulation, become a most useful and durable agent of ornamental decoration.

Stained Glass Decoration.

The art of painting on glass, or glass-staining, has come down to us so intimately mixed up with the ecclesiastical architecture of the middle ages, that it is almost impossible to view the one unconnected with the other. It was born of the same parent (the Church), and from the first both were equally devoted to her service. Of Gothic architecture, and of it almost exclusively, stained glass has always formed a necessary decoration; it follows, therefore, that its ornamentation is almost wholly traditional, and has relation to the various periods of the Gothic architecture which it accompanies.

Not that it is necessary, or even desirable, that the epochs of the two arts should, in their revival, continue to correspond: but the periods of each, whether simultaneous or otherwise, when utility and beauty were most fully understood and attained, should be diligently studied in search of the principle that guided the artists of those times, and that which is best should be chosen, irrespective of mere correspondence of epoch or antiquarian authority. Moreover, the errors which the ignorance of an early age evidently occasioned should be carefully separated from the truths, and not considered as of necessity a part of the *style* of the period in which they are found—such, more particularly, as bad drawing and want of knowledge of the human figure: at the same time, that simplicity of treatment which is so highly characteristic of early works, which overlooks all details, and renders a composition from the Scriptures, or a single figure, more as a symbol than as a picture, should, if it is found to be a principle of excellence, be carefully retained.

As is the case with all other manufactures and fabrics, so it is with painted glass; the question of utility, rightly considered, will lead us to some knowledge of what is most suitable in its treatment as a decoration. Glass was introduced into the numerous windows of Gothic architecture to temper the glare of light, and to serve in a manner as a blind, by preventing the direct entrance of the sun's rays, and also to shed that solemn religious light which so well accords with the sacred mysteries of religious worship. The mosaic glass of the early artists of the 12th and 13th centuries was most admirably adapted for this purpose: being composed of many small pieces of full and pure tints, with little white glass, the rays of the sun were broken and dispersed, the light lowered in brilliancy, and the whole effect was homogeneous, rich, and solemn, sufficient light being still permitted to enter for the performance of the religious services of the church. Even compositions of figures were subject to the principle that regulated the whole: the figures were small, so that the colour of their draperies and accessories might be broken up into many pieces to give the same equal distribution as in the ornamental parts of the window. It would seem, indeed, that the painter did not intend to simulate a picture, but rather to symbolise a sacred text or thought, and the figures, therefore, were not so much pictorially arranged, as composed with extreme monumental simplicity; thus they not only partook of the general effect of the window, but the attention of the spectator, impressed with the solemn yet beautiful light, was at the same time filled with the holy thought conveyed by the subject, without being distracted by too great an individuality of parts. The representation of shadow, strictly speaking, was not admissable, the composition consisting only of flat forms of the greatest simplicity. For this, even, there would seem to be just reasons: the light being transmitted through the glass to the spectator within, shadow would appear to be anomalous and out of place, since the illumination in such a case emanates from the figures themselves; moreover, the simplicity of the shadowless forms was better suited to impress the eye from the distance at which such works must necessarily be viewed. Such would seem to be some of the principles which ought to regulate, and which in the best times did regulate the design for painted glass. An entirely different view of the art has, however, sprung up with its revival and has obtained many advocates, especially on the Continent. It has been felt how greatly art has advanced in the hands of the historical painter since the time spoken of: that the principles of composition, of foreshortening, of perspective, of light and dark, and of the arrangement of colour, then quite unknown, have been discovered and developed; that drawing, then in its infancy and unaided by knowledge, has now arrived at maturity; and that science has given us power over the materials which they possessed not, and enabled us to conquer difficulties which they considered insuperable; and it is asked why the painter on glass should not avail himself of all these advantages, to perfect his art, and to render it as pictorial as the works of his brethren. By artists who entertain these views the surface of the window is treated almost as a canvas would be: the forms of the figures are large, even as the size of life: the draperies are massive, and the heads painted with great imitative skill and completeness. Clair-obscur and perspective are studied, and foreshortening and pictorial attitudes in the figures supply the place of the monumental and statuesque delineations of the earlier artists; in fact, everything is done to treat the window as a picture.

To the advocates of this style it may be objected, that a picture is specially intended to address itself to the mind and imagination only, while painted glass has a reference to use also; and that, apart from this consideration, each and every art has its own mode of rendering nature—not necessarily implying *deceptive* or complete imitation; thus, for instance, the art of the sculptor is a generalised imitation of form, and even the painter of high art does not desire to make his picture deceptively imitative, but listens with impatience to the remarks of the ignorant, who are apt to praise his work for this quality above others proper to it which they do not understand. An outline of Flaxman's fills the mind with a perfect sense of beauty and with the fulness of a poetical idea; surely, then, the flat and simple treatment of subjects in glass-painting, if such treatment is requisite for its utility and most in consonance with its other qualities, may be found sufficint to give as complete an expression to the pictorial rendering of a Scripture truth as the material and situation of such works require.

It would seem to be a great fault in glass to have a prevailing tint or hue, since by a truly harmonious composition of colour such a result would be avoided. This defect is visible in the glass exhibited in the North-east Gallery, in some of which a prevailing green, in others a yellow hue, is observable. This is often the case also with the modern French glass, as seen in some of the restored churches of Paris, more especially the pictorial glass, in which a hot red hue is often present, sometimes to a painful extent: the flesh especially is hot, and dirty in the shadows. It is to be doubted, indeed, if, with all our knowledge of the harmony and complements of colours, we have yet attained to the principles by which the old glass-painters arranged their agreeable combinations. Whatever was the method, the effect was coolness of general tone: the flesh had little local colour, the prevailing tints of the draperies and accessories were blue, cool green, and amethyst, and even the red was cool, inclining to crimson. The hot browns of the flesh in the modern glass, together with its opacity, are often very disagreeable; and the effect of scarlet instead of crimson may be seen in the work of Marechal, "St. Charles administering the Communion to the Plague-stricken," where the robe of the cardinal is of that hue, and greatly tends to increase the hot and glaring effect of the whole. In the Parisian churches, where ancient and modern glass are both to be found, even when the former is not of the best period, as in St. Germain l'Auxerrois, for instance, it is quite refreshing to turn the eye from the modern to the old glass, showing how far more harmonious the one is than the other.

In estimating the excellences of the one or the other methods of glass-painting which have been spoken of, the superior durability of the earlier method is to be noticed; also the much smaller liability to accidents from the diminished size of the pane, and the much less damage if a fracture does take place: an unlucky blow may immediately destroy the finest portion of a pictorial window, while it could do but small injury to a work on the older principle. These are minor merits, but to them may be added the greatly increased brilliancy of colour occasioned by the more frequent interposition of the dark line of the *leading*, and the lustre occasioned by the slight change of plane, in the smaller pieces of the early method, bringing out thereby the richness of the glass, as the varied facets of the lapidary do of the precious stone. Indeed, it may be doubted if the subject of *leading* has had all the attention it so well deserves. The skilful manner in which this was executed in the early works is apparent from the preservation of the windows, unharmed by the storms and winds of centuries. It is certain that a varied surface was at times adopted in such works, for resisting, as has been supposed, the pressure of the winds: thus, at Haddon Hall, in the long gallery, glazed in the reign of Elizabeth, each window is waved inwards and outwards over the whole surface, and each piece of glass cut to adapt it to this treatment: the result has been great durability, even although the lead itself is extremely narrow. These, are, it is true, windows of uncoloured glass; but it may probably point to some such method being used in decorated windows to enhance their brilliancy and increase their effect.

Inlaid Floors, Mosaic Pavements, Inlaid Tiles, &c.

The ornament of this section seems the soundest and most satisfactory in the Exhibition—the most free from false principles, the most thoroughly amenable to true. Although this no doubt partly arises from the conditions of the manufacture, it is, in a degree, to be attributed to other causes. The modern introduction of such works in England, was at a fortunate time, when the attention of the ecclesiologists and of able artists was called to the revival of mediæval art, and to the study of the best works of Greece and Italy. The designer, therefore, started upon just principles, and continues to adhere to them, even repudiating some of what must be considered errors in the ancient works which have been handed down to us, such as those arrangements of light and dark inlays, giving the appearance of relief, which are found occasionally even in the best ancient examples. The "designs" exhibited are almost wholly on the English side. Apart from those in conjunction with manufactured specimens, Mr. Digby Wyatt's are the most important: they are varied and fanciful, thoroughly flat in treatment, and consisting mostly of combinations of simple geometrical forms, although there are some of Italian conventionalised ornament. They evidence the careful examination and study which the artist has given to the best antique and mediæval treatments of mosaic.

Mr. Minton exhibited an intaglio and enamelled tile of a Moorish pattern, for covering the surface of a wall with an ornamental *texture*, and with a broken harmonious richness of colour, in very durable materials, for which purpose it is admirably adapted. This manufacturer exhibits also many novel and praiseworthy works in burnt and coloured clay to facilitate the application of design and colour to the exterior of buildings. Among others, a species of Majolica ware, with ornament in relief, coloured with delicate tints, intended to be introduced into friezes, stringcourses, panels, &c., and other combinations of the art of the designer with the skill of the tile-maker and the potter, which will enable the architect to break the monotonous surface of brick buildings, and introduce ornamental forms and colour without the necessity of resorting to plaster and stucco, so long the wretched resource for such purposes. From the geological position of London, bricks must always be the prevailing material for building purposes: such means, therefore, for the safe introduction of colour and ornament, are especially desirable, and should be carefully studied, that the most judicious and sound principles of ornamentation may be adopted in these newly-revived materials. It is curious to see how instantly the removal of the excise-duty on bricks has been followed by the infusion of a new life into the manufacture, both as to novel forms and the application of coloured ornament to their surface; it must be remarked, however, that the ornament of each separate brick should be perfect in itself as well as perfect in combinations, a circumstance which has not been attended to in the glazed and coloured bricks exhibited by Mr. Minton.

From the general use of carpets, considered, as they are, as a necessary comfort in this country, inlaid floors are far less used here than on the Continent, and it is on the foreign side, therefore, that the best design applied to such works must be sought, The principle of ornamentation, of course, is the same as that for mosaics and other inlays; care, however, should be taken to select wood without a strongly-marked form in its grain, since this is likely to interfere with the pattern of the inlay in general; also right-lined figures are preferable to curved ones, from there being less need of crossing the grain of the wood in cutting.

Many skilful and ingenious combinations of geometrical forms are seen in the works of this kind in Belgium, Austria, Russia, and France; among others, the flooring of the bed-chamber in the Austrian room, of which the border, consisting of violet ebony and mahogany banded with maple-wood, is simple and pleasing in effect.

Paper and other Hangings.

If the use of such materials is borne in mind, the proper decoration for them will at once be evident, since this ought to bear the same relation to the objects in the room that a background does to a picture. In art, a background, if well designed, has its own distinctive features, yet these are to be so far suppressed and subdued as not to invite special attention, while as a whole it ought to be entirely subservient to supporting and enhancing the principal figures—the subject of the picture. The decoration of a wall, if designed on good principles, has a like office: it is a background to the furniture, the objects of art, and the occupants of the apartment. It may enrich the general effect, and add to magnificence, or be made to lighten or deepen the character of the chamber: it may appear to temper the heat of summer, or to give a sense of warmth and comfort to the winter: it may have the effect of increasing the size of a saloon, or of closing-in the walls of a library or study: all which, by a due adaptation of colour, can be easily accomplished. But, like the background to which it has been compared, although its ornament may have a distinctive character for any of these purposes, it must be subdued, and uncontrasted in light and shade; strictly speaking, it should be flat and conventionalised, and lines or forms harsh or cutting on the ground as far as possible avoided, except where necessary to give expression to the ornamentation. Imitative treatments are objectionable on principle, both as intruding on the sense of flatness, and as being too *attractive* in their details and colour to be sufficiently retiring and unobtrusive. Some of the best examples, as well of paper as of silk, velvet, and other hangings, are treatments of *texture* in a self-colour: as of flock on plain or satined ground in paper, of tabby and satin in silk hangings, of stamped forms or cutting in velvet, or the same contrast of pattern with the ground in various mixed stuffs. By these means the ornament is necessarily flat, and does not disturb the general effect. With the slightest attention to the choice of form it can hardly be in bad taste, whilst great elegance and beauty often arise from such treatments. Next to these, graduated tints of the same colour produce a safe and quiet ornamentation for such fabrics; or gold upon a coloured ground, where the gold is sparingly distributed, and the colour not too strongly contrasted, since in all cases a general *tone* of surface is to be sought for rather than pronounced individual forms. Further richness may be obtained by the judicious use of two or more colours, either, according to the ancient method of harmony, separated from each other by bands of black, white, or gold, or contrasted and enhanced by their complementaries, and enriched by flock in either case, in the latter by gold. But it is everywhere apparent that the combination of many colours, though it may increase expense from the number of blocks, is far from producing richness in the same degree, while it has often quite the contrary effect, and results only in poverty and meanness. It is necessary, however, to advert to a perfectly different treatment of these materials quite at variance with these rules, and bound by no such principles, by which paperhanging becomes a pseudo-decoration, the wall being divided into compartments often irrespective of architectural construction, and pilasters, friezes, and mouldings imitated in false relief on its surface, with compositions of pictures, statues, hangings, flowers, fruits, &c., skilfully designed and well drawn, and it may be, often most ably blocked for the purpose of printing; it is, however, at best but a sham decoration, amenable to no laws, necessarily false in light and shade, often constructively inapplicable, and always impertinent and obtrusive, and should be left to those who, desiring display, are too much wanting in taste to be annoyed at its untruth and extravagance. It perhaps is not quite out of place in the saloon of a theatre, in cafés, or taverns, but ought to be confined to such localities, and only used there until the general taste is so far instructed that the public will no longer tolerate gaudy shams and false magnificence.

The same laws which ought to govern design for paperhangings would, therefore, appear proper to regulate hangings of other fabrics, tapestries, &c. Although far from looking at ornament in that exclusive spirit which would reject what is beautiful when it does not square with the requisitions of a theory, it must be obvious that pictorial and picturesque treatments for such fabrics are wrong whenever they intrude on the domain of another art. Thus figures, landscapes, fruits and flowers, when rendered as they would be in works of fine art, are almost of necessity inferior to the pictures they imitate, even when they are as skilfully and wonderfully wrought as in the works exhibited by the national establishments of the Gobelins, where every effort of skill and science has been most successfully used for their manufacture and embellishment. Indeed, it is a matter of doubt whether custom, and the authority of great names and of past times, are not the cause of the continued admiration of such decorations, which perhaps we rather persuade ourselves we like than are fully satisfied with.

With very few exceptions, the exhibited "designs" for hangings appear to be totally unregulated by any perception of rules for their ornamentation, and, even when they happen to be on just principles, would seem to be so by chance rather than by choice. They are mostly florid and gaudy compositions, consisting of architectural ornament in relief, with imitative flowers and foliage. In some of the cleverest designs, the flowers and foliage are perspectively rendered with the full force of their natural colours, and light and shade; moreover, they are often three or four times as large as nature, whereby the size of a room would be apparently diminished. The French are the largest contributors, and their designs are characterised by the foregoing remarks; they are, however, exceedingly skilful in their details, the flowers and foliage well understood and artistically arranged, and *blocked* with great skill and knowledge; but as to style, they are most objectionable, and lead to the worst results, especially in the common manufacture of such goods.

The pupils of the government schools exhibit, among other designs, some meritorious ones for paperhanging. It is evident that their general taste is controlled and regulated by the knowledge of the just principles which should govern the ornamentation of these as well as of the other manufactures for which they have laboured. Being students' works, they can hardly be expected to abound in fancy or invention, and it is sufficient to find that they are well drawn, skilfully executed, and amenable to just laws of composition. In examining the design applied to the manufactures themselves, the same want of just principle is observable as in the works of the designers. It is true that manufacturers must produce works in every style, as well to suit those who are unable to appreciate what is good, as those of more informed taste; but it might be expected, in an exhibition of this nature—an Exhibition of skilled labour, and of the strife after excellence—that excellence would be the rule, and error the exception, whereas the reverse is generally the case. Were it a part of the duty of the reporter to enter into the clever and skilful execution, the treatment of the pigments, the excellent blocking or the general manufacture of such fabrics, there would be much to say of the foreign exhibitors, and of others on the English side; but in the *design* of their papers there is little to commend, and works of passable excellence in this respect are the rare exceptions of their collections. The English and foreign manufacturers seem equally at sea; with the exception of a few simple diapers, which hardly call for individual remark, the works of the best exhibitors on the English side, while they are very heterogeneous, are less original, and equally wanting in a sound knowledge of what is properly characteristic for such works.

There are, however, honourable exceptions to these remarks: after passing in review the paperhangings of the various countries, it is quite refreshing to meet the clever wax-cloth decorations by M. E. T. Vivet (France.) The ornament of these works is without shadow or imitated relief, thoroughly flat in its forms, which consist of graceful and flowing lines; the colour is equal in scale, without harsh contrasts, and of semi-neutral hues. There is no attempt at shams, to imitate marble, or oak, or any carving; nor to panel it, which is left to arise out of the architectural forms; but a series of graceful lines, with a quiet uniformity of tint, satisfy the mind and give repose to the eye. Moreover, having laid down certain principles on which manufactures and fabrics should be designed with a view to the true use of materials, and to avoid unnecessary display, by the proper application of ornament, it is impossible to refrain from speaking in high terms of the works contained in the Mediæval Court, manufactured under the direction and from the designs of Mr. W. Pugin. Some may object to the exclusiveness of the style, and to its too purely ecclesiastical and traditional character, even in domestic works; but for just principles of decoration, for beautiful details, for correct use of materials, and for excellent workmanship, the general collection is unique. Thus, in the paperhangings, for instance, there is no throwing away of many blocks to obtain richness, when one or two can be made sufficient; there is a perfect flatness and a subdued harmony of colour in all such works; and if Tudor roses and heraldic lions are sometimes too pronounced, and there is occasionally a little excess of ornament, richness is generally obtained at the smallest sacrifice of means, and without any sacrifice of truth. The same may be said of the hangings in silk and wool, and the carpets in this collection, the designs for which are highly commendable for their strict adherence to true principle.

Without having any sympathy with the *application* of decorative paperhangings of France, it would be unjust to pass them without praising the artist-like design, the powerful execution, and the great ability displayed in these works by the French artists. In that by Delicourt, besides the skilfully-blocked hunting subject of the centre panel, the details of the parts, such as the grouping of the game and arms on the pilasters, and of the birds and children on the frieze, have great merit, apart from the skill with which the whole has been adapted for block-printing. The same may be said of the work exhibited by Mader Brothers (France), which is an extremely fanciful and clever piece of decoration, and in as good taste as such false treatments can well be. The frieze of children is well designed and ably managed for printing; the landscape of Zurban (France) has also much merit in its details; and the work of Genoux has parts worthy of examination.

These decorations bear out the remarks at the opening of this Report as to the superiority of the French working artists. The men who carry out the designer's inventions in France must themselves have a large share of skill and art-knowledge to be able to prepare the design for the manufacturer's processes with the ability so evident in the works just remarked upon.

Among the English contributions in paperhanging are specimens of the lately introduced processes of printing by such machinery as is used for cotton goods, and of applying many colours from one block. These are likely to create a style of ornamentation for such fabrics of the most depraved kind. The largeness and flatness of details attainable by block-printing are less suited to cylinder-printing than more minute details, and the new processes offer ready means of applying several colours at a small expense; the reverse of what has hitherto been the case; hence the effort has been to impress as many tints as possible on paper, and excellence is reckoned rather by the number of colours than any other quality. Thus we are informed that works are printed in "sixteen colours," in "fourteen colours," &c., the works themselves evidencing the absence of all knowledge of the effective arrangement of colour; while violent, crude, and harsh tints are too often used to give greater impression of this *excellence!* and the result is littleness and extreme meanness; in fact, such papers are, in point of design, much inferior to those printed in two colours by the same machinery. Well-considered design, thoroughly adapted for this process, would enable the manufacturer to unite good taste with extreme cheapness; whereas the only present result is by increased labour to detract from the beauty of the ornamentation. It is impossible, however, not to remark the skilful printing exhibited by our English manufacturers.

Exterior and other Metal Work.

The works in metal of this section which are exhibited, consist chiefly of constructions for fountains, and of ornamental iron-work in gates and balconies, and for door-panels, lamp-pillars, flower-vases, and tazzas. The best of the metal fountains are so nearly within the limits of fine art, that their consideration may be left to that class. It is, however, to be remarked, that the zinc castings of the French and German founders show how suitable that metal is, as the means of spreading the best art, for any exterior purpose, in a cheap and durable material, as well as of embellishing public works of the above-named character at comparatively small cost, without the evils arising from oxidation when iron is used. Notwithstanding all that has been said about the incongruity of our climate with public fountains, there are undoubtedly long periods of the year, and those when London is most crowded as well as with her own resident population as with visitors, when such works are not only extremely ornamental, but when an exhausting atmosphere would render them of real utility and refreshment. The motion of water, at any season, has a great charm, and is peculiar in its power of giving pleasure even in the simplest jet or fall, agreeably and artistically disposed; and ornamental arrangements for its full display would not only be picturesque additions to our city, which offers so many localities for their adoption, but would afford to our artists motives for combinations of figures with ornamental decoration, and thus, perhaps, be a means of once more uniting fine and ornamental art, which, sadly to the deterioration of public taste, have for so long a time been almost wholly separated. It may be doubted if the public would willingly part with even the tame and commonplace repetitions which adorn Trafalgar-square; and those who have had the pleasure of enjoying the fountains of Italy and France will be quite prepared to judge of the effect which more skilfully-designed structures would have on the public mind here.

Such works in iron as gates, balconies, and panels are, for the greater part, in cast metal, which of late years, from its capability of cheap ornamentation, has almost wholly superseded wrought-iron for these purposes. Where the object is intended to be fixed and immoveable, as a balcony or panel, cast work is not unsuitable, and is capable of much beauty of ornamental design, as we see in panels exhibited by Muehl, Wahl, and Co. (France.) In these the ornament adds to the strength by its numerous articulations, while it is light and elegant in its forms. Works of this kind are generally of a size to admit of casting in one piece, insuring thereby strength and lightness by continuity of parts. But in cast-iron constructions intended to be moveable, as in the various kinds of gates, a very different character of design is necessary; in the first place, because entire casting is not always possible, both from the difficulty of running the metal into the numerous ramifications of the ornament in works of such increased size, and from the fear of warping in the cooling, as well as the great expense of a mould, which is saved by forming the ornament of a series of parts. This leads to the necessity of framing the work in wrought, and applying the ornamental details in cast iron; but hence results this evil, that the ornament has little constructive use, and is apt to look rather an addition than an integral part of the work. In the park-gates exhibited at the south end of the transept, great pains have been taken to get over this difficulty, but not with success, since the two metals are joined in parts wholly at variance with constructive strength; in fact, it is a wrought-iron design, partly executed in cast metal. Moreover, cast-iron ornament is necessarily far heavier than that of wrought-iron from the extreme brittleness of the cast metal; this heaviness is sadly opposed to its real constructive strength in the manner usually adopted for putting together; the ornamental parts of such structures being riveted or screwed into the framing, there are smaller points of attachment than in wrought-iron; the parts bed themselves less perfectly at the junction, since it is impossible to assist this union with the hammer, and the metal has small tenacity, and easily breaks with any sudden jar: thus there is much less power to support, while there is of necessity much greater weight to bear; and without very careful and well-considered design, making the ornament as far as possible a brace to the work, the whole is apt to be an insecure aggregation of parts, without constructive unity or truth. In large works cast in one piece, such difficulties are greatly surmounted, as weight can then be made to add strength, instead of detracting from it. In the old hammer-wrought gates, the ornament was not only a truly integral part of the work, but most materially assisted in the general support. Thus great lightness and elegance were, in this case, consistent with great strength, since the ornamental details supplied a means, not only of tying and bracing the work together, but of preventing the front of the gate from drooping with its own weight, to the great hindrance of its use, and which in cast works of this kind has often to be assisted by the use of friction-rollers—a make-shift that the older workmen would have despised. When, therefore, we consider the varied beauty of which wrought-iron is capable, its far greater durability, its tenacity and power of resisting accidents, the individuality of design which arises from its being wrought by the hand, instead of cast in a mould (thereby leaving the fancy and the feeling of the workman untrammelled), it seems not too much to say that it is to be hoped the use of the wrought metal will again prevail over that of cast for such purposes.

The gates and pilasters exhibited by the Coalbrookdale Company, at the north end of the transept, from designs by Charles Crookes, are an excellent specimen of casting, being wholly of cast-iron, each gate in one piece. Much of the false construction alluded to has consequently been avoided, and many of the difficulties overcome. The design of the gates, however, partakes too much of that adopted in wrought constructions, especially in carrying up the form of the centre, at the top, into florid ornamentation, which tends in this weightier metal to sway down the gate, without any compensating beauty or usefulness. The introduction of a heavy panel of ornament below is also rather commonplace, and due regard seems hardly to have been had to the *whole* surface in designing the ornamentation. The pilasters have more originality: the small twisted bars surrounding the centre columns give a lightness, compared with the strength obtained, which adds to the elegance: the striking-plates of the hand-gates, however, should have been ornamentally constructed or banded in with the pilasters in the centre, to increase the strength and resist the jar of the closing. The other great work in metal by this Company is an ornamental dome of cast-iron. This is a work of much pretension, designed in the natural style, the pilasters representing oak-stems, ornamented with leaves and acorns, and with the intervening branches twisted into an ornamental form: this treatment is mixed with some conventional ornament, here and there, as it were, indiscriminately introduced into the pilasters, having a very patchy effect. The pilasters, also, arising as they do from a single stem, and widening above their base, have an unsteady and insecure appearance, which might easily have been avoided. The great fault, however, is in the setting on of the dome, which from the outside seems to have no constructive connection with the pilasters, since in it the rusticated treatment is abandoned, and it seems dropped in among the branches, without any proper support. The work, nevertheless, has a certain impressiveness, from its size, and its general proportions are well chosen.

There are in various parts of the Exhibition garden-seats and chairs in cast-metal, which are principally to be noticed from the great want of due consideration of the material evidenced in their design: thus sometimes they are ornamentally constructed of branches and foliage naturally imitated, or of branches alone; while, in others, carved and flowing lines are given to the back, arms, and legs of the seat, which add nothing to the comfort of their use, and sadly detract from the form properly belonging to such works in cast-metal, which should be right-lined, and have a geometric character both of ornamentation and construction. It must be confessed, indeed, that the tendency to consider the ornament before either the requirement of the material or the use to which the work is to be applied, is but too evident in many of the works in metal in this class. Thus, two large lamp-pillars, designed by an architect, and exhibited in the Austrian department, have as much iron in their over-charged bases as would found three pillars, each capable of sustaining the taper upper shaft of the same design. The application of metal to the construction of the building is, on the other hand, an excellent example of just use, construction having had the first consideration, and ornament being entirely subservient; a due amount of elegance has nevertheless resulted from its simplicity, and from the true principles on which it has been designed.

AUGUSTUS NORTHMORE WELBY PUGIN.

A PAINFUL interest has lately been excited by the distressing account of the state of mind of this eminent man, being such as to render confinement necessary. Still, hopes of his ultimate recovery were entertained, and he was removed to his residence at St. Augustine's, Ramsgate—a house erected by himself for his own special occupancy, in singularly archaic taste. It was there that he breathed his last, on Tuesday, the 14th September, in the 41st year of his age. He was the only child of Augustus Pugin, a native of France, but long established in this country, and an English artist, who acquired a brilliant reputation by his excellence as an architectural draughtsman, and his works upon paper. One of his earliest works was the designing the furniture for Windsor Castle. Besides being an architect of very extensive practice—chiefly in the erection of Roman Catholic churches and colleges—he did as much with his pen as with his pencil, in most of the publications which bear his name. The work on Gothic Furniture, as well as that on Iron Work, was published in 1835. His 'Contrasts, or a Parallel between the Noble Edifices of the 14th and 15th centuries, and similar Buildings of the present day, showing the present Decay of Taste, accompanied by appropriate text,' which appeared in 1836, made quite a sensation among the profession, not only on account of the severity of its remarks, but for the novelty of its form and spirit, it being a direct satire upon the taste and practice of his contemporaries. Neither Smirke nor Soane were spared; James Wyatt was spoken of as "Wyatt of execrable memory;" Regent-street and the Regent's-park as "nests of monstrosities;" and such "public monuments" as Buckingham Palace, the new British Museum, Goldsmiths' Hall, &c., declared to be nothing less than "a national disgrace." So bold and unprecedented an attack on his professional brethren and their employers, and that, too, by so young a man, could not fail to fix attention upon its author. He now evinced a determination to preach up Gothic architecture and mediævalism, and to assail "modernism" unsparingly, in all its shapes. This he was enabled to do the more safely, as by his conversion to their creed, he had obtained the countenance and favour of the Roman Catholics.

His 'True Principles of Pointed, or Christian Architecture, 1841, answers well to its title, as being not only an able advocacy of that style, but explanatory of its elements, its nature, and constitution. Even then, however, he indulged in many satirical remarks upon the architecture of our own times; introducing, by way of specimens of it, some grossly extravagant caricatures.

His 'Apology for the Revival of Christian Architecture in England,' which appeared in 1843, has a dedication in black letter to the Earl of Shrewsbury. It is thoroughly in keeping with its dedication, and is fraught with an enthusiasm for mediæval art and for archaic fancies that partakes of the pedantry of the cloister. His greatest work, 'The Glossary of Ecclesiastical Ornament,' was published in 1844.

Mr. Pugin brought out several other publications, chiefly illustrative of mediæval ornamentation and design; but it is only those we have been speaking of which can claim to be considered literary productions. Yet although not without considerable merit and interest, they did not engage public attention.

The following are some of his principal works:—St. Mary's, Derby; St. Chad's, Birmingham; St. Mary's, Wymeswold; St. Wilfred's, Manchester; St. Barnabas', Nottingham; St. Martin's, Buckingham; St. Bernard's, Leicester; St. Mary's, Beverley; —churches at Kenilworth, Oxford, Hammersmith, Pontefract, Fulham, Woolwich, Liverpool, Newcastle-on-Tyne, Rugby, Northampton, Ware, Preston, Cheadle, and Stockton-on-Tees; cathedrals at Killarney, Enniscorthy, and St. George's, Southwark; convents at Birmingham, Nottingham, Leicester, Liverpool; colleges at Radcliffe, Rugby, and Maynooth. Alton Towers received several additions under Mr. Pugin's direction.

ENGINEERING IN THE GOLD REGIONS.

1. *Report of* JAMES BLACKBURN, C.E., City Surveyor, *on the Proposed Improvement in the Communication between Hobson's Bay and Melbourne.* Nov. 21, 1851.
2. *Report of the City Surveyor on the Proposed Waterworks at Melbourne.*

AMONG the persons to whom the gold discoveries in Victoria have given greater scope for exertion has been the City Surveyor of Melbourne, Mr. Blackburn, from whose pen we have before us two reports on important subjects. The port of Melbourne is in Hobson's Bay, between which and the city flows the small winding stream of the Yarra Yarra, to which both the reports refer. At present the navigation is circuitous, and only accessible to small vessels; and Mr. Blackburn therefore proposes to supersede it by cutting a ship canal of about 2½ miles across a neck of land, so as to reach the deep water in the bay. He canvasses several schemes for improving the navigation; but notwithstanding his remarks, we cannot but think a railway is preferable, for whatever measure he might adopt, the silting now going on at the mouth of the Yarra Yarra, and to which he strongly directs attention, would, as all experience shows, take place at the mouth of his cut or ship canal. With a railway no disturbance would take place, and docks might be carried into the deep water with rails on the quays.

With regard to the water plan, Mr. Blackburn proposes a comprehensive system, so as to give the city a constant service, and at the same time to provide mill sites and power, which would give a considerable additional revenue.

The Practical Examinator on Steam and the Steam-engine, with instructive references relative thereto. By WILLIAM TEMPLETON, Engineer. London: Atchley and Co. 1852.

THIS is the second edition of a very useful work, the want of which has long been felt among engineers, as its object is to assist the memory in all questions respecting steam-engines. It contains many valuable tables (in this edition considerably enlarged), numerous rules and observations of a practical nature, and altogether will prove a very valuable work to those whose occupation may render a book of this kind necessary.

LAUNCH AT CHERBOURG.

The following letter, describing the launch of the *Austerlitz*, at Cherbourg, appeared in the *Times* on the 28th ult., from its correspondent:—

"The *Austerlitz* is a noble vessel of 100 guns, having a colossal bust of the Emperor for a figure-head. The upper deck is flush fore and aft, and of the extraordinary length of 75 mètres (243 feet English). She has been 23 years on the stocks, but to make her subservient to the present wants of the service she has undergone considerable modifications. The whole of the afterpart has been taken away, the hull lengthened, and the stern made completely round, finishing in a graceful curvature in her inferior parts. She will mount 40 guns of large calibre on each of the two lower decks, and 20 guns (which may be augmented to 30) on her upper deck. In order to render her as formidable as possible, the round stern has been adopted, which will diminish the comfort of the officers, for they must live in the cabins, surrounded by the guns; but that form adds greatly to the strength of the vessel. The part that most interested me was the contrivance for the machinery, on the screw principle. The well-part of the vessel is the weakest part, but the French engineers seemed to have arrived at a satisfactory result; the sternpost is consolidated by a massive framing in bronze, which goes all round and unites it to the body of the vessel; it is all in one piece, and the finest piece of bronze-casting I ever saw. To judge from the centre of the hole for the shaft of the screw, which is about 8½ feet from the keel, the screw will be about 17 feet in diameter. This can be removed on and off in ten minutes, I was assured. From the improved system of the machinery, it will be so far submerged in the water as to put it completely out of all danger from projectiles in action. Her engines are of 500-horse power, which will give her a speed, like the *Charlemagne*, of ten miles an hour.

"On the day before the *Jean Bart*, of 100 guns also, was launched at L'Orient; thus making four vessels of this rank (three of which have been launched this year), and a frigate. It is surprising that the English government should have remained so long ignorant [?] of what the French were doing to introduce a new feature into their navy. On the other hand, if they knew it, perhaps they treated the idea of giving a sailing vessel of 100 guns a speed of ten miles an hour by steam alone as chimerical. Be that as it may, the French have solved the problem, and have even arrived at the fabulous speed of 13 French knots (nearly 15 miles) an hour! But this was not the only question to be resolved; the essential condition was to place the whole of the machinery out of danger of the enemy's projectiles, and this they have done by submerging their improved engines so much as to give perfect security. It is evident that paddle-wheels can only be employed for transport in the naval service, for the first shot may put them *hors de combat*. So long ago as 1843 the first essay to adopt the screw to war vessels took place on board a corvette built expressly for this purpose, the model of which may still be seen in the Musée de la Marine at the Louvre. The result was very satisfactory, and this led them to try it on a frigate of 36 guns (the *Pomone*), which was equally successful. Thus encouraged, the government resolved to try this new principle, called the mixed—that of sailing and steaming—on a vessel of 100 guns, and the *Napoleon* was constructed for that purpose. After various modifications in her machinery, which is of 950-horse power, but which is effective to 1300, they have at last arrived at a result that surpassed all expectations. The *Napoleon* has a speed of nearly 15 miles an hour under steam alone, without detracting anything from her sailing qualities; on the contrary, from her length and peculiar form, she is found to go in a light breeze seven knots an hour where an ordinary vessel of her rank will go no more than four. To have vessels of war possessing these advantages, sacrifice must be made of something. The ponderous machinery with a supply of 800 to 1000 tons of coals, takes up a considerable space. The question was, whether a sacrifice should be made in the armament of the vessel, or whether it should fall on the provisions and stores not indispensably necessary. In the position of the French, who have no colonies to protect that require a steam navy, there could be no hesitation. Six weeks' provisions would enable them to cross the Channel as well as the ordinary supply of six months."

NOTES OF THE MONTH.

Ventnor Independent Chapel.—Sixteen designs were sent in for competition; that of Mr. Raffles Brown has been selected, the style being Early Decorated, and the cost 1200*l.*

Balmoral.—It has been determined to build a new palace for the Queen at Balmoral. It is to be built on a site between the river and the present castle, fronting the south, and is estimated to cost from 80,000*l.* to 100,000*l.* The architecture is modern, and will combine the ornamental with the useful. A new bridge is to be thrown over the Dee; and the public road which now leads through the forest of Ballachbine, is to be shut up, and a better road provided along the south bank of the river. The old palace is to be entirely removed. The new palace is already staked out.

Monument to Charles Albert.—A colossal bronze statue, about 60 feet in height, is proposed to be placed at the top of the *Colina della Regina*, which overlooks the Po, and is situated between Soperga, where Charles Albert is buried, and Moncalieri, where he used to pass the summer. Notwithstanding its immense bulk, this statue is to be highly finished, and is to represent Charles Albert proclaiming the nationality of Italy and granting the constitution.

London Necropolis and National Mausoleum Company.—On Tuesday, the 14th September last, about 200 gentlemen, forming the vestries of the metropolitan parishes, left the Waterloo Station of the South-Western Railway by special train, on the invitation of the directors of the company, as a deputation, to view the burial-ground belonging to it at Woking Common, about twenty-five miles from town. On arriving, they were welcomed by Mr. J. H. Voules, the chairman of the company, who informed them that the spot where they then were had been selected for their leaving the train, in order to refute a report that the ground was of a marshy nature, it being 75 feet above the level of the high-water mark. The visitors then dispersed over the grounds (2000 acres in extent, and laid out under the direction of Mr. H. R. Abraham, of Howard-street, architect), the geological formation of which is Brixton gravel at top, and from the rounded form of the pebbles, is evidently a marine deposit; then peat of a dry nature, then red gravel, and, lastly, red sandstone of the new formation. At two o'clock they assembled in a marquee, for the purpose of doing justice to a luncheon provided for them. After the usual loyal toasts had been drunk, they were addressed by Mr. Voules, who eloquently pointed out the advantages that would accrue from the adoption of the scheme, which is the allotment of a portion of ground to each of the metropolitan parishes, to be under their own individual and separate control, without any interference from the company. There would also be an allotment to Roman Catholics and dissenters. As regarded burials, an arrangement had been made with the railway company, by which the deceased and their friends might be brought from town in thirty-five minutes, by a special train, to a station erected on the grounds, the railway passing through them. Several gentlemen then addressed the meeting to the same effect, which, after drinking the health of the chairman, returned to the train, and arrived in town soon after six.

Land Slip.—A land-slip occurred on the Birmingham and Oxford Junction Railway, on the 24th ult., at the embankment between Temple-row and Monmouth-street, where forty yards of massive brick-work, four and a-half feet thick, and between thirty and forty feet high, fell with a tremendous crash, bringing down with it the back premises of several houses. The line is to be opened for passengers and general traffic on the 1st of the present month.—*Birmingham Gazette.*

Improvement of the River Wear.—The Commissioners of the River Wear have, on the report and recommendation of their engineer, Mr. Meik, determined to carry out some important improvements on the river, principally with a view to the encouragement of iron shipbuilding in Sunderland. The improvements will consist in the erection of new quays, and the narrowing of the channel from the Wreath-quay as far as Hylton. The Pallion Canch and the Mannigan Sands will thus be taken in, and by this means about seventy or eighty acres of ground, which is now waste, will be recovered, and let for the purpose of iron shipbuilding, for which the situation is well adapted. The river will also be deepened three feet the whole length of the quays; and, altogether, this will be one of the most important improvements ever effected on the Wear.

Manufacture of Iron.—A very interesting experiment in the manufacture of pig-iron, by the use of "Cannel coal" in the furnace, has been recently tried in Cincinnatti, U. S., at the Buckeye Furnace, Jackson County. Commencing the blast entirely with charcoal, they gradually introduced first one-quarter, then a-half, and finally three-fourths of Cannel coal. An improvement in the working and yield of the furnace was noticed at each successive addition to the charges of Cannel coal. We understand that this interesting experiment will be further prosecuted. The Buckeye Furnace estate contains exhaustless quantities of Cannel coal.

Large Timber Bridge in America.—The bridge over the Genessee river, at Portage, is one of the most stupendous structures of the kind in the world. It is 800 feet long, and 234 feet high, from the bed of the river to the rail.

Stone abutments in river	30 feet.
Trestles	190 "
Truss	14 "
Total height	234 feet

It contains 1,600,000 feet b. m. timber; 108,000 lb. iron bolts, &c., and 9000 yards masonry. There are nine trestles or bents above the abutments, of which there are four in the river. The bridge was commenced July 1, 1851, and was crossed by a locomotive and cars for the first time on the 14th of August, 1852. It is estimated that the trestles will sustain a weight of 3100 tons in addition to their own weight. While sitting on one of the lower bents, a train of six passenger and a large number of platform cars, filled with passengers, passed over, and had it not been for the noise, no one would have known of the passing, so little was the jarring. This stupendous structure, together with the natural scenery in the immediate vicinity, must form one of the popular attractions of the country. Just below the bridge, the first falls of the Genessee occur, 90 feet high; a little further on are the second, 110 feet high; and about a quarter of a mile below these, the third, 60 feet high. The banks rise up from the river perpendicularly from 300 to 500 feet high, and the whole presents a grand and picturesque appearance. The canal crosses the river in an aqueduct at the village of Portage, and winds along about midway up the eastern bank of the river, passing under the bridge.

Gigantic Boring Apparatus.—For the purpose of carrying the Troy and Boston Railroad through the Hoosac Mountain, the construction of a tunnel is necessary; and, with a view to expedite this operation, the contractors have erected a huge machine for excavating the rock by drilling instead of by hand labour. It consists of a train of powerful wheels, fixed in a stupendous frame, which act upon an immense iron shaft as thick as a beer barrel, and of great length, terminating in a drill five inches in diameter, which bores the centre hole. On the same shaft is a wheel 25 feet in diameter, carrying on its circumference a series of cutters made in the form of pulleys, which revolve as they cut the rock, thus forming an annular incision the full diameter of the tunnel, the flooring of which has to be levelled by hand. When the boring has proceeded a certain distance the centre core is charged with powder, the rock blasted and carried away, and the operation is again resumed. The frame is moveable, so that when the shaft is carried to its extreme length into the rock the whole machine is advanced forward. The hard flint and mica schist with which the rock abounds completely destroyed the first cutters, and, although they were to be made much stronger, some doubts were entertained as to ultimate success. The contractors, however, feel no doubt on the subject. It cuts from a sixteenth to an eighth of an inch in each revolution, making five or six per minute, which more than meets the obligations they have undertaken. The stoppage of the machine for blasting and removal of the stuff is the greatest difficulty.

Danish Railways.—A concession has been granted to Mr. Peto for the introduction of railways into Denmark. The first line to be constructed will be from Tonningen to Flensburg, a distance of 35 miles, which will open up a rapid communication with the Baltic, and, in conjunction with the contemplated operations of the North of Europe Steam Company, give a powerful impulse to the already important trade of that district. This road will pass over a dead level, and its cost is estimated not to exceed 10,000*l.* a mile. The concession, which is for 100 years, gives exclusive privileges also for ulterior extensions, and the general arrangements entered into, both with regard to the occupation of land and the security for an adequate return upon the outlay, are believed to be extremely favourable.

The Iron Trade.—Much excitement has prevailed in this trade throughout the last week, and it is with great difficulty that business can be transacted. Most of the large makers have yet orders on hand, taken at the low prices, that will consume a large portion of the ensuing quarter to work off: and manufacturers in general are so pressed by their customers at the 20*s.* advance already declared, and even at higher figures, that they feel much hesitation in making sales. It is stated that circulars have been sent out by some houses quoting from 30*s.* to 40*s.* advance upon their last quarter's sales; while the more moderate are refusing to accept orders, unless subject to future alterations. From London, Liverpool, and all the places of export, report speaks of extraordinary activity, and doubtless there exists, both here and in all other iron districts, still a decided upward tendency; but we are not aware that any formal declaration of more than 20*s.* on the nominal price of iron will be proposed at the preliminary meeting which is announced to be held at Wolverhampton. The result of its deliberations is looked forward to with some anxiety; but it should be remembered, as we some time ago stated, that to reach even the prices that would be so declared, a very much larger advance than 20*s.* (in some cases full 40*s.*) will have to be obtained, and to anything further we do not think purchasers would be at all inclined to submit. In the meantime meetings have been held in the different localities to arrange the amount of wages to be given to the various classes of workmen, and the time from which the advance shall be paid; and we trust that a better understanding has now been established, and that no further interruption will be experienced in that quarter to the progress of a sound and healthy improvement in the trade.—*Birmingham Gazette.*

LIST OF NEW PATENTS

GRANTED IN ENGLAND FROM AUGUST 26, TO SEPTEMBER 24, 1852.

Six Months allowed for Enrolment unless otherwise expressed.

William Henry James, of Great Charlotte-street, Surrey, civil engineer, for improvements in heating and refrigerating, and in apparatus connected therewith.—September 3.

Peter Armand Lecomte de Fontainemoreau, of South-street, Finsbury, for improvements in producing gas, and in its application to heat and light. (A communication.)—September 7.

John James, of Leadenhall-street, London, manufacturer, for certain improvements in weighing machines and weighing cranes.—September 9.

Henri Francois Toussaint, of Paris, gentleman, for improvements in obtaining a product from the wood of the cactus.—September 10.

Julian Bernard, of Guildford-street, Russell-square, Middlesex, gentleman, for improvements in the manufacture or production of boots and shoes, and in materials, machinery, and apparatus connected therewith.—September 10.

John Wright Treeby, of Elisabethan Villa, St. John's-wood, Middlesex, gentleman, for improvements in regulating the flow of liquids.—September 10.

Stephen Taylor, of New York, gentleman, for certain improvements in the construction of fire-arms, and in cartridges for charging the same.—September 10.

Alexander Stewart, of Glasgow, North Britain, manufacturer, for improvements in the manufacture or production of ornamental fabrics.—September 10.

Frederick Sang, of Pall-Mall, Middlesex, artist in fresco, for certain improvements in floating and moving vessels, vehicles, and other bodies on and over water.—September 16.

Charles Augustus Peller, of Abchurch-lane, London, merchant; John Eastwood, of Bradford, York, woolcomber; and Samuel Gamble, of Bradford, aforesaid, machine-maker, for improvements in machinery for combing, drawing, or preparing wool, cotton, silk, hair, and other fibrous materials.—September 16.

John Macintosh, of New-street, Surrey, civil engineer, for improvements in manufacturing and refining sugar.—September 18.

James Pillans Wilson, of Belmont, Vauxhall, Surrey, gentleman, for improvements in the manufacture of cloths, and in the preparation of wool for the manufacture of woollen and other fabrics, and in the preparation of materials to be used for these purposes.—September 18.

John Mitchell, of Calenick, Cornwall, for improvements in purifying tin ores, and separating ores of tin from other minerals.—September 18.

William Smith, of Little Woolstowe, Bucks, farmer, for improvements in machinery for reaping.—September 18.

George Hutchinson, of Glasgow, merchant, for a method of preparing oils for lubricating and burning.—September 18.

James Warren, of Montague-terrace, Mile-end-road, and Barnard Peard Walker, of North-street, Wolverhampton, for improvements in the manufacture of screws and screw-keys, and in the construction of bridges, applicable to floorings, roofings, and paving.—September 18.

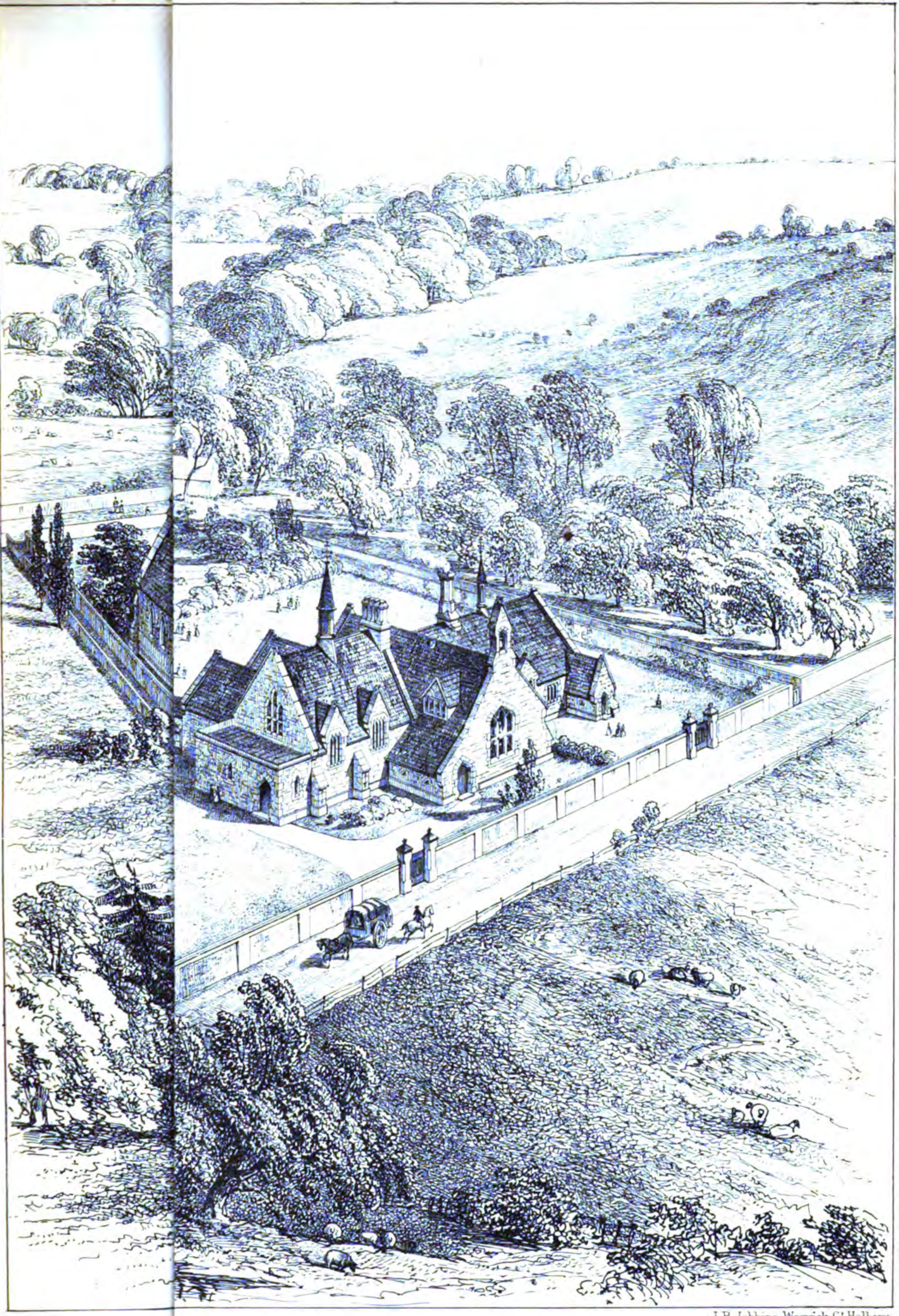
Moses Poole, London, gentleman, for improvements in combining caoutchouc with other matters.—September 18.

Francois Mathieu, of Hatton-garden, Middlesex, gentleman, for improvements in apparatus for containing, aerating, refrigerating, filtering, and drawing off liquids, and in ornamenting such apparatus.—September 23.

John Lawson and Edward Lawson, both of Leeds, machine makers, for improvements in machinery for scutching and cleaning flax straw.—September 23.

Jacques Leon Tardieu, of Paris, gentleman, for certain improvements in the colouring of photographical images.—September 23.

Robert Bowman Tennent, of Gracechurch-street, London, merchant, for certain improvements in the mode of pulping cherry coffee, and in the machinery applicable thereto.—September 24.



J. R. Jobbins, Warwick Ct Holborn.

N FOR SCHOOL MISTRESSES

GLOUCESTER AND BRISTOL DIOCESAN TRAINING INSTITUTION.

Messrs. J. Clarke and J. Norton, Architects, London.

(*With an Engraving, Plate* XXXVIII.)

On several occasions lately we have had to record the erection of a new class of buildings of an important and somewhat collegiate character, destined to furnish our various dioceses with a long-felt desideratum—namely, a supply of male and female teachers, qualified by previous education and training for the discharge of the important duties required by the advanced and enlightened spirit of the times for the office of Masters and Mistresses of Parochial and Village Schools. It is confidently asserted, that in a few years hence an efficient and well-trained class of young persons will be supplied by the exertions now making, sufficient for the demand, and the clergy will thus be relieved from a source of constant annoyance and difficulty. It is a matter of exultation to all friends of the Established Church that the great movement which is daily adding increased facilities of education to the poorer classes all over the country, will not depend solely on the existing and precarious supply, but that authorised institutions, under diocesan supervision, will afford a certain guarantee to founders and promoters of church schools that the exigencies of the times have been met, and that competent persons will ever be ready at hand to carry into effect their benevolent wishes of affording to the classes most needing it the advantages of a sound education, based on the teaching of the Church of England.

The building to which we wish particularly to refer our readers forms the subject of illustration in the present number, and is now progressing at Fishponds, near Bristol. Although the buildings are nearly half completed, the chief stone of the chapel was only laid on the 28th ult., by the Lord Bishop of Gloucester and Bristol.

Similar institutions have recently been erected near Birmingham, for the Diocese of Worcester; at Bishop's Stortford, for Rochester; at Culham, near Abingdon, for Oxford; and in other places; and, as stated in the inscription, the latter is in connection with the Institution under notice, which will accommodate seventy-five mistresses, whilst the sister building, near Oxford, provides for one hundred masters, jointly for the use of both dioceses.

The Oxford buildings form a conspicuous object from the Great Western Railway, rising up in the flat country between the town of Abingdon and the branch line to Oxford. The site of the Fishponds Buildings is altogether secluded, and not inappropriate to its scholastic character. The village is situated about three miles north-east from Bristol, on the old Gloucestershire road, and is in the parish of Stapleton, where is situated the Episcopal Palace. The building is placed out of sight of the main road, between the village and the river Frome, the picturesque banks of which afford so many subjects for our annual exhibitions, and are to be recognised in the charming sketches of Müller, West, and other of Brislot's artistic celebrities. The scenery over the valley of the Frome is finely wooded, and commands a view of Stoke House on the opposite heights, and the romantic and secluded village of Stapleton. But as this is indicated in our view, we will add some notes on the arrangement of the building itself. The plan is unusually broken and irregular; but as this is characteristic of the style adopted—the Middle Pointed or Decorated Gothic of the age of the Edwards—much picturesqueness results. We are informed the site proved to have been quarried irregularly all over; and to avoid expensive foundations, the architects were confined to the irregular outline occupied by the buildings; but lovers of the picturesque will not regret the difficulty, for the bold breaks and receding blocks of buildings form an ensemble somewhat novel and refreshing in this age of monotony and show fronts, which so frequently satiate without pleasing the eye.

The chapel, placed with due regard to orientation, forms the first feature, and is a single parallelogram, with enriched and traceried windows, and an ornate bell-turret on its western gable. A series of open arches forms a sort of cloister to the chapel, and connects with the main college buildings; and in continuation of this cloister is a wide corridor, or ambulatory, extending the entire length of the front, lighted by a series of mullioned windows.

The first block of buildings comprises class-rooms, library, and music-room, opening into the ambulatory. The main entrance for visitors forms the feature of the tower, opposite which is the principal staircase to the dormitories. The pointed windows to the right light the dining-hall, which is of noble dimensions, and a corridor extends westward from this to the residence of the matron, which has a frontage towards a road leading to Stapleton behind. The dormitories for the pupil teachers are large and lofty, being obtained partially in the high pitched roofs. Separate divisions are formed for each pupil by wood framing, and in each division is the apartment of an assistant mistress, for purposes of supervision.

A block of low offices connects the scholastic buildings with the residence of the Principal, who will be a married clergyman, and (with the matron) superintend the working of the establishment. A covered way extends from this point across the field to the block of picturesque buildings in the foreground. These are destined for "Practising Schools," for the use of the pupil teachers, and consist of three rooms of large dimensions for girls, infants, and the children of yeomen of the surrounding villages, with class-rooms and their needful accessories. The roofs of these rooms are open, of high-pitch, and well broken up with louvres, chimney-stacks, and other constructive features. Playgrounds will be formed for the use of the children, and gardens and walks for the recreation of the inmates of the college. The entrance-drive will be from the road leading to Oldbury, through a pointed archway, at the side of which is a lodge for the gate-keeper and gardener.

It is expected the establishment will be completed by about May 1853, and we learn the cost will be under 9000*l.* (irrespective of fixtures and furniture.) The stone for walling, paving, and tiling for roofs, being quarried on the site, or close by, has materially reduced the amount of the contracts. These are undertaken by Messrs. Willcox, of Bristol, with the exception of the iron castings for floors (which are constructed fireproof, on Fox and Barrett's patent), supplied by the Butterley Iron Company. The necessary funds have been raised by the exertions of the Bishop of Gloucester and Bristol, assisted by the clergy and many wealthy laymen of his diocese interested in the cause of education based on Church principles, further aided by large grants from her Majesty's Committee of Council on Education, and the National Society.

The architects are Messrs. Joseph Clarke and John Norton, of London, who are now engaged in carrying their design into execution.

EXCAVATIONS AT SAWLEY ABBEY, CRAVEN.

On the Excavations recently made at Sawley Abbey, in Craven, a Ruin situate in the Vale of the Ribble, immediately above that point of the river where it becomes the boundary between the counties of York and Lancaster. By John Richard Walbran, of Ripon.—(Paper read at the Thornton College Meeting of the Lincolnshire and Yorkshire Architectural Societies.)

After giving a sketch of the history of the convent, which was of the Cistercian order, and founded by William de Percy in 1147; an account of its suppression in consequence of the attainder of the abbot in 1537; the descent of the estate from the crown grantee, Sir Arthur Darcy, to its present possessor, the Earl de Grey; some particulars relative to the site of the village of Sawley, that has sprung up within it since the Reformation,—Mr. Walbran proceeded to detail, with great minuteness, the result of excavating what has previously appeared only to be a shapeless mass of rubbish. Though, with the exception of a portion of the church, no part of the wall rises much above 10 feet high, yet the greatest part of the entire ground-plan has been discovered, and many singular and interesting objects brought to light.

According to the usual Cistercian arrangement, the church was on the north side of the cloister court, though only bounding it for a small space; the chapter-house, and two other small apartments, flanked its east side; the frater-house, kitchen, refectory, and scullery, were on its south side. The west side of the quadrangle has been so much spoliated, that it is impossible to say more than that it has been formed of buildings appropriated to domestic uses, and, though contrary to all rule, not improbably, by the abbot's house. The plan of the church is cruciform, but with this singularity, that its width from north to south, along the transept, exceeds its length from west to east by 24 feet. Of this latter space the nave, which is a mere excrescence from the transept, contributes only 39 feet. It has been exceedingly gloomy, and without aisles. In the Decorated period, however, it had become necessary to add a north aisle, though this was done in the most clumsy manner, no opening having been made either by arcade or otherwise towards the nave, and to the transept only by a rude aperture that would admit of light but not of transit; and, in the excess of parsimony, the altar has been formed out of the very wall through which the opening has been quarried. The transept, which measures 132 by 32 feet, has been entirely reclaimed by the excavation. The east side is flanked, on each side of the choir, by three chapels, large portions of the altars remaining, except in those immediately joining the choir, which appear to have been cleared previously to the Reformation, when a new choir was in progress. In the floor of the southern chapel is a large sepulchral slab, remarkable for the sculpture of two foliated Early English crosses of similar design and dimension. That this design, which though very unusual is not unique, has not proceeded from the fancy of the sculptor is evident, for two skeletons were found immediately below in one shallow undivided grave. Near this stone, but in the transept, is a large slab which the circumscription tells us covers the remains of William de Rimington, once prior of this house and chancellor of the University of Oxford in 1372, and, as Mr. Walbran conjectured, the writer of some manuscript treatises against the Wickliffites, now in the Bodleian Library at Oxford. When the stone was repaired and adjusted, the skeleton of a tall and athletic man was seen below. There is no sign of interment in the next chapel, but the pavement is one of the most beautiful of the geometrical polychromatic works of the 13th century that has been discovered, and so nearly resembles one found in the Abbey of Meux, in 1760, that it is evident both had been copied from the same design. The middle chapel in the north transept has also a pavement of similar character, and in excellent preservation. The pavement of the northenmost chapel has been too of this sort, until disturbed by the insertion of a large sepulchral slab which covers, according to the inscription, in Norman-French, Robert de Clitherhow, rector of Wigan in Lancashire; a fact of more than ordinary interest, since this was the person who not only raised men to support Thomas of Lancaster against Edward II., but who also offered absolution to all who would join, in that quarrel, the standard of the barons; an offence for which he was brought to trial and condemned to death, but escaped by a timely application of his purse. West of this stone is a noble slab of marble, which, beside an Early English cross, bears on one side of it a sword, and on the other an object to which no use can be assigned, unless a sling for casting stones is thus meant to be represented. The choir, according to Norman fashion, has been very contracted, measuring only 40 by 25 feet; an inconvenience endured nearly to the time of the Reformation, when a spacious structure, 111 by 58 feet, was begun, though it is impossible to say how far perfected, since the foundation alone remains. At the same time, too, it was intended to enlarge the nave, as is shown by the foundation of the south wall running the whole length of the cloister-court. The chapter-house, a rectangular apartment, 45 by 20 feet, has been torn down nearly to the floor; but neither there nor in the church are any tombs either of the noble founder or of Lord William de Percy, who died in 1244, or of his son, Lord Henry de Percy, who sided so actively with King Henry the Third in the Baronial wars, and were all buried here, can now be identified. In the remaining parts of the building, which, though spacious, were poor like the rest, in architectural character, nothing is to be noted of particular interest, save that the ruin of the Gate-house has been cleared of the hovels by which it was surrounded, and that the Abbey mill and garners were leased to the father of the late Sir Robert Peel, who, finding the utility of the water power created by the dam, that has now for seven centuries stemmed the torrents of the Ribble, superinduced a cotton-mill, now happily abandoned, on the walls of the old structure, which still remains in tolerable preservation.

During the excavation, which was directed by Mr. Humphries, of Ripon, with unusual taste and judgment, many curious relics were discovered. Among the singular encaustic tiles described by Mr. Walbran, one has the inscription, "Johes Sallay Abbas xrs. ihu." Several hundred pieces of stained-glass were also picked up among the rubbish, mostly in good preservation, exhibiting beautiful patterns of diapers and borders, and part of a series of the twelve apostles, of the Decorated period, each delineated after a very unusual fashion at that time, on one pane or piece of glass. There were found also a few coins, a hawk's bell, a bronze needle, part of a candlestick or corona lucis, and three templets of lead, used in carving wooden tabernacle work, which are perhaps unique specimens of this kind of working-model.

The paper, which was of considerable length, and was heard with great interest and attention, will, we understand be published, with many illustrations, in the forthcoming volume of the *Transactions* of the united architectural societies.

PROGRESSION IN ARCHITECTURE AND ART.

By James Edmeston, jun.

At the opening meeting of the Architectural Association, on October 1st, the Annual Address was delivered to a very numerous audience, at their rooms, Lyon's-inn, by Mr. James Edmeston, the Vice-President, as follows:—

"In the absence of our respected President, I have the honour to open this, the tenth Session of the Architectural Association; and without entering for one minute into the history of its past proceedings, or attempting to declare what may be its future success, I will venture an observation or two upon the work we really have in hand—upon the *importance* of the objects which societies like ours are endeavouring to attain; important, because they are demanded of us by the times we live in. We hope by so doing we may all be stimulated to a fresh and vigorous exertion in the session now commenced.

True that we, as students of an art by which perhaps many of us are to gain our daily bread, by which we hope to reach a position of eminence and respect in society—perhaps a proud distinction—attach a real sense of utility, and find a real profit in our labours here for mutual advantage; and it is our happiness to mix up the grateful pursuit of knowledge and the cultivation of taste with solid considerations of substantial reward; but beyond all this, we may have the pleasurable consciousness of being workers in that great field of healthful thought and feeling, of bearing part in those efforts to develope the higher intellectual faculties by means of the gentle yet powerful teachings of the beautiful, which mark so distinctively the present age—the result of long years of peace and plenty; the growth first, and then the nourishment of a generally-diffused elevation of national morality.

The schools of design established all over Europe—the art societies—the artizan schools, and numbers of similar associations—all point plainly towards the direction public taste is taking, and are all called into action by it; and if one proof could be found stronger than another, it is to see, at this moment, the hard, calculating spirit of trade, deliberately counting the cost and relying on the profit to be reaped by an expenditure of large treasure in furnishing forth a resort of public amusement with food for the mind, and not merely for the eye and ear; in sending forth two gentlemen of known ability to select and purchase at great cost works of art the best and most rare—efforts of the highest taste and genius—and that to please and entertain a holiday multitude.

A better comprehension and criticism of works of art is becoming more widely diffused each day; the eye of the beholder becomes more alive to the beauties that may be placed before it, and learns to discriminate between the fictitious, the clap-trap, the merely mechanical, as opposed to the true and the poetic.

Since the first establishment of the schools of design in this country, in 1836, there has been a rapidly increased knowledge and demand on the part of the public for artistic treatment; and perhaps the great opportunities for comparison and for the exercise of judgment afforded by the Exhibition of 1851, have immensely contributed to advance this state of things. Time was when, from the highest branches of poetical design, down to the lowest connection between design and production of all kinds, there was but little encouragement afforded by the public at all. In manufactures the direct application of art was not understood, and there was a general absence of enlightenment and perception upon all matters of decorative art in all forms; and Professor Cockerell himself complained very justly, before a Select Committee of the House of Commons, that while the improvements in the science of building gave us great advantages over our forefathers, Architecture, as an art, had lost ground, and its principles were less understood than formerly.

At that time it was no fashionable subject of research; it was matter of caprice as to what style, of any age or country, could be called the best (the prevailing taste, indeed, was Elizabethan)—a state of things to be truly laid to the ignorance of the mass in matters of taste. But it was time that things should mend: manufacturers found there was a necessity to adopt different views—art manufactures and applications were called into existence—an art journal found a widely-extended support—books were written—lectures given—papers read before societies, the least and the worst of all as indicative as the best, of an earnest desire, an awakened spirit; calling into action all sort of argument, warm discussions, almost hostile demonstrations—so that opinions heretical to all before received became a creed to some, and the even, easy path of professional life became filled with stumbling-stones, with gaps and holes, hidden and unseen before; till the weary mind was well nigh tempted to put the whole down as empty trash, and to listen no longer.

But not so: the change within the last fifteen years is no less real than startling. The dark and changeful atmosphere of conflicting opinion for a time was calm, and the Great Exhibition rose like a work of enchantment, to bear an unimpeachable testimony to the work that had been doing. It is gone; but not its influence—not its effect upon the minds of the mass so inert before—not the interest in the admirable lectures by Redgrave, Wyatt, Jones, and others—not the love of the beautiful, engendered, perhaps for the first time in the minds of many, and the critical spirit aroused.

Without doubt, most of the false notions at one time universal, as to what constitutes an art, are now done away with; people understand that the material has little or nothing to do with the question, and that the hand and the mind are the same, whether applied to wood, stone, metal, or composition of any kind, no matter what the purpose or use of the thing itself. Much remains to do, but much has been done, to awaken an appreciation of beauty by its application to things of everyday necessity and common use. The industrial arts are leading the way, and each day the public mind will become more alive to, and will learn to relish, the higher and more ideal creations of fancy. Insensibly the public eye will become educated; the demand will be raised; and our business it is to be prepared to satisfy it, and to see that the noble art of architecture is not alone behindhand: and there is, indeed, much to do. In all this great city of London, how little is there which attempts, or professes in the least degree, to bear any part whatever in the general progress.

Time was when fashion, not principle, governed architecture—when it was a purely imitative, not an inventive art. The Elizabethan is no longer the rage. We have had a rage—the Gothic; but under the new influences how different to former imitative efforts! They failed, indeed. Far different the results achieved by those many active, zealous, intelligent minds, brought to bear, not on the best mode of exactly repeating something already existing, but in searching out undiscovered principles. And the more this is done, and the more it is felt, we see the imitative habit thrown off, and the inventive faculty called into active action; so that now there is hardly any Gothic church erected which can be pointed at as copied from any example—at least, not by any of the masters in the art. The mass is unfortunately not yet so well instructed but that in some—in many—cases the matter is intrusted to ignorant and imbecile hands.

Mr. Dickens finds fault with those who "have put back the hand on the clock-face of time;" and a talented lecturer is so far carried away by his identity with the present, as to designate Gothic architecture a "galvanised corpse;"—a venerable body it may be, yet alive with meaning, principle, and science. Let us not forget the immediate and excellent subject it furnished at the right moment for the spirit of investigation, and the discovery of principles which, so far from being exhausted, still offer an almost entirely unworked field for invention. The habit thus once engendered will become fixed; and the art will insensibly leave its leaning-post, and learn to run alone.

Nor have the profession been idle amid the general stir after improvement. I might dwell upon the great good that was done when its members banded themselves together, and occupied a high and influential position as the Royal Institute of British architects. I might allude to many societies, some of older standing—some of yesterday—some in the first stage of formation merely. But our immediate business to-night lies naturally with the mode in which *this* Society is made to bear its part towards the end to be reached,—as to how it can best improve its members in those qualities which we have endeavoured to show the age is unmistakeably demanding of them.

The architectural student labours under many difficulties. No mere drawing school or school of design will do for him; it would be quite insufficient, because his pursuit is mixed up with the technical knowledge of numerous handicrafts, of which he could not possibly gain any experience in a school. In the office it has been the custom to give him at the best a technical education—he is rarely or never consulted even on matters of taste; much less is there any regular course of instruction in its principles. The technical education is good, it is absolutely indispensable; and he has ample opportunity, with ordinary attention, to obtain a vast scientific and practical knowledge, particularly if he have the good fortune to be connected with talented and enterprising masters.

In the time of Angelo, Raffaelle, Corregio, &c., there were truly no such schools; but then the master and his pupils formed a sort of school in themselves, and worked through the several gradations of handicraft to the final artistic finish, from beginning to end, and the learner had far superior opportunities to him of the present day.

We have then a blank to fill up: and how can we do it better than by the formation of societies, combining the discipline and emulative character of the school, with a spirit the freest and most unshackled—where not only the experience of different members on practical points may be brought together for careful study and consideration, but where in addition there may be undisguised discussions and siftings of those artistic views present to the minds of all—besides the opportunity of putting upon paper results of such discussions or convictions produced periodically, and subject to a like open criticism. We may observe many of these efforts now upon the walls and tables, some of great merit; and there is not even a failure which has not in some degree benefitted the designer, if he be of an earnest and right spirit; and left him better than it found him.

In commencing a new term of our delightful labours, it will be well to remind ourselves of a few of those great general principles which we should ever have before us, and in the observance of which lie weighty aud important results. For example, I would say, let us start fair without the trammels of prejudice, and, in estimating the works of others, and the efforts that come before us here, consider above all things, not whether they are good Gothic—correct Italian—a pure Greek—but whether they are good Art; and by this ground let them stand or fall.

As to decoration, I would say that an edifice is to be ornamented, not converted itself into an ornament; that all decorative art must be considered entirely with reference to construction; that a sham construction to show ornament can be allowed on no plea whatever, however good in itself, however perfect in some other situation; and that unless it be the growth of local necessity, and be in harmony with the building it belongs to, it cannot be good.

Let all merely imitative attempts be shunned; let the architect realise and cleave to guiding principles, grapple manfully with the demands of utility, welcome all the wants of the society of this day, and resist every temptation to shams of all kinds: so will his invention have a character of its own and of the time.

Let all designs in any of the preceding styles be made with a clear perception of their principles, rejecting peculiarities simply because they are such, and adopting the spirit in its purest and best form.

Everything should be designed with the most complete reference to the material and its constructive necessities. A cast-iron door, made on the model of a wooden one, with stiles and rails, would be a manifest absurdity—yet not so great but that it has been often done: witness also for a similar error the malachite doors in the Great Exhibition.

I might pursue this subject further; but I see around me gentlemen, not only eminent in the profession, but who may also claim a high position in the world of literature and learning; and I trust they will take it up for an improvement, and not leave us this evening without the benefit of their experience.

I would say, finally, above all things let us join in this present session, with an earnest and untiring zeal, in advancing the objects we have in hand. Let all minor considerations be lost in the full appreciation of the work we have to do; and, I doubt not, this session now commenced will be as interesting, as instructive, and more so, than any that have preceded it."

FRESCOES IN THE TOWNHALLS OF ACHEN AND ELBERFELD, GERMANY.

Fresco painting is undoubtedly that pole of pictoral art most turned towards the cause of the people—the painting for *all*. It is in Germany, however, where this tendency has been eminently followed of late, reminding us of the best times of the Italian commonwealth. And thus Kaulbach and Cornelius, names world-known, have been succeeded by junior artists, fully promising to follow in the path of their great masters. M. Alfred Rethe is a pupil of the Munich school, but mostly exerted himself in the Rhinelands. There he first painted his scenes of the Introduction of Christianity into Germany. His St. Winfried is as well a historical tablet as a historical picture. There, amongst the primeval forests of old Germania, stands the saint, surrounded by the sturdy, golden-haired (*gold-harigen*) inhabitants of those wild countries; at his command the oak consecrated to Wodan is cut down, to serve as the material of the new Christian temple, the plan of which the apostle draws on the surface of the sand. This and similar performances spread the fame of the artist, and when the Dusseldorf Art-Union decided on ornamenting the guildhall of Achen with frescoes, Rethe's designs obtained the prize, and are to be executed at their expense. The following subjects show the judicious selection of this artist amongst the important historical events of Germany, fit for a great pictorial representation:—the Destruction of the Irmensul, the great heathen memorial of the Teutones; a Battle with the Saracens near Cordova; the Baptism of Wittekind; the Building of the Achen Cathedral; Coronation of Charlemagne in Rome; and the opening of the Sepulchre of Charlemagne by Otho III. The completion of these frescoes will make the guildhall of Achen one of the most interesting in the whole of Germany. M. Rethe has of late been sojourning in Rome, being occupied with drawings of an especially daring character—the Passage of the Alps by Hannibal, copied from the description of Titus Livius and Polybius. Some of these designs are of the highest character, and denote the great art-daring in grappling with such vast masses and scenery as the snow and wilds of the Alps, &c. It is very probable, however, that these sketches will never be executed on the continent, but that M. Rethe, like his fellow-artist, Leutze, will adorn therewith some of the public buildings of the great republic of the West.

In conjunction with the works of Rethe, we may name those of M. Joseph Fay, of Cologne, whose frescoes for the townhall (*Rath-haus*) of Elberfeld attract general notice. They represent scenes of the primeval history of the German people, recalling the vivid descriptions of Tacitus. Thus, a sword-dance, where splendid, youthful figures, full of life and daring, jump through and around the swords planted in the ground. Another cartoon represents the religious rites of the ancient Germans. A grey-haired priest stands before the fiery pile, engaged in imprecation and prayer. This night-scene has been especially admired in Munich and Paris, where M. Fay has exhibited his cartoons, and which, when executed, will place high in the scale of art the comparatively modern city of Elberfeld.

J. L.

THE CONVERTIBILITY OF PHYSICAL POWERS.

Sir—I have just seen Mr. W. J. M. Rankine's paper on this subject in your last number; in this paper he notices the results of my experiments on locomotives, and adduces them in favour of his principle of the convertibility of heat with mechanical power. Fixed and acknowledged principles are certainly desirable, even when they may not have any direct influence upon practical arrangements, as they at least prevent useless speculation and economise intellectual labour. I do not believe that much more can be said for the doctrine of mechanical equivalence and convertibility advocated by Mr. Rankine, even if it be well founded; and it is my impression that he has overstrained his conclusions, while he has certainly misinterpreted the evidence of my experiments. His principle is, specifically, that "when saturated steam, or any other vapour, gives out mechanical power by expansion, the heat converted into mechanical power by the expansion is greater than that supplied by the reduction of temperature corresponding to the reduction of pressure; so that," he adds, "a portion of vapour must be liquefied to supply enough of heat to expand the rest." He distinguishes also between the condition of expanding steam or air moving a load, or doing work, and its condition while flowing freely into the atmosphere, as a jet; and finds that in moving a load, a quantity of heat is converted into mechanical power, and, as heat, permanently disappears; whereas, in expanding freely, the heat consumed by expansion is restored when the agitation subsides, by the friction of the particles.

Now, it appears to me that much more direct and decisive evidence is wanting for the establishment of these principles than Mr. Rankine has supplied; for the phenomena he adduces in support of his doctrine are equally and much more simply explained by the ordinary laws of nature. The distinction between expanding steam moving a load, and expanding steam flowing into the atmosphere is merely circumstantial: in the former case the steam moves something else; in the latter, itself. Its expansive force is the same in both cases, and, so far as expended, does the same amount of work.

In his allusions to my experiments, Mr. Rankine does not fairly represent my views, for he gives it as a conclusion of mine, "that during the expansive working of steam a portion becomes liquefied, unless it is supplied with heat from without." He should at least have added that not only does the steam condense during expansion, but that in such a case it condenses also during its admission into the cylinder; moreover, that when the expansion is sufficiently protracted, the condensation ceases at a certain stage, and a reverse process of re-evaporation takes place during the later part of the expansion; and to such an extent may this reacting process be carried, that the quantity or weight of steam at the end of the expansion often greatly exceeds the weight of steam at the moment of suppression or cutting off. My explanation of these remarkable results was, that the material of the cylinder extracted the heat of the steam at the higher pressure, during the first part of the stroke, and restored it to a greater or less extent towards the end of the stroke, when the temperature of the steam fell below the newly acquired temperature of the cylinder. In my second paper on the subject, read before the Institution of Mechanical Engineers, and also in my work on 'Railway Machinery,' I have given numerous confirmations of this view of the question; and I do not see that Mr. Rankine's theory explains the phenomena referred to, with anything of the probability that attaches to the explanation already given and fortified by varied observation.

But, indeed, it is no notion of mine that steam *must* be partially liquefied during expansion, unless supplied with heat from without. What I hold is, that if the temperature of the cylinder be at least as great as that of the steam, there is no condensation; and that the steam becomes slightly surcharged in the mere act of expanding,—which I think is very plainly proved by Mr. Siemen's experiment. In short, it would be sufficient for the dry expansion of steam that the material of the cylinder be a perfect non-conductor of heat.

D. K. Clark.

29, *Buccleuch-place, Edinburgh.*
October 23, 1852.

ON THE SIZES OF MAINS AND SEWERS.*

The general practice with respect to the sizes of sewers constructed previous to the investigations made by the Commissioners, and even yet very commonly adhered to, is concisely given in the evidence of Mr. Kelsey, then surveyor of the City Sewers Commissioners, taken before the Commissioners for inquiring into the means of improviag the Health of Towns:—

"For the ordinary purposes of one house an 18-inch main drain receiving collateral 9-inch drains may with fair usage last many years without cleansing, but when it has to be cleansed, the trouble and the cost of digging pits from the surface and raking out the filth will be considerable. But for the use of a line of houses in a public street, wherein some one or other will treat the drains unfairly, it may be laid down as a first principle that no common sewer should be so small that an ordinary-sized man could not get in to cleanse it: for if it were so small it would not only soon become choked up, but opening the surface to cleanse it would stop or more or less impede the traffic of the

* General Board of Health.—'Minutes of Information collected with reference to Works for the Removal of Soil Water or Drainage of Dwelling-Houses and Public Edifices, and for the Sewerage and Cleansing of the Sites of Towns.' Ordered to be printed for the use of Local Boards and their Officers, engaged in the Administration of the Public Health Act. Presented to both Houses of Parliament by command of Her Majesty. London: Eyre and Spottiswoode. 1852.

street. Taking a man of ordinary size, it will be found that a height of 1 ft. 11 in. will just allow him to squeeze through on hands and knees, and 3 ft. 3 in. will admit him crouching, and 4 feet stooping. To these must be added two or three inches to allow of the raising of the body when moving forward, and there should be some additional allowance made for indurated soil in the bottom of the sewer. Taking these data, one can scarcely allow less than from 2 ft. 4 in. to 2 ft. 6 in. for a man to crawl through; and 3 ft. 6 in. for a man to crouch through; and 4 ft. 4 in. to 4 ft. 6 in. for a man to stoop through; and as few men are less than 21 inches across the shoulders, it would not be unreasonable to say that 2 feet is the least width in which a man can work effectually, although he may pass sideways through 14 inches. Applying these to the question of what is the best sized sewer that ought to be built in any street, one is compelled to admit that it ought not to be less than 30 by 24 inches, and its depth not less 12 feet in its shallowest part. The thickness of the brickwork cannot be less than 9 inches, nor would it be prudent to leave fewer than two tiers of strutting and planking in the ground. The cost of such a sewer would probably be about 9*s.* 9*d.* a foot, being somewhat less than half the cost of a sewer 4 ft. 6 in. high, and 2 ft. 6 in. wide. But this assumes that the work is done under the most favourable circumstances, and at the present low prices; and the calculation of course, does not include gulleys, man-holes, &c., nor securing the houses of a narrow street. The term 'common sewer' (as for more than one house) is used in contradistinction from public sewer (as unfit for more extended purposes), and taking the limited height of 20 inches from the bottom of a public sewer to the bottom of a drain, as a fair and reasonable allowance for the accumulation of soil in such sewer, before the private drains can be obstructed and the sewer said to be foul; by adding 2 ft. 6 in. to that, we shall find that 4 ft. 2 in. is the least height which it is advisable to give a *public sewer*, but 4 ft. 6 in. is better as allowing freer space for cleansing."

It would be better that sewers of deposit, in their frequent condition, should be required to be opened to the surface as house-drains of deposit are, for cleansing, rather than that it should be permitted to continue the practice of sending men to crawl up them amidst foul ordure, to the certain injury of their health and at the hazard of their lives.

Main sewers were very generally found to be of larger sizes, with the certainty of containing greater accumulations than those in the circular form constructed for the City of London. For the convenience of working in them, they were commonly made with nearly flat segmental bottoms, and with upright sides and spreading footings. Circular work being more difficult or troublesome, it was found that the builders commonly preferred a similar construction for the smaller sewers, as the whole were built upon the hypothesis that deposit must accumulate; and except in the case of main sewers in valley lines, with considerable runs of water, it does so.

The whole evaporating surface of stagnant and pestilential matter beneath the houses and streets of the metropolis has been estimated to be equal to a canal 50 feet wide, 10 miles long, and above 6 feet deep, such as, if spread out 6 inches deep, would form a putrid swamp nearly 800 acres in extent, being nearly three times as large a surface as the whole population could lie down upon.

Sometimes large sewers as well as large drains are filled nearly to the top with deposit. In many lines of sewers irregular accumulations were found to have been deposited in consequence of uneven bottoms, junctions at right angles, or other causes. When large bodies of water, from sudden and extraordinary storms, have been driven into sewers containing such accumulations, the sewers have become completely choked, and have caused flooding, not, as was commonly supposed, because they were too small to convey away the storm-water, but because they were too large to be kept clear by their usual streams. The instances cited to prove the insufficient capacity of sewers, really proving their extravagant sizes, or their bad construction, or both.

It is important that the result of inquiry on this point should be understood—namely, why a small channel or drain, properly adjusted to the run of water to be discharged, will be kept clear, while a large channel, with the same quantity of water to be discharged, and with the same fall or inclination, will accumulate deposit.

In large drains, a given run of water is spread in a thin sheet, which is shallow in proportion as the bottom of the drain is wide; hence friction is increased, the rate of flow retarded, and, according to a natural law, matters at first held in suspension, and which a quicker stream would have carried forward, are deposited. If there be any elevated substance, the shallow and slow stream, having less velocity and power of floating or propelling a solid body, passes by it. But if it were a 4-inch drain, the same quantity of water would assume a very different relative position; and it will be readily understood that the deeper stream of the contracted channel would be more powerful to remove any obstructing body.

Instead of concentrating the flow of small streams, and economising their force, the common practice is to spread them over uneven surfaces, which "deadens" and "kills" them. In a small drain an obstruction raises an accumulation of water immediately, which increases, according to the size of the obstruction, until four, five, or six times more hydraulic pressure is brought to bear for its removal than could by any possibility be the case in a large drain; for in a large drain of three or four times the same internal capacity, the water can only be dammed up to the same relative height by an accumulation of matter three or four times higher and therefore twenty-seven or sixty-four times greater, which will gradually lengthen out, and then be beyond the power of removal by the water.

Earthenware pipes, if properly constructed and non-absorbent, wear away less than brick drains do, and much less frequently want repair. From their reduced size less earth has to be excavated from a narrower trench, and they may be laid down more quickly and with more certainty than the common brick-drains. Rats cannot work through earthenware pipes, and as, when properly laid, they detain no deposit, and when smoothly made, give no foothold, they afford neither food nor shelter for such mischievous vermin.

Observation of the laws of moving water, or the conditions under which water in slow motion deposits matter in suspension, and, with increased motion, lifts and removes, first, fine sand, then, with accelerated motion, coarser sand; then pebbles; then large stones; and, lastly, boulders and vast masses of rock; and the consideration of the inclinations by which velocities might be regulated, should have prevented the expensive errors which are displayed in the sewage arrangements for towns. But such investigations have yet to be made and recorded, at least as respects flows on the scale of rivers; though authentic and trustworthy experiments, made under varied circumstances, would be a work of national importance. The data usually referred to as governing practical applications were found upon inquiry to be wholly unsatisfactory; as, for example, those in Professor Robison's 'Treatise on Rivers,' which proved to be largely at variance with other observations.* Some of these discrepancies appear to have arisen, from partial investigations, from the omission to notice, amongst other things, that the power of water to suspend and to remove solids along the same line of inclination or fall, is as the depth or head of water flowing. Thus a stream of water 4 feet wide and 1 inch deep, with a fall of 1 in 150, is sluggish; the same water, if passed through a pipe of 12 inches diameter, having the same rate of fall, would be comparatively a rapid stream. The one would deposit silt or sand, the other would certainly remove both.

It will be seen it would be far better, were it necessary for the inhabitants of many houses to pay for new tubular drains every year, and run the risk of having them stopped up every month, than to have large drains, detaining and spreading deposit, and facilitating decomposition within the walls and beneath the floors of their dwellings.

The necessity of the construction of house-drains with better materials and forms became immediately manifest upon the sanitary inquiry in 1842, but at that time nothing of the kind existing or being known in the house-building trades, Mr. Roe was requested to get some pipes made. Being afterwards asked to ascertain experimentally, for the immediate purposes in view, the difference of the run of water in an earthenware tubular drain, as compared with that through a tubular or barrelled brick drain, he found that the gain of velocity in favour of the better formed and less inexact surface was not less than one-

* He states, for example, as a general proposition, that a velocity of a stream of half-a-mile an hour, will separate and lift up particles of coarse sand, and of about three-quarters of a mile fine gravel; whereas an instance was given of the velocity of water in the Bridgewater canal, towards the locks at Runcorn, of a velocity of about one mile an hour, at which silt is *deposited* by the water. Rivers in many parts of the world deposit silt so as to raise the surface of their waters above the adjoining land.

third; there would consequently be, with the same quantities of water, nearly a double power of cleansing. But the tubular drains of the description tried, though the best that could then be obtained, were by no means perfectly true in shape, and they may still be rendered much more exact by a pressure applied by a machine when half dried. With this increase of exactness, and with but slight variation in diameter, it appears that they discharge one-fourth more water in the same time even than the rude hand-made pipes first tried.

It appeared to be a common doctrine which governed the construction of such works, that it mattered little whether the surface of sewers or drains was smooth or rough; that even if they were made of rubble stone the only practical effect would be to diminish the diameter of the drain to the space between the points of the protuberances. Upon investigation this doctrine was found to be wholly erroneous in respect to sewers as well as house-drains; Mr. Roe showed that brick sewers, whenever the surface was made comparatively smooth with cement, were kept clear of deposit, whilst the sewers having rough brick surfaces, with the same inclinations and the same quantities of sewerage, accumulated it.

Subsequently other trial works were directed to be made to ascertain the correctness of the existing hydraulic formulæ, and their applicability for determining the sizes of underground channels which might serve for town-drainage. The chief results as respects the house-drains are thus described in an examination of Mr. Medworth, the surveyor appointed to make the trials:—

Among other things, were you not directed to try the flow of water from pipes of different constructions—some formed with pressure and some formed in the common way?—I was.

Did you not find that making the pipes smooth in the interior gave an increase of velocity of a third or fourth through a 3-inch pipe?—I did. Experiments were made with redware pipes, smooth, but not glazed.

What quantity of water would be discharged through a 3-inch pipe on an inclination of 1 in 120?—Full at the head it would discharge 100 gallons in three minutes, the pipe being 50 feet in length. This is with stoneware pipe manufactured at Lambeth. This applies to a pipe receiving water only at the inlet, the water not being higher than the head of the pipe.

What would be the rate of discharge supposing the whole 100 gallons to pass through the drain from the back to the front of the house, say some 60 feet, and how soon would the water be clear of the premises?—All that could be swept away by 100 gallons would be discharged clear of the house at the rate I have already stated.

What would be the power of sweep?—Sufficient to remove any and even more than ordinary and usual semi-fluid deposit that is found in house-drains—that is, supposing the whole of the 100 gallons was to be discharged in the time stated.

What water was this?—Sewage-water of the full consistency, and it was discharged so completely that the pipe was perfectly clean.

At the same inclination what would a 4-inch pipe discharge with the same distances?—Twice the amount (that I found from experiment); or, in other words, 100 gallons would be discharged in half the time. This likewise applies to a pipe receiving water only at the inlet, and of not greater height than the head. In these cases the section of the stream is diminished at the outlet to about half the area of the pipe.

Then a 4 inch pipe will discharge a 24 hours' supply of sewage-water a distance of 50 feet in a minute and a half?—Yes; taking the 24 hours' supply to be 100 gallons.

Did you not try the force of this discharge with sand? and if so, with what proportions?—Yes, with sand, in proportion of from $\frac{1}{16}$th to $\frac{1}{20}$th the volume of the water, and the whole was entirely removed.

But the different construction of the pipe with respect to smoothness will make full a fourth difference in the rate of velocity?—Yes; with the redware pipes formed by pressure, the accelerated velocity due to regularity of form and smoothness of surface was one fourth.

What pipes did you use in these experiments?—In some experiments, including those previously referred to, we used redware pipes, but principally glazed stoneware pipes were used in the experiments at Greek-street.

Have you not found that exactitude in the make is more important than the glaze?—Yes; the exactness of form and *accuracy of joint* are very important, so that the pipes may run into each other and form a complete cylinder. As an instance of the importance of exactness of joint, I had a case happen at one of my houses within the last few days. The tenant complained of the stoppage of the train from the closet, &c. Upon sending a man to make an examination, it was found that the trap contained several oyster-shells, and one had been discharged into the drain where it was arrested by an imperfectly-formed joint.

Then you found on experiment that this exactness of form expedited the discharge full one fourth?—Yes; as before stated in the case of the redware pipes.

Before these experiments were made, were there not various hypothetical formulæ proposed for general use?—Yes.

What would these formulæ have given with a 3 inch pipe, and at an inclination of 1 in 100? and what was the result of your experiments with the 3-inch pipe?—The formulæ would give 7 cubic feet, the actual experiment gave 11½ cubic feet; converting it into time, the discharge according to the formulæ, compared with the discharge found by actual practice, would be as 2 to 3.

Or, putting it into another form, if there were a given quantity of detritus or fæces to be removed, it would according to the formulæ, require nearly double the quantity of water that was found absolutely requisite in practice?—The proportionate discharges were found to be as 2 to 3, therefore the power required would be in those ratios.

How would it be with a 4-inch pipe?—The formulæ would give about 14·7 cubic feet per minute, whereas practice gave 23 cubic feet per minute.

Take the case of a 6-inch pipe of the same inclination?—The result, according to Mr. Hawkesley's formula, would be 40½ cubic feet per minute; from experiment it was found to be 63½ cubic feet per minute.

Will you convert that into time, and consider the 6-inch pipe as a small branch sewer? Within what time would 100 gallons be discharged at the same inclination over 50 feet?—It would be discharged in 15 seconds.

That is to say, that the actual experiments prove how much less water can be made to suffice than these formulæ prescribe?—Precisely so.

Then with respect to mains and drainage over a flat surface, the result of course becomes of much more value as the difference proved by actual practice increases with the diminution of the inclination?—Certainly, to a very great extent. For example, the tables give only 14·2 cubic feet per minute as the discharge from a pipe 6 inches diameter, with a fall of 1 in 800; practice shows that, under the same conditions, 47·2 cubic feet will be discharged.

Will you give an example of the practical value of this when it is required to carry out drainage works over a very flat surface?—An inclination of 1 in 800 gives only 14 cubic feet per minute according to theory, while, according to actual experiment, and with the same inclination, 47 cubic feet are given.

Then this difference may be converted either into a saving of water to effect the same object, or into power of water to remove feculent matter from beneath the site of any houses or town?—It may be so.

And also the power of small inclinations properly managed?—Yes; for example, if it was required to construct a watercourse that should discharge, say 200 cubic feet per minute, the formula would require an inclination of 1 in 60 = 2 inches in 10 feet; whereas, experiment has shown that the same would be discharged at an inclination of 1 in 200 = ⅝-inch in 10 feet, thus effecting a considerable saving in excavation, or a smaller drain would suffice at the greater inclination. The practical importance of knowing the precise value of inclination is incalculable, and will be found so in laying down drainage for a flat district, or through loose and wet soils, where the extra labour in excavating the last few inches in depth to obtain a given level will often exceed in cost as many feet. I have frequently met with such cases. To name one, I will state that, during the progress of a sewer contract I had in 1842 for the Commissioners of the Holborn and Finsbury district, the depth of the trench was about 9 feet, and perfectly dry; the cost for labour was 8*d.* per cubic yard; the invert of the sewer, according to the levels given by the surveyor, required to be about 6 inches lower, and this proved to be in a running sand of the most troublesome nature, and cost me at the least 10*s.* per yard in the removal before the invert could be laid down.

Gain of Fall on the same Levels by small Tubular Drains.

Besides so much gain in the force of sweep at similar inclinations, obtained by the use of tubular drains, gains in fall are obtainable from their reduced size, improved form, and smoother surface. In level districts this will frequently be a most important advantage. The height from the top of a 9-inch barrel drain to the bottom of the opening is 13¼ inches, while that of a 4-inch tube is only 5 inches, consequently, if the former must be level, the latter may have a fall of 8 inches; this, in a drain of 90 feet in length, would give a fall of 1 in 135. If a brick drain 60 feet long must be level, a 4-inch pipe may be laid with a fall of 1 in 90; if 30 feet long, with a good working fall of 1 in 45; whilst with the shorter lengths of discharge available by means of back drainage, say of 10 feet, the fall would be 1 in 15. This is of great consequence, as the velocity of discharge and its cleansing power increase proportionately with the fall.

Gain in Fall and diminished Friction of House Drains by Improvement in their Direction.

Besides reducing the sizes of house-drains, it appeared upon investigation that great alterations were required to improve their inclinations, or fall, and also to reduce their length. Water is chiefly used in and about the back offices of houses; water-closets are generally situated there, and thence the discharge of waste water will principally be.

The common or general practice has been to place sewers for the reception of house-drains so as to compel the passage of the refuse by a drain across the court-yard, underneath the back room or kitchen, underneath the front room, front pavement, and half the carriage pavement, to the centre of the street; whereas, if sewers had been laid at the back of the premises, frequently a house-drain of about one-third the length would have sufficed, and by the same means more rapid falls would have been obtained. The frictional area over which the refuse must be carried, by placing the sewers in the centre of the streets, will be many times greater than that which would occur in carrying the branch-drains to the back of the premises.

By the common practice of draining houses separately from the back, through the house, into the sewer placed in the centre of the front street, the offensive and noxious matter is carried completely under the house, instead of directly away from it, and the chances of stoppage are increased in proportion to the increased frictional area, and to the diminution of the fall. By these ignorant and mischievous arrangements, when a stoppage does occur, it can frequently be remedied only by taking up the floors of the front as well as the back room, and opening the foot and carriage pavement to the sewer in the centre of the street, all which work must be done at great inconvenience, and at oppressive expense.

The openings made by rats, through defective brick-drains, permit the escape into houses, not only of noxious effluvia from deposit in the house-drains, but also from that in the still further elongated cesspools—the sewers—as commonly constructed. A house-drain, as commonly constructed and arranged, acts as the neck of a retort, of which the sewer is the bulb, containing decomposing matter, which is discharged in the gaseous form into the premises.

Trial of Tubular House Drains.

The great majority of a town population do not differ so much in their habits, either as to the use of water—or in other respects affecting this question—to prevent the well-observed experience of an average group of houses sufficing, as to the main points, for general comparison; and the first trial works, which were made under the careful attention of the Dean of Westminster, were by him considered to afford a decisive proof of "the efficacy of draining by pipes, and of the facility of dispensing entirely with cesspools and brick sewers."

A severe epidemic fever had burst out in the houses connected with the cloisters at Westminster. Thirty scholars and inmates had been attacked, of whom several died. The houses had nearly all cesspools, and the inmates, during the variations of the weather, were beset with foul smells. On examination, it was found, that beneath the houses in which the fever raged there was a net-work of cesspools, old drains, and sewers. From beneath fifteen houses which were the chief seats of fever, 150 loads of ordure were taken; and from drains and cesspools connected with the houses, upwards of 400 loads were taken. These cesspools and old drains were all filled up, and an entire system of tubular house-drains with water-closets, substituted.

The changes in the sizes of the drains are thus stated:—"At the outlet, the main sewer in the old works was 4 feet high, by 3 ft. 6 in. wide, varying in width to 6 or 7 feet, and in height in one part to 17 feet. In the new drainage substituted there are two 9-inch stoneware mains, the united sectional area of which is but one-sixtieth of the area of the smallest part of the old sewer, and not more than one-half the area of the average of old single house-drains. We state that the secondary pipes are of 6 inches diameter, and the branches of 4 and 3 inches: 4-inch pipes were however used in many parts where 3-inch would have amply sufficed for all the requirements of the drainage, from an apprehension that the irregularity of the pipes would tend to create a certain amount of obstruction. This new drainage conveys the refuse and rain-water from fifteen houses, the Westminster School Buildings, the Chapter House, and Cloisters of the Abbey, Little Dean's Yard, &c., comprising an area of about two acres. There is a total length of drain of upwards of 3000 feet. The cubical capacity of the interior of the whole of the new main and branch drainage is about one thirty-second part of the cubical capacity of the interior of the old sewers; or the capacity of a portion of the old system is 32 times the capacity of the whole of the new system, exclusive of the old house-drains and cesspools; or the capacity of the old sewers is equal to a depth of water of more than 2 inches on the whole surface drained of about 87,120 square feet, or two acres; and they would have retained a rain-fall of this depth on the whole area."

In this block of buildings, the noxious evaporating surface underneath the area was upwards of 2000 square yards. The flow of gaseous emanations from such matter in certain thermometric or barometric conditions was such as, in a stagnant atmosphere, would have filled the school in about three hours, the houses in about sixteen hours, and the abbey itself in about ninety-three hours. It would have been a great gain to the inhabitants and scholars had the extent of the evaporating surface been merely diminished in proportion to the reduced cubical capacity of the tubular drains, but the whole of the old deposit was removed; with that deposit, the foul and noxious smells arising from beneath the premises have ceased, there has since been no epidemic fever, and a greater improvement in the general health of the population has succeeded than might be reasonably expected in a small block of houses, amidst an ill-conditioned district from which it cannot be completely isolated.

With respect to the action of the pipes, the result of this change, which has now (1852) been in operation more than three years, proves that, notwithstanding intermittent and ill-applied supplies of water, the force of the sweep in 4-inch tubular drains, properly laid, keeps them clear of all deposit, and also further proves that they require no extraordinary flushings. An accumulation of noxious deposit under houses, appeared upon investigation to be often due even more to the vicious construction of house-drains than to the bad falls produced by the defective arrangement of the system of sewers. One of the inspectors states, that in Sheffield a difference of 10*s.* in one particular case, between the tender of a responsible contractor, and one upon whom no dependence could be placed, determined the drainage of some valuable buildings in favour of the latter. In six months, the whole length of drain was full of deposit, and had to be reconstructed, at his own price, by the more responsible person. The proposed saving was about 3 per cent.; the eventual loss was 106 per cent. The owner was wealthy, and a clever business man. Similar cases frequently occur, and are not confined to any one locality.

The clearance of common house-drains, as well as sewers, when made on the hypothesis that they will accumulate deposit, is a source of constant expense. On an inquiry as to the cost of cleansing the brick-drains of 8000 middle-class houses in the metropolis, it was found to be, on the average, nearly 1*l.* each per annum, which, as it included the expense of making them good, as well as of opening and cleansing, may be said to include the expense of repairs. If the expense of cleansing the brick street-sewers were charged upon each house according to the frontage, at the average expense of about 29*l.* per mile per annum, it would amount to 6*s.* or 8*s.* per house, in addition to the expense of cleansing the brick-drains.

If the expense of removing all the stoppages which have occurred either in tubular house-drains or sewers were to be taken as a necessary and constant charge, it would be very trivial in amount as compared with the expenses above referred to. But stoppages in earthenware pipes are found to be due to want of care or skill, and are preventible. The stoppages in pipe-sewers, where they have occurred, have been chiefly from the bad quality, the thinness, and the breakage of the pipes in sandy or slippery soils, where they have been laid without proper protection,—from the inlets not being properly protected,—from not putting cesspits to prevent the admission of granite detritus into pipes, sewers provided with only very small or intermittent runs of water,—from the inlets of the house drains not being protected against the admission of large solid substances,—or from the drains being badly laid, with insufficient fall, or through ignorance or gross carelessness laid with reverse inclinations. In the metropolis, however, during the years 1849, 1850, and 1851, there have been laid down about 50 miles of pipe-sewer, and upwards of 150 miles of private pipe-drains, or a total of 200 miles, which keep clear by the action of their ordinary runs of water, where the older constructions—large sewers and brick drains—regularly accumulate deposits. The expense of cleansing the old brick sewers in the metropolis has been from 17,500*l.* to 18,500*l.* per annum. The same extent of cleansing, if it had been performed by hand labour or cartage, would, at the former contract prices, have been more than ten times as much. In the metropolis upwards of 18,000 houses have been pipe-drained.

NEW YORK EXHIBITION OF THE INDUSTRY OF ALL NATIONS.

Messrs. Carstensen and Gildemeister, Architects.

(*With an Engraving, Plate* XXXIX.)

The Exhibition of Raw Materials and Produce, Manufactures, Machinery, and Fine Arts (including Paintings, Sculpture, &c.), is to be opened in the City of New York, on the 2nd May, 1853. The directors have decided that prizes for excellence in the various departments of the Exhibition shall be awarded under the superintendence of eminent persons. The building, of which we give an engraving, is in course of erection on the ground in front of the Croton Reservoir, called Reservoir-square. The materials used in the construction are chiefly iron and glass.

The ground-floor is a regular octagon, 365 ft. 5 in. in diameter. This measurement does not include the three entrance-halls, each of which projecting 27 feet, is 40 ft. 5 in. wide. On each side of these entrances offices are attached, projecting 18 feet from the main building, and being 27 feet in width.

The interior consists of four great divisions, each having a main avenue with side aisles, which are connected on the ground-floor by four triangular sections. These main avenues unite at the dome, and together form a Greek cross, which shape is preserved in the gallery floor.

Dimensions.—Diameter of dome, 103 feet; height of dome from floor to skylight, 122 feet; height of avenues in the clear, 67 feet; height of first story in the clear, 24 feet; height of second story in the clear, 21 feet; height of aisles, total 45 feet; width of aisles, 54 feet; height of triangular sections, 24 feet; height of substructures, varying from 8 inches to 8 ft. 4 in.; width of avenue 41 ft. 5 in.; width of galleries, 54 feet; width of each front, 149 ft. 5 in.; diameter of each of the eight octagonal towers, 8 feet; height of towers above side-walk, 75 feet; area of principal floor, 111,200 square feet; area of entrances, halls, and offices, 6000 square feet; area of galleries, 62,000 square feet.

The building is being erected under the superintendence of Mr. Delmold, C.E.; the iron contracts having been taken by various houses. The chief part of the castings will be delivered from the 1st to the 15th December. The inauguration of the first column will probably take place about the 15th October; the time from 1st September until now being occupied with the masonry work. The cost will be about 45,000*l.* Mr. Carstensen is also the designer of the Casino and Tivoli at Copenhagen.

THE BROCK MONUMENT, TORONTO.

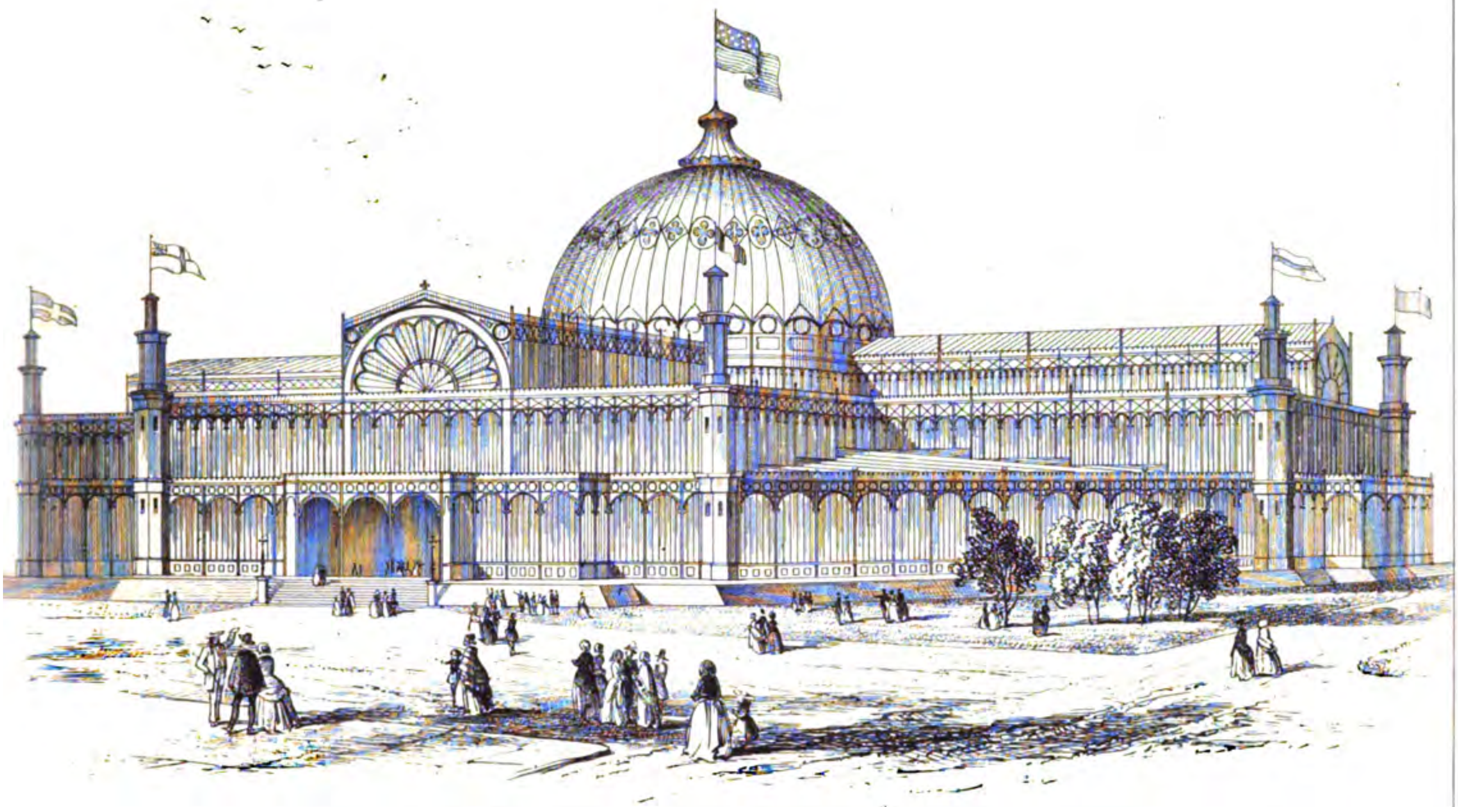
A monument is to be erected to the memory of the late General Sir Isaac Brock, at Queenston Heights, Toronto; and considering the nature of the work to be constructed, and how seldom an opportunity is afforded for the exercise of taste in so popular and attractive a subject, the competition appears to have signally failed. This may probably be traced to the fact that most of the architects declined to interfere in consequence of the claims of one of their number, whose design was approved and accepted some years since. Seven designs only were submitted for the premium of 25*l.* by five competitors. One a Grecian-Doric column, chaste and effective in character, by Mr. Young (the author of the design originally adopted). Two from Mr. Thomas—the first a Composite column on a high pedestal and stylobate, extremely graceful in design, of great altitude, but perhaps somewhat too delicately enriched; and the second, an arch surmounted by an equestrian statue of the General—which could not be said to offer any rivalry to the before-mentioned work by the same master. Another design—a Greek column, of no established order, but elegant in outline and detail, by Mr. Hutchinson Clarke, of Hamilton; two by an anonymous contributor—a Corinthian column with a garland wreathed around a shaft (!); and a Gothic mausoleum of most wretched charater and miserably rendered; with a Doric column, having sculptural ornamentation by a Boston sculptor, completed the number of essays submitted for this unquestionably attractive subject. From amongst these the committee have selected Mr. Thomas's Roman-Composite column, 185 feet in height, including statue, to be executed in Queenston stone, the construction of which is to be immediately commenced, and which, when completed, will doubtless approve itself to the public as worthy of its purpose and of the high reputation of its author.—*The Canadian Journal.*

EVIDENCE ON VENTILATION AND LIGHTING OF THE HOUSES OF PARLIAMENT.

Analysis of the Evidence given before the Select Committee appointed to Consider the Ventilation and Lighting of the Houses of Parliament and their Appendages.

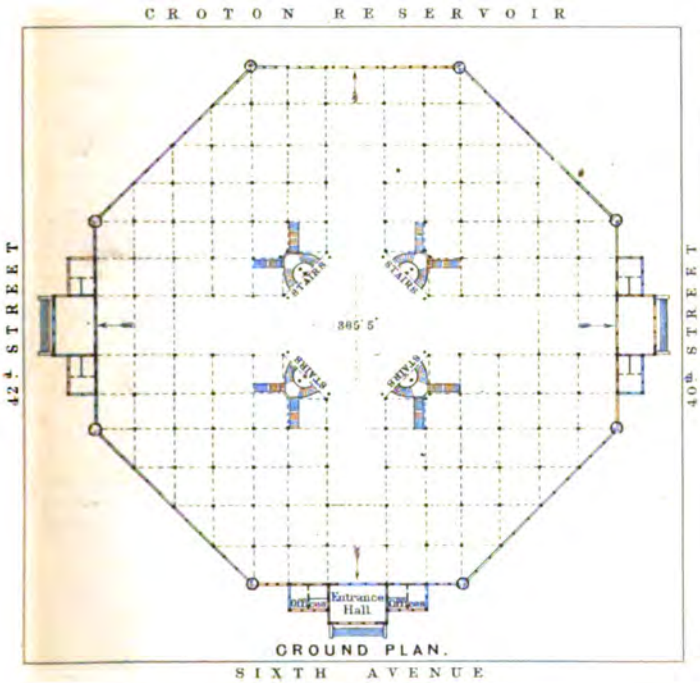
(*Concluded from page* 344.)

King (Alfred, Engineer, Liverpool)—Has been employed in lighting large buildings. The most important building which witness has been employed in lighting is the Philharmonic Hall at Liverpool: it is rather more than 120 feet long, 60 feet wide, and about 60 feet high; it is lighted simply by a row of jets; the ceiling is coved. Mr. Cunningham was the architect of the room; a good deal of attention was given to the construction of the room, in order that it should be properly ventilated. Natural currents are resorted to for the ventilation of the room successfully. Never heard any complaints. The centre part of the ceiling is flat, but the sides are brought down by curves to the cornice, which surmounts the walls. On the cornice are placed the lights, which are simply a row of 942 very small naked burners; over the orchestra there is one large clustered naked light, containing about 170 of the same lights as those on the cornice. That lights the whole of the orchestra, but the rest of the room is lighted from the cornice by the continuous row of lights. The flame is horizontal; a small jet of gas is always burning near to them, so that when the large supply is turned on, it instantly lights it, it flashes at once; the large sun-burner or cluster is lighted by a small jet of gas being always burning. Each jet of gas is sufficiently near to the next, that if one is lighted, it makes a train throughout the burner: it does not follow that they need necessarily touch to do that. The lights around the cornice are lighted by hand in sections. The supply-pipe is not a continuous supply throughout the building, but there is one large main supply from which there are branch sectional pipes; one pipe, perhaps, supplying twenty burners. A portion of the latticed-work of the cove falls forward, forming a trap-door, and then, by a staff, the twenty lights, which have been turned on, are lighted, and the person goes to the next and turns on another section, and so lights the whole. The greater portion of the light is produced by the direct light from the cornice. 2000 cubic feet per hour are consumed in the Hall, which will cost 9*s.* The horizontal light has been used in Liverpool four or five years. The rose light is a combination of vertical flames; the sun-burner a combination of horizontal flames. There is a cone of metal over the clustered burner, over the sun-burner; this cone or exit-pipe is only 6 inches in diameter, and even that is obstructed by means of a valve. That arrangement is necessary, in order to get the flames of the sun-burner to burn horizontally; for if the full amount of draught up that central pipe were allowed, the flame would be drawn together up the tube; but when that tube is used for purposes of ventilation (and a very powerful ventilator it becomes), it is surrounded by other tubes of a much larger size. The rarefaction produced within those larger tubes by the heat of the central pipe is so great that a very powerful current rushes up those exterior tubes. There is a valve in the ventilating-pipe over the clustered lights. It is simply a circular disc, supported on an axle which can be either turned in a vertical position in the pipe, or in a horizontal one, so that the quantity of draught in the pipe can be regulated by the position in which the disc of metal is placed. It never is closed, the current is only moderated; but even if it were closed, the products of the combustion would escape over the edge of the cone, and immediately flow up the surrounding tubes. They are concentric tubes, the burner being in the centre; then around the central pipe or cone, which contains the burner, is placed a large cylinder, and around that a still larger cylinder. These arrangements are necessary to secure the building from fire. They are introduced not simply for the purposes of ventilation, but also for protection. In some cases the cone, the internal portion of this arrangement, is at a dull red heat: it affords an immense amount of ventilation. The air enters the room for the supply that is taken out by these pipes all along the sides of the wall, about 5 feet from the level of the floor, through perforated zinc plates; it is either cool or warm air as the case may require. Witness has seen the contrivance adopted in the House of Commons at present for lighting. Is of opinion that no advantage would be gained by having ground glass placed beneath the lights. There is no doubt that great advantage is derived in the lighting of a room

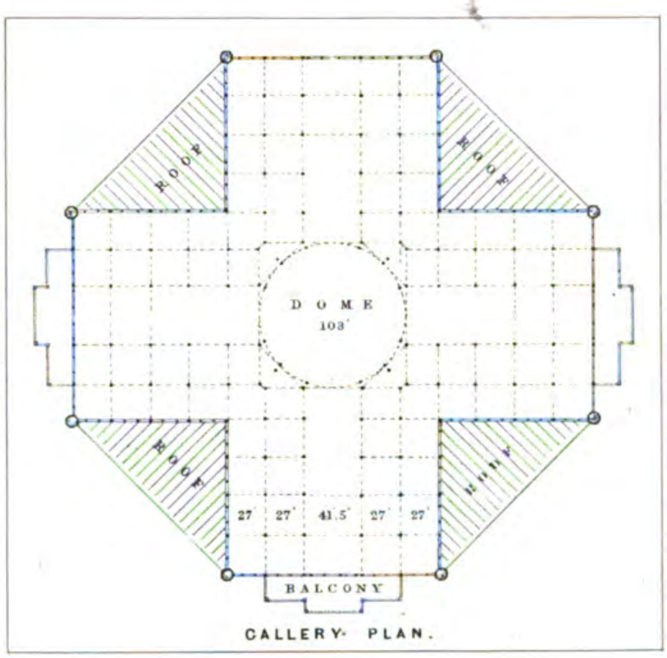


NEW YORK EXHIBITION BUILDING

From a design by Mess^rs Carstensen and Gildemeister.



GROUND PLAN.



GALLERY PLAN.

Scale 100 feet to 1 inch.

50 40 30 20 10 0 100 200 Ft

J R J

from the colour of the wall; white is the best for economising the light. Is of opinion that the lights might be so arranged in the present House of Commons that there should be no offensive shadow. The House of Commons might be lighted very differently from what it is. Witness's principal objection to it is its inefficiency, and it is also unsightly. It is always desirable that the light should be placed as much as possible above the line of vision. The same system of lighting might be adopted in the cornice in the square part of the House. It might be lighted by a combination of sun-burners and lights round the cornice. Witness does not contemplate that there would be any flickering in the light.

PRICE (HENRY CRUGER, C.E.)—Has been upwards of twenty years engaged in warming and ventilating buildings. About twenty years ago he took out a patent for a new hot-water apparatus. His system had been applied at Windsor Castle and Colney Hatch Lunatic Asylum.* Has warmed several county prisons and county lunatic asylums, and other public buildings. He adverted to an asylum which he has recently completed in the county of Wilts. At Windsor Castle he depended almost entirely, and at all seasons, upon what is called natural or spontaneous ventilation and warming. At Colney Hatch, in the winter, they relied entirely, and obtained all the results that are required there, by natural ventilation also; but in the summer they have the artificial motive power of a furnace for occasional use; constant use of it, even in summer, is found unnecessary. But in the Wilts asylum the warming power is hot water, and the ventilating power is hot water also. He mentioned that particularly, because, in his judgment and experience, that is the right combination. He used the hot-water coil as an extracting power; it is preferable to the furnace, as there are none of the fluctuations in the one that there are in the other. He recommends the following method for warming and ventilating:—"One feature of my method of warming is to accumulate a large amount of warming power in a comparatively moderate space. I centralise it. I do not mean that if I have a very large building to warm I place the whole warming power at a central point. I do not; that is highly injudicious, and involves a great deal of expense and difficulty. Another essential feature of my system of warming and ventilating is to pay a scrupulous regard to the relative and proper proportion of the areas of the air-passages. For instance, the main ducts should be calculated with areas equal to the precise demand that will be made upon them; then all the tributary, all the branch flues, must have a relative proportion of area to the main; so that in fact the whole thing is systematised. If a heating chamber for a large building like Colney Hatch were to be centralised, you would scarcely be able to move the air through it. When I mention that at Colney Hatch we have 25,000 superficial feet of warming surface, and that that building is 1800 feet long, if the power were placed centrally you would have to move the air horizontally 900 feet right and left; and as you would want to reach the remote parts to produce the same effect as in the near ones, the channels for air must be of a uniform area throughout, which would involve enormous expenses." His method is by low-pressure hot water; fixing the maximum temperature in most cases at 170°, that is 42° below boiling point. You cannot bring atmospheric air in contact with the surface at 212° without impairing its qualities. He adopts the ascending, the natural movement always, and relies principally upon the natural force of the differences of specific gravity, and only adds artificial force at that point where nature fails to be sufficient; and whenever the warming power is in operation, which it is during the winter season, then it is not requisite for artificial power to be added. It is only when there is a tendency to approximate in temperature, and when the specific gravity of the external air and the internal nearly approach each other, that it becomes necessary to assist nature by the application of artificial motive power. All systems of warming tend more or less to alter the natural hygrometric and electric states of the air. For every additional 27° of Fahrenheit that the air is raised in temperature, its capacity for moisture is doubled. The low-pressure hot water disturbs the balance of the air much less than the higher one; because, with the low-pressure, limiting the maximum of temperature to 170°, the temperature of the in-flowing air, which is of the greatest importance, can be limited, and it is found that that limit can be fixed at 80°. His objections to the descending movement are, that it necessitates artificial power; it will not act except under compulsion; then it brings the vitiated and breathed air, that ought to be carried away, and not breathed over again, down to the lungs to be re-inspired. It also tends to subvert another natural law by keeping the head in the hottest medium and the feet in the coldest, and the ventilation is arrested altogether if the motive power is not kept in constant operation; whereas, in greater portion of the year, nature will accomplish it, if allowed to do so. He should aim at keeping the temperature at 65°. Five cubic feet per minute to each person would sustain a thoroughly pure atmosphere; 3 feet per second would be a proper velocity. There is a fixed law of cooling applicable to windows: it is that it cools down the air of a room from whatever temperature it may be, to the temperature of the external air, at the rate of 1¼ cubic foot per minute for every superficial foot of glass. This applies to glass placed under any form. The mode of lighting the House is a very important ingredient in the plan of warming and ventilation; if the mode of lighting be one that generates a large amount of heat, it may produce a greater power of rarefaction than is required for ventilation. There would then be great difficulty; an excess of air would have to be drawn to answer that rarefaction. The downward radiation of heat from the ceiling is a most important consideration. It is very easy to account for the bad smells. The air is allowed to come in contact with all sorts of things and all sorts of persons, the channels being thoroughfares, aud the nature of the surfaces of those large passages being objectionable. Witness saw, in what is called the Mixing Chamber under the House of Commons, no less than six persons dusting. The present system of ventilating the House is altogether bad and unsatisfactory. Mr. Price stated his system of warming as follows:—A rising pipe from the boiler opens into a square vessel, technically called the expansion-box, to admit the increased bulk which the water takes by being raised in temperature, and it also leaves a certain space for the escape of the air which is held by the water when cold, and set free when warm. The heated water that rises from the boiler flows along a feed-pipe, which has the same number of flanges and apertures as there are flat vessels. There is a corresponding feed, or rather return pipe, which, in like manner, is attached to the lower ends of the flat vessels, and brings back the cooled water to the boiler to be re-heated and re-circulated through the flat vessels or air-warming surface. This supply-cistern maintains the water-line (which is of course above the feed-pipe), and keeps the whole apparatus charged with water—cold water in the first instance, and of one temperature. The equilibrium is disturbed and motion imparted simply by the action of the fire; then the hottest part rises here, and the coolest returns to the boiler. It is like the circulation of blood in the human system, it keeps flowing out and returning back in the same manner. The effect of this form and disposition of the warming surface is, that every one of the flat vessels answers the purpose of spreading out the hot water which is rapidly circulating through them into numerous and thin streams. The thickness of the sheets of water is 1¼ inch, and the air spaces between these flat vessels are 1¼ inch also, so that there is an alternation of thin and numerous streams of water with equally thin and equally numerous streams of air. The air from the outward atmosphere, falling by its own gravity down the flue, is then drawn, by the rarefaction produced by the warming vessels, into the chamber. Then the single current of cold air thus brought down is divided into 40, 50, or 1000 streams, if there are so many flat vessels, and there is a thin stream of air, of 1¼ inch thick and 3 feet square, touching at each side each pair of flat vessels: so that in fact each stream of air and each stream of water thus brought into close contact are each of only ⅝-inch in thickness. As these surfaces are all arranged vertically, in order to favour and develope the natural upward tendency of the air, the air passes up between them with a freedom and a velocity that causes the cold air to abstract the caloric of the water very rapidly, and thus attempered fills the air-chamber with hotter and hotter water, and the water as it cools flows back with a proportionate and accelerated velocity to the boiler, the source of heat. The air, on the other hand, rises continuously upward, and never returns: there is no mixing

* The following public buildings have also been warmed and ventilated by Mr. H. C. Price:—Wilts County Lunatic Asylum; Lincoln County Lunatic Asylum; Leicester and Rutland Lunatic Asylum; Oxford and Berks Lunatic Asylum; Bucks County Lunatic Asylum; Usk County Prison; Leicester County Prison; Oxford County Prison; The Small Pox Hospital, Highgate; Naval Hospital, Chatham; Fever Hospital, Bedford; County Infirmary, Derby, new buildings; Brecon County Courts; Derby Diocesan Training Institution; Chester Diocesan Training Institution; Rochester Diocesan Training Institution; Oxford Diocesan Training Institution; Marlborough Clergy College; Cirencester Agricultural College; Admiralty Department, Somerset-house; Rolls Court and Chapel; Institution of Civil Engineers; Indigent Blind School; Insolvent Debtors' Court.

of air. The communication is unbroken between the vertical shaft and the air-passages. It has no contact with anything; nothing tainted or impure can touch it till it is discharged into the House. The operation of the apparatus upon the hygrometric state of the air is not attempted till the air begins to flow towards the House. Suppose the interior of a chamber to be four brick walls; round these are a certain number of covered trays; when you do not want to vaporise the air those covers are down, but when you want to vaporise it you throw those covers open; then you expose the surface water. The air absorbs the vapour, and then flows onwards, charged with its natural amount of moisture; 27° of Fahrenheit additional temperature doubles the capacity of the air for moisture, and in very cold weather, and especially with the easterly winds, there is an absolute dryness in the natural atmosphere, independently of any operation to increase its temperature. In such a natural condition of the atmosphere, the dew point being very low indeed, a certain amount of moisture must be imparted beyond that which is due to the air's increased capacity for moisture arising from increase of temperature. For reducing the temperature, stop-cocks are employed. They are shut off, which stops the circulation directly, but without stopping the flow of fresh air; the air continuing to flow over the surfaces, and the water having no power of return to the boiler to have its temperature restored, is reduced 10° or 20° in the course of fifteen or twenty minutes. The hygrometer ascertains the quantity of moisture.

MEESON (ALFRED, C.E.)—Is in charge of the ventilation of the Houses of Parliament, with the exception of that portion under Dr. Reid's superintendence. The object of the system of ventilation of the House of Lords is to obtain a plenum. The extracting power is a steam-jet in some instances, and in other instances it is a coil of pipes heated with steam, and both in some: it is never in such force as to commence a vacuum, except in the Smoking-room, which is a vacuum ventilation; if it were a plenum ventilation there might be a liability, if the plenum was in excess in that room and the adjacent corridor and staircases, that the smell of tobacco would get into other parts of the building: therefore, whenever the door of the Smoking-room is opened, the air goes into instead of out of it. Self-regulating meters to measure the supply would not answer for the Houses; a little anemometer, by simple inspection, tells how much air, at the moment the observation is taken, is thrown into the building. The pipes are heated entirely by steam, with the exception of the Journal offices on the ground-floor, which are heated by hot water. The steam-pipes do not act on the air prejudicially in the tempering-chamber, where the air is first admitted in contact with the pipes; the temperature of them is seldom so great but that a person's hand could be borne on them. Any quantity of steam can be admitted, and any temperature produced. They are distributed through a large chamber; there is a rapid circulation of air around them, and that keeps the temperature of them so low. The pressure of steam is from 3lb. to 5lb., but it is wire-drawn into the pipes, so that any amount of heat can be produced in the pipes. The pipes are filled with hot steam at less than 212°, or rather hot vapour. It condenses through these pipes into water more rapidly than it is supplied, or as rapidly as it is supplied, therefore it distributes itself instantly into a rarer vapour throughout the pipe. The temperature of air in the tempering-chamber can be reduced 15° in ten minutes. The tempered air is mixed with the warmed air by passing the former from the tempering-chamber into a channel that conducts it into the Committee-rooms; that channel has also a side chamber, in which is the additional warming apparatus. The tempered air is permitted to pass from the first channel directly on into the second chamber, where the warming apparatus is, and may be passed through both at the same time; it then comes up into a chamber which is under the principal floor, and from thence passes through other ducts to the rooms that are to be supplied; so that for each of the Committee-rooms there are four channels of supply, two for tempered air, and two for the tempered air after it has been warmed; they unite in one chamber, and the air passing from that through flues to chambers under the floors up the buttresses to the ceiling of the room, is there passed through a trelliced frame. In this passage it becomes so thoroughly mixed that there is no need for any further mixing of it. A downward ingress of air is used principally, upward subordinately. In the House of Lords the ingress is in the centre portion of the ceiling; it is forced up from the fan under the House up vertical channels. The fan is in the channel near the tempering-chamber; it throws a portion of air into the chamber, and throws another portion on the other side of the fan, without passing into the tempering-chamber, directly into the House of Lords. The fan draws from the main air-channel; the air returns horizontally down into the House, and descends to the floor before it seeks for its exit. There is power to obtain air from the throne, and from the ends of the side framing. A series of flaps placed along the risers at the back seats, admit of being opened some two or three inches; there are some hung on centres that admit of being opened to a larger extent; at the table there is an aperture about 18 inches square on the top, covered with a finely perforated piece of zinc. In the Committee-room of the Inquiry, the ingress is from the east side of the ceiling over the windows, extending some two or three feet along the north and south sides; around the skirtings there is a moulding which is kept some short distance away from the plinth of that moulding, leaving a channel of about ½-inch wide; at the top of the wall-framing there is a provision made for a supply, but it is not used. The egress is from the west side of the ceiling, extending also some few feet on the north and south sides eastward. There is a coil of pipes at the windows for giving additional warmth to the window-side of the room in times of very severe easterly winds and north-easterly winds, by radiation; it is very difficult to counteract, unless by some local heat, the effects of cold from such large windows. The whole of the Committee-rooms for Inquiry have one channel throughout the whole length in the vaults below, 100 feet in area; each room is distinctly separated from another room by a fire-proof material all the way down to the vaults; from the vaults vertical communication is made, by four channels about 2 feet square each, with the horizontal part of the ceiling in each Committee-room. Two of the flues are used for warm air, and two for tempered air; all four are not usually used at the same time. For egress the air passes out upwards into a channel about 50 feet in area; that goes the whole length of the river front over the corridor, and passes out through a tower or louvre, which is situated at the Speaker's house, and another at the Black Rod's house. The channel serves for twelve Committee-rooms and the corridors, and is drawn along by a steam-jet and by its natural temperature—by the temperature it acquires. The air is forced into the rooms by a fan; the admission of air is regulated at the commencement by four valves at the bottom of the vertical flues in the vaults; they are closed when there is the requisite quantity of air. The ingress of air to the House of Lords is at the rate of 4 feet per minute; about 1 foot from the ceiling the velocity of vitiated air, where it passes from the ceiling upwards, is about the same. The floor of the House is of iron perforated, covered with lead; the whole exit takes place at the two sides of the ceiling, and a portion from the riser of the first step of the raised seats on either side of the House. It is better and simpler if the air enters at the ceiling, to let it go out again at the ceiling, and not by the floor.

LESLIE (JOHN, Engineer)—Considers that drawing air down long open brickwork shafts; pulling it by means of powerful steam-engines along damp, dirty cellars and vaults; moistening it; causing it to pass over heated iron surfaces; tempering, moistening, and equalising it—destroys all the original freshness and purity of the air, and forms a most deteriorated mechanical mixture, combining dust and other impurities, and producing an atmosphere injurious to the health and comfort of those who are compelled to breath it. Objects to the manner in which the air is forced through a number of small apertures; the velocity of these separate currents, impinging on the human body, causes a sensation of cold, and, by experiments he showed, lowered the thermometer. The egress of the air is most objectionable: the vitiated air passes through slots or longitudinal apertures of about an inch wide all round the edges of the panels; the ascending current strikes against the whole bottom of the panel, causing a general reverberation, producing eddies and currents, consequently permitting only a partial escape of the vitiated air; the remainder of which, by this reverberation, is caused to diffuse itself again, and return into the general atmosphere of the room. Witness's remedies, which he would propose to apply to the defects of the House—reserving his opinion for the moment, that the Houses of Parliament, the Committee-rooms, the halls and corridors, could be much better warmed and ventilated separately, than by any one combined system for the whole buildings—are, that he would lead in from the highest and least objectionable sources a copious supply of fresh air through glazed earthenware pipes, of large diameter, the joints of which being most perfectly secured; these earthenware pipes traversing into and round and round a large heating chamber; the floor and walls of this heating-chamber being made of fire-brick materials, in the centre of which, and upon the fire-brick floor, he would erect one of his patent fire-brick grates, with an independent supply of air to support combustion, by means of which any desired temperature of the air circulating through these hermetically-jointed earthenware pipes could be secured, and the air from them could be led in similar pipes of smaller dimensions to the different points, rooms, or places requiring the supply; the air would nowhere be brought into contact with heated metal. The results of the present means of supplying air and carrying off the vitiated atmosphere of the Committee-rooms are very unsatisfactory. A large quantity of coals is consumed in the Committee-rooms; one quarter of the coals would be sufficient on witness's system. As to the manner in which the Committee-rooms should be warmed and ventilated, he should lead in an entirely new and copious supply of air through one opening in the floor of the room, taken from the outside of the wall; the portion that was for warming the room would pass round the fire-place to be sufficiently warmed, and the portion that was reserved for the occasional acceleration and proper support of combustion would be contained in a chamber immediately before the fire-place. This air he would cause to circulate round the bottom and sides of the grate, and discharge itself into the room, either at the sides of the fire-place or at the opposite end of the room, as might be found most convenient. He would have also a small supply of air brought in by the same channel to support or accelerate the combustion in that grate when it was a very cold day, so as to have an independent supply of air for the fire burning, without drawing upon the general air that was in the room. The fire-brick grate he would make in a circular form, because it is most easily managed by increase or decrease of fuel, according to the alterations of external temperature which so frequently occur. The whole fuel necessary would not cost 4*d.* a day upon the average for a room. The egress for vitiated air would be simply by the chimney, as close to the ceiling as possible, which would answer perfectly well, even when there is no fire in the grate. He would shut off all blow-pipe influences from the floor and sides of the House; shut off every sort of connection as to descending currents of air; would remove the whole of the centre framing and panels of the ceiling. The floor of the House should be constantly and uniformly warm; this he takes to be the basis of all good ventilation; and would shut off all influence of air entering from below. The supply of air should be self-regulating; the removal of the vitiated atmosphere should pass quietly away, and with the least possible frictional interruption. The supply of air on the separate system of warming and ventilating the House would be similar to the Committee-room detailed above. The supply for the House he would bring down from the exterior of the roof in glazed earthenware pipes. Calculates that four square feet of supply-channels would be amply sufficient: two from the east side of the House and two from the west side. That consequently would necessitate two fireplaces, one on either side of the House. The exit of the vitiated atmosphere would be through the large aperture in the ceiling, conveyed away through a shaft, the moving power of which should be a small fire-brick open grate, costing for fuel about 6*d.* a day, and which power would remove more foul air from the body of the House, and there would be a consequent acceleration of supply of fresh air as you increased the height in that shaft. Proposes open fireplaces in the House, so as to cause a current of warm air to pass all over the floor of the House. As to lighting the House, thinks lighting the gas-lights during the time the House is sitting a great inconvenience. Suspending lights from the roof is very dangerous. To avoid these objections, he takes a gas supply all round the edge of the panels, with perfectly fixed and secure lights inside of the opening. Would apportion 3 cubic feet of purified cannel coal gas per hour; the House would be perfectly lighted for 2*s.* 6*d.* an hour; would place these lights one foot above the existing ceiling, so that as soon as the order was given for artificial light, the men would go and light those burners without interrupting the House at all, or without the chance of the least accident in the House from anything falling. The chamber which is now called the roof would be a chamber of light; would place no obstruction of glass in the panels, by which a great per-centage of light would be lost. Removing the panels from the ceiling would not affect the hearing in the House. The failure of the ventilation has chiefly arisen from there not being sufficient means of escape for the vitiated air. Considers there is a great deal too much care taken as regards forcing air into the House, rather than taking it away. Stated the importance of his burner. If 3 feet of cannel coal gas be taken, properly purified, and passed through the burner, he can probably get the amount of light of from sixteen to twenty wax candles; but if the mode of consuming it be changed by putting on a glass a little longer, he decreases the light and increases the flow of gas. The more the glass be elongated, the less is the light and the more the gas, because the ascending current is increased by the length of the chimney, and the gas being of lighter specific gravity than the atmospheric current which is passing through it, the atmospheric current takes the gas away unproductively for the purposes of light. Would not take the responsibility of the red hot tube mentioned in Mr. King's evidence.

Appold (George, C.E.)—Has paid great attention to the subject of warming and ventilating buildings. The present state of the ventilation of the House of Commons is very pleasant and regular. Witness made experiments to ascertain the variation of the temperature of the House, and obtained very satisfactory results. Thinks the light being in the roof is decidedly the best plan. If the lights were put outside the windows, and passed through stained glass, there would be three or four times the heat now experienced: there must be so much more light, and that light must strike upon the coloured glass, and make it hot. The plenum is the most preferable system; he would use no extracting power. In order to have a plenum, care must be taken that the ingress is larger than the egress, otherwise a forcing power must be employed to keep up a balance. The passage of air over iron pipes heated with steam or hot water is very injurious to the qualities of the air; so much so that he uses a self-regulating gas-stove. Witness has one in use at his own house; it is a square iron case, with a large gas-burner inside. There is a connection of about 1000 feet of pipe from the top; the air goes up the stove; the pipes are all vertical, and connected with the bottom of the stove as well. There is a current of air through the stove down the pipes, which comes to the bottom of the stove again. And besides that, there is another connection to carry off a certain current of air up the chimney, to give more warmth up the House. By that means a very large surface altogether is obtained. There are about 1000 feet of pipe, which is kept at a very low temperature, and then the heat of the stove is regulated by a self-acting thermometer, about two stories away from the stove—that is to say, upstairs; and when the House gets half-a-degree warmer in the staircase, the gas is turned off, and put completely out, except in the cigar-jet, which is a little jet merely kept alight, being handy. By that means, the instant the House is warm enough, then the stove is out, and afterwards the House gets cool. Mr. Appold said:—Supposing I am going to have a party, lighting and other heat warms the place. My stove is then put completely out, which before I found a nuisance with the stove. With hot-water pipes you have your hot water; your friends come, and the House keeps warm. I think there ought to have been here a very large chamber to heat the House, so as to get about the quarter of the size of this room with gas inside, and pipes passing through that channel and air through the pipes. The instant the House is warm enough, instead of shutting the air off to let it out in contact with the hot pipes, you could let the gas out entirely if you like, or only partially out, as I do. I go out, and nobody knows anything about the stove but myself, and it is never out of order, except I show it to some gentleman and forget to put it to rights again. If the pipe gets too hot, the hygrometric balance is destroyed; in that case I only care about my bed-room. I have a hygrometer there; if the atmosphere gets too dry, the hygrometer opens the valve, which lets about ten quarts of water on to 300 feet of pipes, which are covered with blotting-paper. In ventilating the House of Commons, would regulate the temperature by an aperture at the outlet; the velocity of a current of air upon a dry-bulb thermometer immediately causes the temperature to sink; the air should be sifted by passing through a wire gauze at the source of supply. Placing two or three thicknesses of hair-cloth over the floor where the members walk would remove all the inconvenience at present felt from the dust, and tend to improve the diffusion of the air. Has inspected the plan of lighting the Philharmonic Concert-room at Liverpool; approves of the sun-burner method of lighting as adopted at Liverpool; it would do very well in the House of Commons. The side-lights adopted at Liverpool would not be applicable for the present House of Commons. Prefers the present system of lighting the House of Commons, in conjunction with the sun-burner, to any other, because it takes the products of combustion off so well.

Brown (Thomas, Architect, Edinburgh)—Has erected several public buildings; almost all the prisons erected or enlarged in Scotland for the last twelve years have passed through witness's hands. Dr. Reid has made from time to time several suggestions on the subject of ventilation. Witness finds every day that the more he attends to carrying out the views which he suggested when fair opportunities occur, the better he succeeds. He introduces his system of ventilation from prison to prison as they go on. He introduced the descending current of ventilation into the prison at Berwick; this prison was erected under the management of the English Board of Commissioners. Witness prefers the ascending current to the descending. The arrangements for warming and for the escape of air are very nearly perfection, if they were properly managed. It is possible to carry out a system of ventilation without making use of the windows as a means of ingress. Witness has no objection to the supply of air for the House being taken from the vaults, provided they are kept clean and absolutely dry. Mechanical power need not be used for forcing the air in, as quite sufficient air could be obtained without it. The furnace in the shaft witness considers to be a very manageable power, and preferable to the jet or fan. There does not appear to be any unnecessary apparatus used in the warming and ventilation of the House. The lights very much assist the ventilation of the House. In bringing air in at the roof and carrying it out at the roof, witness doubts whether it would go down to the floor. Witness showed the difficulty of working a system of ventilation where the floor is made both the ingress and egress of the air, but with respect to certain parts there is no difficulty. Mr. Brown, in relation to this, informed the Committee of the following arrangement:—In some of the prison cells the inmates use a chamber vessel of ordinary earthenware, and in the wall close upon the floor is formed a small cast-iron box with a door upon it, in which this vessel is set. While drawing off the air from the cell at the ceiling, we have also a draught on this small box to take away the effluvia. We are there then drawing off at both floor and ceiling. In the one case it is a small flue, and in the other it is a large one. There is a pipe attached to the box which contains the utensil, which goes into some flue, and there is a method by which from a certain portion of the floor, you draw off foul air at the same time that you draw the general foul air of the chamber from the ceiling. He never found the air damaged in any way by heating it with hot-water pipes.

Stephenson (Robert, M.P., C.E.)—Has been down to Liverpool to look at the lights in the Philharmonic Concert-room. The chief feature was the great advantage of the extreme diffusion of light. The diffusion was almost as uniform as the light of day, and not unpleasant, excepting under the sun-burner, which is simply for lighting the orchestra. The cornice-light would be inapplicable to the House of Commons; it would be brought down to too low a level. Witness also considers the sun-lights, as applied in the Philharmonic Room, would be an objectionable mode of lighting the House. Sun-burners for such purposes as lighting an orchestra or a small space from above, so as to give, as it were, a radiance as over the altar of a church, the effect is very beautiful: but if sixty-four of these clusters were diffused over the flat part of the ceiling of the House of Commons the effect would be extremely good. The effect of the light in the Philharmonic Room at Liverpool is very much the same as the effect of Dr. Reid's lights in the hollow pyramids, because the room has been simply plastered, and it is now perfectly white; therefore a great deal of reflected light comes to the eye, and perhaps the larger bulk of it is still reflected light; although the lights are not screened, they extend over such a large surface that the eye does not receive from any one point an inconvenient amount of intensity. Dr. Reid's opinion as to the lighting of the House appears to correspond with witness's, as Dr. Reid first of all proposed to put a separate light in each panel. Witness objected to this in the beginning to save expense, but thinks Dr. Reid was perfectly right. The hollow pyramids are not very sightly, but might easily be made so. At present the lighting is so contrived as to have a very material and beneficial effect on the ventilation; placing there sixty-four sunlights in the panels would not interfere with the ventilation, but would rather improve it. The system of sun-lights, in an economical point of view, is to be recommended. Witness does not object to the shadow beneath the galleries; and is of opinion that it is desirable that there should be some portions of the House on which the eye may rest without being affected by the large amount of light necessary for business purposes; a mitigated light might easily be thrown under the galleries. Making an increased number of openings in the ceiling of the House would not interfere with the acoustic principle upon which it has been constructed: the roof being broken up is beneficial; its flat surface is perhaps objectionable; if it were broken up it would prevent any confusion of sounds. Witness considers all the apertures for egress too contracted; a number of small apertures is by no means equal to the same area in a large one. There is no difficulty in ventilating downwards or upwards. In the House of Commons, which is occupied at night, and where an abundance of light is necessary, it would be counteracting the very tendency which that light has to ventilate the House, to have the access of air from above; but in the Committee-rooms, which are used only during the day, it is a very good plan. He would certainly not have the access for fresh air and the egress for vitiated air on the same level.

Report of Messrs. S. W. Daukes, Architect, and H. C. Price, C.E.

Among the principal defects in the present systems of warming and ventilating the Houses of Parliament, three may be specified as demanding the gravest consideration:—First, the general supply of atmospheric air to the Houses, which is insufficient in quantity; secondly, the nature of the temperature, which is irregular and conflicting; and, thirdly, the quality of the air, which is so inferior as to be unfit for respiration.

It naturally follows, and such indeed are the actual complaints urged against the present systems, that the interior temperature of the Houses is frequently either too hot or too cold. That the ventilation is most commonly insufficient, and at other times excessive. That there is a prevalency of unpleasant odours. That the effect of the general atmosphere of the building is to excite sensations of closeness and oppression; and, in short, that there is nearly a total absence of that consciousness of elasticity and freshness which is incident to the breathing of the natural atmosphere.

In seeking for the grounds of these complaints, and the sources of these great and undoubted defects, we have arrived at the conclusion that the insufficiency of the general supply of air to the Houses arises in a great measure from the imperfect and conflicting arrangements which have been made for the ingress of the fresh air, and for the egress of the foul air.

A large and excessive amount of mechanical power is doubtless provided for propelling the air through the channels constructed for its transit, and a corresponding power is provided for extracting the vitiated air; but before it reaches its destination, which is the interior of the Houses of Lords and Commons, Committee-rooms, &c., its progress is impeded by the mechanical hindrances of a countless number of minute, wire-drawing, and friction-creating orifices in the shape of perforated iron floors, porous hair-carpets, and other contrivances; and its intended operation is obstructed by arrangements which violate both scientific and natural principles, and even reverse the intention of the inventors, by carrying off at the ceilings the air that should descend to the floors, and drawing off at the floors the air that should ascend to the ceilings.

The irregularity and contrariety of the temperatures are occasioned by the unsuitableness of the motive powers employed for moving the air through the Houses, and the numerous and contrary operations performed upon the air with a view to attemper and otherwise prepare it for the use of the Houses; first, inflicting upon it a wetting process, then a drying one; secondly, overheating it, then cooling it; and, lastly, mixing, or rather attempting to mix intimately two distinct currents of air at different temperatures, both being propelled in parallel currents with considerable velocity.

The remaining, and certainly the greatest and most serious defect of the three, the bad and unwholesome quality of the air supplied to the Houses, chiefly arises from the very unsuitable and impure character of the air-passages, by which we mean the large subterranean vaults and other channels through which the atmospheric air is compelled to travel from its first descent down the Clock and Victoria Towers to the interior of the Houses of Lords and Commons, Committee-rooms, &c.

The damp and mouldy state of the surfaces of those vaults, and the large amount of extraneous and contaminating materials, and even persons, that are to be found in those and the other channels for air destined for the use of the Houses, abundantly reveal the source of much of the deterioration and injury suffered by the air in its passage merely through these interior thoroughfares.

There is likewise an extensive contamination of the general atmosphere of the building proceeding from numerous other sources, which, although they operate but indirectly upon those apartments immediately surrounding the Houses of Lords and Commons, yet materially tend to aggravate the effect of those specific and more direct influences to which we are here adverting.

We allude in particular to escapes of gas, leakages of steam, smell of oil and jointings of pipes, suffocating atmosphere of the engine-room, emission of noxious fumes from open coke fires, and generally the impure atmosphere of the numerous unventilated, or, at all events, ill-ventilated, passages, staircases, &c., which exist in all directions.

One purpose of the present communication being to present to your Committee, in few and concise terms, the nature of the principal errors committed in devising and executing the systems of warming and ventilation for the Houses of Parliament, and of the remedies that should be applied to them, we resignedly restrict ourselves to the foregoing heads, and not because there are not many more, and those very substantial objections, to be raised against other mistakes of principle and practice which have been committed, but because we presume that in respect of any system which does not thoroughly and successfully deal with conditions of such obvious importance as purity and wholesomeness of atmosphere, and equality and uniformity of temperature, it must plainly be matter of very secondary consideration how many or how few of the inferior requirements may be fulfilled.

We recommend, in the first place, that the present practice of moving the air through the Houses by mechanical power only should be abandoned, and that for the future the chief reliance (except in the summer months) should be upon the natural power of the spontaneous upward movement.

Secondly. That the downward movement of the air currents shall be entirely abandoned, and with this "noxious fallacy" should also be relinquished the fallacious attempt to produce and sustain such opposite and contrary forces as the plenum and vacuum principles of ventilation in the same rooms and at the same time.

Thirdly. All the present air-passages, whether for the transit of fresh or foul air, should be reconstructed, or at all events so remodelled as to combine in one appropriate and uniform system a series of free and unobstructed, but closed, air-channels, arranged in strict accordance with the natural upward tendency of warm air currents, and framed with a scrupulous regard to the greatest possible uniformity of form, and by a rigid observance of those definite and proportionate relative areas between the main and branch flues, without which we do not hesitate to assert that no system of ventilation, however skilfully devised in other respects, can be protected from those adverse and disturbing influences which must peril the success of any scheme whatever.

Fourthly. We advise that the use of steam at 230°, or even 212°, as a medium of heat for giving temperature to the air-warming surfaces, should be abandoned, and hot water, at a maximum heat of 170°, be substituted. Steam over-heats and over-dries the air, and admits of no gradual control over the extensive range of temperature that lies below 212°. Hot water can be employed at any desired degree of heat below the boiling point, and admits of the most minute and gradual control over that range of temperature which lies below the degree of 212; a point of the utmost importance in relation to one of the most essential requirements of the House of Commons; and hot water likewise affords a most ready and simple means of imparting moisture to the air in correction of any undue state of dryness, whether arising from the operation of artificial warming, or a state of absolute dryness in the natural atmosphere itself; a question this of considerable interest, when it is remembered that the capacity of air for moisture is doubled by every 27° Fahrenheit increase of temperature; when, as is also known, that the most salubrious state of the air is when the dew-point is not less than 10° nor more than 20° below the temperature of the room. And, moreover, when, as is likewise understood, that evaporation tends to relieve the unpleasant effects of imperfect ventilation, by producing positive electricity of the air, and by adding moisture renders it a good conductor of atmospheric electricity, while dry air, on the contrary, is an extremely bad conductor.

Fifthly. We recommend that the air-warming surfaces should be vertically, and not horizontally arranged, and that they should be so altered from their present form as to spread out the air and water in thin and numerous alternating streams; the first condition being essential for the full and free development of the natural ascending movement, and the second material for the rapid abstraction by the cold air of the caloric of the heated water. These features of the warming surface also involve another important element of good ventilation—namely, concentration of large power within a moderately small space.

Sixthly, and lastly. We advise that in the manipulation of any system provided for warming and ventilating the Houses of Parliament, that the attempt—the worse than useless attempt—to meet the continual and conflicting wishes of individual members in respect of temperature, should be discountenanced; for we are convinced that the operation of no system whatever, however perfectly carried out, can be made generally satisfactory under such a course of proceeding. Neither are any such futile attempts necessary, nor, if practicable, are they advisable. On the other hand, we beg to represent to your Committee, in the strongest possible manner, that in our deliberate opinion, a course the very opposite should be pursued; which is, that the great aim of the person in charge of the ventilation of the House should be to avoid all changes and fluctuations in the ventilating power whilst the House is sitting, and never to practise any sudden and perceptible changes in this respect during that period. There are doubtless certain contingent circumstances bearing on this point, as also upon the temperature of the House, which are of ordinary occurrence, and we will cite one to which, by common consent, the greatest degree of importance is attached—namely, that adjustment of the rate of ventilation which is supposed to be, and of the degree of temperature which really is imperative, from the sudden and large fluctuations which take place in the number of members present at the same time in the House, small numbers tending to a depression of temperature, and large numbers causing an inconvenient elevation.

Now most certainly, the way of meeting this contingency is not by suddenly raising or suddenly lowering the temperature of the House 5° or 10°, nor by, with equal suddenness, reducing or increasing the ventilation; since both these courses produce strong sensations of heat and cold, and powerful impressions from altered velocity of the air currents.

These fluctuating demands must assuredly be answered, but it ought to be by some simple and gradual process; not by opening or shutting an indefinite number of ingress and egress air-valves, nor by the projection into the House of forcible and successive hot and cold currents of air, but by permitting all the ingress valves to remain undisturbed, by making no change whatever in the amount of ventilation, that having been properly determined before the sitting of the House; but by simply and gradually effecting the changes of temperature in the warming power, which, without augmenting or diminishing the renewal of air, will in a sufficiently short space of time accomplish the desired end, whether that be to meet the demand arising either from a sudden increase or an equally sudden decrease of the number of members in the House.

Letter to the Committee, from Mr. William Bardwell, Architect.

It appears to me that the result to be obtained by this Committee hinges upon the Committee's opinion of the ascent or descent of the products of combustion and respiration. I unhesitatingly affirm that these products ascend: that carbonic acid gas, as found in coal-mines or in wells, is heavier than atmospheric air, has long been ascertained; but it is probable this gas is never found in an uncombined state, or rather in noxious quantities, at the surface of the earth; for if it were so existing, then would the basement-floors of our houses be uninhabitable, and the Thames Tunnel would be impassable. On the contrary, that it ascends is proved by the smoke from our chimneys, by the air in a crowded church or theatre being far more agreeable on the floor than in a gallery, and far more agreeable in the open space than beneath a gallery; further, if in a room on fire you remain upright, you will be suffocated; whereas, if you creep along the floor, you may breathe in comfort. Moreover, if in frosty weather we see the breath and sweat of horses ascending into the air, we may confidently assume that the emanations of our bodies are combined with sufficient caloric and aqueous vapour to carry them to the top of any room. How unwholesome, therefore, and destructive to health must be the attempt to bring in fresh air by a ceiling, and thus cause these emanations to be breathed or inhaled over and over again! A mode of ventilation like this, which shuts out all ingress of air except through certain tortuous passages, which alters the natural course of our vital support, however it may be admirable as showing the power of mind over matter, is highly objectionable in practice, placing the human beings subject to its operation exactly in the situation of so many mice under the bell of an air-pump, with just as much or as little air as the operator chose to afford them. But living as we do, immersed in a subtle fluid, there are physical impossibilities against the complete development of such a system, and hence it must ever be unsatisfactory.

Nor is this all; for both in the House of Lords and in the House of Commons, provision being made for bringing in air from the top, from the bottom, and from the sides, commingling together like the waters of a Maelstrom, up and down, and round and round, the air is in that state of commotion that the sound of the voice cannot radiate. Throw a stone into the placid waters of a lake, and the effect will be seen in a series of concentric circles. Sir Isaac Newton says that sound is communicated in a similar manner; but throw a stone into a Maelstrom, and no such effect can be produced; hence the acoustical property of the Houses is rather destroyed by the mode of ventilation than by architectural defects.

In addition to the inconveniences which are felt, I apprehend it is capable of proof that the expenditure incurred in carrying out false principles has been nearer 300,000*l.* than 200,000*l.*, and that their maintenance involves a cost of some thousands of pounds a year, while the remedies which I propose may be effected and kept in operation at an expense of a few hundred pounds a-year.

Having asserted a broad and distinct principle, these remedies will be easily understood and easily executed.

The officers of the Houses complain of the draughts of air sent upon them in their apartments. And no wonder; for, like those persons waiting in the corridors, all are blown upon or are stifled, without any power to help themselves. Now, it is clear the chief of every office should have the right of admitting as much or as little air as he finds agreeable; and this, by a simple arrangement of the fire-place, at a cost not exceeding 5*l.* to each room, and by stopping up the holes in the ceiling, with the addition of casements to the windows, I could easily put into his power.

So, also, in the Committee-rooms, a man, as Lord Bacon says, does not know where to "become" to be out of the draughts, besides having the unpleasant notion that he may be inhaling the air just emitted from another person's lungs; a similar arrangement as that just recommended for the office fire-places may be made at an expense not exceeding 5*l.* for each room, reserving the holes in the ceiling for the exit of foul air, and adding a hot-water pipe to the transom of the windows. So perfect would be this ventilation, that as soon as it was brought into operation in this noble pile of buildings, every palace, every public office, and every good house would be fitted in like manner, thereby adding many years to the lives of the occupants, and health and comfort to those lives.

Both the House of Lords and the House of Commons being beautifully arranged for ventilation, I would introduce an air-shaft 4 feet by 1 foot beneath each window on each side of the House, the outer end of such shaft (having a valve to regulate the admission of air) opening into one of the courts, the other end opening into the House at 6 inches above the floor beneath the graduated seats. In front of this opening must be placed a coil of hot-water pipe; the shafts must be near the ceiling of the lower corridor slanting upwards; the fresh air would then be constantly flowing into the air-chamber, be warmed on entering to any desirable temperature, pass into the House through boxes opening about six inches below the seats; it would then rise upward, carrying with it all exhalations, and pass out at the ceiling, its exit being assisted by the centre gas-burners, the chimneys of which would enter a close shaft running through the roof into the open air. The floor of the House and the floors of the corridors must be laid with tiles, not only to assist the acoustic property of the House, but also to preserve the members from dust and bad smells, by cutting off all communication with the chambers or vaults below. The floor beneath the rising seats may be covered with boards.

That the air on the surface of the earth is sufficiently pure for the maintenance and promotion of robust health, is proved by the healthy appearance of hawkers, of the sellers of fruit and fish, of the omnibus and cabmen, of the park-keepers, and of the watermen, all of whom probably at night occupy close and ill-ventilated lodgings.

The House may be lighted equally and uniformly in every part, without heat, without shadow, and with the pure white light of day, in the following manner, using glass just sufficiently tinged with blue to alter the yellow rays of light. One cluster of gas-burners in each of the five great compartments of the horizontal ceiling, each cluster to have a dish composed of five plates of glass, each 2 feet square, suspended beneath it. The windows to have double casements, the one containing the present glass for day, the other filled with pale blue glass for night, to open and shut alternately, and to have gas-burners outside the windows. Ten of the panels of the sounding-boards beneath the galleries on each side of the House to be removed and filled in with glass, to have a gas-burner behind forming an illuminated panel, the space to communicate by pipes with the open air, or with the corridor, and not at all with the House. Thus no one would ever come into the House for the purpose of lighting it; the centre gas-burners being always alight to assist ventilation, the light is instantaneously heightened by turning a cock; while the other burners are lighted from the outside.

ON NAVAL ARCHITECTURE.

By Baron Dupin.*

It is not unworthy of remark, as being a singular feature in the maritime history of Great Britain, that whilst, during a period of war, vast improvements were being made in its military service, very little was effected for its navy until after the Treaty of Peace. It was not until a general pacification in 1814 had freed Europe from a severe and terrible military struggle, that Sir Robert Seppings, then Surveyor of the Navy, brought forward his improved method of naval construction. The lower parts of the frames of ships of war were then for the first time filled in, and no longer afforded interstices for the accumulation of dirt and putrid water; and the frame-timbers of the bottom presented a compact mass of wood from the keel up to about the light water-line. Besides this great improvement, the whole fabric was further strengthened by means of a system of diagonal trussing, which, together with the solid bottom, opposed such resistance to the forces due to the weight of the hull and its contents acting downward, and to the forces due to the displacement or pressure of the water acting upward, as effectually to prevent the keel from shortening, and consequently the ship from hogging or breaking down in the direction of her length, as it was liable to do formerly, or otherwise yielding to the forces of pressure under sail, or those of pitching and rolling in a tempestuous sea.

In addition to these first great steps in the progress of ship-building, the upper parts of men-of-war were much improved in form and strength; the stern, instead of remaining open to the fire of an enemy, has been more strongly built, in a semicircular, or rather elliptical shape, better fitted for defence in every direction. The upper decks have also been enlarged, and space gained for working the guns. The building of ships of war has been further improved in many ways which cannot be explained here. More solidity has been obtained by greater precision in joining the various masses of wood constituting the ship. By such means the *working* of the timbers in a heavy sea is greatly prevented; and both solidity and greater durability are obtained.

Instead of firing the great guns by the same mechanism as old muskets, caps and hammers have been adapted to them. Advantages of still higher importance have been obtained by the introduction of guns of a very large calibre, mainly due to General Paixhans, which were introduced nearly twenty years ago, and called *canons à la Paixhans.* At first very few such

* 'Reports by the Juries on the Subjects in the Thirty Classes into which the Great Exhibition was divided.' London: Clowes and Sons. 1852.

guns were placed in each ship; but now we find complete batteries of 68-pounders, the effect of which cannot fail to be tremendous.

The combination of large masts has been rendered more economical, easy, and solid, by the employment of coaks or cylinders of hard wood, inserted one-half of their length into each of the pieces of the masts brought into contact.

Sir W. Symonds, who succeeded Sir Robert Seppings in 1832, as Surveyor of the Navy, turned his attention towards an improved form for ships of war, and designed them of such figure and dimensions as to require very little ballast; this he in great measure accomplished by a considerable increase of the breadth. This system had many advantages; it gave greater stability, and in sharp ships more space below for stowage, besides a larger field or deck for working the guns; and although many talented naval constructors and officers considered this form unfavourable to an easy motion at sea, and liable to distress the spars, we have, nevertheless, great cause to be thankful to this talented and meritorious officer for his laudable and unwearied endeavours to improve the construction of ships of war.

We are further indebted to Mr. J. Scott Russell, the distinguished Secretary of the Royal Commission, for a series of valuable experiments and researches on the form of least resistance at high velocity; this form being determined by examining the form of waves produced by drawing vessels through a canal at different degrees of speed. Further experiments are being made by this gentleman in the application of his deductions to sea-going ships, and he has our best wishes for their ultimate success.

The theory of stability, so important in the navy, and which we considered in a geometrical point of view, has been examined, both successfully and ingeniously, by the Rev. H. Moseley.

The stowage of ships has been much improved of late years, both in the form and disposal of stores; thus, water-casks are replaced, at the suggestion of General Bentham, by iron tanks. The cubic or prismatic form of these tanks insures great economy of space as compared with the cylindrical form of casks; they also preserve the water perfectly pure during long voyages; casks, on the contrary, have the soluble part of their wood dissolved by the water, causing putridity, which produces various diseases, especially in hot climates. Equally important with the improvements in keeping water free from taint must be considered the mode invented by M. Appert for preserving all kinds of meat.

The preservation of gunpowder free from humidity, so necessary for ships of war, is now rendered perfect by the employment of hermetically-sealed metallic cases, or wood cases with metallic lining; an improvement due to the British navy. In the French navy great improvements have been made by separating passages for the conveyance of cartridges from the magazine up to the various batteries of the ship. These arrangements were particularly remarked by the English during their visit to the French fleet at Cherbourg in 1850.

We now come to a series of improvements of the highest importance to the safety of ships. The hemp-cables formerly employed were very objectionable, being liable to rapid decay, particularly in hot climates. When the anchor was cast on a rocky bottom, the cable was frequently cut by the rocks, and very often parted, so that the ship was greatly endangered. A captain of the British navy (Sir Samuel Brown) introduced cables made of iron links, so arranged as to be easily worked. These chain-cables are now in general use, not only in ships of war, but also in the commercial shipping of every maritime nation. We should have been happy if so vast an improvement had been recent enough to have received the highest of our awards as being one of the greatest effected for the shipping interests and the preservation of life and property.

The first method for stopping iron cables is due to the English; the last and best belongs to the captain of the French frigate *Legoff*. A high encomium is due to M. Barbotin, *capitaine de vaisseau* in the French service, for having devised the means by which the chain-cable can be worked on the capstan. The various links as they succeed each other fall into grooves, on the periphery of a large polygonal prism forming the body of the capstan. When the capstan is put in motion, the links of the chain-cable have in succession half their thickness lodged in these grooves, and successively disengage themselves with mathematical precision.

The improvement in cables naturally leads us to speak of anchors. Very remarkable improvements have been recently made by Lieut. Rodger, R.N., insuring a better distribution of the metal in the direction of the greatest strains. The palm of the anchor, instead of being flat, presents two inclined planes, calculated for cutting the sand or mud instead of resisting perpendicularly; and the consequence is, that these new anchors hold much better in the ground. The Committee of Lloyds, so competent to judge of every contrivance likely to preserve ships, have resolved to allow for the anchors of the ships they insure, a sixth less weight, if made according to the plan of Lieut. Rodger.

Another source of safety most important to ships is an efficient application of metallic conductors by which they are secured against the destructive element of lightning. Franklin made the immortal discovery of the identity of artificial electricity and that from the thunder-cloud, and through the instrumentality of the lightning-rod, devised a happy application of his discovery to the preservation of buildings and ships in thunder-storms. The variable and complicated circumstances, however, under which ships are necessarily placed, rendered the use of such rods on ship-board difficult and apparently impossible. The masts—the only parts to which they could be well applied—consist of many distinct portions; these it is often requisite to move one upon another, and sometimes to remove altogether; they are also liable to injury from wind and other forces acting on them. The defence of ships from lightning had hence been confided to a small chain or rope of wire temporarily applied along the rigging; but which, from the very nature of the case, fails to afford the full amount of security to be derived from a more powerful conductor permanently fixed along the mast. Sir W. S. Harris conceived the idea of making capacious metallic conductors an integral part of the masts and hull of the vessel, so as to bring the general fabric into that perfect conducting or non-resisting state it would assume, in respect of the matter of lightning, supposing the whole mass to be metallic throughout; this he has effected by incorporating with the masts and hull a series of copper plates, so arranged as to meet all the varying conditions of the spars, and so tied together that an electrical discharge striking upon any part of the vessel cannot enter upon any circuit of which the conductors do not form a part, and thus the ship is preserved from the effect of lightning at all times and under all circumstances, without the officers and crew being in any way concerned in the matter. Sir W. S. Harris has shown, by original researches in science, that in whatever position the sliding-masts may be placed, a line or lines of conductors pass through the ship into the sea, affording less resistance to the passage of the electrical discharge than any other arrangement which can be devised. The most perfect security is derived from the plan thus introduced. Sir Baldwin Walker, one of our fellow-jurors, has himself experienced the great advantages of this system in a large frigate commanded by him, which was struck both on the fore and main masts by heavy discharges of lightning on the coast of Mexico. In this case the force of the discharge was such as to partially fuse the metallic point aloft on which the lightning struck, and leave spots of fusion on the surface of the conducting-plates, but without the least damage being done to the spars or hull; and this, too, while the top-gallant masts were housed.

Another source of safety in the construction of ships is the substitution of iron for wood. In a country like Great Britain where iron is so abundant, cheap, and well adapted to various purposes, it was natural to use it instead of wood for shipbuilding. Iron ships have the great advantage of not being liable to that rapid decay to which wooden ships are subject, especially in hot climates; and to the dry rot which attacks them in moist climates; iron, likewise, cannot be attacked by the worms so destructive to wood under water. Iron ships can also be made lighter, with the same bulk, as compared with wooden ships; and they resist better in case of being driven on shore, or upon a bank of sand. Such are the advantages which justify the employment of iron in shipbuilding. In ships of war, however, the iron sheets of the hull are liable to be rent by cannon-balls in such a way as, in many cases, to render it impossible to stop the leak and save the ship. Maritime countries have, therefore, after expensive experiments, abandoned the idea of wholly substituting iron for wood in the building of ships of war.

The rigging, blocks, and sails of ships have been improved both in their combinations and materials. The construction of blocks is managed with remarkable economy since the invention

TABLE I.—*Principal Dimensions and Calculated Elements of a Series of Sailing Ships of the Royal Navy.*

Specification of the Principal Dimensions, and Calculated Elements.	Royal Albert, 120	Queen, 116	Albion, 90	Hannibal, 90	Cæsar, 90	Superb, 80	Cressy, 80	Cumberland, 70	Emerald 60	Narcissus 50	Diamond, 18	Arachne, 18	Siren, 16	Pilot, 12	Britomart 10
Length on the load water-line from the fore part of stem to after part of post, in feet and inches	222 3	204 7	205 0	207 7	209 10	191 0	200 9	181 6	186 7	181 7	140 9	114 8	109 6	104 6	92 0
Breadth on the load water-line to outside of planking, in feet and inches	60 10	59 2¼	59 4	58 0	56 0	56 3	55 0	53 6	52 0	50 10	41 4	35 0	34 0	33 0	28 8
Relation of length to breadth at the load water-line	3·65	3·45	3·45	3·577	3·734	3·395	3·652	3·392	3·588	3·576	3·405	3·276	3·220	3·166	3·241
Load draught of water, in feet and inches, forward ..	23 9	24 6	23 5	23 6	23 6	23 11	23 3	22 10	21 0	21 0	16 6	14 6	13 9	13 8	12 3
Load draught of water, in feet and inches, aft	25 3	26 0¼	25 3	24 6	24 6	25 4	24 3	24 2	21 9	21 9	17 6	15 0	14 6	15 3	13 6
Mean draught of water in relation to the extreme breadth at load-line	0·402	0·426	0·410	0·413	0·428	0·438	0·431	0·439	0·411	0·424	0·411	0·421	0·415	0·439	0·449
Height of the lower port-sill from the load water-line, in feet and inches	7 0	6 8	6 2	7 3	7 0	6 3	6 6	6 6	9 0	9 0	7 2	5 9	4 6	4 2	4 7
Depth of the keel and false keel below the rabbet of the keel in feet and inches	1 6	1 9	1 0	1 6	1 6	1 7	1 6	1 9	1 5	1 5	1 6	1 1	1 2	1 0	0 9
Distance of the greatest transverse section before the middle of the load water-line, in terms of its length	0·069	0·057	0·061	0·041	0·026	0·029	0·066	0·057	0·087	0·069	0·052	0·043	0·062	0·092	0·065
Distance of the centre of displacement before the middle of the load water-line, in terms of its length	0·015	0·003	0·003	0·009	0·017	0·008	0·014	0·006	0·016	0·016	0·010	0·014	0·028	0·029	0·011
Circumscribed rectangular parallelopipedon contained by the length of the load water-line, breadth on water-line, and mean draught of water, in cubic feet	331227	305836	296017	288951	282011	264565	262229	228191	207357	197261	98892	59193	52593	49996	33961
Displacement, in terms of the said parallelopipedon ..	0·529	0·538	0·516	0·516	0·527	0·497	0·490	0·489	0·469	0·469	0·409	0·382	0·370	0·390	0·383
Area of the circumscribed rectangle contained by the breadth of the water-line, and depth from the water-line to the lower side of the rabbet of the keel, in square feet ..	1399	1391	1348	1305	1260	1294	1224	1164	1048	1025	640	478	442	445	348
Area of the greatest transverse section, in terms of the said rectangle	0·763	0·760	0·713	0·753	0·729	0·700	0·693	0·704	0·678	0·675	0·632	0·618	0·578	0·595	0·600
Area of the circumscribed rectangle contained by the length and breadth on water-line, in square feet	13519	12112	12166	12039	11750	10744	11041	9710	9703	9231	5817	4013	3723	3448	2637
Area of the load water section, in terms of the said rectangle	0·857	0·873	0·864	0·847	0·883	0·860	0·857	0·854	0·829	0·833	0·804	0·762	0·782	0·816	0·796
Depth of the centre of gravity of the greatest transverse section, in terms of the mean draught of water	0·390	0·382	0·374	0·375	0·349	0·363	0·367	0·360	0·345	0·346	0·322	0·326	0·321	0·335	0·334
Distance of the centre of gravity of the load water section from the middle of the load water-line, in terms of its length	Abaft 0·002	Abaft 0·002	Abaft 0·004	Before 0·003	Before 0·008	Abaft 0·006	Abaft 0·006	Abaft 0·005	Before 0·003	Before 0·001	Abaft 0·058	– – 0·000	Before 0·007	Before 0·005	Abaft 0·248
Height of centre of effort of sails above the load water-line, in feet	95·7	91·4	86·6	89·0	88·3	85·26	85·7	81·66	76·8	76·9	63·66	53·0	53·0	49·5	44·4
Distance of centre of effort of sails before or abaft the centre of gravity of displacement, in relation to the length of the load water-line	Before 0·121	Before 0·011	Before 0·014	Before 0·012	Before 0·006	Before 0·008	Before 0·007	Before 0·012	Before 0·002	Before 0·005	Abaft 0·014	Abaft 0·023	Abaft 0·016	Abaft 0·020	Abaft 0·006
Relation to the moment of the sails abaft the centre of gravity of displacement to the moment of the sails before the said centre	0·864	0·920	0·914	0·918	0·959	0·942	0·988	0·916	0·968	0·965	1·022	1·24	1·052	1·144	1·045
Area of sails in relation to the area of the greatest transverse section	28·9	27·75	30·48	32·55	32·97	30·57	32·67	30·19	34·13	35·04	37·68	40·16	41·73	36·3	36·25
Area of sails, in square feet, in relation to the displacement	0·176	0·178	0·198	0·216	0·203	0·211	0·215	0·221	0·249	0·261	0·376	0·516	0·546	0·493	0·580

TABLE II.—*Principal Dimensions and Calculated Elements of the Experimental Frigates of the Royal Navy.*

Specification of the Principal Dimensions, and Calculated Elements.	Arethusa, 50	Indefatigable, 50	Leander, 50	Phaeton, 50	Raleigh, 50	Nankin, 50	San Fiorenzo, 50	Thetis, 38	Inconstant, 36	Eurydice, 26	Spartan, 26
Length on the load water-line from the fore part of stem to after part of post, in feet and inches	182 2	182 4	182 8	185 8	181 6	187 2	189 10	163 8	161 7	143 3	133 6
Breadth on the load water-line to outside of planking, in feet and inches	52 2	51 6	50 6	49 4	49 6	50 8	50 6	46 6	45 4	38 2	40 0
Relation of length to breadth at the load water-line	3·49	3·54	3·615	3·763	3·66	3·695	3·759	3·562	3·56	3·75	3·337
Load draught of water, in feet and inches, forward	21 9	20 4	20 3	21 0	20 8	21 0	20 9	18 10	18 8	15 11	16 10
Load draught of water, in feet and inches, aft	23 2	21 4	21 6	22 11	21 8	22 6	21 9	20 4	19 3	16 7	18 0
Mean draught of water in relation to the extreme breadth at load-line	0·431	0·404	0·413	0·446	0·428	0·431	0·420	0·421	0·417	0·425	0·435
Height of the lower port-sill from the load water-line, in feet and inches	8 6	9 4	9 2	8 2	9 7	8 10	9 0	8 2	7 3	6 0	5 9
Depth of the keel and false keel below the rabbet of the keel in feet and inches	1 8	1 3	1 8	1 8	1 6	1 3	1 6	1 6	1 4	1 2	1 0
Distance of the greatest transverse section before the middle of the load water-line, in terms of its length	0·073	0·070	0·024	0·069	0·086	0·030	0·039	0·032	0·072	0·042	0·097
Distance of the centre of displacement before the middle of the load water-line, in terms of its length	0·010	0·012	0·013	0·022	0·016	0·605	0·013	0·014	0·020	0·027	0·030
Circumscribed rectangular parallelopipedon contained by the length of the load water-line, breadth on water-line, and mean draught of water, in cubic feet	213594	195593	192556	201104	190106	206230	203711	150828	138448	88829	93023
Displacement, in terms of the said parallelopipedon	0·436	0·481	0·427	0·457	0·473	0·431	0·469	0·447	0·440	0·403	0·398
Area of the circumscribed rectangle contained by the breadth of the water-line, and depth from the water-line to the lower side of the rabbet of the keel, in square feet	1085	1008	970	1001	973	1038	997	841	797	576	657
Area of the greatest transverse section, in terms of the said rectangle	0·649	0·716	0·651	0·739	0·679	0·662	0·698	0·639	0·660	0·625	0·621
Area of the circumscribed rectangle contained by the length and breadth on water-line, in square feet	9511	9390	9224	9158	8984	9482	9586	7703	7325	5466	5340
Area of the load water section, in terms of the said rectangle	0·819	0·809	0·824	0·797	0·851	0·814	0·842	0·846	0·820	0·803	0·810
Depth of the centre of gravity of the greatest transverse section, in terms of the mean draught of water	0·343	0·356	0·332	0·369	0·349	0·345	0·386	0·318	0·370	0·327	0·344
Distance of the centre of gravity of the load water section from the middle of the load water-line, in terms of its length	Abaft 0·206	Abaft 0·005	Abaft 0·002	Abaft 0·009	Before 0·0204	Abaft 0·001	Before 0·005	Before 0·002	Before 0·006	Before 0·005	Before 0·001
Height of centre of effort of sails above the load water-line, in feet	75·93	77·63	77·75	76·20	78·70	76·94	77·33	70·70	70·50	61·70	61·50
Distance of centre of effort of sails before or abaft the centre of gravity of displacement, in relation to the length of the load water-line	Before 0·008	Before 0·002	Before 0·016	Abaft 0·006	Before 0·011	Before 0·009	Before 0·004	Before 0·007	Before 0·015	Abaft 0·011	Abaft 0·024
Relation of the moment of the sails abaft the centre of gravity of displacement to the moment of the sails before the said centre	0·943	0·977	0·897	1·025	0·922	0·933	0·976	0·964	0·904	1·064	1·180
Area of sails in relation to the area of the greatest transverse section	34·42	33·58	38·38	32·77	36·60	35·30	34·85	36·65	37·85	39·40	34·78
Area of sails, in square feet, in relation to the displacement	0·264	0·257	0·290	0·263	0·270	0·273	0·254	0·292	0·326	0·396	0·382
By whom designed	1	2	3	4	5	6	7	8	9	10	11

1 Sir W. Symonds; 2 Mr. W. Eyde; 3 Mr. R. Blake; 4 Mr. J. White; 5 Mr. Fincham; 6 Mr. W. O. Lang, jun.; 7 Messrs. Read, Chatfield, and Creuze; 8 Messrs. Read, Chatfield, and Creuze; 9 Admiral Hayes; 10 Admiral Elliot; 11 Sir W. Symonds.

TABLE III.—*Principal Dimensions and Calculated Elements of the Experimental Brigs of the Royal Navy.*

Specification of the Principal Dimensions, and Calculated Elements.	Flying Fish, 12	Espiègle, 12	Daring, 12	Osprey, 12	Mutine, 12	Water Witch, 10	Pantaloon, 10
Length on the load water-line from the fore part of stem to after part of post, in feet and inches	102 2	105 3	104 2	100 10	101 4	91 0	89 0
Breadth on the load water-line to outside of planking, in feet and inches	32 0½	31 6½	31 0½	31 6½	31 6	28 10	28 6
Relation of length to breadth at the load water-line	3·18	3·34	3·35	3·20	3·21	3·191	3·123
Load draught of water, in feet and inches, forward ..	13 6	12 9	12 5	12 2	12 8	10 6	11 7
Load draught of water, in feet and inches, aft	14 7	14 9	16 9½	15 1	14 2½	14 2	13 3
Mean draught of water in relation to the extreme breadth at load-line	0·440	0·434	0·474	0·431	0·427	0·427	0·435
Height of the lower port-sill from the load water-line, in feet and inches	4 4	5 0	4 5	4 6	4 9	4 8	4 4
Depth of the keel and false keel below the rabbet of the keel in feet and inches	1 0	1 3	1 4	1 0	1 1	1 3	1 4
Distance of the greatest transverse section before the middle of the load water-line, in terms of its length ..	0·027	0·010	0·072	0·075	0·061	0·031	0·093
Distance of the centre of displacement before the middle of the load water-line, in terms of its length	0·012	0·013	0·018	0·013	0·016	0·016	0·029
Circumscribed rectangular parallelopipedon contained by the length of the load water-line, breadth on water-line, and mean draught of water, in cubic feet	46112	45456	47115	43193	42800	32348	31478
Displacement, in terms of the said parallelopipedon ..	0·374	0·377	0·396	0·395	0·394	0·356	0·355
Area of the circumscribed rectangle contained by the breadth of the water-line, and depth from the water-line to the lower side of the rabbet of the keel, in square feet ..	419	394	410	397	387	319	315
Area of the greatest transverse section, in terms of the said rectangle	0·606	0·592	0·685	0·633	0·622	0·605	0·595
Area of the circumscribed rectangle contained by the length and breadth on water-line, in square feet	3270	3318	3227	3176	3194	2623	2536
Area of the load water section, in terms of the said rectangle	0·761	0·781	0·770	0·785	0·801	0·751	0·769
Depth of the centre of gravity of the greatest transverse section, in terms of the mean draught of water	0·333	0·296	0·346	0·322	0·322	0·318	0·326
Distance of the centre of gravity of the load water section from the middle of the load water-line, in terms of its length	Abaft 0·006	Abaft 0·022	Before 0·001	Before 0·002	Before 0·003	Abaft 0·0031	Before 0·0095
Height of centre of effort of sails above the load water-line, in feet	48·9	49·8	48·2	48·7	49·2	44·9	44·7
Distance of centre of effort of sails before or abaft the centre of gravity of displacement, in relation to the length of the load water-line	Abaft 0·007	Abaft 0·026	Abaft 0·035	Abaft 0·019	Abaft 0·009	Abaft 0·013	Abaft 0·011
Relation of the moment of the sails abaft the centre of gravity of displacement to the moment of the sails before the said centre	1·112	1·195	1·375	1·016	1·016	1·028	1·072
Area of sails in relation to the area of the greatest transverse section	34·07	38·3	32·0	37·3	37·35	39·13	40·3
Area of sails, in square feet, in relation to the displacement	0·493	0·521	0·477	0·527	0·527	0·655	0·675

of the admirable block machinery by the late Sir J. Isambard Brunel, in his youth a French naval officer. We have awarded Prize Medals to improvements in the construction of large blocks composed of several pieces of wood, by which are obtained economy in material and a better fitting of their hooks and rigging. Rope-making is likewise improved. We owe to British ingenuity the obtaining of equal tension amongst the threads of which the largest ropes and cables are now made, and the operation of laying the ropes by mechanical power with mathematical precision. The commercial marine of France exhibit cordage made in this manner, which is certainly much better than any shown on the English side of the Exhibition. Both countries have improved the texture of their sail-cloths.

We shall conclude these general remarks upon Naval Architecture, with some interesting documents relative to various classes of ships, which we have before adverted to.

The Admiralty and merchant builders having contributed a large number of models of ships to the Exhibition, for the purpose of illustrating the forms and other characteristics of ships of the most recent construction: we conceived that some record of those ships should be preserved, in order to indicate the present state of naval architecture in Great Britain. With this view we present a series of tables, containing the principal dimensions and such other mathematical elements relating to the construction of these ships as could be obtained.

Table I. contains the dimensions and calculated elements of a complete series of sailing-ships, from a first-rate man-of-war to a small brig. Within the last twenty years, ships in the navy have been constructed with greatly-increased width or breadth of beam. To some extent this increase of breadth may have been necessary to enable them to sustain—without too great inclination under sail—the increased weight of armament now placed on board ships of war by most naval powers. But the general opinion founded on the result of experimental trials of these ships with those of former years is, that breadth of beam, when carried to excess, contributes to make the ships roll quickly, and in some cases deeply also. As this is a most serious evil in ships of war, materially affecting their efficiency in the use of their guns, ships of more recent construction have had increase of length as well as of breadth given them; but the latter to a less extent; thereby obtaining the requisite amount of stability without rendering them liable to those sudden impulses produced by great breadth at the water's surface alone, which causes the side to round greatly inwards, both above and below the water-line. The ships referred to are nevertheless a very fine class of ships; and in the *Queen* we see a first-rate ship, combining with great speed, stability, easy motion, and every other essential property of a man-of-war.

Table II. contains the principal dimensions and other elements of a number of frigates constructed by different persons with a view to competition. Several of these frigates have been attached to the late experimental squadron, under the command of Commodore Martin, for the purpose of fully testing their sailing and other properties as ships of war. The results of

TABLE IV.—*Principal Dimensions and Calculated Elements of Ships-of-War fitted with Screw-Propellers.*

Specification of the Principal Dimensions, and Calculated Elements.	St. Jean d'Acre, 100	Agamemnon, 90	Imperieuse, 50	Arrogant, 46	Tribune, 30	Highflyer, 20	Archer, 12	Cruizer. 16	Reynard, 10
Length on the load water-line from the fore part of stem to after part of post, in feet and inches	240 6	231 6	214 8	202 4	192 10	191 3	180 6	160 4	147 6
Breadth on the load water-line to outside of planking, in feet and inches	55 4	55 4	50 0	45 6	43 0	36 0	33 10	31 10	27 7
Relation of length to breadth at the load water-line	4·346	4·184	4·293	4·446	4·484	5·312	5·335	5·037	5·348
Load draught of water, in feet and inches, forward ..	23 6	23 6	21 0	19 0	17 3	15 6	13 11	12 0	11 3
Load draught of water, in feet and inches, aft	25 0	24 0	21 9	20 0	18 9	16 0	14 5	14 0	12 6
Mean draught of water in relation to the extreme breadth at load line	0·438	0·429	0·427	0·428	0·418	0·437	0·419	0·408	0·430
Height of the lower port-sill from the load water-line, in feet and inches	6 6	6 6	9 6	9 6	7 6	11 2	9 4	8 9	6 11
Depth of the keel and false keel below the rabbet of the keel in feet and inches	1 0	1 0	1 0	1 4	1 0	0 9	1 0	1 0	0 11
Distance of the greatest transverse section before the middle of the load water-line, in terms of its length	0·082	0·049	0·055	0·061	0·059	0·031	0·029	0·055	0·033
Distance of the centre of displacement before the middle of the load water-line, in terms of its length	0·034	0·023	0·025	0·013	0·033	0·034	0·012	0·024	0·015
Circumscribed rectangular parallelopipedon contained by the length of the load water-line, breadth on water-line, and mean draught of water in cubic feet	322692	304211	229686	179517	149250	108439	86526	66343	48323
Displacement, in terms of the said parallelopipedon ..	0·595	0·598	0·497	0·504	0·498	0·560	0·506	0·502	0·500
Area of the circumscribed rectangle contained by the breadth of the water-line, and depth from the water-line to the lower side of the rabbet of the keel, in square feet ..	1286	1259	1020	827	731	540	446	382	304
Area of the greatest transverse section, in terms of the said rectangle	0·857	0·858	0·725	0·733	0·756	0·862	0·838	0·828	0·834
Area of the circumscribed rectangle contained by the length and breadth on water-line, in square feet	13307	12809	10733	9206	8292	6885	6106	5103	4071
Area of the load water section, in terms of the said rectangle	0·858	0·865	0·831	0·823	0·821	0·825	0·777	0·798	0·782
Depth of the centre of gravity of the greatest transverse section, in terms of the mean draught of water	0·426	0·413	0·364	0·363	0·377	0·412	0·395	0·315	0·415
Distance of the centre of gravity of the load water section from the middle of the load water-line, in terms of its length	Before 0·0073	Before 0·0001	Before 0·009	Before 0·008	Before 0·011	Before 0·013	Before 0·011	Before 0·008	Before 0·0095
Height of centre of effort of sails above the load water-line, in feet	88·75	88·75	76·8	73·6	70·1	58·6	53·4	52·6	43·8
Distance of centre of effort of sails before or abaft the centre of gravity of displacement, in relation to the length of the load water-line	Before ·0037	Before ·008	Before ·0018	Before ·0197	Abaft ·005	Abaft ·014	Before 011	Abaft ·0056	Before ·0075
Relation of the moment of the sails abaft the centre of gravity of displacement to the moment of the sails before the said centre	0·912	0·929	0·987	0·877	1·038	1·109	0·905	1·047	0·947
Area of sails in relation to the area of the greatest transverse section	27·1	27·5	33·2	36·9	36·5	31·6	31·8	34·4	32·8
Area of sails, in sqaure feet, in relation to the displacement	0·154	0·163	0·212	0·248	0·271	0·232	0·271	0·327	0·343

these trials, in so far as they have yet been determined, have been indicated in a Report ordered to be printed by the House of Commons, on the 1st July, 1851. The superiority of sailing was in favour of the *Phaeton* over other frigates similarly fitted. Her superiority was maintained, notwithstanding various changes in the trim of the rival frigates. the *Leander* and *Arethusa*; but the *Arethusa* had tbe advantage over the two others in respect of stowage, and she sailed better than the *Leander*.

Table III. gives the principal dimensions and other elements of several brigs which have been tried together at sea for the purpose of ascertaining their relative merits in regard to sailing and other necessary qualities for vessels of this class. The results of the trials of the brigs in Table III. are given in Captain Corry's Report, published in Parliamentary Paper, No. 394 (A), Session 1845.

Naval architecture, as far as it concerns ships moved by wind and sails, has thus presented to us many improvements. But we have now to speak of progress, by far more complete and important, in ships moved by the power of steam.

Paddle-Wheel Steam-Ships.

Many persons, in various countries, claim the honour of having first invented small boats propelled by steam; but it is to the undaunted perseverance and exertions of the American, Fulton, that is due the ever-lasting honour of having produced this revolution, both in naval architecture and in navigation. When the general peace took place in 1814 there was not a single steam-ship in the ports of England; Scotland, however, had one small vessel of this kind. For several subsequent years *steam-boats*, of small size and with very insignificant engines, were employed in rivers or along the coasts, but the idea of going far out to sea with them was considered very presumptuous. In 1818, however, an American captain traversed the Atlantic in a steam-ship, the *Savannah*, touching first at England, and then proceeding up the Baltic to St. Petersburgh. About seven years after this steam was applied to railway travelling on shore; and then it was that most important attempts were made to extend the power of steam to long voyages by sea, and to the passage across the Atlantic from England to the United States. In accomplishing this, however, far more powerful engines, and much larger ships than had yet been built, were absolutely requisite.

Steam was soon applied very generally, both to the commercial navy and to ships of war; a main object being the application of such velocity combined with economy and safety as would induce persons to travel by sea. To procure such a velocity it was not enough to increase the propelling power; it was also indispensable thoroughly to modify the forms of the vessels, to diminish the bulk of the prow and stern, to reduce the breadth, and proportionally increase the length. In this way the forms of steam-ships have been made very similar to those of the galleys of ancient times; when, instead of steam power, human labour was applied to propel the vessel by means of oars; whereas now, the mechanical force is transmitted by the paddles of wheels or screws acting longitudinally.

Such is, at present, the empire of man upon the sea, that calms, contrary winds, and adverse currents, formerly so detrimental to speedy navigation, are quite overcome. Periodical steam-ships start and arrive on fixed days, and almost fixed hours, at the ports of Liverpool or Havre and New York; as well as from London or Marseilles to Constantinople and Alexandria; and from Suez to Bombay, Ceylon, Calcutta, Singapore, and Hong Kong. Contracts are made between the Admiralty of Great Britain and steam navigation companies, obliging the vessels of the latter to cross the Atlantic and the Mediterranean at the rate of at least nine miles an hour, taking all the chance of contrary winds. Great Britain, ever attentive to the preservation of her maritime power, looks upon the great steam-ships built by private companies, and under contract with the government, as a valuable reserve in case of war; with this view, special articles of the contracts with the companies oblige them to build their ships of wood, and not of iron, because with the latter material they would not be so fit for defence, as we have already explained. At the first signal of war, the Admiralty would, from this source alone, have an auxiliary steam navy of 20,000-horse power! The exertions of private speculators, and of the English government, during the last fifteen years, in securing the conveyance of letters, valuable goods, and passengers between Europe, America, Africa, and Asia, are deserving of the highest admiration. The many rich and powerful companies engaged in promoting similar undertakings, by ordering steam-ships to be built of great dimensions, either of wood or iron, so as to be at once very solid and sufficiently light, have greatly advanced the science of naval architecture. We have to award medals to several eminent shipbuilders who have presented the Exhibition with models of the excellent steam-ships which they have lately designed and constructed.

We should have been glad if the great maritime nation of America, instead of sending incomplete and imperfect models or drawings of their steam-ships, had furnished us with the requisite data for estimating the degree of perfection arrived at by their best shipbuilders, so as to have enabled us to recognise their incontestable merit. The United States cannot at present compete with Great Britain in the number of their great and regular communications by steamers, although on the lines opened by them they are nothing inferior to their mighty rivals. The depth and vastness of the rivers of the United States, such as the Mississippi—the greatness of their lakes, which are indeed so many inland seas, have enabled the Americans to build steamers which may be considered as floating cities, and which satisfy the wants of the greatest wayfaring nation of the world. The Americans, however, are to be reproached for their recklessness, and the little care they take to avoid evident peril. Catching fire, blowing up, or foundering from the effects of the latter—accidents which a little foresight might have prevented—are considered and accepted by them as casualties very little to be regarded. They brave these dangers knowingly, and to meet competition with a rival ship. Hence the accidents which occur are frequent and dreadful, and still they do not teach the commercial navigators to be more circumspect. The steam-ships of war, however, reserving danger for the time of battle, exhibit, on the contrary, a prudence which makes velocity subservient to security.

In the British navy much has been done experimentally for the best application of steam power to naval architecture. We shall notice in our reports the results of these experiments, which are well worthy of attention. The experiments we allude to are mainly relative to navigation with recently-adapted screw-propellers. This method of propulsion has the advantage of acting entirely under water, and is consequently protected from the fire of an enemy, an advantage not possessed by paddle-wheels. Paddle-wheels, also, by the large space they occupy on both sides of the ship, do not permit the use of guns along the whole length of the deck.

Several French professors, engineers and naval officers, have made some interesting experiments on steam propulsion, with ships varying in form and size. The researches and experiments of Messrs. Bourgois and Moll have been already proclaimed and recompensed by the National Institute of France. These gentlemen are still pursuing their inquiries at the great manufactory of steam-engines for the French Marine at Indret.

We much regret that the maritime nations of the Continent did not contribute examples of their naval architecture to the Great Exhibition. The Norwegians and Swedes, those excellent and bold navigators, have not sent any models or designs of the ships they employ either on the ocean or the Baltic. Their shipbuilders, inheritors of the science and art of the celebrated Chapman (the eminent author of 'Architectura Navalis Mercatoria,' Stockholm), would have figured honourably, even in comparison with the most advanced seafaring people.

Since the last change in the Navigation-laws of Great Britain, the Anglo-Maltese purchase merchant-ships of the Greeks, and have them registered with those of the United Kingdom—finding these ships of very little cost, and well adapted to the navigation of the much intersected seas of the Cyclades and other parts of the Levant. The Greeks, however did not send us models of any of their ships. The Venetians, the Genoese, and even the Dutch, a maritime people both by nature and necessity, failed also to send models. Finally we regret that the French shipbuilders of Havre, of Nantes, of Bordeaux, and of Marseilles, who do not want either ingenuity, learning, or experience, have not contributed in any way to this Exhibition. We had only from that country a model of the great iron steamers which are built for the navigation of the Rhone, the most rapid and dangerous of the French rivers. M. Schneider, of Creuzot, constructed these ships and their machinery.*

In twelve years there have been built at Creuzot for the Rhone, under the direction of M. Schneider, eighteen steamers, the first of 89-horse power, and the last of 300, to carry 620 tons, and to overcome a mean velocity of the Rhone equal to at least two mètres per second, ascending from Arles to Lyons in 36 or 38 hours. Other steamers, built for passengers, make still quicker voyages. Machinery for war steamers has been constructed for the French government at Creuzot, of 453 and 609-horse power, with remarkable success.

Screw-Propeller Steam-Ships.

The application of the screw-propeller to ships of war is of comparatively recent date, but has, notwithstanding, been so successful as to lead to the expectation that it will ultimately be generally applied to ships in the navy, either with full or auxiliary steam-power. The first ship in the navy to which the screw-propeller was applied was the *Rattler*, of 888 tons, in which with engines of 200-horse power, a speed of 10 knots per hour was obtained. The results of the trial of the *Rattler* with the *Alecto*, a ship built from the same lines, and having engines of the same nominal horse-power, but fitted with paddle-wheels, proved so highly favourable to the screw-ship, that the Admiralty, in the year 1845, were induced to order four old ships of the line of 74 guns, and four old 46-gun frigates to be fitted with screws, with a view to their being employed as block-ships or harbour guard-ships. The *Blenheim*, *La Hogue*, and *Ajax*, three of these ships, were therefore fitted with screws and with engines of 450-horse power, and have been recently tried at sea. The speed obtained so greatly exceeded anything contemplated, whilst their efficiency as men-of-war for general service became so fully established, that they are no longer regarded as fit only for harbour service, but are considered as sea-going ships, possessing powers and capabilities far exceeding those of ordinary sailing ships.†

The speed obtained by steam-power alone varies, in these ships, from 6½ to 7½ knots per hour: and by sail and steam combined, a speed of about two knots more than that which sail alone would give is frequently obtained, with the power of sailing closer to the wind. The forms of *La Hogue*, *Blenheim*, and *Ajax*, although more or less altered abaft to adapt them for the screw-propeller, cannot be regarded as altogether well suited for its effectual operation. Daily experience shows that much greater comparative length than these ships possess, combined with a bow or entrance, as well as a fine run, is necessary to insure the best results from the screw.

By comparing the dimensions of ships in the mercantile navy with those of the royal navy, it will be seen that screw-ships for this service are of still greater comparative length than in the royal navy; and that, in consequence, still better results have been obtained.

Table IV. contains the dimensions and some of the calculated elements of a series of screw-ships of the most recent construction.

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* To M. Schneider, when minister, we are indebted for the selection of the thirty-six French Jurors and Associates sent to the Exhibition.

† As soon as the conditions of this new problem of naval architecture were known to the public, Baron Charles Dupin, in a report to the French House of Peers, announced, in positive and strong terms, the great success to be expected from men-of-war so fitted. He pointed out the new services which they could fulfil, not merely as harbour guard-ships, but as a squadron of attack, for the remotest points of the European seas, and even farther.

BRITISH ASSOCIATION.

Selections from Papers read at the Meeting held at Belfast, September, 1852.

CHEMICAL COMBINATION.

On the Nature and Effects of Chemical Combination. By Thomas Woods, M.D. (Paper read before the Chemical Section, by Dr. Gladstone, Secretary.)

Dismissing all hypothetical ideas, and arguing from such phenomena only as can be demonstrated, I will endeavour to divest chemical action of any mysterious character or properties more than those belonging to the ordinary changes in simple matter, and extend the laws which regulate the latter to combining and decomposing substances.

If two similar bodies, unequally heated, be placed together, one expands and the other contracts, until an equal volume is attained by both. If two bodies of equal volume be placed together, and then pressure be applied to one, the other becomes heated or expanded in proportion to the pressure or diminution of volume of the former. If any substance expand, it deprives some other of heat or volume; as in the solution of salts, &c.

In the foregoing molecular changes of mattter, it is evident that to whatever cause they may be attributed, there are equal movements simultaneously occurring in opposite directions. (No. 1.)

Every substance is compressible, and has a certain specific gravity, proving that it is composed of particles, whether these be what are called atoms or otherwise; and that, because it has a specific gravity, these particles must be separated by a definite space or distance, which is always the same for the same body at like temperature and pressure; and at any distance from the zero of temperature, or absolute contact of particles, these particles must be at different distances in different bodies, for bodies expand differently when heated. It follows, then, that the space and matter which compose every substance must be related; or, in other words, that the distance between the particles of a body must be some function of, or have some dependence on, the nature of the matter composing it (No. 2).

To these propositions may be added a third—that particles form one body when they are at insensible distances (No. 3).

Now, before chemical action can take place, the bodies about to act must be brought together at insensible distances—that is, form one body; but if two substances of different kinds form one body, and that the distance between particles be some function of the nature of the matter (No. 2), it follows that the distance between the particles of the mixture of the two bodies cannot be the same as that of either. Hence, the distances must change; and as (No. 1) every molecular change must be accompanied by an equal and opposite one, when the distances diminish, the distances between the particles of some other body increase, or heat is produced. Chemical action may, therefore, be said to consist in an alteration of the distances between the particles of matter, consequent on the change that is produced in the nature of the matter itself, by the substitution of a mixture of two bodies for one; and as, if two substance be brought together from sensible to insensible distances, any alteration in the distances of particles must be a lessening (for if it were an expansion the bodies would not come to an insensible distance at all, or at least could not be brought nearer than the very bounds), the heat of chemical action is—the necessary simultaneous equal and opposite molecular movement or expansion. If two simple bodies, therefore, combine, the distance between the elements of each compound particle being less than that between the particles of either bodies in the uncombined state, heat or expansion in some other substance must be produced; just as when the particles of iron for example contract or come together from pressure or any other cause, expansion in another substance is the result. I proved in the *Philosophical Magazine*, for October 1851, that the opposite effect, or cold, is the consequence of the expansion among the particles in the decomposition of a compound.

The value of external circumstances in chemical combination may be estimated by the fact, that although at first the compound particle may absorb the expansion or heat produced by combination, yet other bodies in the end take it up; and this equal and opposite movement must be modified by them. If it be true, then, that the distance between the particles of a body depends on the matter composing it (No. 2), and that chemical combination depends on a lessening of this distance, or rather consists therein, it follows that affinity results from the circumstance, that when two bodies are mixed together, the nature of the mixed matter requires a smaller distance between the particles than that of either body separately; and elective affinity is —that, when three bodies are brought together at insensible distances, those two which require least distance between the particles always must unite—and, as the opposite movement or expansion always accompanies the combination, the heat produced is a measure of the affinity; or, if heat be produced, by mixing a simple with a compound body, it shows that the former decomposed and united with an element of the latter—notwithstanding that the decomposition of the latter produced cold, yet the combination that takes place at the same time produces more heat than counteracts that cold; because, if that were not the case, the particles of the combining bodies would not have come more closely together than those of the decomposing one, and no change at all have taken place. For example—if potassium or zinc be placed in water, their metal, the oxygen and the hydrogen, are at an insensible distance from each other; but, as the distance required between oxygen and the zinc is less than between any other two of the elements, or between the particles of either of the elements by itself, the oxygen and zinc unite or come together, while the opposite movement or expansion is supplied partly by the expansion or separation of the oxygen and hydrogen, and partly by external bodies. Zinc can, therefore, decompose water; but, if copper be placed in water, as it does not produce as much heat by combining with oxygen as hydrogen does (or, in other words, does not lie so closely to it in combination), no change is produced—the water is not decomposed. If, however, oxide of silver in solution be substituted for the water, as copper produces more heat in combining than silver does with oxygen, the oxide of silver is decomposed, the oxygen uniting with the copper; or if nitric acid and copper be mixed, as the last proportion of oxygen does not produce so much heat with the nitrogen as they do with the copper, the nitric acid is decomposed and oxide of copper formed.

Thus the heat produced is a measure of the so-called affinity of bodies; for heat is but expansion among particles, and whenever expansion occurs, contraction must be simultaneously going on. That contraction in chemical action is a lessening of the distances between the combining particles; and the greater this is, the greater is the heat.

The movements occurring in chemical combination are thus referred to the same causes, and made to differ in nothing from those occuring in simple matter when it contracts or expands. Perhaps the phenomena of what is called "latent heat" may more clearly express my meaning. I consider the particles of combining bodies to be similarly circumstanced with those of steam becoming condensed—the distances between the particles in either case becomes less; the opposite effect, or expansion or heat in case of steam, is called the latent heat; in the case of the chemical action it is called the heat of chemical combination. They differ from each other in nothing except amount; and this I endeavoured to account for in the *Philosophical Magazine* for January 1852.

To account, then, for chemical action, and the heat produced by it, we have only to admit the existence of two laws:—1. That the distance between the particles of bodies has some dependence on the matter composing them; 2. That any change in their distance is necessarily accompanied by an equal and opposite one among others.

As a postscript, I would say that the idea of attractions and repulsions between particles of matter should be altogether dismissed, as, to say the least, unnecessary—for in all the cases where they are supposed to exist, they must be acting equally and in an opposite direction, so annulling each other. If attraction be imagined to keep the particles of bodies together, an equal repulsion must be imagined to exactly counteract the force, or the particles should collapse; and if attraction be said to cause chemical combination, an equal repulsion must, at the same time, be supposed to act; for expansion or heat simultaneously occurs. I believe the particles of bodies are perfectly passive with respect to each other, and only move in expansion or contraction as the opposite movement is at the same time determined by the law of relation, volume, or distance, as spoken of above.

I would refer, for other particulars of the theory I offer, to the *Philosophical Magazine* for January 1852; the present paper contains a mere outline. As I remarked in this paper, that theory pointed out the circumstance that bodies which produced most heat had the greatest affinity; or that, in fact, the heat produced by combination might measure the amount of that affinity. I made some experiments to test the truth of this opinion. In another paper which I submit with this one to the meeting, I give the amount of heat which various simple bodies produce with oxygen; and it will be found that those bodies which produce more heat are also capable of taking oxygen, from its combination with those producing less; and that if two bodies be combined, a third will cause their separation if it can produce more heat with either element than the other element does, and will have no effect if otherwise.

I will briefly sum up my opinions—I conceive that there is a mutual dependence or relation between the space and matter which compose a body, such relation causing the distance between the particles to be definite; that, therefore, if the nature of the matter changes, the distance between its particles must also change; that, if two bodies be mixed or brought together, at insensible distances, as in solution, they are no longer two but one body; and, as they were dissimilar previously to being mixed, the one body they form must be dissimilar from either separately, and so the distance between the particles must be different. It must also be less; for, if greater, the bodies could be brought nearer at sensible than insensible distances, and so could not form one body at all, which is contrary to our supposition. But, as every molecular movement is accompanied by its opposite, this lessening of distance between combining particles is attended with expansion among others, and this expansion is the heat.

COMBINATIONS OF METALS INTO OXYGEN.

On the Amount of Heat produced by the Combination of several Metals with Oxygen. By Thomas Woods, M.D. (Paper read before the Chemical Section, by Dr. Gladstone, Secretary.)

The reasons spoken of in the foregoing paper having led me to the opinion that the heat of chemical combination is not the result either of opposite electricities uniting, or the disengagement of any subtle fluid, or any affection of matter which is not met with in simple bodies: but the compensating, or accompanying and opposite movement among particles, whereby the loss of volume or distance between the particles uniting is balanced; and judging from the theory I advanced that in a mixture of bodies those particles which could come the closest together would unite to the exclusion of others—or, in other words, would have the greatest affinity—I concluded that as the heat or expansion is equal, although opposite, to the contraction of the combining bodies, it would be a measure of the affinity exerted between different substances. I accordingly endeavoured to ascertain the amount of heat liberated by the combination of several substances with oxygen, in order to find whether those which produced most heat were likewise the strongest bases. The method I adopted is partly founded on the inference I drew in the paper published in the *Philosophical Magazine* for October 1851. From the fact I there proved, "that the decomposition of a compound body gives rise to as much cold as the combination of its elements produces heat," I said that "it might be made the means of determining the amount of heat produced by the combination of bodies, as the loss occasioned by their decomposition shows the gain by their combination." Knowing, then, the amount of heat produced by the combination of hydrogen with oxygen, I knew that if water were decomposed, a like amount would be absorbed; and therefore if any body were placed in contact with water, and could decompose it by joining with its oxygen, the amount of heat of such combination could be calculated by adding the heat absorbed by the decomposition to that marked by the thermometer. For instance, if potassium be placed in water, the oxygen unites with it, and a certain amount of heat is produced; but the decomposition of the water to supply the oxygen absorbs a certain amount also—the latter must be added to the former, and the sum is the quantity of heat the combustion of potassium in oxygen would produce. If the addition of sulphuric acid be necessary to make the metal continue the decomposition of the water, as in the case of zinc, then the heat produced by the combination of the oxide with the acid must be allowed for; and in cases (such as copper) where the metal cannot decompose water, some other fluid must be substituted, as nitric acid, and the amount of heat absorbed by its decomposition allowed for in the general result.

I would remark, as a preface to the following experiments, that although they are given as if an equivalent (oxygen being 1) of each metal were dissolved in a quantity of fluid equal in value of being heated to 60 gr. of water, no fixed weight of each was used; but, according to circumstances, a portion being weighed accurately, was dissolved, and the amount of heat being marked, the result was calculated. For instance, when experimenting with potassium or sodium, I always weighed whatever happened to come from the bottle, the pieces varying from $\frac{1}{2}$-gr. to $2\frac{1}{2}$ gr. Zinc I used in larger pieces than mercury, because it was more quickly acted on, &c., but I calculated what an equivalent of each would produce from knowing what the weight used developed in each case. The fluid, however, was, in every instance, the same in quantity. It amounted to 180 gr. when nitrid acid was used, and 207 gr. when dilute sulphuric acid or water—that is, the menstruum, the vessel containing it, and the thermometer, were all taken together, equal in value on being heated to this quantity of water. As an example of the exact steps followed, I will copy from my note-book one experiment with potassium. Having ascertained, by previous experiments, that the value of the glass tube which contained the fluid and the thermometer were equal in value to 27 gr. I placed in the tube 180 gr. of water; its temperature, 59°; temperature of room, 63°.* I rolled $1\frac{1}{2}$ gr. of potassium in 10 gr. of platina foil, in order to make it sink in the water, and, having placed it in the fluid, the water was decomposed, and the oxygen uniting with the potassium, the temperature rose to 70°—that is, 11°. Calculating from this experiment, 1 gr. of potassium would raise the temperature of 60 gr. of water 25°·3, or 5 gr. of potassium (equivalent to 1 gr. of oxygen) would raise the temperature of 60 gr. of water to 126°·5. But to this must be added the heat absorbed by the decomposition of the water. According to Andrews, 1 gr. of oxygen uniting with hydrogen would raise the temperature of 60 gr. of water 126°·5, therefore potassium must produce, by the combination of an equivalent of oxygen, exactly twice as much heat as hydrogen, or 253°. According, however, to Grassi, the combination of 1 gr. of oxygen with hydrogen would raise the temperature of 60 gr. of water to 130°.

Each of the following results is calculated from a mean of several experiments:—

Sodium.—3 gr. of sodium, by dissolving in water, raises the temperature of 60 gr. 154°, decomposition of water, to supply 1 gr. of oxygen, absorbs 130°; therefore the 3 gr. of sodium (or 1 equivalent) raises the temperature of 60 gr. of water 154 + 130 = 284°, by combining with oxygen.

Potassium.—5 gr. of potassium raises the temperature of 60 gr. of water by dissolving in it 126°·5; add 130°, for the heat absorbed by the decomposition of the water, and 256°·5 is the amount of heat liberated by the combustion of 1 equivalent of potassium.

Zinc.—The solution of 4 gr. of zinc in sulphuric acid (dilute) produces heat sufficient to raise 60 gr. of water 72°. The combination of the oxide formed and the sulphuric acid developes in the same quantity of water 42°·2; this must therefore be subtracted from the 72°, as it is not due to the oxidation of the zinc, and there then remain 29°·8; but to this quantity must be added 130°, absorbed by the decomposition of the water, and 159°·8 is the amount of heat that the combustion of zinc would produce in 60 gr. of water.

Copper.—Copper will not decompose water; nitric acid was therefore substituted for the dilute sulphuric acid. 3·96 gr. (or 1 equivalent of copper) by dissolving in nitric acid raises the temperature of 60 gr. of water 77°·2; but in this is included the amount of heat produced by the combination of the oxide of copper with the nitric acid, which is 35°; subtract this sum therefore, and 42°·2 remain; but as the decomposition of sufficient nitric acid to give 1 gr. of oxygen would absorb as much heat as would lower the temperature of 60 gr. of water 30°·4, this must be added to the 42°·2, and we obtain 72°·6 as the amount of heat produced in 60 gr. of water by the combustion of copper.

The manner in which I found that the decomposition of nitric acid absorbs the above amount of heat was by dissolving 4 gr. of zinc in 180 gr. of the acid; it liberated heat sufficient to raise 60 gr. of water 171°·6; as this included the heat of combination of the oxide of zinc and nitric acid 42°·2 must be abstracted, and there remain 129°·4: but in the former experiment with the dilute sulphuric acid, it was shown that 4 gr. of zinc being oxidised would raise the temperature of 60 gr. of water 159°·8, therefore the difference 159°·8 and 129°·4, equal to 30°·4, is absorbed by the decomposition of the acid.

* In this paper, degrees of Fahrenheit are signified in every case.

Bismuth.—8·9 grains of bismuth, by its solution in nitric acid, developes sufficient heat to raise the temperature of 60 gr. of water 80°·1. Subtract 36° for the heat of combination of the acid and oxide, and add 30°·4 for the absorption of heat by the decomposition of the acid, and the result is, that 1 equivalent of bismuth produces by its combustion as much heat as would raise 60 gr. of water 74°·5.

Lead.—12·7 gr. or 1 equivalent of lead, by its solution in nitric acid, produces heat sufficient to raise the temperature of 60 gr. of water 106°, including 37° for the combination of the oxide with the acid; the latter being extracted leaves 69°, to which must be added 30°·4 for the amount absorbed by the decomposition of the acid, and there remains 99°·4 as the amount of heat produced in 60 gr. of water by the combustion of 1 equivalent of lead.

Mercury.—I could not ascertain satisfactorily the amount of heat produced by the oxidisement of mercury, its solution in nitric acid is slow, and its equivalent number is high, and the combination it forms with the acid is not well ascertained. It is generally thought that when there is an excess of acid, the salt formed is a *sub*-salt, Hy2O being the base. If such be the case, 25 gr. of mercury raises the temperature of 60 gr. of water 50°, including the combination of the oxide with the acid, and this produces sufficient heat to raise 60 gr. of water 40°; the oxidisement alone produces 50°—40°=10°; to this sum add 30°·4 for the heat absorbed by the decomposition of the acid, and it leaves 40°·4 as the quantity of heat produced in 60 gr. of water by the combustion of 1 equivalent of mercury.

Silver.—13½ gr. (or equivalent of silver), by its solution in nitric acid, raises 60 gr. of water 40°·5. Subtract 32° for the heat produced by the combination of the acid with the oxide of silver, and add 30°·4 for the heat absorbed by the decomposition of the acid, and 38°·9 is the number of degrees 1 equivalent of silver, by its oxidisement, would raise 60 gr. of water.

Iron.—The amount of heat produced by the oxidisement of iron could not be calculated with any certainty, from its solution in dilute sulphuric acid, as it required a large amount to be dissolved to cause a perceptible rise of temperature. The heat it produces must be very nearly the same as that produced by hydrogen; as if it differed considerahly a small quantity of it would give rise to a large amount of heat, as its equivalent is small. The heat absorbed by the decomposition of the water very nearly balanced that produced by the combination of the iron with the oxygen. Iron produces only a very little more, if more at all, heat with oxygen than hydrogen does. When iron is dissolved in nitric acid, the peroxide is formed, and 2⅓ gr., or 1 equivalent—for 2⅓ gr. unites with 1 gr. of oxygen—when dissolved in nitric acid, produces heat sufficient to raise 60 gr. of water 102°. As 1 equivalent or 10 gr. of peroxide of iron, by combining with acid, produces heat sufficient to raise 60 gr. of water 20°, 2⅓ gr. must raise it 6°. Subtract this number from 102°, there remain 96°, and add 30°·4 for decomposition of the acid, and 126°·4 is the quantity of heat produced by the oxidisement of iron.

Tin.—When tin is dissolved in nitric acid 3⅔ gr., take 1 gr. of oxygen to form the peroxide, and raises the temperature of 60 gr. of water 105°. If the combination of the peroxide with the acid produces the same amount of heat as the peroxide of iron does, 6° must be subtracted; there remains 99°. Add 30°·4 for decomposition of acid, and 129°·4 is the number of degrees the oxidisement of tin would raise 60 gr. of water.

Summary.—The following table gives, at a glance, the number of degrees that 1 equivalent of each metal, by its combination with oxygen (1 gr.), would raise 60° gr. of water. Subjoined are the results that Andrews arrived at for such of the metals as he has experimented with by directly burning them in oxygen calculated to the same standard as my own—viz., the quantity of heat their combustion would produce in 60 gr. of water.

Amount of heat produced by the combination of an equivalent of each metal with 1 gr. of oxygen in 60 gr. of water.

Sodium	284°
Potassium	256°·5
Zinc	159°·8
Tin	129°·4
Iron	126°·4
Lead	99°·4
Bismuth	74°·5
Copper	72°·6
Mercury	40°·4
Silver	38°·9

Andrews gives zinc, 160°·8; tin, 126°·9; iron, 124°; and copper, 71°·8.

The length to which this paper has run prevents me remarking on the foregoing table as fully as I would wish. It will be, however, seen those metals which are capable of displacing others from neutral solutions produce most heat by their combination with oxygen; or, according to the view I take of chemical combination, require less distance between their particles and those of oxygen than do the other metals. Thus, when a salt of silver in solution is poured on copper, oxygen, silver, and copper are brought together, at an insensible distance, mechanically, for the first instant, forming one body, their particles lying together, perfectly passive with respect to each other; but as we deduce from experiment that oxygen and copper lie more closely together than oxygen and silver, the particles of the oxygen and copper are exactly in the same predicament as a heated body would be in conjunction with a colder one—the particles being separated from one another to a distance greater than natural, so to speak, for the mean temperature—these particles, therefore, move together, or contract, just as those of a heated body would do; and the particles of oxygen and silver which may represent the colder body separate or expand to supply the opposite movement. It will be seen I do not attempt to explain why copper and oxygen lie more closely together than silver and oxygen in combination. I merely say that as their uniting is accompanied by a greater expansion or heat in other bodies, and as that expansion may be taken as equal and opposite to the contraction between the uniting bodies, those substances producing most heat must lie more closely together; and that, therefore, all such hypothetical ideas as electricities, subtle fluids, modulations, &c., may be discarded in accounting for the heat of chemical combination; and the movements immediately concerned in producing it may be looked on as being in nothing different from those where heat is given out from a simple body whose temperature is more elevated than surrounding ones; except in this particular, that a simple body, whose temperature is raised, loses its volume to other bodies by an approximation of its own, or similar particles, but in chemical combination it is the approximation of diverse particles moving to unite.

GEOLOGY OF IRELAND.

Outline of the General Geology of Ireland. By Mr. Griffith. (Paper read before the Geological Section, Lt.-Col. Portlock, R.E., F.R.S., President, in the Chair.)

Mr. Griffith, having directed attention to his most interesting map, and to the various improvements which he had been enabled to make on it since 1838, acknowledging with thanks the services rendered to him by Colonel Fordyce, and Messrs. Bryce and M'Adam, of Belfast, proceeded to take up the subject of his lecture.

On looking at the map, it will be found, he said, that the conformation of Ireland is peculiar, the coast being mountainous and the interior flat. Taking the line from Dublin to Galway, which is 120 miles, the summit level is seen to be only 160 feet above the level of the sea; hence it is that our canals and railways have been made at an expense so comparatively trifling. Lough Allan, which may be considered the source of the Shannon, is 160 feet above the level of the sea; while between Killaloe and the tide-water at Limerick, a distance of about twelve miles, the fall is only 110 feet. The average fall is less than six inches to the mile—a circumstance to which we are to attribute so many sluggish rivers, and the existence of large tracts of country flooded during six or nine months in the year. The mountain-ranges which indicate the strata of Ireland, run in the north from north-west to south-east, and in the County Cork from nearly east to west. Beginning with the foundation and going to the top, it may be said that the mica-slate, which forms the basis of all the sedimentary rocks of Ireland, occurs in great abundance in the Counties of Londonderry and Donegal, where it is found twisted and contorted in every direction by the protrusion of the granite. The granite was formerly considered among geologists to be the oldest rock, though now, in many cases, it has been proved to be among the most recent. The greenstone of the County Donegal is older than it, as is proved by the appearances exhibited at Talcorrib, on the coast at the west of Dungloe. In this locality the strata consist of mica slate and quartz rock, which have been elevated by the protrusion of enormous masses of greenstone, and this greenstone itself contains masses of mica slate and quartz rock, thus proving that it is newer than them. Immediately to the south the granite occurs, cutting through the greenstone and the quartz rock, and containing angular fragments of both, thus leading to the conviction that the granite is the newest rock of the three. Mr. Griffith next alluded to stratifications in the Counties of Mayo and Galway, which, he remarked, were chiefly composed of mica slate, granite rock, and limestone. Granite also occurs to the north of Galway Bay, where it is succeeded by metamorphic rocks and mica slate. To the north of the grand boundary several granite rocks occur, protruding through the mica slate and limestones. In this district there appears the green marble, which is only limestone metamorphosed by the action of the granite. Passing northward, the mica slate is found covered by silurian rocks in an unconformable position. These rocks contain numerous fossils belonging to the silurian system, and are succeeded by enormous masses of conglomerate, containing large pebbles of grey granite, some of them nearly a ton in weight, and perfectly rounded. The granite thus observed is quite distinct in its character from the granite of the district, and clearly enough belongs to an older period. The thickness of the silurian strata, including the conglomerate, may be set down at about 5000 feet. The speaker next alluded to the slates and silurian ranges of the promontory at Dingle, in the County of Kerry, and described similar formations in the Counties of Waterford, Wexford, and Wicklow, remarking that the granite in the same localities is found to be newer than the slate—a fact proved by the protrusion of several granitic hills through the most of the slate district. To the north of Dublin there is another slate district, similar in character to that of Wicklow and Wexford, and probably belonging to a lower silurian series; though, as no fossils have been discovered in it, except at the south portion, its exact age remains undetermined. This is accompanied with the granite at the Mourne Mountains, which Mr. Griffith conceives to be newer than the slate. One of the most interesting silurian districts in Ireland occurs near Pomeroy, in the County Tyrone. It was discovered by Colonel Portlock, who has fully described it in his valuable works on the geology of the County Tyrone and the neighbouring districts. The learned gentleman next described the old red sandstone, particularly alluding to the large district which occurs in the County Tyrone, and which, apparently has some relation to the silurian district at Pomeroy, described by Colonel Portlock, and then pointed out on the map several mountain ranges which are capped by the deposit, particularly the Galtees and Knockmedown Mountains, Slievenish, in the west of the County Kerry, and districts north of the County Cork. Having remarked that the old red sandstone is succeeded by the great mountain limestone district of Ireland, which occupies two-thirds of the entire country; and which, on account of its lithological character, he was accustomed to subdivide it into five portions, consisting of the yellow sandstone, the carboniferous slate, the lower limestone, the calp or shale series, and the upper limestone, he proceeded to say, that as this would form the subject of a separate paper, he would decline entering into its consideration on the present occasion. The carboniferous limestone series, he observed, is altogether about 6000 feet thick, 3000 feet of which belongs to the lower portion of the series, and 3000 to the upper. He next described the several coal districts of Ireland, commencing with Ballycastle at Fair Head, on the north coast of the County Antrim. This district, which is of greater antiquity than any other in Ireland, had, he remarked, been worked to a considerable extent. The coal was worked by tunnels, and the beds, which were affected at different elevations by the protrusion of dykes of greenstone, have been nearly worked out, though at Murlough Bay, which contains bituminous coal or stone-coal, there some beds, whether exhausted or not, he had not information to say. The next coal district is that situated near Coal-island, in the County Tyrone. It is very small, and the beds are now nearly all worked out. A third occurs in the Counties of Leitrim, Cavan, and Roscommon, stretching to Lough Island, which contains only one bed, not exceeding two feet in thickness, though in this locality there is a site of the Arigna Iron Works, which, though they are not worked at the present time, formerly attracted much attention in this country. The shale accompanies the coal with rich beds of argillaceous ironstone, some of it containing so much as 40 per cent. of iron; indeed the iron that was made at Arigna was found to be of very superior quality. Mr. Griffith next described the Kilkenny coal district, which contains, he said, an unflaming coal or mineral charcoal alone. There are several beds in this district, two of which are 3 feet in thickness, one 4 feet, and two less than 3 feet. The upper beds have been long since worked out; the lower ones still remain, though they are so impure in quality, and contain so much sulphur that they are not used except to burn limestone. The Munster coal district was next dwelt upon. It occupies a considerable portion of the Counties of Clare Limerick, Cork, and Kerry, and contains three beds, some of which are not more than 6 inches in thickness. The most valuable portion is found at the south, immediately to the north of the river Blackwater, where several excellent beds of anthracite occur. The learned gentlemen having remarked that he would not say that a valuable coal-bed would not be found in Ireland, though he believed that no such coal would be had in the country as is to be found in England, proceeded to take up the new red sandstone. The new red sandstone, he said, is very sparingly developed in Ireland. The most southern locality in which it is found is at Carrickmacross, in the County of Monaghan, where in sinking through it to obtain coal, a bed of gypsum, 40 feet in thickness, was discovered; and the districts in which it is found most extensively are in the Counties of Tyrone and Antrim. At Tyrone it adjoins the coal district, and rests upon it. It also occurs in the valley of the river Lagan, in the Counties of Down and Antrim, continues under Belfast, and again displays itself at Carrickfergus. This stratum contains gypsum in thinner beds, however, than those mentioned as occurring at Carrickmacross. Some time ago, when sinking through it to obtain coal, a bed of salt was discovered; this discovery, however, he would not touch upon, as he understood a local paper on the subject would be presented to the Association during the sitting. The new red sandstone, he proceeded to say, is covered by the lias, which is similar to that in England, and this again by the chalk, which, in the north of Ireland is called white limestone, owing to being more dense than the chalk found in England. The chalk is covered by lobatin trap, which occupies a large portion of the Counties of Antrim and Derry. Mr. Griffith next went on to explain the position of the tertiary beds,—remarking that a very interesting tertiary district occurs in the south side of Lough Neagh, in the Counties of Tyrone and Down. It is ten miles in length and four in breadth: a bore was made through it to the depth of 300 feet, with a view to obtain coal, and the strata was found to consist of alternations of white ironstone and blue clay, with surlurbrand or wood coal—a series precisely similar to that at Bovey, in Devonshire. The level of the Bore, which was situated not far from the coal field, and adjoined the coal district, was about 70 feet above the level of the sea; and as the boring itself was 300 feet deep, the depth of the series was 230 feet below the level of the sea, though even at this distance it was not penetrated. Mr. Griffith next alluded to the tertiary districts situated on the coasts of the Counties of Wicklow, Wexford, and Waterford, and concluded a most interesting sketch of the geology of the country by a rapid view of the escarp hills and diluvial gravel which cover so large a portion of Ireland, and which appeared to him to have been produced by currents setting in from the north-west towards the south-east.

The President, having alluded to the many obligations under which Mr. Griffith had placed the Association, proceeded briefly to state the various interesting points in that gentleman's address. Mr. Griffith had shown, by a reference to the north or north-west, that the granite includes pebbles of greenstone and mica slate; and that, therefore, the granite must be newer than the greenstone and the mica slate. This was a most valuable fact; and there was another stated by Mr. Griffith not less so—namely, that in the east and lower east, in which the granite occurs, it is newer than the old red sandstone, though the new red sandstone is as it were formed of the detritus of the granite. Another point of very great interest was the scarcity of coal. Here was a matter in which geology was of vast importance, as it was desirable at once that the geologist should point out where to obtain valuable minerals, and that he should exercise a wise discretion in preventing others expending time and money in investigations where these properties are not to be expected. It was clear by Mr. Griffith's statement that coal is not to be found in any quantity in Ireland; and therefore every attempt to leave that impression, and to induce parties to embark in speculations which must prove fruitless, ought to be discouraged.

Mr. Saull expressed his surprise at one remark which he said had been made by Mr. Griffith—that in which he asserted that the mica slate was older than the granite. That was so contrary to his own understanding, and so opposed to hundreds of facts, that he could not but hesitate in accepting it.

HARBOUR OF BELFAST.

On the Improvements made in the Harbour of Belfast. By J. Garrett. (Paper read before the Mechanical Section, J. Walker, Esq., President, in the Chair.)

The town of Belfast is situated on the river Lagan at its junction with the extensive inlet from the Irish Channel, known as Belfast Lough, which extends in a south-westerly direction for about 11 miles from the general coast line, and is bounded on the south-east and north-west by the Counties of Down and Antrim respectively. The lough is seven miles in width at its seaward entrance, and decreasing gradually towards its southern extremity, presents a well-formed receptacle for the western portion of the north tidal stream. The courses of the flood and ebb tides through the lough do not differ materially—a circumstance of much importance, as tending to prevent the formation of any formidable shoal or bar, so often found to exist at harbour entrances, but from which that of Belfast is entirely free. The anchorage is about 14 square miles in extent, with from two to ten fathoms water, and affords excellent "holding-ground," consisting principally of blue clay. The importance of this lough as a harbour of refuge is clearly pointed out in the following extract from the Admiralty sailing directions:—

"The bay of Belfast is, with moderate caution, free from dangers of any kind; the shores on either side being approachable by the lead to a moderate distance, and a ship may anchor in any part of it claer of the banks for a tide. Even in the event of a ship running in dismasted, and without cables and anchors, she might with confidence run upon Garmoyle bank, or as nearly as possible to where vessels lie. She would make a dock for herself, and remain in safety till fine weather; and this is an advantage which few other ports on the coast of Ireland possess."

The river Lagan rises in the Mourne Mountains, and empties tself into the lough after a course of about 36 miles in length, through a catchment basin of 200 square miles in extent. The tidal water flows up the river for about two miles above the town, where its further progress is prevented by the works of the Lagan Navigation, by means of which a water communication is afforded between the port of Belfast and the interior of the country.

The earliest mention of Belfast as a trading town is in a charter granted by James I., in 1613, to empower a "guild of freemen to erect a wharf or quay in some convenient place in the bay or creek;" and until the year 1720 the only accommodation which the town afforded for shipping was in the above-mentioned "creek," formed by a small river running down the centre of High-street, which is at present covered over, and forms one of the sewers of the town. The first authentic plan of the town was by order of government in 1685, to enable them to lay out fortifications, and in it the harbour is shown as above described; and the Long Bridge, which was commenced in 1682, is represented as being in course of erection. In 1720, the first quay-wall along the Lagan was built; and from this date very little alteration was made in the harbour until the year 1785, which may be considered as marking the commencement of its progress. From this date up to 1814, many improvements were made in the harbour; these, however, were not of such a nature as to alter materially the previous character of the navigable channel, which remained narrow and tortuous (bounded on either side by very extensive banks, uncovered at low water) for a distance of about three miles, extending from the roadstead called Garmoyle to the quays at the town.

We learn from Mr. Rennie's report in 1821, that the channel was only from 2 to 4½ feet deep at low water opposite the town, and continued with little increase for about 2½ miles lower down, when it was joined by the Seal channel, through which was conveyed the greater portion of the water covering the large area of the low banks along the Antrim side of the lough at high water; at this point the depth was about 8 feet, and increased gradually to 16 feet at Garmoyle, showing an addition of 8 feet in depth in the short distance of half-a-mile. Mr. Rennie, however, in noticing this increase, does not mention that the Conswater river, which conveys the drainage of a considerable district in the County Down, in addition to a large quantity of tidal water, discharged into the main channel near the same place.

The roadstead, or pool of Garmoyle, had a depth of from 18 to 20 feet at low-water spring tides, with good anchorage, and was so well sheltered that vessels could lie in it safely during every wind. As the rise of spring tides was only 12 feet, and neap tides 8 feet, vessels drawing 14 feet and upwards could not proceed to the town, but were necessitated to remain in Garmoyle until the greater portion of their cargoes had been discharged by means of lighters—a mode of operation both inconvenient and expensive.

The unsatisfactory state of the harbour, which has been described, together with other imperfections causing annoyance and delay to the revenue department, induced the Commissioners of Customs (in 1814) to give instructions to Mr. Killaly to report to them on the improvement of the port; but this gentleman's attention seems to have been directed mainly towards providing dock accommodation, without seeking to effect any improvement in the means of communication between the town and the sea.

In 1821, the late Mr. Rennie, by the direction of the Lords of the Treasury, reported upon the general improvement of the harbour. He stated that the first thing required was a sufficient depth of water to enahle vessels to come up to the quays without being obliged to discharge part of their cargoes in the lough; and, secondly, improved dock arrangements. To supply these deficiencies he proposed two measures. The first was (in the words of his report), "to convert the whole of the river in front of the town into a wet dock, and from thence to make a ship canal into the deep water of the lough. This ship canal must terminate either at the buoy of the flats, at the head of Garmoyle, or at Whiteabbey, adjoining the town of Carrickfergus, about five English miles from Belfast." The second was to have the quays and harbour as they then were, and to make a wet dock (capable of receiving all the vessels with exciseable or customable cargoes), having a canal to communicate with the lough either at Garmoyle or Whiteabbey, and a lock to communicate with the existing harbour.

The first plan would have involved the necessity of making a new course for the Lagan through Ballymacarret, and a canal from it into the wet dock also; if the ship-canal had been carried to Whiteabbey (as recommended in the report), a sheltering pier would have been necessary to protect the entrance from the sea. For the second plan, it was recommended that the entrance to the proposed canal should be constructed at Garmoyle.

In 1824, the Ballast Corporation requested Mr. John Rennie (now Sir John) to report to them his views with respect to the best mode of improving the harbour, and about two years afterwards he submitted to them three designs. The first was to form an open-tide canal to Garmoyle, and make the river at the town into a wet basin, or to make a basin independent of the river. The second, to make a lock-canal to Garmoyle, and a basin as in the first, having a communication with the river. The third (which he recommended for adoption) was to form a basin, as in No. 1, and make a ship-canal from it (nearly on the line of high-water mark along the Antrim shore) to Silverstream, about 5 miles below the town; and at this place to construct an entrance-harbour, with locks, &c., so arranged as to admit the largest vessels into the canals at all times.

Mr. Telford was next consulted on this important question, and in 1829 reported his opinion in favour of the formation of a canal, connecting Garmoyle with three new floating docks at the town—the canal to have a double lock at its entrance into Garmoyle, and to be so constructed as to admit vessels drawing 20 feet of water during neap tides. This plan rendered it necessary to divert the course of the river Lagan, and to erect a weir, &c., to keep the water in the river above up to the level of high-water spring tides.

In 1829, Sir John Rennie reported a second time, and recommended the formation of wet docks at the town, with a canal leading to Garmoyle; he also proposed to dam up the river above the town, and form a new channel for its overflow waters. This design is almost identical with that proposed by Mr. Telford.

Mr. Walker was now asked for his opinion, and in 1830 Messrs. Walker and Burges recommended the design which has been, with some slight modification, adopted. This was in general terms to straighten and deepen the river channel from Garmoyle to the town, by means of two new cuts, which, although in the same line, were quite distinct from each other —to construct a large floating dock, communicating with the river through an entrance lock—to extend and improve the existing quays, and form new wharfs on the County Down side of the river.

In 1835, Mr. Cubitt (now Sir William) reported to the Board of Works on the several plans proposed, and suggested two designs himself for the improvement of the harbour. The first was to form a new channel for the river through Ballymacarrett, turn the existing river course and the quays into a floating-dock, and make two new cuts between Garmoyle and the town, the upper one to be formed into an entrance basin, with a single pair of gates at the lower end and a ship lock at the upper. The second plan was to form the docks and cuts towards Garmoyle as in the first; but instead of a new course being formed for the river, it was to be dammed up and its overflow waters discharged over a long weir.

Many other plans were proposed by various gentlemen, but as they do not contain any different principle, and merely vary in detail from those already enumerated, it is unnecessary to describe them here.

From 1814, when the first of the reports above described was made, until 1839, when the first of the works designed by Messrs. Walker and Burges was commenced, many improvements of a minor character were made in the port, which need not be detailed here; but in order to assist in forming an estimate of the extent of improvements effected in the harbour generally by the subsequent extensive alterations, it may be stated that, in 1837, there were about 5 feet maximum depth of water opposite the quays, and about 8 feet in the south channel below the town, at low water. The accommodation for shipping consisted of four tidal docks (one of which could accommodate twenty-five vessels of 400 tons, but the others were only fit for the reception of small sloops &c.); there were two graving docks suitable for vessels of from 300 to 600 tons, and the entire quay room was about 3000 feet, of which a large proportion was not available for vessels of considerable tonnage.

Before proceeding to notice the results which have flowed from the execution of the design of Messrs. Walker and Burges (which, so far as carried out, has fully realised the anticipations of its projectors), it may be well to direct attention to two points in particular, in which it differed from the various projects recommended by the other eminent engineers whose attention was directed to the subject. First, the design adopted possessed the great practical advantage of an arrangement of parts which admitted of its being executed in distinct sections, which were each in itself attended with beneficial results, independent of their combined effects as portions of one comprehensive design; secondly, that the flow of the tide up the estuary, instead of being opposed by barriers to prevent its progress (or, at best, put aside as if unworthy of attention), was treated as a valuable ally, and so guided as to aid by its unceasing action in giving permanence to the improvements effected in the channel.

The great increase in shipping accommodation afforded by the late works (which have been so well carried out under the superintendence of Mr. Smith, the Resident Engineer to the Harbour Commissioners) may be observed by comparing the account previously given of the state of the port in 1837 with the following statement of its present condition. The depth of water opposite the quays is 9 feet at low water. There are 6980 feet of quayage; two tidal docks, capable of accommodating fifty vessels of from 200 to 400 tons; two graving docks and two patent slips—showing an increase of upwards of 3000 feet of quayage, and an additional dock accommodation for twenty-five vessels, together with the advantage to the shipping interest derived from the facility of repairs afforded by the patent slips.

The period which has elapsed since the completion of the new channel (the second portion of which was opened in July, 1849) is rather short to enable one to pronounce as to its ultimate effects; but it is gratifying to understand that the results, so far, are most favourable. Scarcely any dredging is now required to maintain the depth of water in the new cuts, and no injurious effect on the channel lower down has been observed. This is to be attributed, in a great measure, to the increased velocity of the current, caused by the superior facilities afforded for the passage of the tidal and river water, by the more direct course of the new cuts, together with the increased inclination given to the bed of the channel by the shortening of its course.

The formation of floating docks (in which vessels may lie afloat at all times of tide) is an important portion of the design remaining yet to be executed, and when this shall have been accomplished (for which there are local facilities possessed by very few ports in the kingdom), Belfast may be justly pointed out as an eminently-successful development of the idea—that an improved river with docks is better than the substitution of docks for a river. The truth of this must appear forcibly to any one who witnesses the advantages enjoyed by the public from the present arrangement, which admits of the free arrival and departure of steamers and vessels of a similar draught of water, with nearly equal readiness at all times of tide, and who considers the delay and inconvenience which would necessarily ensue from any system which would render "locking" necessary at all times, except at or near high water.

The average daily arrivals and departures at present are thirty-two sailing vessels and twelve steamers.

The paper then proceeded to mention some facts connected with the extensive slob-banks on the borders of the lough, which have undergone considerable changes at a comparatively recent period; which changes the author attempted to show to be the effects of natural causes.

Mr. Godwin, C.E., took the opportunity of bearing testimony to the great improvements which had been made in the harbour of Belfast, as stated in the paper by Mr. Garrett, and considered that the Harbour Commissioners had been exceedingly fortunate in adopting the plans which had been carried out, and in having a man of Mr. Smith's ability as their engineer. He had no faith in the principle of canals, and thought that the advantages of vessels coming up to the town should be always preferred. He alluded to Newry as a case in point, and believed that if the people of that town had expended the 200,000*l.* which their present harbour accommodation had cost them in following up the principle laid down at Belfast, they would have found the same benefits as had been discovered here. He observed that any alteration in the course of the river would have the effect of making a change in the length of the river, and instanced the case of the river Chepstow. If the course of the river be contracted, or, as in this case, narrowed, it would produce a greater rise in the water further up towards the river's head, although it might not make much difference in the instance of the Lagan. Mr. Godwin wished to know whether, by the water being allowed to pass over the slob-lands, the scour of the channel would be improved, or whether, towards that end, it should be confined as much as possible to the course of the river? This was a subject which he thought worthy of the attention of the meeting.

Mr. Garrett remarked that by the rise of the tides the water flowed up the new channels, and covered the slobs, and that on the fall of the tide it returned back by the same course.

Mr. Walker, the Chairman, said that he had the honour of acting as engineer for the harbours of the Clyde and Belfast, and he believed that the eminent Engineer to the Belfast Harbour Commissioners had performed all that could be desired for the benefit of the trade of the port. When he was applied to by the Commissioners to propose a plan for the improvement of the harbour, he at once saw the necessity of large steamers being able to run to and from the town; although he did not think, if that end had been accomplished, all the credit was due to him. At Glasgow, when he was studying at the University there, the depth of the water at the quays was not more than 4 feet; only very small vessels being able to come up to the town. Mr. Smeaton, the eminent engineer, when spoken to by the Glasgow people on the contemplated improvements to their quay, assured them that if they would follow his advice he would give them 4 feet of water at low, instead of high tide. This of course was deemed next to impossible, but had been fully accomplished—a vessel drawing 20 feet of water, and of 2500 tons burthen can now come up to the town. This, he thought, should have satisfied the people of Glasgow, but it had entirely failed in doing so.

SAFETY HARBOURS.

Design for Safety Harbours. By Joseph Saunders.—The advantages of the design are—durability, cheapness of execution, and security from damage during the progress of the work. The sea pavement, which has heretofore been the ruin of our best harbours, will be by this design dispensed with, substituting a strong sea-wall instead. The bell-work to seaward will be constructed upon an entirely new plan, diminishing 1 foot in each course till it reaches low-water mark, on which the great sea-wall will commence with the ordinary batter; this wall will be supported from the interior by horizontal arches and sectional walls; and the horizontal arches will be filled with concrete and small stones to high-water mark.

DISCHARGE OF WATER.

On the Discharge of Water. By J. BARKER, C.E., of Manchester.

Mr. BARKER communicated a series of observations on the discharge of water for the purpose of driving machinery; and in the course of his remarks he laid down the following certificates for calculating the velocity of water discharged through various apertures:—Through an opening 6 feet long and 6 inches deep, with curved approaches inside, and formed with a radius of 2¼ inches, the coefficient proved to be 7·8; through an opening of the same dimensions, but curved inside only, the coefficient proved to be 7·04; through a similar opening, but curved outside only—merely resembling the discharge through a thin plate—the coefficient proved to be 5·6; and the coefficient ordinarily used by engineers was 5·1; and the coefficient for theoretical velocity was 8·04. Mr. Barker further stated that his experiments proved the accuracy of formulæ established by Chevalier Dubuet for calculating the mean velocity of water in the separate channels.

REVIEWS.

A New General Theory of the Teeth of Wheels. By EDWARD SANG, F.R.S.S.A., Professor of Mechanical Philosophy in the Imperial School, Muhendis-hana-berrii, at Constantinople. Edinburgh: Black. 1852. 8vo. pp. 120; 53 plates.

ODONTOGRAPHY, or the delineation of the teeth of wheels, has frequently engaged the attention of mathematicians and mechanicians for the last two centuries. It does not appear, however, that the results of theoretical investigation are very generally and scrupulously observed in practice. The mathematician demands, for the practical application of his results, an amount of labour of numerical computation, and of delicacy of mechanical execution, which the workman is unable or unwilling to bestow. It is a very common practice with those whose business it is to set out the teeth of wheels, to draw their lines in accordance with the dictates of experience and a general judgment, rather than by exact scientific methods.

Professor Willis, who brings to bear on the subject not merely his theoretical attainments, but also a long and extensive experience, and admirable powers of mechanical invention, discussed the theory of wheels in a memoir published in one of the earlier volumes of the *Transactions* of the Institution of Civil Engineers. He was of opinion that ordinarily the form of each half-cog might, with sufficient exactness, be represented by two *circular arcs* of proper radii. He therefore reduced the difficulty to that merely of finding the centres from which these arcs should be struck, and for this purpose he invented an instrument called the *odontograph*.

Mr. Sang, in the elaborate work before us, proposes much more operose methods; and though cases might perhaps arise in which delineation by pairs of arcs would not be sufficiently exact, we should imagine that it would be hardly possible to meet with instances requiring all the labour proposed in the present treatise. It is, however, replete with information of great value to the practical mechanician, and the remarkably original investigations exhibit an immense amount of careful thought and labour.

The problem of odontography is here regarded from a point of view different from that ordinarily adopted. Instead of the proposition—Given one revolving contour; to find another which will move in exactly rolling contact with it—we have this:—Given the *path of the point of contact*; to find the corresponding truly rolling form of *each* wheel. It is clear that each wheel will have a different form for different angular velocities, and that, therefore, there is an unlimited number of contours, each of which will work properly with any one of the rest under the prescribed condition.

The curve described on a revolving disc by a tracing point moving in a given path, does not seem to have been separately investigated by Mr. Sang. The differential equation may, however, be easily found as follows. Let x, y, be co-ordinates of the tracing point, at the time t; the axis of y being in a line through the pivot of the disc; θ the angle through which it has revolved; b the co-ordinate of its pivot. Now, the whole velocity of the tracing point *upon* or *relatively* to the disc is equal to the difference between the absolute velocity of the tracing point parallel to either axis, and the velocity with which the point under it of the disc itself moves in the like direction. The latter velocity due to rotation is $(y-b)\frac{d\theta}{dt}$ parallel to x, and $-x\frac{d\theta}{dt}$ parallel to y. The inclination of the resultant velocity is the direction of the tangent of the curve traced on the disc: but this direction has for its tangent the ratio of the relative velocities on the disc parallel to either axis. In this ratio omit the common denominator dt, and call dx^1, dy^1, elements of the curve on the disc. Then

$$\frac{dy^1}{dx^1} = \frac{dy + x\,d\theta}{dx - (y-b)\,d\theta}$$

This is the required differential equation to the curve traced, in terms of the simultaneous increments of the co-ordinates of the tracing point and the angle of rotation. The condition that two contours so traced may roll truly together requires their tangents to have the same direction at any time t. Hence, from the last equation

$$\frac{dy + x\,d\theta}{dx - (y-b)\,d\theta} = \frac{dy + x\,d\theta^1}{dx - (y-b^1)\,d\theta^1},$$

where θ^1 is the angle through which the second disc has turned, and b^1 the co-ordinate of its pivot. This relation between the motion of the tracing point and the rolling pair of contours agrees with Mr. Sang's obtained in a different manner.

From this fundamental relation all the theorems and principles of the formation of wheels are derived by him. The application of the equation requires the arbitrary assignment of the path of the point of contact of the teeth working together. For this path Mr. Sang finds that the "hour-glass curve," as he designates it, which resembles in form the figure 8, is convenient. Giving different proportions to different parts of this curve, he traces the consequent variations of the forms of the teeth traced out by a point moving along it; distinguishing, with great skill and care, the relative merits of the several results—such as the number of teeth simultaneously engaged—freedom from abrupt changes of curvature—from obliquity of pressure, &c.

One of Mr. Sang's propositions has somewhat more generality than he seems to have noticed. The absolute velocity of the point at the distance b from the pivot of the disc revolving with the angular velocity $\frac{d\theta}{dt}$ is $b\frac{d\theta}{dt}$. Suppose, now, that in the last equation $b\,d\theta = b^1\,d\theta$; that is, let the angular velocities be to each other in a constant ratio, and let the origin be at that point in the line joining the pivots which has the same velocity on both discs (called the *pitch* point). Also let this velocity be $-\frac{dq}{dt}$. Then the foregoing equation will be found to become simply

$$x\,dx + y\,dy = x\,dq.$$

It would appear hence that this transformation requires not that the angular velocities be constant (as is stated p. 5), but merely that they be in a constant ratio.

The pitch point is that at which both discs have the same velocity: hence it is that at which they would touch each other if they were merely two circles, without teeth, revolving by rolling friction with the assigned angular velocities. If these be in a constant ratio, the pitch points trace circles on the discs.

As a remarkable property of the pitch point in relation to the forms of teeth, we suggest the following simple demonstration. Suppose the wheels in equilibrium, acted on by the mutual normal pressure of one tooth of each, and each by one of the forces having the moments M, and M^1, respectively, to turn it about the pivot. Let the direction of the pressure (P) on the teeth meet the line joining the two pivots at the angle φ at the distances c, c^1, from them respectively. Then, for the equilibrium of the wheels separately, taking moments,

$$M = Pc\sin\varphi;\quad M^1 = Pc^1\sin\varphi.$$

Also imagine a slight displacement of rotation: then, by virtual velocities, for the equilibrium of the whole system,

$$M\,d\theta = M^1\,d\theta^1;$$

or using the above connecting equation for b and b^1 when those quantities express the distance of the pitch point from the pivots,

$$\frac{M}{M^1} = \frac{b}{b^1}.\quad \text{But } \frac{M}{M^1} = \frac{c}{c^1}$$

from the preceding result; also the distance between the pivots $= b + b' = c + c'$.* Hence $b = c$, $b' = c'$, and consequently the normal pressure passes through the pitch point. Hence the important result that the line joining the pitch point and the point of contact of the teeth is always a normal to the contours of both.

The mechanical, as well as geometrical, principles relating to the teeth of wheels are examined by Mr. Sang. He investigates the loss of force due to the friction of teeth, and arrives at the conclusion that the loss of force arising from the friction of involute teeth is independent of the obliquity of action, and is proportional simply to the square of the distance passed over by the pitch line. An increased obliquity augments the pressure on the surface of the tooth, but lessens, in the same ratio, the amount of sliding.

Where several teeth are engaged at once, the pressure becomes indeterminate. Its distribution depends on the compression of the parts, and therefore on their curvature. In default of exact information, Mr. Sang supposes the pressures equally shared by all the teeth, but acknowledges the assumption to be arbitrary. It does not seem to us the most probable that could be suggested. When the teeth are in contact they touch, not in mere lines or points, but, on account of their elasticity, in cylindrical surfaces of small magnitude. For equal compressions these surfaces are as the square roots of their radii of curvature. For let these be r, r', respectively before compression, and let $l\theta$, $l\theta'$ be the arcs which the two equally compressed surfaces subtend at their centres of curvature. Then the distance of compression $= r$ ver sin $\theta = r'$ ver sin θ'. Hence, θ and θ' being small, $r\theta^2 = r'\theta'^2$ nearly, and the surfaces compressed are as $r\theta$ to $r'\theta'$; or as $\sqrt{r}$ to $\sqrt{r'}$.

The pressure depends not only on the surface compressed, but on the degree of compression. The total mutual compression of the surfaces is proportional to the virtual velocity of the pressure (supposing the general form of the wheel constant), and therefore increases with the distance from the centres of the wheels and the obliquity of action. As the pressure is a function of both the surface and pressure, we might, as a first approximation, take it to vary as the first power of each.

That the pressure depends on the curvature may be easily conceived from this analogy:—If a carriage having many wheels rest on a yielding road, the wheels of large radius (*cæteris paribus*) sustain the greatest pressure. That the pressure on the teeth increases with the obliquity of action may be seen from the consideration, that if the action be very oblique, the teeth are in risk of being "jammed" fast together.

Amongst the interesting mechanical investigations of the present work are those of the effects of abrasion in altering the forms of teeth, and the increase of pressure and strain due to variations of angular velocities. A valuable set of tables and plates accompany the work, which must have been one of immense labour. Indeed, one cannot help thinking that Mr. Sang sometimes encounters toil for the sheer love of it—*exempli gratiâ*, his painful numerical computations for a train of wheels connecting the hour-wheel of a clock with one which turns once in the tropical year of 365·242217 mean solar days. However, the treatise is certainly an admirable example of the amount of new and valuable knowledge, which patient thought and scientific attainments may discover, even in a subject so frequently investigated as that of odontography.

* We perceive, after the greater portion of this review had gone through the press, that the figure (ʼ) has in every case been inadvertently substituted for the accent (′).

A Practical Treatise on Chimneys; with a few Remarks on Stoves, the Consumption of Smoke and Coal, Ventilation, &c. By G. F. Eckstein. London: J. Weale. 1852.

In this small work Mr. Eckstein has, in a very praiseworthy and homely manner, submitted to the public his experience on the cause of smoky chimneys, how they are to be prevented smoking, and how they may be improved. He first gives fourteen causes of smoky chimneys:—

"*Cause* 1. Chimneys, especially kitchen chimneys, frequently smoke from their being too small.

"2. In the chimney-pot being too small to allow the free passage of the smoke from a kitchen, or other large fire-place.

"3. Chimneys frequently smoke from their being too short, as in attics; for, although the openings for the stoves in that part of the house are usually small, which is an advantage, the flues have not power to contend against the dense air at the top, and the various currents and eddies occasioned by the wind.

"4. A large opening of fireplace—that is to say, an opening disproportionately large to the size of the chimney. As water passes more slowly (which is perceptible), through the wide part of a river, or stream, than it does through the narrow, or under a bridge where the piers, &c. reduce the water-way, the same quantity of water having to pass, so kitchen chimneys, with large openings at bottom, are more disposed to smoke than those with narrow ones, as the air in entering them, being dispersed over so large a space, the current is not sufficient to carry up the sooty particles with it, and allows much to fall in the room. The air will, however, pass more freely under that part of the chimney breast that is immediately beneath the upright shaft, and the range or grate should be so constructed for the fire part to be as nearly as possible at that point; *i. e.* towards the right or left of the fire opening as the shaft may be. It is *not* said with reference to the front part of the grate being *forwarder* than the shaft.

"5. Chimneys frequentlysmoke from being in a cold situation; as in an external wall with only the thickness of half a brick between the flue of the cold or damp atmosphere, which is very usual in detached houses; also in low out-buildings where the chimney is carried up alone above the roof, and all sides exposed to the cold, or against a wall with three sides exposed.

"6. In the case of a low chimney being near a high building, where the air, passing over the high building, will drop like a waterfall upon the low chimney; or, when blowing strong from the contrary point against the high building, will rebound and form an eddy upon the top of the low chimney, and thus impede the free ascent of the smoke from the same.

"7. In there being two or more fireplaces to one flue; which, unless very judiciously arranged, is nearly certain to cause smoke.

"8. In the want of a proper supply of air.

"9. Large rooms having two fireplaces, or drawing-rooms communicating by doors; if one flue is in a warmer stack than the other, or has a stronger fire kept in the fireplace, that one will take away the necessary supply of air from the other or weaker one, and cause the smoke from it to descend into the room; and should there be no fire in the second grate it will even draw the smoke down that chimney from the surrounding chimney-tops to feed that one fire and flue.

"10. Many chimneys are called 'dreadfully smoky' where the fires are seldom lighted, except in the evening, as is frequently the case in bed-chambers and dressing-rooms.

"11. Another annoyance from smoke is sometimes occasioned by the relative situations of the doors and windows in the room, by which the current of air from a door or window, having an outlet at another door or window, creates a sort of whirlwind, and drives the smoke out of the fireplace into the room before it reaches the chimney-breast, as if bellows be used to a fire obliquely, the smoke and flame will be driven to the contrary side of the grate; the flue having no control over the smoke, which is driven away by a strong current before it reaches the chimney, as the air to supply the flue will pass immediately under the chimney-breast, while the smoke is carried away by an under-current into the room.

"12. Another, and a very prevailing annoyance is, the smoke from an adjoining chimney, or from one in an adjoining stack passing down the flues that are entirely out of use, or at the time that there is not any fire in them.

"13. It is not uncommon for chimneys to smoke at the sudden shutting of a door, especially in well-fitted rooms where there is an inadequate supply of air. When a door is opened inwards, it presses the air towards the chimney, and when suddenly shut, the air is drawn back from the chimney into the room, and this will generally produce a puff of smoke.

"14. Many chimneys smoke from not having been properly cored at the time of the building of the house."

Mr. Eckstein then gives us several cases of chimneys, which were smoky, remedied by him; the principal defect, he tells us, is either through building the chimneys too small,, or putting chimney-pots too small. One instance will show how a very bad case was remedied:—

"At a vicarage-house in Hampshire, where I was consulted on the contruction of the flues, earthen pipes 9 inches in diameter for a chamber flue in an *upper floor*, and 12 inches in diameter for the kitchen, where the opening for the range was to be 5 feet

(Cause 4) were actually provided (Cause 1). The building being only two stories high, and one side of the stack of chimneys exposed to the cold (Cause 5), not only would the above-sized flue have been totally inadequate to carry off the smoke from the kitchen fire, but quite insufficient to cause the jack to perform; I therefore directed the flues to be built 14 inches square for the chamber (which, being very short, required to be of large capacity), and 18 by 14 inches for the kitchen chimney. I also provided for the ventilation of the kitchen by constructing an air-flue immediately under the ceiling, 14 by 4½ inches, close to the flue from the range, that it might be always warm to insure an upward current; but as the ventilating fluid would take much air from the kitchen (Cause 8), I procured a good supply of fresh air through the ash-grate in the hearth, by an air-drain communicating with the external atmosphere, which was also very useful for the range flue, and for the supply of combustion, without having recourse to opening a door or window."

We must conclude our notice of this very useful work by giving one more extract, on the construction of new flues, which will not only be useful to our professional readers, but will, we hope, at the same time induce them to refer to the work itself:

"Kitchen-chimneys with small fireplaces should not be less than 14 by 9 inches; and if the opening of the fireplace exceed 3 ft. 6 in. in width, the chimney should be 14 inches square, or 18 by 9 inches, whichever way be the most convenient in the arrangement of the building, only providing that the flue have an area of 200 square inches. But the square chimney is preferable, it being more suitable to the brush for sweeping than is 18 by 9 inches. If the opening of the fireplace exceed 6 feet in width, the chimney-shaft should be 18 by 14 inches, or of an area of about 250 square inches. If the chimney-shaft be less than 36 feet in height, the sizes should be severally 14 inches square, 18 by 14 inches, and 18 inches square, in lieu of the above dimensions.

"Dining-room or ground-floor, and drawing-room or first-floor chimneys in lofty houses, may be built in the usual way, 14 by 9 inches.

"Upper stories, the chimneys of which are usually 10 feet or more shorter than the drawing-room floor, should have them 14 inches square.

"Attic chimneys should be still larger till near the top, where they should be reduced, to keep out the weather, or to receive a chimney-pot.

"Cottage buildings or detached houses, which are usually low, should not have any chimney less than 14 inches square, and the upper floor 18 by 14 inches. When chimneys are exposed to the air and damp by being in an external wall, it will be a considerable advantage if the brickwork can be left 9 inches thick between the flue and external air, instead of 4½ inches as is usual.

"If a kitchen fireplace be required in the upper part of a house, and consequently the chimney cannot be long, it must be made up in size. I would recommend two flues of the dimensions given for low buildings, or one flue of double those given dimensions; the top to be reduced about 150 square inches, or if two flues about 150 square inches for the two.

"Having given the dimensions which I think necessary for the construction of flues for dwelling-houses generally, perhaps it may be advisable to state what I consider the best method for constructing the throat or commencement of those flues.

"The kitchen-flue is generally commenced first, and frequently it is required to gather it over very quickly on one side to make room for the fireplace upon the floor above. It often happens that the commencement or throat of the chimney is very considerably out of the centre, and this becomes an evil; therefore I recommend that kitchen chimneys should be gathered over on each side, if possible; and when that is done, the direction of the flue afterwards is of very little importance, providing that it can be properly cleansed.

"When the elevation of the kitchen is so low that the flue cannot be gathered over upon each side, a piece of stone or slate, or some other substance, should be placed on the opposite side to the gathering wing, so as to cause the air to enter the flue as near the centre as possible; or if that cannot be done, the grate should be so constructed that the fire part be as much as possible under the commencement of the flue. And this is necessary for two reasons: first, that as the air will enter the fireplace with more rapidity at that part of the chimney-breast which is immediately under where the upright shaft starts from, it should be brought as much as possible in contact with the fire to be heated, and thereby receive its ascending power; secondly, that as the air proceeds more rapidly at that point, it should be brought in contact with the smoke, so as to carry off the heavy particles emitted from the coal. As to chamber-flues where register-stoves are to be fixed, it is not important to attend to this rule, as the register-door forms a central opening for the air and smoke, whether the flue be gathered over upon one side or both.

"In small fireplaces with short shafts, I would not gather them over at all till compelled to do so, but would leave all the size I could to give extra power to the chimney."

The Principles and Practice of Hydraulic Engineering, applied to Arterial and Thorough Drainage, the Conveyance of Water, and Mill Power; also Tables of Earthwork for finding the Cubic Quantities of Excavations and Embankments in Railways, Roads, Rivers, Drains, &c. Second Edition. By JOHN DWYER, C.E., Assoc. Inst. C.E. Ireland. Dublin: M'Glashan. 1852.

THE extension of hydraulic engineering as a distinct branch of the profession, has caused the development of a new department of literature which has produced several works of great practical utility and of material assistance to our members. Among them is the work of Mr. Dwyer, which has reached a second edition, and thereby given him the opportunity of making very considerable improvements and additions. It has also the special advantage of being particularly directed to the use of hydraulic engineers in Ireland, a class who are obtaining extensive employment in the great public improvements in that country. There is thus a large field for experience; and Mr. Dwyer, in addressing himself to the practical wants of the profession, has succeeded in drawing together a mass of information which can nowhere be found so conveniently nor so well digested. The tabular matter is very extensive and well worked out.

Handbook of Natural Philosophy and Astronomy. By DIONYSIUS LARDNER, D.C.L. Second Course: Heat—Common Electricity—Magnetism—Voltaic Electricity. London: Taylor, Walton, and Maberley. 1852.

THE book now before us is the second portion of a set of popular treatises on natural science by a popular writer. When, however, we speak of this as a popular work, it must not be understood as in any way implying that it is carried below the level of scientific instruction. Being intended as an educational work, and more particularly for self-instruction, the experienced writer has endeavoured to make it as practical as possible, and thereby popular, at the same time that he has brought it within such compass as to be readily mastered by the student whose time is limited.

Lancaster; with Morecambe Bay and the Lake Mountains. By W. LINTON.

THIS is a drawing of scenery which is among the most beautiful in the world, though little known and appreciated. The lithograph from Mr. Linton's picture is admirably executed by Mr. J. Needham; and here we have before us the town and picturesque castle of Lancaster filling up the foreground, the glorious bay of Morecambe with its fine sheet of water crowned by the amphitral hills of Furness and the lakes. Harbours and watering places are coming into life on the shores of this hitherto neglected inlet, and the railways, of which one breaks the foreground, are now pouring visitors into its valleys. The day will come perhaps when its shores will be as crowded with villas as those of the Neapolitan bays.

Six Views of the Antiquities of Rome. Drawn on Stone, by T. C. TINKLER, Esq., Architect.

THESE six views are drawn in a very spirited manner, and form a series of architectural sketches, taken on the spot by Mr. Tinkler during his travels through Rome. They consist of the Forum of Nerva—the Temple of Antoninus—the Forum—the Arch of Constantine—the Temple of Jupiter Stator—and the Coliseum. In order to encourage the fisheries in Ireland, Mr. Tinkler, in a very praiseworthy manner, has presented these views for publication in aid of the funds of the Fishing and Industrial Settlement for Boys, at Belmullet, Mayo.

DRAUGHT OF WAGONS WITH BREAKS.

By M. Jules Poirée, C.E.

[*Paper read at the Society of Civil Engineers, Paris, and Translated for the C.E. & A. Journal.*]

In the sitting of the 17th September (M. Eugene Flachat, C.E., in the chair), M. Jules Poirée, Engineer of the Ponts et Chaussées, read a paper on the *resistance to traction of wagons with breaks*. The experiments were made on the Lyons Railway, and their object was to measure the resistance of wagons to traction when the breaks are put on, or when the rolling friction becomes a sliding one. The wagons were common, and unsuspended, and were tried on wet as well as on dry rails. A ballast-wagon was used, weighing empty 3400 kilog. (68 cwt.), and the dynamometer was one of Morin's, placed between the tender and the wagon.

It was observed that in the experiments of the 12th, 14th, 16th, and 21st July (the suspending springs of the wagon being free), the body was exposed at high speeds to very marked vertical oscillations; but in the experiment of the 31st (the springs having been *calé*), the wagon slid like a sledge, without any movement of oscillation. At low speeds the draught worked by very quick shocks, so that it was impossible to obtain a regular working. The wagon being low, it was not thought necessary to take account of the resistance of the atmosphere.

The Table A shows the result of the experiments made on the draught of wagons with the breaks screwed up.

Table A.—*Experiments on the Draught of Wagons.*

Weight of the Wagon.	Speed in Mètres per Second.	Distance for which the Draught and Speed remained Constant.	Draught.	Proportion of Draught to the Weight Drawn.	State of the Rails.
1851. July 12. 3400 kilo.	4·6	500	710	0·208	Rails dry.
	7·8	800	609	0·179	
	10·0	800	570	0·167	
	14·3	1600	492	0·144	
July 14. 3400 kilo.	7·9	800	839	0·246	Rails dry.
	13·	300	758	0·222	
	18·	1000	690	0·202	
	22·	400	637	0·187	
July 16. 8400 kilo.	8·8	1000	930	0·110	Rails wet.
	20·8	750	698	0·083	
July 21. 3400 kilo.	6·	400	704	0·201	Rails dry, but had been wet in the morning.
	8·	400	640	0·182	
	9·2	450	615	0·175	
	13·2	500	570	0·162	
6450 kilo ..	9·	500	1092	0·169	
July 31. 3400 kilo.	7·25	300	700	0·200	Rails dry; & suspension springs of the body of the wagon calés.
	10·8	850	604	0·172	
	15·7	750	541	0·154	
	20·	1300	464	0·132	

The experiments which are given, though few, are held by the writer sufficiently in accordance to admit of the following conclusions being drawn:—

The resistance of wagons with breaks is proportional to the weight of the wagons. It may vary with the state of the rails from single to double—that is to say, for low speeds, from 0·11 to 0·25 of the weight drawn.

The resistance of wagons with breaks diminishes when the speed increases. Within the limits of the customary weight and speed, the diminution of resistance resulting from the augmentation of speed is almost independent of the weight of the wagon and of the state of the rails, and may be represented by the following formula of velocity:

$$25\,V - 0{\cdot}35\,V^2;$$

and consequently the resistance of the wagons with breaks may be given by the formula:

$$f = K\,P - 25\,V + 0{\cdot}35\,V^2.$$

P being the weight of the wagon;
V being the velocity;
K a constant coefficient, varying only with the state of the rails. We may employ approximatively:
K = 0·14 for wet rails;
K = 0·25 for dry rails, but having been lately wet;
K = 0·29 for very dry rails.

The formula must, however, only be applied for speeds comprised between 5 and 22 mètres per second.

It is admitted as a rule that the sliding friction is independent of the speed of rubbing bodies. This law, established by experiments in which the speeds were comprised within very narrow limits, will be found to prevail with very high speeds.

We may be allowed to doubt this; such, at any rate, is the general opinion of practicians, and the experiments here reported confirm these doubts. It has indeed been seen that the draught of wagons with breaks, sliding on the way like sledges, diminished gradually as the steam was augmented,* but it must be observed that, on account of the discontinuity of the rails, the train received a shock at each joint, the shocks being greater as the speed increased; and these shocks would necessarily cause loss of power, and increase the draught. The sliding friction will therefore diminish when the speed of the rubbing bodies increases, and this diminution will be more rapid than that given in the preceding formula.

Another portion of the subject was on the *resistance of trains to traction*. These experiments were made between Paris and Melun by means of a Morin's dynamometer placed between the engine and the train.

The first experiments as to traction are summed up in Table B.

Table B.—*Total and Means of the Run from Paris to Melun, and back.*

Total length run	85.840 m.
Time of the run in seconds	7.072 „[1]
Time of the run in hours and fractions, decimals of an hour	1 h. 96
Mean speed of the run in mètres per second	12 m. 17
Length on which the steam acted	77.030 „[2]
Corresponding time in seconds	5.693 „
Corresponding time in hours and decimal fractions	1 h. 58
Mean speed corresponding in mètres per second	13 m. 55
Weight of the train in tons	46 t.[3]
Weight of the gross in tons	86 t.[4]
Total work for haulage of the train alone	39.487.690[5]
Mean resistance for the train hauled on the length run—total	513 k.
Mean resistance for the train hauled during the action of the steam—per ton	11 k. 15
Mean resistance for the train hauled on the total length run—total	460 k.
Mean resistance for the train hauled on the total length run—per ton	10 k.
Force in horse-power for haulage of the train alone	92 h. p.[6]
Force in horse-power for haulage of the gross train, deduction made for additional friction of the engine of the train	172 h. p.
Force in horse-power for haulage of the gross train, taking into account the additional friction of the train engine	185 h. p.[7]
Consumption of coke during the action of the steam—total	520 k.
Consumption of coke during the action of the steam per hour	329 k.
Consumption of coke during the action of the steam per hour and per h. p. of the train hauled	3 k. 58
Consumption of coke during the action of the steam per hour and per h. p. of the gross train	1 k. 91
Consumption of coke during the action of the steam per kilomètre	6 k. 75
Consumption of coke during the action of the steam per ton of the train hauled and per kilomètre	0 k. 146
Consumption of coke during the action of the steam per ton of the gross train and per kilomètre	0 k. 078
Consumption of water during the action of the steam—total	4340 litres.

1 Deduction made for all stoppages.
2 *i. e.* length during which the regulator of the train engine was open.
3 Including the engine and a truck, weighing 3 tons 7 cwt.
4 Including the working engine, the engine hauled, and the truck put between them.
5 Given by the dynamometer.
6 H.P. reckoned during time of action of the steam.
7 The additional frictions are reckoned approximately for 0·15 of the draught.

* The same has been found in experiments on canal propulsion.—Ed. *C.E. & A.J.*

Consumption of water during the action of the steam per hour	2747 litres.
Consumption of water during the action of the steam per hour and per h. p. of the train hauled	29 l. 8
Consumption of water during the action of the steam per hour and per h. p. of the gross train	15 l. 9
Consumption of water during the action of the steam per kilomètre	56 l.
Consumption of water during the action of the steam per ton of the train hauled and per kilomètre	1 l. 22
Consumption of water during the action of the steam per ton of the gross train and per kilomètre	0 l. 65

M. Poirée has endeavoured to ascertain the resistance of the air developed by a train, employing a cast-iron plate of a ¼-mètre, which, being above the carriages, registered on a special dynamometer the resistance to which it was exposed.

Experiments between Paris and Melun.

Total effect of the wind on the surface of the anemometer having a section of 0·25 mètre	203,078
Total effect on a surface of 1 square mètre	812,312
The anemometer having worked over 41,220 mètres, the mean resistance of the air per square mètre was	kilog. 19·70
The force in horses corresponding to the time during which the steam acted was nearly	h. p. 3·5
During the experiment the natural wind made a mean angle with the railway of	70°
The resultant of natural wind and of the speed of the train made with the railway an angle of	4°·30

Experiments between Melun and Paris.

Total effect of the wind on the surface of the anemometer, having a section of 0·25 mètre	230,762
Total effect on a surface of 1 square mètre	923,048
The anemometer having worked over 43,000 mètres, the mean resistance of the air per square mètre was	kilog. 21·42
The force in horses corresponding to the time during which the steam acted was nearly	h. p. 4·6
During the experiment the natural wind made a mean angle with the railway of	113°
The resultant of natural wind, and of the speed of the train made with the railway an angle of	6°

It results from these indications that the natural wind was of no importance, the atmosphere being almost calm. During the experiment the cylinders of the engine were oiled with the greatest care, and no piece heated.

CALORIC ENGINES.*

Two caloric engines are at work in the foundry of Messrs. Hogg and Delamater, foot of Thirteenth-street, New York, one of 5 and the other of 60-horse power; the latter has four cylinders. Two, of 70 inches in diameter, stand side by side. Over each of these is placed one much smaller. Within these are pistons, exactly fitting their respective cylinders, and so connected that those within the lower and upper cylinders move together. Under the bottom of each of the lower cylinders fire is applied. No other furnaces are employed; neither boiler nor water is used. The lower is called the working cylinder, the upper the supply cylinder. As the piston in the supply cylinder moves down, valves placed in its top open, and it becomes filled with cold air. As the piston rises within it these valves close, and the air within, unable to escape as it came, passes through another set of valves into a receiver, whence it has to pass into the working cylinder to force up the working piston within it. As it leaves the receiver to perform this duty it passes through what is called the regenerator, which we shall soon explain, where it becomes heated to about 450°, and, upon entering the working cylinder, it is further heated by the fire underneath. We have said the working cylinder is much larger in diameter than the supply cylinder. Let us, for the sake of illustration merely, suppose it to contain double the area. The cold air which entered the upper cylinder will, therefore, but half fill the lower one. In the course of its passage to the latter, however, we have said that it passes through a regenerator, and let us suppose that as it enters the working cylinder it has become heated to about 480°. At this temperature atmospheric air expands to double its volume. The same atmospheric air, therefore, which was contained within the supply cylinder is now capable of filling one of twice its size. With this enlarged capacity it enters the working cylinder. We will further suppose the area of the piston within this cylinder to contain 1000 square inches, and the area of the piston in the supply cylinder above to contain but 500. The air presses upon this with a mean force, we will suppose, of about 11 lb. to each square inch; or, in other words, with a weight of 5500 lb. Upon the surface of the lower piston the heated air is, however, pressing upward with a like force upon each of its 1000 square inches, or, in other words, with a force of 11,000 lb. Here, then, is a force which, after overcoming the weight above, leaves a surplus of 5500 lb., if we make no allowance for friction. This surplus furnishes the working power of the engine. It will be readily seen that, after one stroke of its pistons is made, it will continue to work with this force so long as sufficient heat is supplied to expand the air in the working cylinder to the extent stated; for, so long as the area of the lower piston is greater than that of the upper and a like pressure is upon every square inch of each, so long will the greater piston push forward the smaller, as a 2 lb. weight upon one end of a balance is quite sure to bear down 1 lb. placed upon the other. We need hardly say that, after the air in the working cylinder has forced up the piston within it, a valve opens, and, as it passes out, the pistons, by force of gravity, descend, and cold air again rushes into and fills the supply cylinder, as we have before described. In this manner the two cylinders are alternately supplied and discharged, causing the pistons in each to play up and down, substantially as they do in the steam-engine. We have endeavoured to explain the construction of the caloric engine. Its most striking feature consists in what is called by its inventor the regenerator. The power of the steam-engine depends upon the heat employed to reduce steam within its boilers, but that heat, amounting to about 1200°, is entirely lost by condensation the moment it has once exerted its force upon the piston. If, instead of being so lost, all the heat used in creating the steam employed could, at the moment of condensation, be reconveyed to the furnace, there again to aid in producing steam in the boilers, but a very little fuel would be necessary; none, in fact except just enough to supply the heat lost by radiation. Now, the regenerator is composed of wire net somewhat like that used in the manufacture of sieves, placed side by side until the series attain a thickness, say of 12 inches. Through the almost innumerable cells formed by the intersection of these wires the air must pass on its way to the working cylinder. In passing through these, it is so minutely subdivided that the particles composing it are brought into close contact with the metal which forms the wires. Now, let us suppose what actually takes place, that the side of the regenerator nearest the working cylinder is heated to a high temperature. Through this heated substance the air must pass before entering the cylinder, and in effecting this passage it takes up, as is demonstrated by the thermometer, about 450° of the 480° of heat required, as we before stated, to double its volume. The additional 30° are communicated by fire beneath the cylinder. The air has thus become expanded; it forces the piston upward; it has done its work; valves open, and the imprisoned air, heated to 480°, passes from the cylinder, and again enters the regenerator, through which it must pass before leaving the machine. We have said that the side of this instrument nearest the working cylinder is hot, and it should be here stated that the other side is kept cool by the action upon it of the air entering in the opposite direction at each up-stroke of the pistons. Consequently, as the air from the working cylinder passes out, the wires absorb its heat so effectually that when it leaves the regenerator it has been robbed of it all, except about 30°. In other words, as the air passes into the working cylinder it gradually receives from the regenerator about 450° of heat; and, as it passes out, this is returned to the wires, and is thus used over and over, the only purpose of the fires beneath the cylinders being to supply the 30° of heat we have mentioned, and that which is lost by radiation and expansion.

The regenerator contained in the 60-horse engine we have examined measures 26 inches in height and width internally. Each disc of wire composing it contains 676 superficial inches, and the net has ten meshes to the inch. Each superficial inch, therefore, contains 100 meshes, which, multiplied by 676, gives 67,600 meshes in each disc, and as 200 discs are employed, it follows that the regenerator contains 13,520,000 meshes, and

* Abridged from the *New York Tribune*.

consequently, as there are as many spaces between the discs as there are meshes, we find that the air within is distributed in about 27,000,000 minute cells. Hence it is evident that nearly every particle of the whole volume of air in passing through the regenerator, is brought into very close contact with a surface of metal which heats and cools alternately. The extent of this surface, when accurately estimated, almost surpasses belief. The wire contained in each disc is 1140 feet long, and that contained in the regenerator is consequently 228,000 feet, or 41½ miles in length, the superficial measurement of which is equal to the entire surface of four steam-boilers, each 40 feet long, and 4 feet in diameter; and yet the regenerator, presenting this great amount of heating surface, is only about 2 feet cube less than $\frac{1}{1000}$th of the bulk of these four boilers.

Involved in this wonderful process of the transfer and retransfer of heat is a discovery which justly ranks as one of the most remarkable ever made in physical science. Its author, Captain Ericsson, long since ascertained—and upon this is based the sublimest feature of his caloric engine—that atmospheric air and other permanent gases, in passing through a distance of only 6 inches in the fiftieth part of a second of time, are capable of acquiring or parting with upwards of 400° of heat. He has been first to discover this marvellous property of caloric, without which atmospheric air could not be effectively employed as a motive power. The reason is obvious. Until expanded by heat it can exert no influence upon the piston. If much time was required to effect this, the movement of the piston would necessarily be so slow as to render the machine inefficient. Captain Ericsson has demonstrated, however, that heat may be communicated to and expansion effected in atmospheric air with almost electric speed, and that it is, therefore, eminently adapted to give the greatest desirable rapidity of motion to all kinds of machinery.

The ship is now approaching completion, and is the finest specimen of naval architecture (especially in point of strength) ever built in the United States.

THE VICTORY GATE, MUNICH.

On the 15th October, the inauguration of the great artistic monument, the *Siegesthor* (Victory gate) took place in the city of Munich. It is surmounted by the *Bavaria*, with the quadriga of lions. The lion which obtained the prize at the Great Exhibition will have the precedence of being hoisted first on the platform of the gate. The entire monument has been put together at the royal foundry, and exhibited to the public, in the evenings illumined by gas. On a regal car, of Grecian form, richly ornamented, stands *Bavaria*, in antique attire approaching somewhat the ancient Doric style; the under garment covers the whole body, with the exception of the arms, while a slight over-garment leaves the left shoulder free, and is fastened on the right. The head is covered with a laurel crown, which is moreover ornamented by some drapery descending on the neck. The statue reposes on the left foot, and bends a little forwards for the better direction of the attelage; her right hand grasps the reins, her left the regal staff. Of the four lions attached to the car, the two exterior look down and outwards, and the two inner ones in the opposite direction towards the city. The two inward animals are combined by a yoke, through which pass the reins for the whole four. The idea and symbol intended to be conveyed to the beholder are as follows. The Victory Gate, on which this great work is placed, is dedicated to the Bavarian army: therefore the *Bavaria* is not represented, as statues of Roma and Victory on ancient triumphal arches generally are, turned with her face towards the city, as if preceding the march of a victorious army: the attitude of the *Bavaria* will be turned to the outward, as if welcoming the army returning from victory. By this a lively, joyful attitude will be produced, in juxtaposition to the usual repose and quiet of similar groups. The statue of the *Bavaria* measures 17 feet, the whole monument with car being 22 feet high; the breadth of the lions in front is 27½ feet. Nearly 30 tons of brass were employed in the casting. The lion which gained the prize in London will receive an especial inscription, commemorative of the great event of the universal exhibition. The work has issued from the *ateliers* of M. Miller, of Munich, the casting having commenced as early as the year 1848.

LEEDS POST OFFICE.

W. R. Corson, Esq., of Leeds, Architect.

(*With an Engraving, Plate* XL.)

The engraving here given of the front of the Leeds Post Office exhibits a design lately executed, in cement, for the purpose of givng the appearance of a public building to what has hitherto been a plain brick edifice, with scarcely the slightest pretension to architectural effect. The case presented some difficulties which may be briefly pointed out, as upon the consideration of these, and the means adopted to overcome them, must rest much of the criticism which the design may receive. The establishment occupies, under lease, a portion of a warehouse, and the entrance to it is by an archway which pierces the centre of the front: only that portion occupied by the Post Office, and the gateway, have been included in the design;—the ground-floor required to be greatly free from work round the windows on account of the letter-boxes, &c.;—the windows of the first-floor were not so tall as those of the second and third floors (as may be seen in those of the warehouse to the left); —two windows in each of the upper stories were blanks, and the space between the top window and the eaves-gutter was very small, and insufficient for a cornice such as the height of the building demanded;—the expense, being borne by the proprietor, Wm. Hargrave, Esq. (since deceased), and the Postmaster, James Anderson, Esq., for the public benefit, was necessarily limited.

The cornice springs from below the window-head, and, to gain surface, has a very large projection. The blank windows have been partially built up and treated as panels; the first-floor windows have, as it were, a double architrave lintel to give them height and importance. The cornice has been omitted at the two centre windows to avoid the busy, and, it seems to us, awkward effect of one window standing on the top of another. The archway, formerly segmental, has been changed to semicircular, and enriched to give it importance as the entrance; and the name of the establishment worked into the design in a prominent manner. The clock, formerly flat upon the wall, has been corbelled out to show three faces, so that it may be read from every direction in which people can approach. The motto, "Time and tide wait for no man," warns to punctuality, and the orb and cross surmounting the clock indicate the royalty of the establishment. The side clocks are illuminated very effectively by reflectors placed in the window-reveals. The details (given to one-fourth size) exhibit the character of the mouldings and enrichments; the latter are conventional studies of two kinds of thorn-leaves. Throughout the design all allusion to stonework has been avoided. It is necessary to observe that the enrichments of the main cornice and window-cornices, also the motto under the clock, have been for the present omitted on account of expense, with the intention, however, of executing them in colour.

The plasterer was Mr. Charles; clock-maker, Mr. Groves; M. J. Hall illuminated the clocks; and the architect was W. R. Corson, Esq., all of Leeds.

REGISTER OF NEW PATENTS.

GAS MANUFACTURE.

George Lowe, of Finsbury-circus, civil engineer, and Frederick John Evans, of Horseferry-road, Westminster, civil engineer, for *improvements in the manufacture of gas for the purposes of illumination, and of improvements in the purification of gas.*—Patent dated January 20, 1852. [Reported in *Newton's London Journal.*]

Claims.—1. The combining of gases which possess different degrees of illuminating power, by the introduction of gas, obtained in any of the ways above indicated, into retorts or vessels containing carbonaceous matter under distillation; 2. The improvements in the purification of gas, first, by the use of anhydrous peroxide of iron, prepared as hereafter described; and, secondly, by the use of sulphite and bisulphite of lead, for the removal of sulphuretted hydrogen from coal-gas.

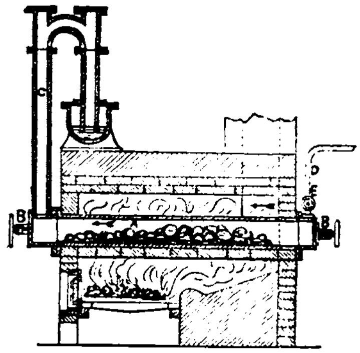
The first part of this invention refers to certain means of enriching or improving the quality of gases, so as to render them fit for the purposes of illumination. In carrying out this

ELEVATION OF THE POST OFFICE, LEEDS.

W. R. CORSON ESQ. ARCHITECT.

J. R. Jobbins 3 Warwick Court

improved manufacture of gas, the patentees pass gas, obtained from any of the sources hereinafter specified, through heated retorts containing Cannel coal, coal, lignite, resin, pitch, tar, oil, retinite, or other substance or substances capable of yielding carburetted hydrogen gas; by which means such a combination of rich and poor gases may be produced as will be exactly suited to the purposes of illumination. For this purpose it is proposed to use retorts open at both ends, as shown in the annexed engraving, which represents a longitudinal vertical section of the apparatus employed in carrying out this part of the invention.



Only one retort is exhibited; but a similar arrangement of retorts may be adopted to that in general use in gas-works. A, is the retort, set in a suitable furnace for heating the same; and B, B, are mouth-pieces and lids, fitted to both ends of the retorts. C, is the pipe for carrying off the gaseous products generated in the retort; and D, is a pipe for introducing into the retort the gas which is intended to combine with the gaseous products of the substances under distillation in the retort. As soon as the retort is charged with coal or other carbonaceous matter, a cock E, in the pipe D, is opened, which allows the gas to flow into the retort; and it then passes in the direction of the arrows, and mingles with the gas that is evolved from the carbonaceous matters contained in the retort; whereby a compound gas is formed, possessing a much higher illuminating power than could have been obtained had the combination taken place after instead of at the time of the generation of the gas in the retort A. The gas, which is brought to the retort by means of the pipe D, may be forced into the retort, so as to overcome the internal pressure put on the retort by means of the hydraulic main; or, instead thereof, an exhauster may be applied to draw off the gas from the retort. Should tar, oil, resin (previously melted), or any liquid hydrocarbon be employed for the generation of the gas, it is to be run into the retort in the way generally adopted for making oil or resin gas.

The sources from which the patentees propose to obtain inflammable gases, to be applied as above indicated, are wood, sawdust in a damp or dry state, spent tanners' bark, and other like substances capable of yielding an inflammable gas. These substances must be put into a red-hot retort, and distilled like coal. The resulting gases may be either purified at once or passed directly to the retort containing the coal or other carbonaceous material. As a general rule, however, these gases are preferred to be stored in gas-holders for use; as, in that case, a more uniform and constant supply to the coal retort may be relied on.

Another source of inflammable gas is from coal of an inferior description, or from peat. These substances having been distilled in a retort, the resulting gas can be then employed as above indicated. It is also proposed to conduct carbonic oxide gas into retorts containing carbonaceous matters under distillation. This gas the patentees obtain from carbonic acid, by passing the latter gas (which may be obtained from any convenient source) through a retort or furnace containing red or white hot coke. Or they utilise a portion of the gases generated in furnaces, by collecting these gases and converting the carbonic acid they contain into carbonic oxide, by passing them through a retort or furnace, as described for treating carbonic acid; or the gases may be conducted directly into retorts, wherein carburetted hydrogen is being generated, for the purpose of effecting the desired combination.

From the foregoing description it will be understood that the object of this part of the invention is to obtain gas of a uniform quality—that is, possessing a definite amount of illuminating power. Now, it is well known that if the gas be too rich in carbon it will burn with a dull flame, and give off a large amount of smoke; and that, if deficient in carbon, it will burn with a blue flame, and possess very little illuminating power. It is therefore proposed to mix the rich and poor gases, obtained as above described, in such proportions as will be needful to produce a highly illuminating quality of gas. As the proportions will depend entirely on the quality of the gases to be comined, no rule can be laid down for the amount of the gas required to be passed into the retorts wherein the distillation is proceeding. The mode, however, in which the gas burns on issuing fron the retort will be a sufficient test for the workman in attendance.

The second part of this invention refers to the purification of coal-gas from sulphuretted hydrogen; and consists in effecting this operation by the use of what has been considered by chemists to be the ferrate of potash, but what is now found to be a peroxide of iron in a peculiar state, and such as results from the employment of the following means:—First the patentees heat together peroxide of iron and caustic potash or soda to a dull red heat, by which a kind of ferrate or ferrite of potash or soda is produced; and when this substance is washed in water, it undergoes decomposition, with the reproduction of caustic potash or soda (which remains in solution), and the precipitation of peroxide of iron in the state fit for the purification of gas. All or any of the peroxides of iron may be used for the above purposes, and will, by its means, become useful for purifying gas, though previously inert; and the solution of potash or soda, when evaporated to dryness, may be again and again employed upon fresh portions of peroxide of iron, so as to communicate to them the peculiar property desired. Or peroxide of iron may be heated with a smaller quantity of caustic potash or soda, and a portion of common salt, in order to economise the potash or soda; the heat in this case should be as before, a dull red; and the same measures must be adopted for recovering the potash or soda and common salt, which may be used over and over again with fresh portions of peroxide of iron. Or the patentees heat the common hydrated peroxide of iron to about 600° Fahr.—taking care that the heat never reaches a bright red; and in this way they obtain a peroxide of iron, having the requisite properties. Or they heat in the same way, and with the same precautions, such of the native ochres or ferruginous compounds as will, after such treatment, become rapidly black upon being subjected to the action of a stream of sulphuretted hydrogen.

A quantity of peroxide of iron, fit for purifying gas, having been procured, by any of the means thus indicated, the oxide is next to be mixed with sawdust or other convenient material, and damped slightly with water; and the mixture is then to be spread in a dry lime purifier, and used in the way adopted with hydrate of lime; or it may be mixed with water, and run into a wet lime purifier, and used in the way adopted with regard to lime when employed in this kind of apparatus. In both cases it will be necessary, after the peroxide of iron has ceased to act upon the gas, to expose it to the air, by which its energies are renewed, so that it may be again and again used for the purification of gas. With the dry lime purifier, simple exposure is all that is required. With the wet lime purifier, the mixture must be run out and left at rest for some time; then, when the fluid has entirely separated from the solid part, it may be allowed to escape; and as the solid portion dries, its power will become renewed: after which it may be mixed with water, and employed as before. The renewal of the peroxide of iron, in both these cases, is known by its changing from black to red or deep brown.

Another part of the invention relates to the use of the sulphite and bisulphite of lead, for the removal of the sulphuretted hydrogen of coal-gas. These substances are to be employed singly or together, mixed with water, in a wet lime purifier, exactly as is practised with regard to lime. When they cease to purify the gas, the mixture is run out of the purifier; and after the water has been removed by subsidence and decantation, or by a filter, the residue is dried and burned, so as to make sulphurous acid, which is employed in the manufacture of fresh sulphite or bisulphite of lead, or in the production of sulphuric acid. The matter which remains, after this burning process, is carefully roasted, and thus converted into oxide of lead or litharge, from which sulphite or bisulphite of lead may be again produced.

RAILWAYS AND CARRIAGES.

Paul Rapsey Hodge, of Adam-street, Adelphi, civil and mechanical engineer, for *certain improvements in the construction of railways and railway carriages; parts of which are applicable to carriages on common roads.* (A communication).—Patent dated March 8, 1852.

The claims in this patent are as follows:—

1. The application of a galvanic or electro-galvanic current to the rails of railways, in order to prevent oxidation of the metal of which they are composed. A galvanic current is sent along one line and returned along the other, it being well-known that electricity operates as a preventative to the accumulation of oxygen upon any surface.

2. An arrangement of moveable points in which springs are used to bring the shifting parts in close contact, so as to insure a firm tread of the wheels.

3. An arrangement of springs for railway carriages, in which india-rubber springs are combined with ordinary springs, and with a cross-head and links. Upon two upright bars is placed the spring ordinarily used. These bars respectively pass through the centre of upright india-rubber springs, constructed after the manner of buffers, so that a double amount of tension is gained.

4. An arrangement of steam spring and lifting apparatus for railway carriages. Above the axle-boxes are placed small cylinders in connection with the boiler, and the pistons of which are connected with the springs of the carriage.

5. Several improved forms of axle-boxes, with double oil or grease chambers. The axle-boxes are fitted with two chambers, an upper and under one; the upper one is filled with oil and wool, and serves to grease the axle. An aperture nearest the wheel leads to the lower chamber into which the waste oil falls, it being carried towards the aperture by the motion of the axle.

6. A mode of constructing railway carriage wheels, with rings of india-rubber interposed between the sides of the nave of the wheel, and collars formed on the axle for the prevention of lateral vibration or jar.

7. An improved form or forms of metal railway wheels. The box is formed of wrought-iron, and the spokes of cast-iron. They are made to cross one another, and to take in and out.

8. An improvement in the wheels of carriages to be used on common roads, which consists in interposing rings of india-rubber between the axle-box and nave of the wheel, so as to prevent lateral and vertical shocks, and deaden the noise produced when the wheel is travelling over uneven surfaces.

RAILWAY CARRIAGES AND WHEELS.

William Pidding, of the Strand, gentleman, for *improvements in the construction of vehicles used on railways or on common roads.* Patent dated March 24, 1852.

The improvements comprised in this patent are as follows:—

1. A method of constructing carriage wheels with spokes composed (for two-thirds, or three-fourths, or whatever proportion experience may discover to be most useful) of spring-steel, whalebone, lance-wood, or some other flexible material. Another feature of this improvement consists in the wheel tyres being divided, and the several portions of tyre covered with a flexible material, such as vulcanised india-rubber or gutta-percha.

2. The combination of the power of the spokes of carriage wheels constructed upon the above system upon one point, by uniting them together by means of catches placed near the axle, by which means the pressure is rendered equal upon all the spokes.

3. The dispensing with lubricating material by the use of friction-roller bearings, formed of pieces of galvanised metal and vulcanised india-rubber, placed alternately, and radiating from a common centre. The whole are then bound together by a band of vulcanised india-rubber, which, by its constant tendency to contract, binds the circle together, and, where the metal by friction wears away, fills up the deficiency.

4. A method of mounting wheels, constructed as above described, on axles the length of which is unequal, thus bringing them close together, by which they are made to project beyond and overlap the other couple.

5. Two methods for the employment of portable rails, to be laid down by an advancing carriage.

6. A method of constructing the panels, mouldings, &c., of railway and other carriages from the following materials, viz., grass, straw, chopped leather, chaff, &c., and of fecula, alone or combined with the last-named materials. These materials are reduced to a pulp in a suitable machine, and baked in a mould of the required shape. It is impervious to the rays of the sun, and does not crack and blister like the material ordinarily used.

MOTIVE POWER.

Antoine Maurice Tardy de Montravel, of Paris, gentleman, for *certain improvements in obtaining motive power, and the machinery employed therein.*—Patent dated March 24, 1852.

Claims.—1. The system or mode of obtaining motive power by the alternate application of heat and cold to atmospheric air or other gases permanently inclosed in a cylinder or other suitable vessel; 2. The use and application of liquid or semifluid matters, between the atmospheric air and the piston; 3. The various arrangements of machinery or apparatus described.

The object of this patent is the obtaining motive power by means of atmospheric air or some suitable gas compressed in a cylinder by means of an air-pump. The cylinder contains a piston working both ways, and which is worked by the alternate expansion or condensation of the air or gas within the cylinder. This expansion and condensation is produced by the alternate application of heat and cold to the exterior of the cylinder. The motion of the piston is made to operate upon a crank, or any other suitable means for obtaining power. To render the piston air-tight, in the place of the ordinary packing, the following system is pursued: at the point where the packing is usually placed, a vacant space surrounds the piston-rod, which is filled with water or grease, soft clay, or any suitable semifluid matter. The patentee describes another method of obtaining motive power by means of a piston partly filled with water, which water is propelled against the piston by the expansion of warm air contained within the cylinder.

STOVES AND FLUES.

Isaac Brookes, of Birmingham, manufacturer, and William Lutwyche Jones, of Birmingham, aforesaid, manufacturer, for *certain improvements in stoves and other apparatus for heating.*—Patent dated March 24, 1852.

Claim.—The general arrangement of chambers, dampers, and flues, described, wherein heated air and products of combustion may be made to pass directly to the exit-flue, or wholly or partially through chambers and descending or ascending flues before passing to the exit-flue, which arrangement may be applied to close stoves, or to open or partially open stoves, or to open fireplaces.

The means employed to effect this object are as follows:—Above the fire-box is a square chamber, divided by a partition into two portions; one portion opening into the fire-box, acts as a receiver for the gaseous vapours arising from the stove. These vapours pass down two tubes placed at the corners of the chamber into another chamber below the stove, from whence they ascend through two tubes placed at the other side of the lower chamber into the second division of the upper chamber, from whence they pass by means of a flue capable of being open or shut at pleasure, and by the partially opening or closing of which flue the degrees of heat may be regulated. The upper part of these stoves is usually made ornamental and hollow to contain water, by the evaporation of which the unpleasant smell usually arising from stoves is prevented, and the air of the room rendered fresh.

STEAM ENGINES.

John Smith, of Bilston, Stafford, brass-founder, for *certain improvements in locomotives and other steam-engines.*—Patent dated March 25, 1852.

Claim.—The application to locomotive and other engines of a moveable valve, by means of which the induction-pipe may be converted into the eduction-pipe, or *vice versa*, at pleasure, and the motion of the engine thereby reversed, and whereby also the engine may be stopped if required.

The means employed to effect these objects consist in a cylindrical box (fig. 1), placed immediately under the receiver. This box is fitted with a partition A, moving upon an eccentric rod passing through the centre of the box, and terminating in a handle at B; C, is the steam-pipe; D, the exhaust pipe. When the partition is in the position 1, the steam entering the space *a b*, by the steam-pipe C, passes through the pipe F F (fig. 2), to where it branches off in two directions, passing through *f*, to the upper side of the piston contained in the cylinder H, and through *e*, to the underside of the piston contained in cylinder I. Should it be wished to reverse the engine, it may be done by

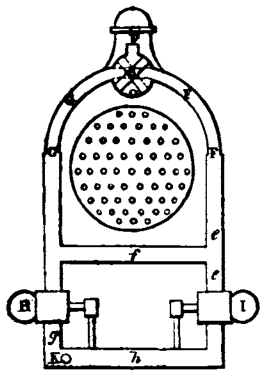


Fig. 2.

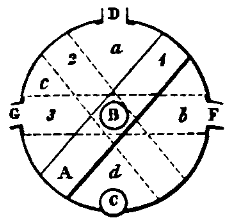


Fig. 1.

turning the handle which shifts the partition A, to the position 2, when the steam passes down the pipe G G, from whence it emerges at K, where it branches off in two directions through *g*, to the underside of piston H, and through *h*, to upper side of piston I. Should it be required to stop the engine, it may he effected hy shifting the partition to position 3, which shuts off all communication between the pipe C, and the pipes F F, and G G. Similar letters on the diagrams refer to similar parts.

MANUFACTURE OF GLASS.

James Timmins Chance, of Handsworth, Stafford, glass manufacturer, *for improvements in the manufacture of glass*. (A communication.)—Patent dated March 29, 1852.

Claim.—The application of anthracite or stone-coal in the manufacture of glass.

The fuel hitherto used has been for the most part bituminous coal, but this evolves so much smoke as to produce an injurious effect on the colour of the glass manufactured; and it is with a view to prevent or obviate such injurious consequences that the present improvements have been devised. The furnaces for burning this description of fuel require to be very little altered from the construction at present in use. The fuel will be supplied by feed apertures, and suitable pipes must he added for introducing a blast of air, which blast may be created by fan or other blowers. The air may be heated by interposing a suitable heater between the blower and the furnace, but the heating is not considered necessary. The beds of the furnaces should be closed, which may be done by "loaming" over the grate bars, or by introducing a moveable plate beneath them; and the ash pit should be made deep enough to contain a considerable quantity of ashes. The pots are of the usual construction, and they should be placed on sieges elevated above the orifices of the blowing pipe to an extent that will admit of the flame being directed against the lower as well as the upper parts of the same.

FIRE-ARMS AND PROJECTILES.

John Walter de Longueville Giffard, of Searle-street, Lincoln's-inn-fields, barrister-at-law, for *improvements in fire-arms and projectiles*.—Patent dated April 5, 1852.

Claims.—1. The construction of fire-arms with the breeches projecting inwards; 2. The construction of projectiles with internal thimbles of hard metal.

The breech or lock end of the fire-arm is caused to project into the barrel, in place of being formed concave or flat; the touch-hole is to be formed from the exterior into the breech, in such manner that the ignition may take place in a line with the centre of the barrel. It may be applied to a rifled or unrifled fire-arm.

The thimbles are formed of metal, tin plate being preferred, by a disc or drawing-through tools; they are introduced into a suitable mould according to the form of the exterior shape intended to be given to the projectile. The thimble to be employed is placed in the core of the mould, and the melted metal is to be run in, and thus will be produced the projectile. The charge of powder is introduced into the hollow interior of the projectile, and is kept there by a paper covering, which is perforated with minute holes, so that the powder will not pass, and yet when the projectile is rammed into a fire-arm, and comes in contact with the interiorly-projecting breech, it will be punctured or torn freely.

ORNAMENTATION OF GLASS AND CHINA.

John Ridgway, of Cauldon-place, Stafford, china manufacturer, for *certain improvements in the method or process of ornamenting or decorating articles of china, glass, earthenware, and other ceramic manufactures*.—Patent dated April 20, 1852.

Claim.—Not to the solutions for coating as such, but to the application of "electrotyping," or electro-metallurgy, to the objects stated in the title, provided the articles be so prepared as to allow them to combine from an alloy with them.

The first object of the patentee is to apply a new glaze, which shall enable the metallic coating to adhere firmly, by capillary attraction, and give affinity for copper as a first coating. In pursuance of this, the article is first submitted to an alcoholic solution, or a gelatinous solution, and then brushing over it an impalpable powder, composed of half carburet of iron and half sulphate of copper. The article thus treated is then to be corroded by the fumes of hydro-fluoric acid; and is then to be smoothed, by brushing it over with silver sand, or by the scratch-brush; but when the shape and nature of the article will not admit of this, it is to be plunged into a liquor, consisting of 6 quarts sulphuric acid, 4 quarts of aquafortis, $\frac{3}{4}$-oz. muriatic acid, and 6 quarts of water. Grease is to be carefully removed from the article, and a thin film of mercury is to be applied. The solution of copper consists of 1 sulphate of copper and 4 filtered water. Suitable solutions for silvering or gilding are to be applied, in accordance with the practice of electrotyping.

SMOKY CHIMNEYS.

William Henry Dupre and Clement le Sueur, of Jersey, for *improvements in certain apparatus or apparatuses for preventing smoky chimneys, applicable to other purposes of ventilation*.—Patent dated April 17, 1852. [Reported in the *Mechanics' Magazine*.]

These improvements consist, 1. In a peculiarly constructed windguard, in which blades or sections of screws ranged round a conical frame are employed to reflect the wind, and produce such a current as to carry off the ascending smoke or vitiated air.

2. In an arrangement of ventilating valves, where glass or other transparent material is used to admit light, and a counterweight employed to retain the ventilator open to any required extent.

SHIPBUILDING.

John White and Robert White, of Cowes, in the Isle of Wight, shipbuilders, for *improvements in shipbuilding*.—Patent dated March 24, 1852. [Reported in the *Mechanics' Magazine*.]

We have pleasure in laying before our readers an important improvement in shipbuilding, which has the advantage of being exceedingly simple and easy of application. Messrs. J. and R. White, of Cowes, finding that the keel of ships built with diagonal planking was very much weakened by the diagonal planks being carried over and across it, conceived the idea of making the diagonal planks terminate in rabbets cut on each side of the keel. By this arrangement the keel is capable of being of the same depth and thickness from stem to stern, and the diagonal planks serve to support it. The whole ship is necessarily much strengthened. We understand that two large steam-ships are being laid down on this plan by Messrs. White, one of which is for the Royal West India Mail Steam-Packet Company. The invention will be better understood by the following description and engravings, which we take from the patentees' specification;—

Whereas, in ships as now built with diagonal planking, the main-piece of the keel is much weakened to allow of the diagonal planks being carried over and across it; the keel becoming, in fact, a hanging keel, brought on after the diagonal planking has been laid, supported only by the outer skin or coat of longitudinal planks, together with bolts. Now, our invention consists in forming a keel from stem to stern, of the same thickness and depth throughout, and with grooves or rabbets cut therein for the reception of the diagonal planks, the which do not cross the keel, but terminate on each side of it in the grooves or rabbets. The keel being laid in a continuous length, the floor-timbers crossed, and the kelson laid and bolted thereto at the commencement of building, we obtain a permanent and solid foundation on which to construct the ship; the planking of the bottom is facilitated, and one length of the planking extends from the keel to the gunwales, the ship is much stronger than if the keel were cut to allow of the diagonal planks being carried across it, and we are also enabled to build ships with diagonal skins or coats of any rise of floor.

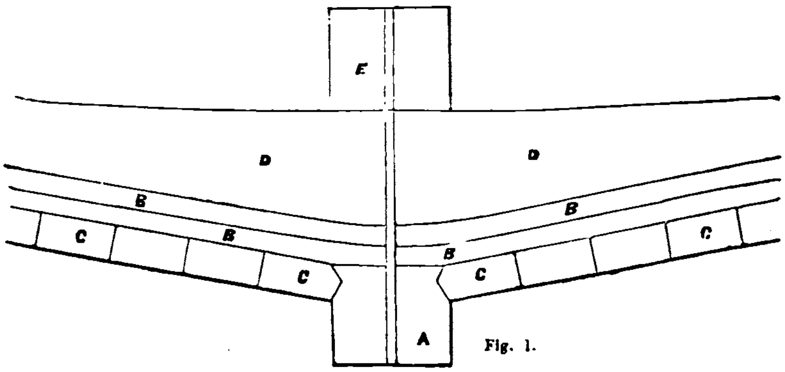


Fig. 1.

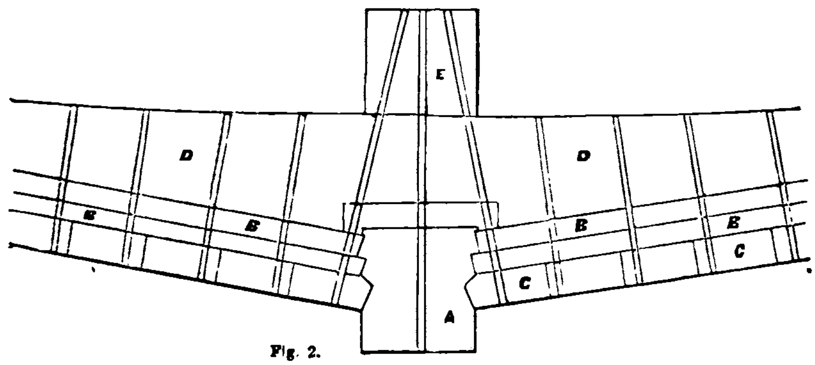


Fig. 2.

Fig. 1, is part of a midship-section of a vessel, construeted according to the present method of diagonal shipbuilding. A, is the hanging keel; B B, is the diagonal planking; C C, the outer and longitudinal planking by which together with bolts, the hanging keel is supported. D D, are the floor timbers; and E, the kelson.

Fig. 2, is part of a midship section of a vessel constructed according to our improvements. A, the keel, solid throughout, having rabbets on each side made for the reception of the ends of the diagonal planks B B, and the outer planks C C. D D, represent the floor timbers; and E, is the kelson. The keel is here thus supported by both the diagonal and longitudinal planks, and the ship is thereby consequently much strengthened.

RAILWAY SUSPENSION BRIDGE, NIAGARA RIVER.

This bridge will form a single span of 800 feet in length. It is to serve as a connecting link between the railroads of Canada and the State of New York, and to accommodate the common traffic of the two countries. It is established by ample experience, that good iron wire, if properly united into cables or ropes, is the best material for the support of loads and concussions, in virtue of its great absolute cohesion, which amounts to from 90,000 to 130,000 lb. per square inch according to quality. The bridge will form a straight hollow beam of 20 feet wide and 18 feet deep, composed of top, bottom, and sides. The upper floor, which supports the railroad, is 24 feet wide between the railings, and suspended to two wire cables assisted by stays. The lower floor is 19 feet wide and 15 high in the clear, connected with the upper one by vertical trusses, forming its sides, and suspended on two other cables, which have 10 feet more deflection than the upper ones. The anchorage will be formed by sinking 8 shafts into the rock 25 feet deep. The bottom of each shaft will be enlarged for the reception of cast-iron anchor plates, of 6 feet square. These chambers will have a prismatical section, which, when filled with solid masonry, cannot be drawn up without lifting the whole rock to a considerable extent. Saddles of cast-iron will support the cables on the top of the towers. They will consist of two parts—the lower one stationary, and the upper one moveable, resting upon wrought-iron rollers. The saddles will have to support a pressure of 600 tons, whenever the bridge is loaded with a train of maximum weight. The towers are to be 60 feet high, 15 feet square at the base, and 8 feet at the top. The compact, hard limestone, used in the masonry of the towers, will bear a pressure of 500 tons upon every foot square.

Weight of Bridge.

	lb.
Weight of timber	910,130
Wrought iron and suspenders	113,120
Castings	44,332
Rails	66,740
Cables between towers	534,400
Total	1,678,722

Weight of Railroad Trains.

	tons.
One locomotive	25
27 double freight cars, each 25 feet long, and of 15 tons gross weight	405
Making a total gross weight of 430 tons, which will fall upon the cables when the whole bridge is covered by a train of cars from end to end; and to this 15 per cent. weight of pressure as the result of a speed of 5 miles per hour, which is a very large allowance	61
Add weight of superstructure	782
Total aggregate maximum weight	1273

The tension of cables which result from a weight of 1373 tons and an average deflection of 59 feet, is 2340 tons. Since the assumed maximum tension can but rarely occur, it is considered ample to allow four times the strength to meet this tension—that is 8960 tons. But assuming 2000 tons as a tension to which the cables may be subjected, five times the strength to meet it is allowed, and an ultimate strength of 10,000 tons provided for. For this purpose, 15,000 wires of No. 10 will be required. At each end of the upper floor the upper cables will be assisted by 18 wire rope stays, and their strength will be equivalent to 1440 wires; these deducted leave the number of wires in the four superior cables 13,560, the number of wires in one cable 3390, diameter of cable $9\frac{1}{4}$ inches. The railroad bridge will be elevated 18 feet on the Canadian, and 28 feet on the American side, above the present surface of the bank, and above the present structure. It will be the longest railroad bridge between the points of support in the world.

The Brussels National Monument—This immense column will be erected in stone, and surmounted by a symbolic statue. The four corners of the pedestal will be adorned by statues representing the four Liberties—that of the Assembly, Religion, Instruction, and the Press. These have been entrusted to Messrs. Simonis, and Guill. and Joseph Geefs. Messrs. Mellot and Pallaert will execute the statues of the nine Provinces of Belgium, which will be placed above the pedestal. The entire monument was designed by M. P. Dens, architect, of Antwerp, and will be completed next year.

NAVAL DRY DOCK AND RAILWAY AT PHILADELPHIA.*

The United States Dry Dock at this port having recently been completed, was successfully tested during the past month by the lifting and hauling out of the steam ship *City of Pittsburg*, of 2200 tons burthen. This Dock and appendages being the largest in the world, merits more than a passing notice. The lifting power consists of nine sections, six of which are 105 feet long inside, and 148 feet over all, by 32 feet wide, and 11½ feet deep; three of them are of the same length and depth as the others, but 2 feet less in width; the gross displacement of the nine sections is 10·037 tons, gross weight 4145 tons, leaving a lifting power of 5892 tons, which far exceeds the weight of any vessel yet contemplated. The machinery for pumping out the sections consists of two engines of 20, and two of 12 horse power. In connection with the sections(which form the lifting power of the dock,) is a large stone basin, 350 feet long, 226 feet wide, and 12 ft. 9 in. deep, with a depth of water of 10 ft. 9 in. at mean high tide.

At the head of this basin are two sets of ways, each being 350 feet long, and 26 feet wide. These ways are level, and consist of the bed pieces, which are three in number, and firmly secured to a stone foundation; the central way supports the keel, while the side ways receive the weight of the bilge; these ways are of oak, and are finished off to a smooth surface. On the top of the bed pieces or fixed ways, comes the sliding ways or cradle, which are also 350 feet long and 26 feet wide, so constructed as to admit of being adjusted to the length of any vessel.

The operation of the dock is as follows:—The sections are sunk so as to allow the vessel to be floated in; as soon as she is secured in the proper position, the pumps are put in operation, when the sections begin to rise, and as soon as they come to a bearing on the keel, the bilge-blocks are run in until they fit the ship. When all is secure, the sections are pumped out until the keel is some two or three feet above the water. If repairs that will only require a short time are contemplated, the vessel is kept on the sections, and no other portions of the dock used. But the *Pittsburg* was taken up for the purpose of testing the several parts of the dock, and after she was lifted out of the water the sections carrying the ship were floated into the basin in line with one of the sets of ways. When this is accomplished, the sections are filled with water, and rest on the bottom of the basin, which is of stone. Bed-ways are now laid on the sections in line with those before-mentioned. When they are secured they are greased, and the cradle is now slid under the ship, and she is blocked up on the cradle, and the blocks on the sections are removed. At this point of the operation a new instrument of power is brought forward for the purpose of hauling the ship from the sections on to the bed-ways in the Navy-yard. It consists of a large hydraulic cylinder, having a ram of 15 inches diameter and 8 feet stroke, and a power of 800 tons. On the top of this cylinder, and attached to it, are two vertical direct acting engines, with cylinders 16 inches in diameter and 16 inches stroke, connected at right angles to one shaft, on which are four eccentrics for working four hydraulic pumps of 1½ inch bore, and 6 inches stroke; the tank which carries the water for the press is also on the top of the cylinder, aud forms the bed on which the pumps are secured. The boiler which supplies these engines with steam is on a sliding cast-iron bed-way, some 12 or 15 feet ahead of the hydraulic cylinder, and connected to it by two cast-iron rods. This boiler is of the usual locomotive form, and has eighty-five tubes of 2 inches diameter, and 9 feet long. To get ready for operation, the hydraulic cylinder is slid down to the edge of the basin, its ram is run in, and a connection made by means of two side rods of wrought-iron from the cross-head of the ram to the sliding cradle which carries the ship. The central bed-way has keyholes mortised through it horizontally, every 8 feet, and there are projections from the hydraulic cylinder, which have corresponding key holes in them. Two cast-iron keys, 24 inches wide, and 6 inches thick, are slid through the key holes on small wheels; these keys secure the cylinder to the central bed-way; the engines and pumps being now put in operation, a pressure is brought on the 15-inch ram, and as soon as the pressure overcomes the resistance, the vessel must move. The estimated weight of the *Pittsburg* was 2800 tons, exclusive of the sliding-ways and blocking; the power required to start this weight on a level, greased surface, was 250 tons.

As soon as the vessel has been moved 8 feet, the keys which hold the cylinder to the central way are withdrawn, and by means of a screw which is attached to the head block of the ram, and driven from the engine, the cylinder and boiler are in their turn rapidly slid ahead, (the water in the cylinder being allowed to escape into the tank,) when the cast-iron keys are again slid in place, and the vessel moved another 8 feet. After the first starting of the *Pittsburg*, the power required to remove her was but 150 tons, and she was moved 260 feet in six hours. To push the vessel off, the cylinder and appendages are moved to the head of the ways, put on a turn-table and reversed, when it is again brought down to the cradle, and the cylinder being secured as before, the head of the ram is applied directly to the cradle, and the vessel shoved back on to the sections, which requires the same time and power as to haul them off. In docking and hauling out the *Pittsburg*, every part of the work gave the most entire satisfaction, no portion showing the least defect, and the time required to go through the various operations being less than was expected. But six sections were used for lifting in this operation, leaving three unemployed. It will at once be seen that the capacity of this dock exceeds that of the stone docks at New York, Boston, and Norfolk, combined, for united they can take but three vessels, while here, two of our longest war steamers may be hauled out on the ways, and two frigates lifted on the sections. The advantages that must result from the facilities of repairing a vessel elevated into light and air over one sunk in a stone dock, are very great, and have only to be seen to be appreciated.

* From the Journal of the Franklin Institute.

SPANISH RAILWAYS.

The government has approved of the plans for the junction line from the port and city of Alicant, on the Mediterranean, to Almaza, a town of Murcia, on the borders of Valencia; with some modifications relative to the works of art. The concessionnaires were to commence the works on the 19th of October. The line will pass near the town of Xixona and by the towns of Elda, Sâx, and Villena. It is probable at this point it will be directed towards Candete, St. Phillipe de Zativa, thence towards Almaza and Bonete. Mr. Mackenzie, C.E., is on the ground arranging the preliminary works; his presence is an indication of activity, which he has always given proof of in directing the works of the Aranjuez line and the first section of the Almaza line. The plans have been forwarded to the government, of the first section of the line from Almaza to St. Phillipe, which is fifteen miles in length, and proceeds by Candete towards the valleys in the neighbourhood of the towns of Onliuente and Albaida, which are situated in a mountainous district. Immediately the plans are approved the works will be commenced with activity. A portion of the line from Valencia to St. Phillipe, about eight miles in length, has been inaugurated. The late rains have been a great trial for the earthworks, &c., but they have not been in the least damaged, they having been constructed with great care, in consequence of the naturally wet soil of Valencia.

The material for the commencement of the line of Granollers, eighteen miles north-north-east of Barcelona, has arrived at the latter city. The works of the line to the town of Martorel, in Catalonia, on the right bank of the Llobregat, are to be commenced, the plans of which are approved. The station at Barcelona will be situated on the glacis at a place called Puntarro.

The project of the line of Saragossa presents probabilities of a speedy commencement. A meeting of shareholders has been held at Barcelona, presided over by the governor of the province: the laws of the company have been approved. This line will unite the railways of Mataro, of the North, of Martorel, and those projected of Sarria and Gracia.

M. Sanchez Mendoza, contractor of the Cadiz and Xeres Railway, has returned from London, where he had purchased a considerable *materiel* for the construction of the line. He departed for Cadiz, to give the necessary orders for the commencement of the works.

The preparatory works of the Lisbon and Santarem Railway which is destined to open a communication between Spain and Portugal, are proceeding with much activity. The negotiations pending on the subject between the cabinets of Madrid and Lisbon are greatly advanced, and, in a very short time, all the difficulties that might have opposed the realisation of a project so useful for both countries will be adjusted.

The first section of Almaza and Aranjuez to the town of Tembleque, in New Castile, will be opened to the public about December. It will be some months before the line of Cuidad Real, from Alcazar to Manzanares, will be ready for traffic. M. Alvarez is the concessionnaire. The works are to be placed under the direction of Mr. Arthur Green, C.E.

Signior Brana, a capitalist of Corunna, has brought forward a railway project, which will depart from that seaport, the capital of Galicia, passing by the Cortenan, the city of Orense on the Minho, the town of Viana, thence to the frontier town of Zamora on the Duero, joining the line of Valladolid.

At Cordova and Seville difficulties relative to the line from Seville to Madrid, through the mountainous province of Estramadura, and also concerning the concession of the line from the port of Malaga to the city of Cordova, have arisen.

A provincial meeting has been held at Cadiz, to consider the line conceded from that port to Seville. A commission was named, which is occupied in concerting measures for the carrying out of it.

The inhabitants of the ancient city of Grenada are consulting as to a branch to connect their city with the line from Malaga to Cordova. It will run in the valley of the Darro and Xenil rivers, passing by the capital town of Santa Fé.

FOREIGN RAILWAYS.

Norway.—A prospectus has been issued of the Norwegian Trunk Railway, with a capital of 450,000*l.*, of which one-half is furnished by the Norwegian Government, while the other is to be raised in this country. From the port of Christiana the line extends a distance of forty-two miles north, through the most populous districts, to the inland lakes of Ojern and Miosen (both in the government of Aggerhuus), and, according to the returns obtained by the government, the traffic is estimated at 6 per cent., without allowing for any increase consequent upon the introduction of a new system. Three-fourths of the work are already constructed, and the entire line will be finished before the end of next year. Interest at the rate of 4 per cent. is to be paid to the subscribers until the opening, and thenceforth the conditions are, that the whole profits of the road shall be applied, first, to insure a payment of them of 5 per cent., after which the government are to take all that may accrue between 5 and 9 per cent., while any surplus beyond 9 per cent. is to be shared equally by both. The grant is for 100 years (at the end of which time the government may take possession upon payment of the 225,000*l.* expended by the company); and during its continuance it gives freedom from all taxes and local dues, as well as the privilege of importing the necessary working materials, including coals, duty free. The engineers are Messrs. Stephenson and Bidder, and the directors appointed by the king of Norway are Messrs. Ricardo, Peto, and Brassey.

Denmark.—The concession of the government for the construction of the Schleswig Railroad by Mr. Peto gives an exclusive right in the line for the conveyance of goods and passengers for 100 years from the date of the opening of the road. During that period no other concession will be granted, under the condition that the road shall be completed within three years. It will run from Flensburg, a seaport, with a population of 16,000, on the east coast of Schleswig, in the Flensborgerwieck Gulf, containing depth of water for the largest ships, traversing South Jutland, to the seaport of Husum, on the west coast of Schleswig, thence to the seaport of Tönningen, a place of great activity on the river Eyder. There will be a line also from Husum to the town of Reudsburg, on the frontier of Holstein, at the junction of the river Eyder and the Canal of Kiel, which communicate with Christiana Haven.

Russia.—Among the improvements which are being executed at the city and port of Riga, for the benefit of its commerce, none are of greater importance than the proposed line of railway between Riga and the town of Dunaburg, on the Dwina, thus branching into the already formed line between St. Petersburg and Warsaw. The execution of the plan is of the highest importance to the well-being of the port. In order to preserve its commercial activity, which is being removed to other places, an engineer is now occupied in taking the provisional levels, which are necessary for obtaining the government guarantee of interest.

Turkey.—We have heard that the question of the railway from Constantinople to Belgrade is definitively settled, and the works will be commenced in the approaching spring. Three of the English engineers who had been charged with the necessary surveys have already submitted their plans to the divan.

Italy.—The Genoa Chamber of Commerce, and the Provincial Council, have demanded that the railway, which is to commence at San Pier d'Arena, should communicate with those of Switzerland and Germany. The Genoa merchants found their future prosperity on their relations with Germany. Railroads altering the condition of States, they desire that Genoa should become the port of the Prussian Zollverein in the Mediterranean. There are two obstacles to the realisation of that project—namely, the Helvetic Alps, and the disinclination of the Swiss cantons to open railroads, which might hereafter afford facilities to invade their country. The Chamber of Commerce obviated these difficulties by saying that the Helvetic Alps could be crossed at the defiles of Luckmainer and Grimsel, and that, as to the apprehensions of the Swiss, they had of late modified their opinions, and did not wish to remain behind in the progress visible throughout Europe.——The construction of the Central Italian Railway has been decided on by the Holy See, Tuscany, Austria, and the Duchies of Parma and Modena, through whose territory it will pass. This railway, which was the object of a special treaty concluded at Rome on May 1, 1851, was conceded on 26th June last to a Company which has been formed at Florence. The duration of the concession is 80 years. A minimum interest of 5 per cent. is guaranteed to the Company for 50 years, on condition that the nett profits over and above 5 per cent. shall be divided equally between the Company and the above five Governments. The starting point of the Central Italian line is naturally the railway which already unites Florence, Pisa, Lucca, and Leghorn, and which is prolonged as far as Rome. The new line will commence at the city of Pistoja in Tuscany, will cross the Appenines at the most favourable point, descend towards Bologna by the valley of the Reno, and then turn in a northerly direction to reach Modena and Reggio. It will there branch off in two lines; one will continue as far as the town of Guastalla in the states of Parma, then cross the Po at Borgo Forte, and proceed to Mantua, where it will join the Austrian line. The other will be directed on Parma and Placenza, to be thence continued as far as Milan, and join the Sardinian lines to Turin and Genoa. This railway, which will cross the most populous and fertile plains of Italy, will be 270 kilometres in length. The necessary expense for the construction and working is estimated at 3,000,000*l.* Taking as the basis the present receipts of the Italian lines at 8 centimes per passenger and 20 centimes per ton for merchandise per kilometre, it is calcusated that the nett produce will be 220,000*l.*——The Neapolitan government has decided on constructing a railroad between the Mediterranean and the Adriatic; that is, from Naples to the seaport and gulf of Manfredonia.——The papal government having failed in their negotiations for the construction of a railway from Rome to Bologna by Ancona, has intrusted the survey of the line to M. Michel, of the French Corps of Engineers, who is to make an estimate of the expense of constructing the railway.

Belgium.—The inauguration of the railway from Charleroi to the frontier of France, took place on the 11th ult. It is twenty miles in length, and will be the direct route from Paris to Brussels and Prussia. At Aulne, where the immense ruins of an ancient abbey are situated, it has been found necessary to have a tunnel 450 yards in length; it is the only one in Belgium.

France.—At Chaumont the engineers of the company of the railway from Blesmes (in Auvergne) to Saint Dizier (Upper Marne), and Gray (Upper Saone), are occupied in recruiting workmen for opening the works of the line. If sufficient are not immediately obtained, foreign workmen are to be sent for.——The government is occupied in the construction of an electric telegraph between Nantes, Vannes, &c., as far as Brest. They will commence placing the posts in a few days.——The works of the railway between Dijon and Besancon are being actively proceeded with in the neighbourhood of Dole, an old town situated on the north of the Doubs, twenty-three miles west-south-west of Besancon. The rails are laid on a portion of the embankment, and on these earth-wagons, drawn by horses, are running.——The section of the railway between the town of Chateauroux, thirty-two miles south-south-west of Paris, and the city of Limoges, two hundred and fifty miles south-south-west of Paris, is being actively proceeded with; the workmen are organised. Notwithstanding the bad weather, a great impulse will be given to the works in the department of the Haute Vienne, the contract for one of the principal works on the line of the centre. The viaduct which crosses the river Gartempe has been conceded; it will be of grand proportions, the length being 2186 yards, nearly one mile and a quarter.

India.—The whole line of the Great Indian Peninsular, between Bombay and Callian, is now under contract, in three separate portions, and the works are in various stages of progress, promising completion according to the several agreements. It is expected that the first portion of the railway, from Bombay to Tanna, will be opened for traffic early in the ensuing year, and a supply of engines, carriages, and other rolling stock has been forwarded to Bombay sufficient for the opening. In the despatches last received, dated Bombay, September 1, the chief resident engineer reports as follows:—"Of the permanent way, about four miles of double line, and sixteen miles of single line are laid nearly three-fifths of the entire length upon the contract, and five-ninths of the ballasting is spread, and I expect that the whole line will be laid by the end of November, or early in December." The whole capital of 500,000*l.* has been paid into the treasury of the East India Company, and the guarantee interest is now accruing upon the total amount. The surveys for the extension of the railway beyond Callian across the Ghauts into the interior have been completed. In the despatches under date September 1st, it was stated that "the drawings, plans, and estimates of the Ghaut Extensions, together with the engineer's report upon them, will be ready in a few days." But the last India mail, which arrived on 15th ult., brought no advices from Bombay, and, consequently, the promised surveys have not yet come to hand.

OBITUARY.

Cowper.—We have the deep regret to announce the decease of Professor Edward Cowper, aged 63, who was well known to the engineering world, and held the professorship of Mechanical Construction in the department of Applied Sciences at King's College. His lectures at that institution were delivered with great clearness, and were illustrated with numerous models. He accompanied the students to most of the principal manufactories in the vicinity of the metropolis, and his great attention to their acquiring a sound mechanical knowledge will be long remembered by them. He was consulted in many of the litigated patent cases, and was a frequent witness at the courts of law. In conjunction with Mr. Applegath, of Dartford, he invented the *Times* printing press. In 1815, Mr. Cowper obtained his patent for curving stereotype-plates, for the purpose of fixing them on a cylinder.

Clarke.—On Sept. 22nd, William Tierney Clarke, C.E., at Hammersmith. He erected several bridges, among which were two over the Danube at Vienna and Pesth; that across the Neva; those at Hammersmith, Shoreham, Marlow, Rochester, Bath, and Welbeck; and the Gravesend town pier was designed by him. He had been for several years resident engineer of the West Middlesex Waterworks Company, and had lately been over to Haarlem, advising on the works being erected there by the contractors, Messrs. Hutchins, Brown, and Co., under the direction of Mr. W. Bland Croker, C.E., for the supply of Amsterdam with water. For some time previous to his death, Mr. Tierney Clarke was engaged in preparing for the press a large publication on his great work, the Pesth bridge, and which was intended as his contribution to the stores of professional literature, in conformity with the example of his great predecessors, being desirous of preserving, too, a proper record of his labours for those students who are unable to visit the original. Very happily the plates had all passed under his own eyes, and are now in Mr. Weale's hands, without requiring more than trifling references and some care in the arrangement.

Colby.—Lately. At Liverpool, died, in the 69th of his age, Major-General Colby, R.E., who was for twenty years at the head of the Ordnance Survey, to which post he was appointed by the Duke of Wellington, when Master-General of the Ordnance. By him this great national work was organised and efficiently conducted.

Slater.—On Sept. 29th, at Monmouth-road, Bayswater, John Robert Slater, C.E. aged 37.

Jesson.—On Oct. 3rd, William Jesson, aged 34. He was formerly attached to the Ordnance Surveys of England and Ireland.

Barnes.—We regret to announce the death of John Barnes, marine engineer. His decease took place on the 24th of Sept. at La Ciotat, near Marseilles, France, in the 54th year of his age, after an illness of about six weeks. No serious apprehensions were entertained in respect to the termination of his illness until within a few days of his decease. Mr. Barnes a few years since was well known in this country as the principal of the firm of Barnes and Miller (now Miller, Ravenhill, and Salkeld), but, at the time of his decease, he was directing the construction of steam-engines and vessels for the service of the great and well-known establishment, the Messageries National of France. Mr. Barnes held a distinguished reputation as a constructor of marine steam-engines. His talents and general acquirements were of a very high order, and indeed his usefulness as an engineer was admitted by those who new him to be unsurpassed. The death of this gentleman (who was the brother-in-law of Mr. Miller), will be a great loss to France, and, indeed, to the whole engineering world.

Clyburn.—On the 18th ult., at Tetbury, aged 56, Richard Clyburn, engineer, formerly of Uley Iron-works, Gloucestershire.

Gears.—On Sept. 29th, at Battersea, Surrey, in the 77th year of his age, Mr. George Gears, for many years clerk of works to public buildings.

Hornby.—On the 10th ult., at Wombleton, near Helmsley, Yorkshire, aged 83, Thomas Hornby, land surveyor. A few years ago Mr. Hornby published a Treatise on Land-Surveying, which was highly appreciated; and he was also a contributor to the Lady's and Gentleman's Diaries, both in the mathematical and poetical departments, for upwards of sixty years.

Griffith.—Lately. At Lyons, Vicars Griffith, Assistant Secretary to the Royal Dublin Society.

Gibson.—Lately. John Gibson, portrait painter, well known at Glasgow, died from the effects of an accident. He had been superintending the hanging of the pictures in the West of Scotland Academy's Exhibition; had returned home and again visited the rooms in the evening. Between ten and eleven o'clock the same night he was found by the watchman lying at the stair-foot, insensible; he died the next day. It is supposed that in the dark he had missed his footing and fell down stairs.

Fairland.—On the 22nd ult., at Aberdeen place, Maida-hill, Thomas Fairland, artist.

Eisensten.—Lately. Dr. Eisensten, aged 30, an eminent mathematician and member of the Berlin Royal Academy of Sciences.

NOTES OF THE MONTH.

The *St. Jean D'Acre*, building at Devonport to carry 90 guns of large calibre, is now in an advanced state, and will soon be ready for launching, and when launched she is to be immediately fitted with engines of 600-horse power, of Messrs. Penn and Sons' construction, on their patent trunk plan, which gave such satisfaction when tried in the *Agamemnon*, 90, now at Sheerness. The engines of the *St. Jean D'Acre* are already in progress, and all the castings and works are to be made and finished from the models used for casting and making the engines of the *Agamemnon*, these models having been used for the first time for the engines of that vessel. The diameter of the cylinders of the engines is 78 inches, the trunk $32\frac{3}{4}$, equal to $70\frac{3}{4}$ inches when the trunk is deducted; the length of the stroke 3 ft. 6 in. the diameter of the engine shaft $13\frac{1}{4}$ inches, and the screw shaft 12 inches. The diameter of the air-pump is $23\frac{1}{4}$ inches, the diameter of the screw 18 feet, with a pitch of 20 ft. 6 in., the length being 3 ft. 4 in. The boilers are in four pieces, and the tubes 1904 in number, each $2\frac{1}{2}$ inches diameter outside, and 6 ft. 6 in. long. The fire-grates are twenty in number, and so arranged that the position for the stokers is well ventilated. There is also ample space for getting to every part of the engines, and the whole of the boilers and engines being considerably under the water line, they are well protected from injury in the event of the vessels in which they are fitted being engaged in actual warfare.

Iron Ships.—The *Liverpool Albion* says, that as a good deal of attention has lately been given to iron ships it may be interesting to shipowners to know that the iron bark *Richard Cobden*, now being overhauled in the No. 1, Canning Graving Dock, was recently bored through one of apparently the worst and most corroded plates in her, Mr. W. F. Sim, the managing owner, being anxious to ascertain what the actual diminution in thickness would prove after eight years' service between this and the East. The result was, that the plate operated upon turned out to be precisely the same thickness that it was when the ship was launched in July 1844—namely, $\frac{9}{16}$-inch on the sixth tier from the keel. The only part of the vessel which, on examination, exhibited any corrosion, and that only slightly, was the bow, where the anchor and chain had chafed the paint or coating with which the vessel is covered as a preservative, and which appears to perform its office effectually.

Monster Blast of Gunpowder.—A monster blast of gunpowder has taken place at Furness Granite Quarry with complete success. The charge consisted of no less than three tons of gunpowder, and was deposited in two chambers—one and a-half tons in each. The shaft was 60 feet in depth, and the chambers in which the powder was placed were 17 feet long. The charge was ignited by a galvanic battery, and lifted an immense mass of rock, computed to have been between 7000 and 8000 tons. The flame belched out on the seaward side.

Slob Lands in Ireland.—The Tralee county surveyor, Mr. Henry Stokes, is surveying the slob lands in Castlemain Bay, for Mr. Dargan, who, it is said, intends applying to parliament for a bill to inclose all the slob and marshes round the south and west coast of Ireland. Mr. Stokes has already surveyed the Cronane and Killorglin sides.

The General Board of Health.—The transactions of the General Board of Health, from its formation to the 4th of June last, are given in a parliamentary blue book which has been printed. From September, 1848, to the 5th of May, 1851, the number of officers was 23. From September, 1848, to April, 1851, the amount expended in respect of the application of the Public Health Act, was 20,592*l.* 8*s.* 5*d.* From May, 1851, to the 4th of June, 1852, the number of officers was 18. The expense of applying the act in the period was 10,505*l.* 6*s.* 3*d.* The book shows the expense of obtaining private acts of parliament. Four are given, and the average cost of each was 2425*l.* 18*s.* 4½*d.* The St. Pancras Paving Bill, 1851, cost 3560*l.* 7*s.* 7*d.*; the Carlisle Gas Act, 1850, 1372*l.* 7*s.* 1*d.*; the Bilston Improvement Act, 1850, 3463*l.* 0*s.* 5½*d.*; and the Brighton Improvement Act, 1850, 1307*l.* 18*s.* 11*d.*

The Julia Basilica.—The Pope has directed the excavations of the Forum at Rome to be continued, particularly in the vicinity of the ruins of the Temple of Castor, and on the Mons Capitolinus, in order to ascertain whether the remains existing there be those of the Basilica, built by Julius Cæsar, under the title of Julia, or not. It is expected these excavations will throw great light upon several obscure passages of the classics.

Ancient Colossal Theatre.—An engineer of the Ottoman Commission of Surveys has discovered a colossal theatre at Smyrna, near the old castle, in the direction of Mount Pazas. It is in tolerable preservation, and is said to be of the time of Strabo.

Bristol General Hospital Commission.—The report of the Committee has been issued, after having called in the professional assistance of Messrs. George Wightwick and T. H. Wyatt; it is decided that Mr. B. W. Gingall shall have the first premium, and be appointed architect; the second premium has been awarded to Messrs. Aickin and Capes; the third to Messrs. Clarke and Norton, and the fourth to Messrs. Coe and Goodwin.

Princess's Theatre. — In the melodrama of Mont St. Michel lately brought out, some excellent scenery is introduced illustrating the bay and sands of St. Michel, Normandy. The representation of the base and upper part of the Mount, with the picturesque castle surmounting it, are ably painted by Gordon. The third scene—the soldiers destroying the interior of the Chateau de Rochemont—affords an opportunity of effective grouping which has been taken advantage of. In the last scene, a mist overspreads the quicksands which favours the escape of the heroine and her father from the castle and convent. They are followed by the soldiers who can only proceed slowly until the dispersion of the mist. The scene is a masterpiece of Mr. Dayes'.

LIST OF NEW PATENTS.

GRANTED IN ENGLAND FROM SEPTEMBER 24, TO OCTOBER 21, 1852

Six Months allowed for Enrolment unless otherwise expressed.

Henry Medhurst, of Clerkenwell, Middlesex, engineer, for improvements in water meters, and in regulating, indicating, and ascertaining the supply of water and liquids.—September 27.

Auguste Edouard Loradoux Bellford, of Castle-street, Holborn, for improvements in the manufacture of boots and shoes, part of which said improvements are also applicable to the manufacture of various other articles of dress. (A communication.) September 30.

Moses Poole, of London, gentleman, for improvements in the manufacture of combs. (A communication.)—September 30.

Sarah Lester, of St. Peter's-square, Hammersmith, Middlesex, executrix of the late Michael Joseph John Donlan, of Rugeley, Staffordshire, gentleman, for improvements in treating the seeds of flax and hemp, and also in the treatment of flax and hemp for dressing. (A communication from the said M. J. J. Donlan.)—September 30.

Christopher Nickels, of York-road, Lambeth, manufacturer, and Benjamin Burrows, of Leicester, for improvements in weaving.—September 30.

Henry Gardener Guion Jude, of Lower Copenhagen-street, Barnsbury-road, Islington, for improvements in the manufacture of type. (A communication)—September 30

Charles Billson, of Leicester, manufacturer, and Caleb Bedells, of Leicester, aforesaid, manufacturer, for improvements in the manufacture of articles of dress where looped fabrics are used, and in preparing looped fabrics for making articles of dress and parts of garments.—September 30.

Edouard Moride, of Nantes, France, for certain improvements in tanning.—September 30.

William Hunt, of Stoke Prior, Worcester, manufacturing chemist, for certain improved modes or means of producing or obtaining ammoniacal salts.—September 30.

Richard Archibald Brooman, of Fleet-street, patent agent, for improvements in knitting machinery. (A communication.)—October 7.

Richard Archibald Brooman, of Fleet-street, patent agent, for improvements in the manufacture of sugar. and in the machinery and apparatus employed therein. (A communication.—October 7.

Alexander Shairp, of Fleet-street, for an improved cutting and slicing machine (A communication.)—October 7.

John Reed Randell, of Newlyn East, Cornwall, farmer, for improvements in cutting and reaping machines.—October 7.

Pierre Armand Lecomte de Fontainemoreau. of South-street, Finsbury, for certain improvements in washing, bleaching, and dyeing flax and hemp, and in mixing them with other textile substances. (A communication.)—October 7.

Solomon Andrews, Perth Amboy, in the United States of America, engineer, for improvements in machinery for cutting, punching, stamping, forging, and bending metals and other substances, which are also applicable to the driving of piles and other similar purposes, and to crushing and pulverising ores and other hard substances. —October 7.

William Edward Newton, of Chancery-lane, Middlesex, civil engineer, for improvements in steam and other gauges. (A communication.).—October 11.

Richard Archibald Brooman, of Fleet-street, London, patent agent, for improvements in mowing, cutting, and reaping machines. (A communication.)—October 14.

Walter Ricardo, of the firm of A. and W. Ricardo. of London, sharebroker, for improvements in gas burners. (A communication.)—October 14.

Thomas Carter, of Padstow, Cornwall, shipbuilder, for improvements in propelling —October 14.

John Field, of Warnford-court, Throgmorton-street, for improvements in transferring and printing.—October 14.

William Brown, of Heaton, near Bradford, York, mechanist, for certain improvements in machinery and apparatus for preparing and spinning wool, hair, flax, silk, and all other fibrous materials.—October 18.

Alfred Vincent Newton, of Chancery-lane, Middlesex, mechanical draughtsman, for an improved mode of manufacturing railway chairs. (A communication.)—October 19.

Joseph Palin, of Liverpool, Lancaster, wholesale druggist, and Robert William Sievier, of Upper Holloway, Middlesex, for improvements in brewing; and also in the production of extracts or infusions for other purposes.—October 19.

William Edward Newton, of Chancery-lane, Middlesex, civil engineer, for improvements in machinery or apparatus for sewing. (A communication.)—October 19.

William Edward Newton, of Chancery-lane, Middlesex, civil engineer, for improvements in machinery or apparatus applicable to public carriages for ascertaining and registering the number of passengers who have travelled therein during a given period, and the distance each passenger has travelled. (A communication.)—October 19.

Edward Henry Jackson, of Titchfield-street, Soho, Middlesex, machinist, for certain improvements in producing artificial light, and also in producing motive power.—October 21.

Edward Brailsford Bright, of Liverpool, Secretary to the English and Irish Magnetic Telegraph Company; and Charles Tilston Bright, of Manchester, telegraphic engineer, for improvements in making telegraphic communications, and in instruments and apparatus employed therein and connected therewith.—October 21.

William Reid, of University-street, electric telegraph engineer, for improvements in electric telegraphs.—October 21.

William Boggett, of St. Martin's-lane, Westminster, gentlemen, and George Brooks Pettit, of Lisle-street, Westminster, gas engineer, for improvements in obtaining and applying heat and light.—October 21.

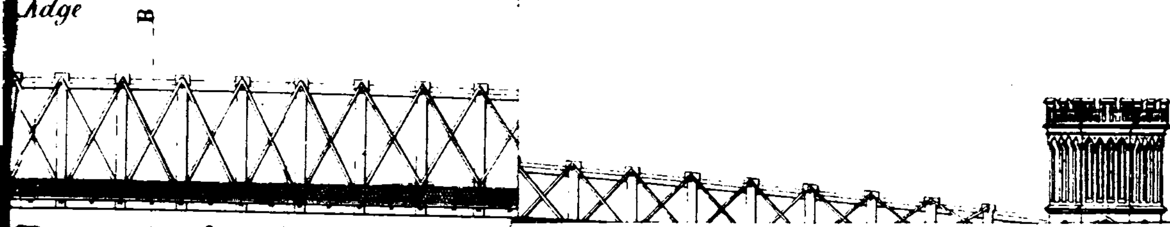
John Charles Wilson, of the Redford Flax Factory, Thornton, near Kirkcaldy, of Fife, North Britain, civil engineer, for improvements in the machinery and processes employed in and for the manufacture of flax and other fibrous vegetable substances. —October 21.

Errata.—In our last number, p. 326, col. 2, line 13, 14, *for* "the engineer's gravatt," *read* "the engineer, Gravatt."—Page 326, col. 2, line 51, 52, *for* "Plazza," *read* "Plazzi."—Page 329, col. 2, line 11, *for* "Loch Loug," *read* "Loch Long."—Page 348, col. 2, line 33, *for* "received," *read* "recovered."—Page 349, col. 1, line [illegible], after the word "abstracted," insert a comma.

ECTION OF BRIDGES.

R.M.Marchant Civil Eng

idge



WROUGHT AND CAST IRON AND WOOD BEAMS.

WITH A DESIGN FOR A BRIDGE, WITH BEAMS ON THIS PRINCIPLE, OVER THE THAMES AT WESTMINSTER,

(*See Engraving*, *Plate* XLI.)

R. M. MARCHANT, C.E., Inventor.

WROUGHT-IRON Beams, which have to a considerable extent superseded the use of cast-iron ones, have had attention more particularly directed to them and to the advantages they offer by their application to works of such magnitude as the Britannia and Conway bridges, and latterly to the Chepstow bridge. The experiments preceding this application of wrought-iron (an account of which is given in the very interesting and valuable work of Mr. Edwin Clarke, on the 'Britannia and Conway Bridges') show that the total capacity of wrought-iron as applied in beams is greater than that of cast-iron so applied in the proportion of about 17¾ * to 12†; and where the material is to be applied in a continuous beam, the partial substitution of a strain in tension for that in compression at the top of the beam increases the advantages offered by wrought-iron as the material for the beam. As experiment gives the relative powers of wrought and cast iron for resisting a strain in tension in the proportion of about 20 wrought-iron to 7 cast-iron, and their relative power of resisting a strain in compression in the proportion of about 16 wrought-iron to 40 cast-iron, the ultimate power of wrought-iron for resisting tension is shown to be about three times as great as that of cast-iron, and its power of resisting compression is only about two-fifths as great, and induces the consideration whether a combination of wrought and cast-iron (each metal being employed in its most favourable position) cannot be so effected as to offer in the construction of beams practically those advantages which their several qualities suggest. It is evident that in a beam which has for its material cast-iron as the material in compression, and wrought-iron as the material in tension, the material as best adapted is applied to each particular strain, and that by adopting cast-iron for the upper portion of the beam instead of wrought-iron, the required resistance to the compressive strain is obtained with two-fifths of the material, and a saving is thus effected of not only three-fifths of the quantity of material which would be required were the top also of wrought-iron, but the beam being also by so much the lighter, less metal is required in the top and bottom to give a beam of equal resistance to the constant strain to which it is subjected by its own weight and that of the roadway. Now, the entire substitution of wrought for cast iron in beams gives us the same strength with about one-third less material, and, consequently, with less strain arising from the weight of the beams themselves to provide for, it also offers greater facility of application on a large scale; and it is submitted that the substitution, for entirely wrought-iron beams, of cast and wrought iron combined, as hereafter suggested, offers the same advantages to a greater extent. The proportions in a wrought-iron beam of the material in the top and bottom should be as 20 top to 16 bottom, or as 1 to ¾;‡ by the substitution of cast-iron in the top three-fifths of the material represented by the 1 is saved, and a lighter and less expensive material is substituted, and the whole material in the top and bottom being represented by 1¾, the saving of material is represented as three-fifths, and a saving in bulk of $\frac{12}{35}$ths of the whole is effected.

The constant strain on a beam arising from its own weight being less by this removal of weight, less material is necessary to give a beam of equal strength, and a further reduction of material is open to us. It is submitted also, that (except as tubular beams with the load passing through them) greater facility for application on a large scale is afforded by beams so constructed, and a design for a bridge with beams on this principle over the river Thames at Westminster is submitted in illustration of the proposed manner of applying the material so combined, and the advantages it offers. In this design the beams to the centre opening are 504 feet in length between the piers, and the constant strain at the centre of each beam from its own weight and that of the roadway is 4645½ tons; 9291 tons being therefore the constant strain on the the two beams. This constant strain on the beams does not equal one-fourth of the capacity of the material for resistance, the sectional area of the cast-iron top at the centre of each beam to meet this strain being 499½ inches, 999 inches for the two beams; and the sectional area of the wrought-iron bottom at the centre of each beam being 969 inches, 1938 inches for the two beams; and the strain from the maximum possible load, which is assumed at 2000 tons on this centre opening (many times any probable load), would not give a strain on the material exceeding one-third of its capacity of resistance. The weight of each beam complete is about 1193 tons, but had the top been constructed of wrought-iron to keep the constant strain from its own weight and that of the roadway within the same limits, the weight of each beam would have required increasing by about 1080 tons—nearly doubling their actual weight, and more than doubling their cost, with no accompanying advantage,* and with greater difficulty of applying the material in a sightly form; for there would be nearly four times the present bulk of material to apply in the top of the beam, to which there would then be required a sectional area equal to about 10½ square feet of solid metal. It is submitted that the cast-iron boxes forming the top of the principal beams as connected at the ends with the wrought-iron plates forming the bottom, offer an advantageous and convenient method of applying the material to girders of magnitude, and that the connecting castings, and plates and tie-rods, give a good and complete connection between the top and bottom of the beams.

The transverse girders, which are 70 feet long between the bearings, have also, as designed, a cast-iron top and a wrought-iron bottom. The weight of cast-iron in the top is 2¼ tons, the weight of wrought-iron in the bottom is 4 tons. It is proposed to connect the top and bottom of these girders by filling the space between the castings and the wrought-iron plates with either oak or pine timber, with a few intermediate connecting castings, and with bolts passing through the whole. It is believed that up to 100 feet span, the connection between the top and bottom of such girders would be well and economically made by timber and bolts. It is believed that for the wrought-iron plates, forming the bottom of these transverse girders, as shown, timber might be advantageously substituted, as hereafter suggested. The intermediate girders are formed of a simple cast-iron plate for the top, and of a wrought-iron plate for the bottom, with a wood and bolt connection, and are calculated to bear, within one-fourth the capacity of the material, a strain at the centre of 28 tons.

The question next arises whether as pine possesses a tenacity of 5 tons per square inch of sectional area, or one-fourth that of wrought-iron, whilst its weight is only one-tenth that of wrought-iron, balks of this material cannot be advantageously substituted in the bottom of such beams for the wrought-iron plates; the great difficulty to be got over in such a substitution arising, at the junction of the balks, from the small capacity of timber for resisting a strain tending to make the fibres separate and slide on each other, its capacity for such a strain being only from 5 to 6 cwt. per superficial inch; and necessitating at the joints such an auxiliary strength as shall, with the resistance given there by the timber to a strain so conveyed, equal the capacity of each balk to bear a strain in tension.

The use of Jeffrey's elastic Marine Glue, in connecting the balks and scarfs for their whole length would, to a considerable extent, lessen the plates and bolts required at the joints. By a substitution of pine balks for the wrought-iron plates, 658 tons of wrought-iron to each beam would be abandoned for 220 tons of timber, and about 100 tons of iron—showing a saving in weight, on each beam, of 338 tons, or a saving in weight on the two beams, to the centre span of the bridge, of 676 tons; and a cost for this portion of the beam, if we estimate the wrought-iron at 30*l.* a ton, and the timber as high even as 8*s.* per cubic foot, of 7400*l.*, instead of 19,740*l.*—or, on the two beams of 14,800*l.*, instead of 39,480*l.* We have also 676 tons less of constant weight to provide for; and the constant tension on the timber bottom for the two beams becomes 7898 tons, or 3949 tons in each beam—giving a constant strain, on the available area, of a little more than 1½ ton per square inch of timber in tension,

* Taking the capacity of wrought-iron for resisting a strain in compression as 16 tons per inch square of sectional area, and its capacity for resisting a strain in tension as 20 tons per inch square of sectional area, gives the quantity of metal required in the top and bottom of the beam in the proportion of 25 to 20, and a mean capacity of the material for resisting the combined strain of 17¾ tons per inch square of sectional area.

† Taking the capacity of cast-iron for resisting the strain in compression as 42 tons per inch square of sectional area, and its capacity for resisting a strain in tension as 7 tons per inch square of sectional area, gives the quantity of metal required in the top and bottom of the beam in the proportion of 1 to 6, and a mean capacity of the material for resisting the combined strain of 12 tons per inch square of sectional area.

‡ The weakening of the bottom by the ordinary riveting appears, however, to about equalise the strength, as the iron is now generally applied, and to necessitate the same quantity of material in the bottom as in the top of each beam.

* The beams would carry a greater maximum load, but this is unnecessary, and not necessarily therefore an advantage.

and with the same maximum load as supposed with the wrought-iron bottom, a maximum strain for the two beams of 12,029 tons, or 6015 tons on each beam—giving a possible maximum tension, on the available area of the timber bottom, of $3\frac{3}{4}$ tons per square inch. The depth of the beam, with a timber bottom, should probably be increased 3, or even 4 feet, and the maximum possible strain kept below 3 tons per square inch of section. It is believed that timber might, in this manner, be advantageously applied to form the chain of a suspension-bridge; as the same strength could be obtained with less than half the weight and cost (but for the plates at the joints, a saving of about six-tenths of the weight would be effected), and it might be so applied as to give a far more rigid structure than hitherto obtained on the suspension principle.

For the purpose of showing the application of the patent to practical cases, the following proportions and calculations have been made by the inventor for the proposed Westminster Bridge.

Centre Span, 504 feet; *Depth of Beams*, 30 ft. 6 in.—The total weight of the bridge and roadway for this centre span may be taken approximately at 4500 tons, which weight is equally distributed over its length, or nearly so, and may therefore be treated as half this weight, or 2250 tons at the centre of the span; therefore the total strain on the beams at the centre of the opening $= (252 \div 30\frac{1}{2}) \times \frac{2520}{2} = 9293$ tons. The constant strain on the beams from their own weight, and that of the roadway, is not to exceed one-fourth their capacity of resistance, which, taking a low average for that capacity, will be 10 tons per square inch of section on the cast-iron in compression, and 5 tons per square inch of section on the wrought-iron in tension; and this necessitates a sectional area to the centre of the beams of not less than 929 inches for the cast-iron boxes forming the top of the beams, and of not less than 1858 inches for the wrought-iron plates forming the bottom. There are two beams, and therefore, for each beam at the centre, these sectional areas become 465 inches at the least for the cast-iron boxes forming the top, and 929 inches at the least for the wrought-iron plates forming the bottom.

Now, at the several distances between the piers of	[. . .			504 feet			. . .]
	63	126	189	252	189	126	63
the strains from an equally distributed load are in the	|	|	|	|	|	|	|
proportion of	7	12	15	16	15	12	7

and as the sectional area of the wrought-iron plates required, as stated by the strain at the centre, is 929 square inches, the sectional area of these plates to bear (within the strain of 5 tons per square inch of section) the strain resulting at the several distances from the piers, of 63 feet, 126 feet, 189 feet, 252 feet, must be respectively not less than 407 inches, 697 inches, 871 inches, 929 inches; similarly at $94\frac{1}{2}$ feet from the piers, the sectional area required (at the strain, as limited to 5 tons per square inch of sectional area) for these plates is not less than 566 square inches; and it is proposed to have these plates, which are to be $28\frac{1}{2}$ inches in width, thus—

plates.		inches.		feet.	
20	(giving a sectional area of	570)	for 5 first bays extending to	70	from piers,
22	(„ „ „	627)	for 2 bays extending to	92	„
25	(„ „ „	$712\frac{1}{2}$)	for 1 „ „	112	„
27	(„ „ „	$769\frac{1}{2}$)	for 2 „ „	140	„
30	(„ „ „	855)	for 1 „ „	154	„
32	(„ „ „	912)	for 2 „ „	182	„
34	(„ „ „	969)	for 5 „ „	252	Centre.

The constant strain at the centre of each beam being 4647 tons, and there being here 34 plates, forming the bottom, the strain on each plate is nearly 137 tons, which will therefore be the shearing strain on the bolts connecting them with the lap plates at the joints; and this strain limited to 5 tons per square inch of sectional area of the bolts, gives the sectional area as $27\frac{1}{2}$ inches at the minimum; and it is intended to connect each plate to the lap plate at the joints throughout, by seven bolts of $2\frac{1}{4}$ inches diameter each, and two bolts of $1\frac{1}{4}$ inch diameter each, and to have the lap pieces 8 inches wider than the plates themselves.

The dimension of each of the cast-iron boxes, of which there are to be 8, forming the top of each of these beams, is to be externally 18″ × 12″ of $\frac{5}{8}$-inch metal from the piers to the distance of 56 feet from them, giving a sectional area of 288 inches;* from these points to the distances from the piers of 98 feet, these boxes are to be of $\frac{7}{8}$-inch metal, giving a sectional area of $395\frac{1}{4}$ inches;* from these points to the distances from the piers of 126 feet, these boxes are to be of 1-inch metal, giving a sectional area of 448 inches;* and between these points they are to be of $1\frac{1}{8}$-inch metal, with a sectional area of $499\frac{1}{2}$ inches.*

* The flanges are not included in the areas here given; their sectional area is 32 inches.

Side Spans of 252 feet *each*; *Depth of Beams*, 19 ft. 6 in.—The total weight of the bridge and roadway, for each of the side-spans, may be taken approximately at 1600 tons, which weight is equally distributed over the length, or nearly so, and may therefore be treated as half this weight, or 800 tons at the centre of the span; therefore, the total strain on the beams at the centre of the opening is $(126 \div 19\frac{1}{2}) \times \frac{800}{2} = 2585$ tons. The constant strain on the beams from their own weight, and that of the roadway, is not to exceed one-fourth of their capacity of resistance, which, taking a low average for that capacity, will be 10 tons per square inch of section on the cast-iron in compression, and 5 tons per square inch of section on the wrought-iron in tension; and this gives a sectional area to the centre of the beams of not less than 259 inches for the cast-iron boxes forming the top of the beams, and of not less than 518 inches for the wrought-iron plates forming the bottom of the beams. There are two beams, and therefore for each beam these sectional areas at the centre of each beam become 130 inches at the least for the cast-iron boxes forming the top, and 259 inches at the least for the wrought-iron plates forming the bottom.

The dimension of each of the cast-iron boxes, of which there are eight, forming the top of each of these beams, is to be externally 12″ × 12″ of $\frac{3}{8}$-inch metal from the piers to the distances of 56 feet from them, giving a sectional area of $139\frac{1}{2}$ inches; and between these points these boxes are to be of $\frac{1}{2}$-inch metal, with a sectional area of 184 inches.

Now, at the several distances between the piers of	[. . . .			244 feet			. . . .]
	28	56	84	112	84	56	28
the strains from an equally distributed load are in the	|	|	|	|	|	|	|
proportions of	8	14	18	20	18	14	8

and as the sectional area of the wrought-iron plates required, as stated, at the centre of each beam, is 259 inches, the sectional area of these plates to bear (within the strain of 5 tons per square inch of section) the strain resulting at the several distances from the piers of 28 feet, 56 feet, 84 feet, 112 feet, must be respectively not less than 104 inches, 182 inches, 234 inches, 259 inches; and it is proposed to have these plates, which are to be twenty-two in number, 1 ft. 1 in. broad, of $\frac{1}{2}$-inch metal for the first two bays extending to 28 feet from the piers, and giving a sectional area of 143 inches; of $\frac{3}{4}$-inch metal for the next two bays extending to 56 feet from the piers, and giving a sectional area of $205\frac{1}{2}$ inches; and from that point to have them of 1-inch metal throughout, with a sectional area of 286 inches.

It is intended to connect each plate to the lap plate at the joint throughout by seven bolts of 2 inches diameter each, and two bolts of $1\frac{1}{4}$ inch diameter each, and to have the lap pieces wider than the plates themselves.

Transverse Girders.—Fifty tons of roadway, including the weight of the girder itself, may be taken as the maximum weight uniformly distributed over each girder, which may be treated as a weight of 25 tons at the centre of the girder; therefore the total strain at the centre of the girder $= (35 \div 4) \times \frac{25}{2} =$ 110 tons. Keeping the constant strain per inch square of sectional area on the cast-iron top in compression, and on the wrought-iron bottom in tension, as for the large beams, we require at the centre of each girder 11 inches of sectional area for the cast-iron top, and 22 inches of sectional area for the wrought-iron bottom. The cast-iron top to these girders is formed by two cast-iron box tubes, each 8″ × 4″ of $\frac{1}{2}$-inch metal throughout the whole length of the girder, giving a sectional area of 22 inches. The wrought-iron plates, which are to be six in number, are proposed of 8 inches in breadth and $\frac{3}{4}$-inch thick throughout the total length of the girder, giving a sectional area of 36 inches.

Intermediate Girders.—The extreme passing load being taken at 4 tons per foot run, each intermediate girder may be considered as liable to an extreme uniformly-distributed load of 8 tons; and therefore the total possible strain at the centre of each girder $= (14 \div 1) \times \frac{4}{2} = 28$ tons; and in this case the extreme passing load is provided for within the limit for the constant strain, and we have 3 inches for the sectional area of the cast-iron top, and 6 inches for the sectional area of the wrought-iron bottom.

Cast-Iron Plates under Roadway.—Taking the extreme passing load as above, there would be an uniformly-distributed load of $\frac{1}{2}$-ton per foot run of plates (of 5 feet in width) $\therefore$ the strain in the centre of the plate per foot run $(25 \div 0{\cdot}5) \times \frac{0{\cdot}25}{2}$ less than $\frac{2}{3}$ of a ton; these plates, as designed, may be cast of $\frac{1}{2}$-inch metal. The strain on the several parts of the bridge, with the maximum load, is now to be considered, and it is assumed that the maximum improbable load would be equal in weight to four lines of locomotive on the bridge, or to 25,250 men who might be made to stand upright on the centre opening, and half that number on each side opening. The first assumption would give a further equally-distributed load on the centre span of about 2000 tons, and on each side opening of 1000 tons; and the latter (at $1\frac{1}{4}$ cwt. per man) would give a further equally-distributed load of 1594 tons on the centre span, and on each side span of 797, which may in either case be treated as half these weights at the centre. Assume the greater of these loads, that from the rows of locomotives, and with such a load the total strain on the two beams to the 500 feet span at their centre is

$$(252 \div 30\tfrac{1}{2}) \times \frac{2250 + 1000}{2} = 13{,}426 \text{ tons},$$

or on each beam a strain of 6713 tons at the centre; to meet which maximum strain there is at this, the weakest point of the beam, a sectional area of $499\frac{1}{2} \times 32$ inches to the cast-iron boxes forming the top of the beam, on which there would therefore be a crushing strain of something less than 13 tons per square inch of sectional area, and to meet which maximum strain there is also at this, the weakest point of the beam, a sectional area of 969 inches to the wrought-iron plates forming the bottom of the beam, on which there would therefore be a tension of something less than 7 tons per square inch of section, or, with this maximum load in each case, a strain of about one-third the breaking strain. The uniform load giving less than one-fourth of that strain, and also with such a maximum load, the total strain at the centre of each beam to the side spans is

$$\frac{(126 \div 19\tfrac{1}{2}) \times \frac{800 + 500}{2}}{2 \textit{ beams}} = 2100 \text{ tons};$$

to meet which strain, there is at this, the weakest point of the beam, a sectional area of 184 inches to the cast-iron boxes forming the top of the beam, on which there would therefore be a crushing strain of something less than 12 tons per square inch of sectional area; and to meet which strain there is also at this, the weakest point of the beam, a sectional area of 286 in. to the wrought-iron plates forming the bottom of the beam, on which there would therefore be a tension of something less than $7\frac{1}{2}$ tons per square inch of sectional area; there being here also, therefore, with this maximum load, a strain of about one-third of the breaking strain, the uniform load giving less than one-fourth of that strain. With such a maximum load, there would be an additional load uniformly distributed over each transverse girder of 56 tons, which may be treated as half this weight at the centre of the girder. The total possible strain at the centre of the transverse girder would then be

$$(35 \div 4) \times \frac{25 + 28}{2} = 232 \text{ tons};$$

to meet which maximum strain there is at this, the weakest point of the girder, a sectional area of 22 inches to the cast-iron top, on which there would be therefore a crushing strain of about $10\frac{1}{2}$ tons per square inch of sectional area; and to meet which maximum strain, there is also at this, the weakest point of the girder, a sectional area of 36 inches to the wrought-iron bottom, on which there would therefore be a tension of less than $6\frac{1}{2}$ tons per square inch of sectional area; there being therefore with this maximum load a strain of little more than one-fourth of the breaking strain.

The strain for all the other parts of the bridge are, at this maximum load, kept within the limits of 10 tons per square inch of sectional area on the cast-iron in compression, and of 5 tons per inch square of sectional area on the wrought-iron in tension; and no strength obtained from the sides or side bracing is taken into these calculations. The advantages obtained in this case by the use of cast-iron in the top of the beams is shown by the fact that had the beams to the 504 feet span been constructed entirely of wrought-iron, the comparative resistance to compression of wrought and cast iron being in the proportion of 16 to 40, and cast-iron being $\frac{1}{10}$th lighter than wrought-iron, instead of the 313 tons of cast-iron which now form the top of each beam, 822 tons of wrought-iron would have been necessary to bear the same amount of strain within the required limits; and each beam becoming from this addition of material 509 tons heavier, its strength would necessarily have to be increased to bring the constant strain on the material from its own weight and that of the roadway within the required limits; and the further strain at the centre of each beam, from its additional weight of 509 tons is 1053 tons, which requires the strengthening of each beam by an additional quantity of metal in the top of 137 tons, and in the bottom of 110 tons; and in so increasing the strength to maintain the constant strain on the metal within the required limits, we again create an additional weight of beam of 247 tons to be further provided for; and it will be found necessary to continue increasing the strength of the beam to provide for the additional weight so accruing until a further quantity of metal of 179 tons weight has been added to the top, and of 145 tons weight to the bottom. Were the beams, therefore, entirely of wrought-iron, each beam would so require to be 1080 tons more in weight than (the 1190 tons) it actually weighs as constructed with the cast-iron top, where the constant strain is within the required limits, which would considerably more than double the cost of the beams as designed for the centre span of 504 feet.

In beams entirely of wrought-iron, as above supposed, although the constant strain is barely within the required limits, there is of course a considerably-increased strength for any passing load—but it is useless, as, with the maximum possible load on the beams with the cast-iron top, as provided, the strain is within the limit of one-third their ultimate power of resistance; and this strain is far above that which would be given by any extreme load at all likely to be put on it, and at least four times that of any probable load; and the beams, as designed, will carry within their breaking weight six times this maximum strain, which greatly exceeds that from any probable load.

It would be almost impracticable, unless as a tubular bridge, to construct a sightly beam of this depth and span entirely of wrought-iron and of sufficient strength to carry the required weight, for in the case given above the average sectional area of a wrought-iron top for such a beam would be 1517 inches, equal to a solid mass of wrought-iron of 3′ 0″ × 3′ 6″; and the average sectional area of the bottom is 1146 inches, equal to a solid mass of wrought-iron of 3′ 0″ × 2′ 8″; which in the top of the beam gives a mass of metal of nearly four times the bulk of that in the beam with the cast-iron top to be dealt with, and gives in the bottom of the beam a mass of metal to be dealt with of nearly $1\frac{1}{2}$ times the bulk of that in the beam with the cast-iron top—involving the necessity of much greater breadth, and creating great difficulty of disposing of the material required in the top advantageously, otherwise than by converting the beam into a tubular beam.

As pine possesses a tenacity of 5 tons per square inch of sectional area, or one-fourth that of wrought-iron, whilst its weight is only $\frac{1}{10}$th that of wrought-iron, it becomes a question whether the difficulty of obtaining such a junction to balks of this material as shall enable a series of them to possess an uniform capacity for resisting a strain in tension, cannot be got over. This difficulty arises chiefly from the small capacity of timber for resisting a strain tending to make the fibres separate and slide on each other, its capacity for such a strain being only from 5 to 6 cwt. per superficial inch; necessitating at the joints such an auxiliary strength as shall, with the resistance given by the timber to a strain so conveyed, equal the capacity of each balk to bear a strain in tension. Supposing that for the wrought-iron plates, forming the bottom of the centre beams to the bridge as shown, a bottom composed of eight balks, each 19″ square, were substituted, and that the joints were formed by scarfs with auxiliary plates and bolts as shown (the thickness of the centre plate being taken out of the adjoining balk and not out of the joint) we should obtain an area of $361 \times 8 = 2888$ inches; but as nearly $\frac{1}{10}$th of the strength of the timber is lost by the bolts and plates passing through it at the several joints we can only reckon on a serviceable area of 2600 square inches capable of bearing a maximum strain in tension of at least 13,000 tons.

The use of Jeffries' elastic marine glue in connecting the balks and scarfs for their whole length will, it is believed, to a considerable extent lessen the plates and bolts required at the joints; but in proceeding with the present statement no allowance is made for its use. By such a substitution 658 tons of wrought-iron to each beam would be abandoned for 220 tons of timber and about 100 tons of iron; showing a saving on each beam in weight of 338 tons, or a saving in weight on the two beams to the centre span of the bridge of 676 tons, and a cost for this portion of the beam, if we estimate the wrought-iron at 30*l.* per ton and the timber as high even as 8*s.* per cubic foot, of 7400*l.* instead of 19,740*l.*, or, on the two beams, of 14,800*l.* instead of 39,480*l.* We have 676 tons less of constant weight to provide for, and the constant tension on the timber bottom for the two beams becomes $(252 \div 30\frac{1}{2}) \times \frac{1912}{2} = 7898$ tons, or 3949 tons in each beam, giving a constant strain on the available area of more than $1\frac{1}{2}$ ton per square inch of timber in tension, and with the same maximum load as supposed with the wrought-iron bottom a maximum strain for the two beams of $(252 \div 30\frac{1}{2}) \times \frac{1912 + 1000}{2} = 12{,}029$ tons, or 6015 tons on each beam, giving a possible maximum tension on the available area of the timber bottom of $3\frac{2}{3}$ tons per square inch. The depth of the beam with a timber bottom should probably be increased about 3 feet, and the maximum possible strains should be kept below 3 tons per square inch of section. There can be little doubt that the transverse girders should have a timber bottom and a cast-iron top on this principle, as balks of sufficient length could be obtained, and the joints would be avoided.

ON THE ORGANIC CONTENTS FOUND BY THE MICROSCOPE IN WATERS SUPPLIED FROM THE THAMES AND OTHER SOURCES.

By Edwin Lankester, M.D., F.R.S.

[*Report made to the Directors of the London (Watford) Spring Water Company.*]

Modern science has placed in the hands of investigators two principal means of ascertaining the purity of waters, and their adaptation to the purposes for which they are employed by man,—chemical analysis and the microscope. By means of the former, the saline or inorganic contents dissolved in water are ascertained, whilst by the latter instrument the organic beings which are nourished and live in water are made apparent.

The observations contained in the following Report have been principally confined to the application of the microscope for the purpose of ascertaining the particular forms of plants and animals found in the waters named. Although in perfectly pure water it would be impossible that either plants or animals should live, yet in a state of nature water is seldom met with that does not contain the elements out of which plants and animals are formed. Of the various elements of which the whole vegetable and animal kingdoms are built up, there are four which are universally present in plants and animals, and which must consequently be always present in waters where either plants or animals exist. These are—carbon, hydrogen, oxygen, and nitrogen. These elements do not, however, occur in their pure form, nor would they, if pure, subserve the nutrition of organic beings; but they are found more especially in the form of carbonic acid and ammonia. The first substance contains carbon and oxygen, the last nitrogen and hydrogen. Just in proportion as these substances abound *within certain limits* will be the abundance of vegetable life, and just in proportion to the vegetable life will be the amount of animal life. Plants derive their nourishment from carbonic acid and ammonia —animals derive their nourishment from plants.

The natural source of carbonic acid and ammonia in water is the atmosphere. Waters exposed to the atmosphere, as in rivers, and rain-water, contain these substances. An additional source of these substances, in rivers and wells, is the presence of organic matter in a state of decomposition. Wherever decaying vegetable and animal substances or excretions are found, they give off these gases—hence one of their uses as manures. In proportion, therefore, to the introduction from without of organic matters, will be the increase of organisms within the water; and as in climates like our own it is only at certain seasons of the year that vegetation is active, there will always be in such waters a quantity of vegetable and animal matter in a state of decay, always disagreeable, and under some circumstances likely to be highly injurious to the health of those who consume it in their diet.

The sources of the organic matter of the river Thames are sufficiently obvious on its banks, where it is found that the sewers of almost every town, village, and house in its vicinity empty themselves into this river. That the organic matter thus discharged into this water is not all decomposed and taken up by its vegetation, is proved by the great deposits of mud above the influence of the tide, and which consists principally of animal and vegetable matter in a state of decay. The sources of these substances when they exist in wells are soakage from manured lands, or percolations from neighbouring sewers or cesspools. Many of the shallow wells in London present from this cause a large amount of organic matter, and of those saline substances which are the result of chemical changes going on in the organic matter in contact with the oxygen of the air. The saline substances thus formed are principally salts of nitric acid, which is formed by the union of the nitrogen of the organic substance with the oxygen of the air. These salts are known to have a very depressing effect upon the human system.

When plants and animals die, and their tissues are exposed to the action of water, many other substances are formed besides those resulting from the compounds of the above-mentioned elements. Both sulphur and phosphorus are found in small quantities in animal and vegetable bodies, and sulphuric and phosphoric acids amongst the saline ingredients of water. Through these substances the gases known as sulphuretted and phosphuretted hydrogens, more especially the former, are produced. The action of these gases on the system is very depressing, and they give the disagreeable odour to water that has been kept for a few days. Very small quantities of organic matter, kept in contact with the salts of sulphuric acid, as I have shown in my work on the 'Mineral Springs of Askern,' will serve to produce quantities of sulphuretted hydrogen that would destroy all vegetable or animal life in the waters which contained it.

Besides the elements carbon, hydrogen, oxygen, and nitrogen, and those of sulphur and phosphorus, there are others contained in water which exert an influence on the life of particular plants. It is well known that sea-weeds will only live in water containing chloride of sodium (common salt). Land and fresh-water plants require potash, whilst a large number of plants flourish in proportion as the salts of lime or silica are present. Where these salts exist they encourage the growth of certain plants, and with them animals which would have no existence without them. These facts will explain the difference observed in different waters with regard to the presence of organic life, and the existence of the latter must be regarded as one of the best tests of the degree of impurity of the waters in which they are found.

Before speaking of the results of a microscopic examination of the waters supplied by the Water Companies from the river Thames and other sources, I may refer to those facts with regard to its condition which are obvious to every observer. That it must contain large quantities of organic matter, is evident by the sewage of the towns on its banks being emptied into it. It runs also through a highly-cultivated district of England, so that the surface drainage which necessarily falls into it is more than usually charged with organic matters from the manure employed in cultivation. As a proof of this, it may be stated that vegetation has been observed to be more prolific in the river after heavy rains, and Dr. Angus Smith states that at such times it is richer in saline contents.

Throughout the whole extent of the Thames from which the present Water Companies obtain their supplies (including the Lambeth Company at Thames Ditton), banks of a black deposit exist, which consist principally of animal and vegetable *débris* in a state of decomposition, and which abounds with animal and vegetable life. In the summer season the Thames abounds with aquatic flowering plants belonging to various species, which grow from the beds of mud on its sides, and indicate by their luxuriance the large supply of manure they receive. Various species of Conferv æ are also abundant. The Thames also abounds with fish and various forms of invertebrate animals easily detected with the naked eye. Mollusca belonging to the genera Limneus, Planorbis, Unio, Cyclas, Palludina, Neritina, and others, are very numerous. The larvæ of almost innumerable forms of insects are found in its mud, and on the stones on its banks. Visible forms of Annelides, amongst which may be mentioned the common leech, with other species of the same genus, occur in great numbers. Various species of water-spider are common. Crustaceans, from the larger forms of the fresh-water shrimps, down to the microscopic Cyclops and Daphnia, which, scarcely seen singly, by their numbers frequently give a yellow colour to the water, are amongst the most abundant forms of its animal life. Of the Radiate animals the Hydra with Cristatella and other forms of Zoophytes are frequently present, whilst the fresh-water sponge (spongilla fluviatilis) is found in some places in great abundance, and its spiculæ form a part of the deposit of the purest specimens of the water.

The plants and animals whose existence and true nature are revealed by the microscope are much more numerous than those discoverable by the naked eye. The mode of proceeding in order to examine these creatures as they exist in waters supplied by the London Companies was as follows: The waters were collected and sent in bottles numbered and labelled, so that they could be identified. After having been placed in various situations, they were examined as to whether any creatures visible to the naked eye were floating about. The clear water was then poured off with the exception of about two ounces, which contained whatever of animal and vegetable matter had been deposited, as well as the majority of the living organisms to be found in the water. These deposits consisted of decomposing animal and vegetable matter, and also living plants and animals. A large quantity of the deposit was composed of disorganised matter, sometimes quite black, at other times of a brown or a light yellow colour. Frequently in the midst of this matter could be seen portions of animal and vegetable tissue in a less decomposed state. Portions of woody tissue, spiral vessels, cotton hairs, fragments of leaves, and parts of small branches, seeds of water-plants, and pieces of wood, were frequently observed. Of animal remains, the legs and cases of the crustacea were most common, but pieces of the skins of the larvæ of flies, as well as the hairs of animals and even portions of muscular fibre, were not unfrequent. It is from such substances as these that living organisms derive their food, plants the gases which they need, and some animals their usual nutriment.

The PLANTS discovered by the microscope belonged to the families Confervaceæ, Desmideæ, Diatomaceæ, and Fungi.

The *Confervaceæ* are generally inhabitants of fresh water. Although many of them grow in pure waters, certain forms of them are adapted to almost every condition of impurity. Thus I have found Calothrix nivea and species of Oscillatoria in the sulphureous waters of Harrowgate, Askern, Moffat, and of other places where these springs exist. The same plants are also present in waters highly charged with night soil or the refuse of towns. The portions of these plants found in the Thames water belonged to those forms which are generated in the above circumstances, and may certainly be regarded as indicative of the impurity of the water in which they were found.

The *Desmideæ* are all of them microscopic plants, which are found in most abundance in still waters; they would therefore not be expected to occur in abundance in waters procured from a running stream. Several species, however, have been found in the waters supplied by the Companies, and great numbers in the mud of the Thames procured in quiet spots far above Teddington Lock. In the case of water procured from the Lambeth Company's supply, which had stood for a few days exposed to the air of a room, the bottom of the vessel was observed to be green, and on examination this colour was found to depend on an immense quantity of a small Desmidian, the Closterium setaceum. An example of one of the most frequent of these plants is shown in fig. 7.

Fig. 7—Scenedesmus quadricauda, magnified 300 diameters.

The *Fungi* are plants rather of the land than of the water. They are found wherever animal or vegetable matter is decomposing in the air. Some of the species, however, are found in the water, and in most of the waters which I have examined the well-known fibrillæ of these plants have presented themselves. They were in considerable numbers in the waters taken from covered wells 94 feet in depth, in the city of Brussels.

The *Diatomaceæ* are by far the most abundant forms of plants of a microscopic size found in water. These beings are endowed with movement, and were at one time regarded as animals. Their distinguishing peculiarity is that they possess a solid framework of flint, which is covered with a membrane of vegetable matter. The specimen (fig. 1) is an example of a

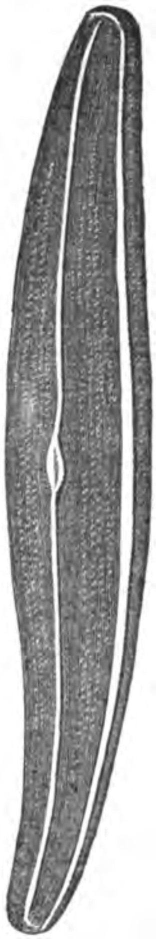


Fig. 1.—Navicula Hippocampus, magnified 470 diameters.

Fig. 2.

(*a*) Vorticella nebulifera,
(*b*, *i*) Species of Navicula,
(*c*, *d*) Fragilaria pectinalis,
(*e*) Cocconema cymbiforme,
(*g*) Navicula arcus,
(*h*) Frustule of Gomphonema,
(*k*) Infusoria,
magnified 100 diameters.

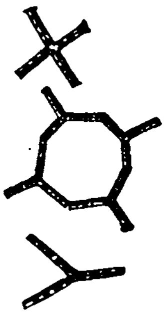


Fig. 3.—Bacillaria elongata, magnified 200 diameters.

Fig. 4.—Synedra Ulna, magnified 100 diameters.

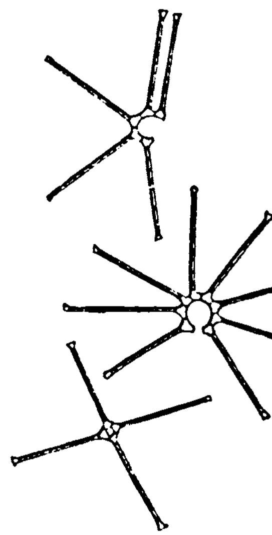


Fig. 5.—Asterionella formosa, magnified 100 diameters.

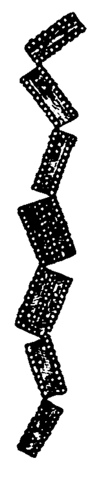


Fig. 6.—Bacillaria vulgaris, magnified 100 diameters.

very common form of these beings, in the Thames water. The flint they contain in their substance must have been derived from the waters in which they live, and they are always indicative of a water containing silex as an ingredient. I have found some form or another of these Diatomaceæ in all the waters which I have examined. They sometimes clothe other substances in clusters, as is the case with the Synedra Ulna (fig 4). As met with in the water, they are mixed with the other forms of animal and vegetable life as presented in fig. 2. The mode of development of these plants is not known, but it is probable that they are propagated by minute spores which evade the filtration to which waters are usually subjected (figs. 3, 4, 5, 6). It is not always easy to identify the spores or reproductive cells of individual species of plants, but in almost every instance I found amongst the decomposing *débris* of the waters examined, the spores of some of the lower forms of plants.

The microscopic forms of ANIMAL life found in the waters sent me for examination were very numerous, and belonged to several families. I have already spoken of the visible forms of Crustacea. Many of the smaller kinds, called Entomostraca, are only discernable by aid of the microscope, although some species can be easily detected with the naked eye when floating through the water. The most common form of these creatures is the Cyclops quadricornis (figs. 20, 21, and 22). The next most common form is the Chydorus sphericus (fig. 23). These creatures are to be found all the year round in waters about the metropolis, but they are more especially abundant in the summer months. They are carnivorous in their habits, and indicate not only that waters contain organic matters, but that plants have been formed and that these plants are inhabited by smaller animals on which they prey.

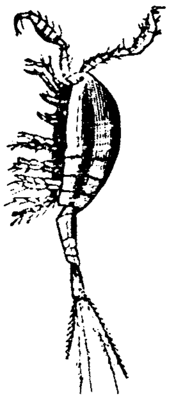


Fig. 21 —Cyclops quadricornis (male), magnified 50 diameters.

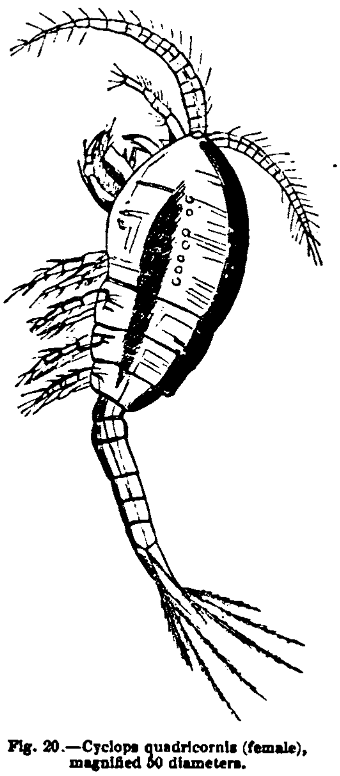


Fig. 20.—Cyclops quadricornis (female), magnified 50 diameters.

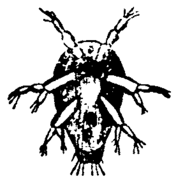


Fig. 22. Cyclops (young), magnified 50 diameters.

Fig. 23. –Chydorus sphericus, magnified 50 diameters.

But few of the true insects in their perfect state are found in the filtered waters supplied for use in London, although water-beetles and other forms abound in the open Thames. The eggs and larvæ of insects, however, are not uncommon. Many of the Neuropterous and Dipterous insects deposit their ova on plants in the water, and after they are hatched the larvæ live on the plants and on the organic deposits of the river. Some plants obtained in the month of May in the River Thames were literally covered with the larvæ of a small fly. Such larvæ are not always easily discoverable from some permanent forms of articulated animals belonging to the family of Annelides, a family to which the leech belongs. A creature evidently related to this family, and known by the erroneous name Vibrio fluviatilis, was found present in every specimen of water submitted to examination (fig. 19). These creatures are always found in greatest abundance where the deposit is thickest and blackest, and are most numerous where the waters contain the largest quantity of organic matters in a state of decay.

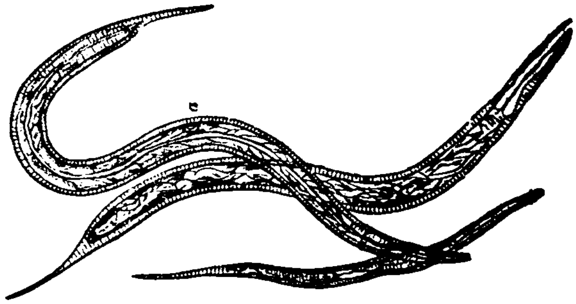


Fig. 19.—Vibrio fluviatalis, magnified 100 diameters.

The creatures mentioned last resemble some of the forms of Entozoa or worms found inhabiting man's body, and it is a grave question for consideration, from whence these creatures are introduced into the body. It is almost certain that they are

Fig. 24.—Chætonotus Larus, magnified 500 diameters.

Fig. 25.—Notommata aurita, magnified 260 diameters.

Fig. 26.—Euchlanis brevispina, magnified 200 diameters.

Fig. 27.—Brachionus urceolaris, magnified 160 diameters.

not generated *de novo* in the human body, and consequently that their eggs or some form of their existence are introduced from without. From what is already known of the history of these creatures in the lower animals, it is probable they are introduced into the system with the water which is drank. Thus it is known that the stickleback swallows the eggs of a species of entozoa called Bothriocephalus, but whilst inside the fish these eggs never develope into a perfect entozoon; but if the fish is eaten by a bird, the creature becomes perfectly developed. The Gordius or hair-worm deposits its eggs in water, but the eggs are not developed in this position; they are first swallowed by insects, and in this position the egg is hatched, produces the gordius which becomes impregnated, and escapes from the insect into waters where it deposits its eggs. The eggs of a species of tape-worm, when swallowed by a rat or mouse, will not produce perfect tape-worms in the inside of those creatures, but if they are eaten by the cat or dog, then the perfect tape-worm is produced. Many other instances might be quoted to show that it is not improbable that some of the forms of animal life which abound in waters containing organic matter, are transitionary states of those permanent forms of animals which infest the body, and sometimes even destroy human life.

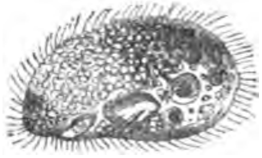


Fig. 11.—Kolpoda cucullus, magnified 300 diameters.

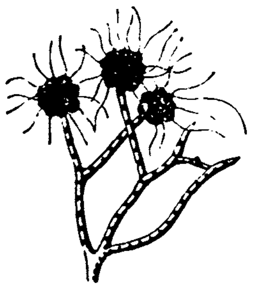


Fig. 13.—Anthophysa Mülleri, magnified 300 diameters.

Fig. 14.—Paramecium chrysalis, magnified 100 diameters.

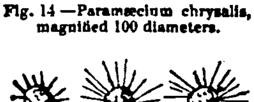


Fig. 17.—Actinophrys Sol, magnified 300 diameters.

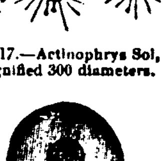


Fig. 18.—Arcella vulgaris, magnified 200 diameters.

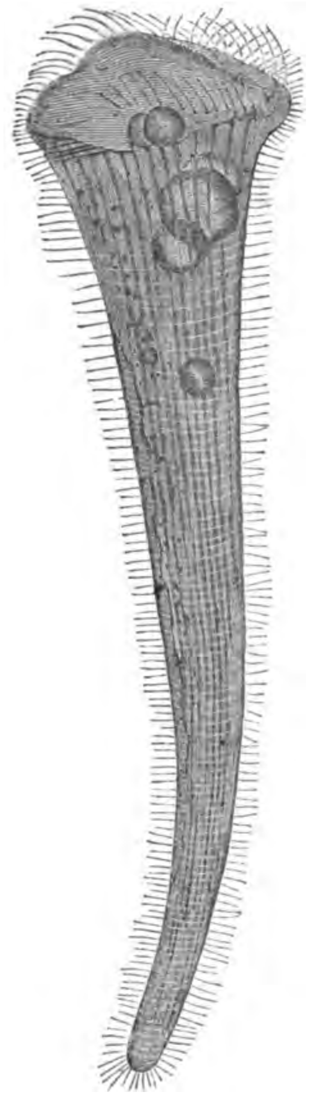


Fig. 8.—Stentor Mülleri, magnified 150 diameters.

Of the animals made conspicuous by the microscope, none have more varied habits, or present so high an organisation for their small size, as the Rotifers or wheel-animacules. These creatures, like the Entomostracous Crustacea, are mostly carnivorous, and indicate, where they are, that lower forms of animal life are present. In the waters examined, I have been enabled to identify twelve species of these creatures. The species represented by figs. 24, 25, 26, 27, may be regarded as types of the forms which these animals assume.

Amongst the first organic beings which are brought into existence by the presence of decomposing animal and vegetable matters are the Infusoria. These creatures, which a little time ago were unhesitatingly classed as animals, must now, many of them, be regarded as plants, as the function they perform in the waters in which they are found is to organise the carbonic acid, ammonia, and other gases which are given off during the decomposition of organic substances. To plants rather than to animals, we may refer such forms as those presented by figs. 11, 13, 14, 17, and 18. Although there is no doubt that these beings are wisely adapted to take up those matters which would be more injurious were they not present, it should be recollected that wherever they exist, they indicate the presence of substances which cannot but be injurious when taken into the human system.

Of the animal character of many of the creatures belonging to this family there can be no doubt. Such are the group of which fig. 8 is the type, and which, when in the water, can be seen to devour many of the smaller forms of animalcules. Such appear also to be the various forms of Vorticellinæ, fig. 2 *a*, fig. 12, and fig. 16. These creatures are found adhering to portions of decaying matter, and living on the more plant-like forms referred to above. Many of the Infusoria are adapted to living in circumstances which would destroy the life of higher animals. Thus with the plants of the sulphureous waters I invariably found associated forms of Infusoria adapted to live upon the plants growing under these circumstances. Such forms as those presented by figs. 9, 10, and 15, are found where decomposition of organic matter is going on most actively.

Fig. 15.—Plesconia vannus, magnified 320 diameters.

Fig. 12.—Vorticella, magnified 100 diameters.

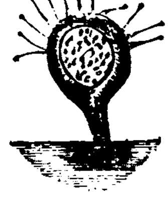


Fig. 16.—Acineta tuberosa, magnified 150 diameters.

Fig. 9.—Dileptus Folium, magnified 400 diameters.

Fig. 10.—Dileptus granulosus, magnified 400 diameters.

There is another group of animals which are perhaps lower in organisation than the Infusoria, and which contribute to the adulteration of the water of rivers: these are the sponges. The fresh-water Sponge (Spongilla fluviatilis) has the solid parts of its body made up of siliceous (flinty) spicula, and when the animal part dies the spicula remain, and are often presented under the microscope.

The waters examined were as follows:—

1. New River water, three quart bottles of which were sent me from 19, Buckingham-street on the 9th of May; they were dated May 6th, and signed James Fry. I also received from Dr. Clark a pint bottle of water, which he stated he had procured from the top of the water at the spring at Chadwell. In all these cases the water presented a considerable deposit of a light brown colour after standing a few hours. In two bottles out of the four, small entomostracous crustacea could be seen floating about with the naked eye. With the exception of the West Middlesex, the New River water presented the greatest number of forms of animal and vegetable life.

2. Water of Lambeth Company supplied from Thames Ditton. Six specimens of this water were sent me: three labelled May 6th, and sent to my house May 8th; two sent May 22nd, and one May 29th, all signed James Fry. These specimens differed little from each other, either in the general appearance of the water, the amount of deposit, or the number of species of plants and animals found in the deposit. The deposit was not so dark in colour nor in so large quantity as in either the New River, West Middlesex, or Surrey Sand waters, but it presented, within three species, as many forms of animal and vegetable life as any of them.

3. West Middlesex Company. Three specimens of this water were sent me, and dated May 8th, and signed James Fry. Single specimens of a small entomostracous crustacean were seen floating about the water. The deposit was of a light brown, and considerable in quantity. Of all the waters examined it presented the greatest variety as well as the greatest number of forms of plants and animals. When exposed for several days to the action of light, the vegetation of Confervæ and other plants at the bottom of the vessel was greater in this water than any of the others I received.

4. Water collected from the Surrey Sands near Farnham, proposed by the Hon. W. Napier, and adopted by the Board of Health. They were sent to my house on the 15th and 16th of May, and examined by me at various dates from the 17th of May to the 5th of June. They were marked as follows: B. S. 1, Bramshot; B. S. 2, Barford Mills; B. S. 3, Cosford House; B. S. 4, Sweet Water Pond; B. S. 5, Northfleet. They had all a light yellow colour, a rather plentiful dark brown deposit, and, on exposure to light, the bottom of the vessel presented a green appearance, from the growth of a species of Conferva. Although the deposit was much the same, the variety of species of animals and plants found in these waters varied considerably. Thus, B. S. 1, gave 24 species; B. S. 2, gave 21 species; B. S. 3, gave 11 species; B. S. 4, gave 10 species; B. S. 5, gave 10 species. These waters contained fewer Diatomaceæ and a larger number of infusory animalcules than any of the others with the exception of the West Middlesex.

5. Water from wells at Brussels. There were three green glass bottles-full sent: the first, labelled "No. I., from a deep well at Brussels 94 feet;" another, "No. II., from a well in the middle of Brussels, Place des Barricades, 54 feet deep, May 14, 1852." The label of the third was lost after it reached my house. All these waters presented a copious deposit, which consisted of crystals, part of which were dissolved up by hydrochloric acid, and part resisted this agent. The former were probably carbonate of lime. Amongst the deposit were portions of decomposing vegetable matter and a certain number of plants and animals. The water having been obtained from deep wells and kept in dark glass bottles was not in a favourable condition for the development of organic beings.

6. Grand Junction Company. The water was obtained from the pipe and cistern at 22, Old Burlington-street. The water was examined from the pipe from the cistern, and after it had been submitted to the action of the house filter. This water did not present so great a variety of forms as many of the others, but the forms that presented themselves were very numerous, especially the Diatomaceæ. Even after the most careful filtering by one of Lipscombe's filters, it presented the following objects: 1. Portions of woody fibre; 2. Navicula elongata (fig. 3); 3. Actinophrys Sol (fig. 17); 4. Numerous Monadinæ (fig. 2, *k*); 5. Kolpoda cucullus (fig. 11); 6. Species of Diatomaceæ (figs. 1—5); 7. Uvella virescens.

7. Watford Spring Water. Of this I have examined several specimens, softened and unsoftened, sent me by Dr. Clark from 19, Buckingham-street, brought by Mr. Dugald Campbell. In some of the first of these specimens, traces of organic matter were found, but after further examination it was discovered that this was probably owing to the difficulty of obtaining specimens from an open spring free from organic matter. In specimens collected with care, and especially when softened, it was found as free from organic matter as distilled water itself.

REVIEWS.

A Treatise on Rural Architecture. By W. J. Gray, Architect. Edinburgh: Lizars. 1852.

We have several times impressed on our readers the importance of this rising branch of practice, on which any information is valuable. In the work now before us Mr. Gray gives the results of his own experience in the construction of several farms, farm-houses, cottages, manses, and schools, the specifications and drawings of which constitute the chief material; and as these are very full, the plates of themselves numbering forty-eight, with full details, the character of the work may be well enough appreciated. It is, indeed, material of this kind which is now chiefly wanted.

Progress in Art and Architecture, with Precedents for Ornament. By John P. Seddon, Architect, M.R.I.B.A. London: Bogue. 1852.

We have already had the opportunity of laying before our readers Mr. Seddon's views on the promotion of architecture, having given full reports of the papers read by him before the Architectural Association, which form the basis of the present volume. This precludes us from noticing it at that length which the importance of the subject would otherwise demand; but we think it right to observe, that in the present work we have a complete exposition and carefully-digested treatise on the subject matter, with very copious illustrations, serving as a very useful compendium of the æsthetics of the Pointed styles. In these plates the varied characteristics of the continental styles will be most readily studied.

Statement of Baths and Washhouses. By P. Prichard Baly, C.E. London: Effingham Wilson. 1852.

Among the various good measures taken by the Committee for Promoting Baths and Washhouses for the Labouring Classes, has been that of directing Mr. Baly, their engineer, to publish a statement of their proceedings. To professional men this will be interesting, because it gives full information as to the working of such establishments; and the more so, because it gives such convincing facts as to their success as must lead to a great extension of the system in our provincial towns. Baths and washhouses, however complete in their individual examples and details, are as yet in their infancy, for they will hereafter be absolutely necessary, and inseparable from town organisation, as other public buildings are now recognised to be.

We should have liked to have gone more fully into the subject, as Mr. Baly's report enables us to do, but want of space unfortunately prevents. We cannot refrain from remarking, as a caution to our architectural friends, that much remains to be done in the way of economy, by adopting the cheapest materials and means, so as to reduce the cost of building. We should, above all, deprecate expenditure in ornament, though Mr. Baly shows a small establishment can be formed for 2250*l.* We shall very probably revert to his work next month.

A Concise Treatise on Eccentric Turning. By An Amateur. London: Pelham Richardson. 1852.

The object of this treatise is on the plan of Mr. Ibbetson's, to furnish a familiar guide to the use of the lathe. The writer takes as his standard one of Holtzapffel's lathes with eccentric and oval chucks, division-plate, slide-rest, and drilling-frame, and bases his instructions accordingly. It is a peculiarity of the book, and will be a recommendation to many parties, that the whole of the illustrations of the book and binding were turned on boxwood and metal by the author himself, who has further worked off the impressions with Mr. Cowper's parlour printing presses. We think this system of decoration might be practically applied for wood engravings and bookbinding more extensively than it is, and that the lathe might become an accessory of the wood-engraver as of the copper-plate engraver. The author of the book before us gives many useful instructions, by which patterns invented by Mr. Ibbetson for complex apparatus are adapted to the common lathe.

Plan for Protecting Railway Trains. By J. P. Wachter, C.E. Rotterdam. 1852.

The plans for the protection of railway trains are numerous; but when they are presented in a practical shape, as this is, and come from a practical man like Mr. Wachter, they merit attention, and therefore we commend his invention to the notice of the railway engineers.

Railway Machinery. By Daniel Kinnear Clark, Engineer. London: Blackie and Son. Part XIV.

We have every reason to confirm the anticipations which we have first held as to this work, and which have been supported in its progress. It is one of the cheapest and most useful works which has been offered to the practical man, and happily combines amplitude of design with copiousness of detail, the text, too, well supporting the engraved illustrations. The part on the Locomotive, now before us, gives full evidence of this.

Society of Arts.—The Society have published their usual list of subjects for which they offer premiums, and it shows a praiseworthy and enlightened zeal for the promotion of industrial interests. We therefore beg to call the attention of professional men and mechanics to the subject, as it is desirable that every means should be taken for promoting the objects of the Society. The list may be obtained at the rooms of the Society.

ON ECCLESIASTICAL DESIGN.

By Samuel Huggins.

[*Abstract of a Paper read at the Liverpool Architectural Society.*]

Mr. Huggins, in introducing the subject said, one of the results of the late extravagant influence allowed to precedent and of the undue attention paid to style, has been forgetfulness of those eternal principles, by the application of which we can alone arrive at real beauty in architecture. Antiquarian research into the art of the past, discrimination of distinctions in style, anxiety after chronological truth in the recombination of ancient elements had left little time or inclination for study of the principles of architecture itself, for gaining a knowledge of those laws that are binding upon all styles and that cannot be suspended in favour of any; and, consequently, ignorance of the conditions of beauty had produced a multitude of buildings, which, however correct in style, do not give full satisfaction to the mind. Before proceeding further he expressed a hope that, in pointing to what he deemed the errors of styles and schools, it would not be supposed that he had any especial allusion to works in Liverpool or its vicinity. He thought that many churches and other structures lately erected in that neighbourhood declare the relative rank of Liverpool in architectural talent to be high. On several works of late emanation from the profession in Liverpool, of both styles, he himself had looked with admiration; though he might have regretted at the time that to a greater or less extent, talent had been misapplied, or purpose misunderstood. He entered at length into the subject of proportion, particularly in reference to spires and towers, and illustrated his remarks by reference to various cathedrals and churches, and concluded by correcting what he deemed an error of Ruskin on the subject, who speaks of the pinnacles being the third term to the spire and tower; he said that the writer had mistaken the meaning of the term proportion, as used by architectural writers, and understood by the profession generally. He treated on the proper connection of spire and tower, and alluded to a remark of Mr. Britton, who had found fault with Salisbury spire. He said the chief scope for feeling in such structures consists in adjusting the tower to the harmonious reception of the spire, proportioning the latter to it, and gracefully joining them together. Church towers, with a pinnacle at each of the four angles, and none in the middle, had been objected to; but perspective, which aids the picturesque, in some measure corrects the fault of equality, as it causes one of the pinnacles, in most views of the tower, to be visually supreme. The height of towers generally throws one angle up so high as to produce sufficient of the pyramidial form to the eye of the spectator. A tower at each of four angles, or four equal towers to a building, is quite justifiable, he considered, when there is a centre feature to unite them, though it might be less in height, provided it be superior in some other respects; as of greater beauty of form—a dome, for instance, as the mosque of Achmet, with its guard of minarets—or even a tower, if greater in diameter, or more light and elegant in shape: it unites them together, as they all refer to it, and seem to exist for its protection. On the subject of outline he dissented from a late writer (the late A. Bartholomew), and entered into a full exposition of his own views thereon, which he concluded by observing that there are principles besides beauty of outline; there was power of effect—expressional requirements, which had been more neglected in the Classic than in the Gothic. He spoke approvingly of All Saints' Church, Oxford, which in most respects, he said, was the best he had seen of its class. The great charm of Aldrich's steeple, he remarked, lies in its simplicity and its power. Complexity and tameness were the characteristics of most others he had seen. Piling order upon order in mid-air, a practice which too many examples exhibited, was a jesting with Classic architecture. and produced at best but so many rivals of the Chinese pagoda. Neither in St. George's Church nor in St. Michael's Church, of this town, had the architects caught the secret of general effect in the composition, which is contrast between the form of the orders or stories. St. George's presents the transition from an octagon to a circle, with no increase of columnar richness, and consequently looks tame; and St. Michael's Church, though far more effective, rises but from a square to a slightly expressed cross; while All Saints' Church breaks at once from a plain square tower to a rich, thickset, circular peristyle, the square basement giving increased effect to the latter, which strikes at once with its classic and artistic beauty. We must fail in these, as in all else, unless we look for inspirations of beauty on the fair face of nature; and for power of effect, on her grander imagery. The poet holds the mirror up to nature and life; and so, according to his power, does the architect, whose art not only yields majestic and beautiful images of nature, refined by human fancy and feeling, but has sympathy by its mysterious forms, and combinations with the triumphs and woes, the hopes and aspirations of humanity. He treated on a variety of topics connected with his subject, and combatted many of the prejudices and errors of the day. He said that to divest the architectural mind of all prejudice and chance associations—of all restrictions imposed by precedent, fashion, bigotry, narrow or false criticism—and bring it to yield obedience to natural laws only, is to be the great task of the day. Freedom is in all things an essential condition of growth and power. Political freedom is not more essential to intellectual, moral, and religious prosperity and progress, than is freedom of mind from all the shackles of precedent, and the bonds of ancient rule, to advancement and success in architecture, which cannot extensively flourish, and reach the excellence of former times, until these are brought into perfect abeyance. He concluded by remarking that the true artist will not restrict himself to one style or language of art, but will extract from all styles for the storing of his mental hive; but he combines them according to new affinities; and from the elements which other minds in other lands have invented, he will rear structures of glory and beauty for every required use—new in the right sense of the word; new, and yet old—new by their originality of conception; old as the universe, by their sympathy with humanity.

Mortise Bricks.—Mr. J. Z. A. Wagner has exhibited to the Franklin Institute a new form of brick of his invention, having a mortise in its centre. The advantages claimed for this brick are, economy of fuel in its manufacture, less liability to absorb moisture, the ease with which it may be divided, and greater strength of wall constructed of bricks of this form.

Specification of Works.—It has been decided in the Court of Exchequer, by the full court, in the case of Instan *v.* Yates, that a specification of works signed by the parties to an agreement for their execution, and referred to in such agreement, but not annexed to or indorsed upon it, should be stamped separately from the agreement. It is too late to make the objection, in moving to set aside the verdict and enter a nonsuit.

ON FITNESS, AS A PRINCIPLE OF DESIGN IN ARCHITECTURE.*

By Joseph Boult.

By fitness in architecture, I wish to be understood as speaking of the adaptation of the internal arrangements of any building to the purposes to which it is applied; of consistency between the external appearance and the internal arrangements; of propriety in the design of the ornamental detail; and of appropriateness in the materials made use of; the whole governed by a regard to the funds at command; so that no incongruity may be apparent in the erection through one part being bedizened with ornament, whilst another is left naked and poverty-stricken.

That every building should be adapted in all respects to the purposes for which it is built, appears at first sight a self-evident proposition, a truism. But a very cursory inspection of almost every public, and of many private edifices, will satisfy any one that it is almost the last idea in the mind of the architect. Nay, as regards public buildings at least, the opposite opinion is not unfrequently inculcated by those who consider it derogatory to an art—that is, a fine art—to submit itself to conditions of every-day convenience; by men who form to themselves an ideal of what architecture should be; which might be realised if the edifices were to form part of a museum of architecture, and were only specimens to look at, not buildings for use and occupation, and erected for a purpose involving considerations common-place perhaps, but also practical, and giving to them, in the estimation of the public, an appreciable value. We should think our host a very unreasonable man indeed if, having loaded his tables with specimens of his confectionary art in filagree work and sugar-candy, and omitted the edibles, he should expect our bodily appetites to be satisfied by the vision of that which is pretty to look at but cannot be devoured. Yet, in architecture, the gratification of the eye only is thought to be the end and aim of the art; and one of our principal architects controverts the opposite opinion as heresy, in the following words:—"It will be proper to make a few remarks on the distinction between mere house building and that high character of composition in the Grecian and Roman orders which is properly styled architecture; for, though we have many nobly architectural houses, we are much in danger of having our public edifices debased by a consideration of what is convenient as a house, rather than what is correct as an architectural design." It must certainly be admitted that the architects of the Exchange Buildings and the Custom-house are not obnoxious to the accusation of having vulgarised their works by any such common-place notions; tested by Mr. Rickman's principle, as far as the absence of convenience is a guide, they should rank as specimens of very high art indeed. But they are not so esteemed by the public, who seem to judge in the spirit of the proverb which speaks of the "proof of the pudding;" and are unable to estimate that art whose quality is so fine as to be inappreciable to their common-sense ideas of utility and convenience.

The advocates of any opinion, and the professors of any art, who do not receive that attention from the public they think their due, may feel satisfied there is some inherent defect either in that they advocate or in their own manner of teaching it; and it would be no unprofitable occupation for an evening if we could help each other to popularise our profession, which ought to rank highly, combining as it does, in its perfect practice, scientific knowledge of no mean character, with a genial appreciation of all artistical beauties.

In the works of that Great Architect, who has strewn the universe with his glorious and his beautiful creations, as far as our finite powers are able to gauge infinite wisdom, we find indubitable evidences of an intention to make all beauty subserve purposes of the highest but most practical utility. Ask the professors of different sciences, whose pursuits are the investigation of various departments of nature, and the astronomer will tell you of the dependence of all the heavenly bodies upon each other by influences so proportioned that any derangement would be felt throughout the universe; of gravity, which rules the planets in their course and bows the snowdrop's pensive head; of the laws of light; of the succession of the seasons; and of the recurrence of the tides: the natural philosopher will appeal to various phenomena, and will prove that the storm and the earthquake are not only grand but beneficial in their influences, and promotive of new phases of beauty; that the thunder is not only awful and the lightning glorious, but that electricity is an active agent in promoting the ends of never-wearying benevolence; that chemistry is ever engaged in decomposing existing bodies when their sphere of usefulness is closed, in order to restore their elements to usefulness of another kind, graced by beauty most transcendent: the geologist will tell us of animals who lived in former ages, the mastodon and the mighty megatherium, the plesiosauros and the icthyosauros, the ammonite and trilobite, having a resemblance to existing species, modified by a regard to an antediluvian world: whilst the natural historian will refer to the works of the inferior animals, and will show how, in the seal's dam and the bee's honeycomb, the principle of fitness reigns paramount: and the traveller will speak of the Esquimaux's hut and the Arab's tent, which are constructed according to its dictates.

Turn where we will, it is only in the architectural constructions of civilised man that we find the most extraordinary discrepancies between the arrangements of a structure and its purposes. Are, then, inconvenience and unfitness evidences of civilisation? or are they rather to be regarded as proofs of the forgetfulness of that instinctive principle upon which all excellence must be based? Stated thus nakedly, the question can receive but one answer; yet how otherwise are we to account for the superiority of the seal and the humble bee?

Much of the unfitness observable is due to the sickening cant with which the study of architecture is overlaid. Each amateur, according to prejudices accidentally imbibed, assumes that his favourite style embodies all excellence, and that the others are barbarous substitutes; and the generality of the profession are either equally prejudiced or are governed by the prejudices of their patrons, and can admire no excellence which is not recorded by Vitruvius or Stuart and Revett, practised by Palladio, or inculcated by the ecclesiologists, just as the whim may take them.

So long as architects will not work out for themselves a standard of excellence—so long as they take their ideal from the whims of their patrons, and it is not the result of study and investigation—architecture will continue as subject to the fluctuations of fashion as do upholstery and paperhanging; and the country will, from time to time, be overrun by a mania for the Classical, the Italian, or the Gothic styles as "time and chance determine."

Let it not be supposed that I wish to underrate the importance of studying the predilections of the age, and of enlisting the more worthy associations of ideas in favour of the work in hand; but this must be done by refining the common-place, by elevating the ruling spirit to a higher standard; it must *not* be done at the expense of the purpose for which the building is erected, or we shall be only copyists and modellers—not architects and professors of a creative art.

If we glance at the course pursued by our architectural predecessors, we shall find that they can be imitated with better effect by studying the spirit rather than the letter of their practice.

We find in the earlier ages, except where the art is in a manifestly transition state between two styles, that it is uniformly governed in its main characteristics by the climate, the materials, and the habits of the people, modified by the associations derived from a preceding age or from other countries. The elements of the colossal architecture of Egypt attain their most perfect development at Thebes and Karnak, and were gradually refined to the slender proportions of Athens and of Rome. Of the private edifices of the Egyptians and the Greeks we have no remains; but their temples and their tombs are embodiments of their religious superstitions, were conducive to the purposes of their erection, and are evidence of their architects' adhesion to the principle of fitness; whilst at Pompeii the architect of later Rome acknowledges the force of the same principle, by studying the convenient arrangement of the different buildings there preserved, and by their appropriate decoration.

The irruption of Northmen completed the destruction of the enervated remains of classical architecture as then practised, and prepared for the evolution of a new style, as different as possible in its principle of beauty and effect; but the mediæval architects—those noble Freemasons who cherished the lamp of science and the elements of civilisation in an age whose internal history is but imperfectly recorded—have left no proof that they wished to traverse this first principle of success in the art. But

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in their cathedrals, their convents, their castles, and in all their works, having left enduring evidence that according to their knowledge the material was that most suited for the purpose to which it was applied; whilst the external forms of the edifice, its outline or plan, and its elevation, were due to the climate and to the convenient occupation of the building.

> "——— the high embowed roof,
> With antic pillar, massy proof,
> And storied windows richly dight,
> Casting a dim, religious light,"

were all subservient to the great purpose of the building—not stuck on and about at random, without judgment and without taste. Their columns and arches, their buttresses, pinnacles, and mouldings, were features essential to constructive excellence—the common-places of building refined, by the taste and imagination of the Freemason, into evidence of his just appreciation of the purpose of the art, which he studied with scientific earnestness, elevated by his artistic feeling, and consecrated by his religious devotion.

Since the dissolution of their mighty union their art has wofully declined, in consequence of the association of ideas produced by the revival of ancient learning, of the increased influence of the Italian republics upon the art, and of the promiscuous application of religious edifices at the Reformation. Here we reach a new era in architectural history; and a glance at this and subsequent periods will afford a clue to our deficiencies.

The confiscation of church property and its bestowal upon laymen, would open a wide door for the admission of numerous incongruities, since many buildings erected for religious societies had to be adapted to the use of private families, and the ecclesiastical edifices of one church applied to the use of another. Hence a necessary violation of the principle of the fitness of the original design; and so also of the conversions of castles and fortified mansions to the purposes of a peaceful age; and as there are in all time men who more admire the errors of those above them than the unpretending excellencies of their own sphere, the blemishes thus produced would find frequent copyists in new buildings of humbler rank or for parvenus; and would be heightened by association with buttresses that strengthened nothing; turrets with blank loopholes containing the chimney-flue; battlements never manned; drawbridges never raised, across moats innocent of water; portcullises which were never lowered; and "arms hung up for monuments" which had not been "bruised" in the stricken field; and occasionally, to give additional piquancy to this mimicry of the baronial hall, a belted knight cased in mail, with lance and shield, kept watch upon a carpeted staircase, doing no deeds of bravery and chivalry, but a mere man of straw after all.

The wealth and magnificent longings of the Italian republics stimulated their architects to strike out forms of grandeur and of beauty, which harmoniously combine many of the features of both ancient and mediæval art, with a natural preference for the former, surrounded as they were with its fine remains, and residing as they did in a climate unfavourable to the highest developments of Gothic architecture.

The wealth, the learning, the refinement, and the commerce of the republics would naturally confer great influence upon their habits and taste, and assist in their diffusion throughout the civilised world. In this country foreign travel and the employment of foreign architects would produce further violations of the principle of fitness, by importations from countries of very different climate, habits, and associations. Classical architecture has found this soil as ungenial to its highest developments as was Italy to the Gothic, the experience of both affording strong arguments in favour of that principle which I believe to be the basis of all excellence in the art.

The revival of literature produced a morbid craving for examples of the temples described in the ancient authors; and as the writings and sculpture of the ancients were manifestly superior to those which were indigenous, it was hastily concluded that so must be their architecture; and therefore were the temples of an extinct or degraded people to be revived and adapted to modern use. In the absence of correct knowledge of the sublime works of Athens, many barbarisms passed muster as classical beauties, and were worshipped as fac-similes of the glorious achievements of the age of Pericles, until Stuart and Revett's delineations directed attention to the true characteristics of Grecian architecture. Experience seems to prove that in its purity this style is quite unsuitable for any country but those which are blessed with a climate similar to that of Greece. Our light is so cold, and the colour of our material, after exposure to a smoky atmosphere, so sombre, that the peculiar beauties of this style are quite lost, and the effect is chilling and repulsive. With the freshness of youth upon them, and with the modifications introduced by the architects, the Assize Courts and the Branch Bank may appear to controvert this opinion; but I am afraid that a very few years will establish its truth as regards them, since it is supported by past experience. The liberties which each architect has ventured to take appear to be conceived, for the most part, in a correct and artistic spirit, particularly at the Assize Courts, and may for a time delay the result, I fear.

Classical architecture, at any rate for the present, has succumbed to the Italian and Gothic styles, but it has left its mark in the numerous unsuitable edifices throughout the country, in which the colonnades of southern Europe give shade and damp to buildings it is sought to enlighten and warm with English windows and fireplaces, which are, for the most part, introduced in downright violation of all propriety, or are masked with all the ingenuity the architect is master of; whilst upon and around this specimen of pure art are placed statues clothed *à la Grec* (that is, one remove from a state of nature), as though they would persuade the shivering denizens of this cold, damp clime that it is the sunny south.

The portico, as now introduced, is generally a mere ornamental excrescence stuck on to the building, not embodied as an essential feature of the accommodation required, as though architects took the idea from meeting a bull with a stag's head, or some similar *lusus naturæ*, which to his perverted imagination appeared worthy of reduplication. Of this we have illustrations in the National Gallery and University College, London, and the southern entrance to the Assize Courts in this town, where the portico is placed at the top of so many steps that any one wishing to shelter under it may be wet through before he reaches it. The Wellington Rooms offer striking evidence of the random manner in which such applications are made. The elegant portico, as originally designed by Mr. Aikin, did not yield the requisite shelter, so the spaces between the columns were built up; and on ball nights a temporary shed is placed across the footpath, to the annoyance of the public, in order that the company may avoid exposure on leaving their carriages. The committee, by whom the portico was closed up, have been, as I think, very unjustly censured for preferring a practical convenience to a merely visionary beauty: the party really open to blame is the architect, for had the original portico been a carriage-porch, it might have retained its pristine beauty, and proved its adaptation to the purposes of the building. The eminent architect of the Assize Courts appears to have completely overlooked any provision for the exigencies of the climate and the use of the building. It is not now too late to repair this deficiency, but if it be amended it should be in a spirit consonant with the talent and taste of the original design. The Temple of Minerva Polias will give a hint as to one way in which this may be done.

[Since this was written, I have perused pretty nearly the whole of Mr. Fergusson's work upon the 'Principles of Beauty in Art,' and in the midst of much that appears on a first reading fanciful but worthy of study, I have been rejoiced to find much sound common-sense and practical appreciation of art, with which I have cordially sympathised.

In concluding some observations upon the studied irregularity which the Greeks observed in the grouping of their edifices, he observes, "Had we any remains of their domestic or civil buildings, it would not now be required to notice or insist upon what is so self-evident; for to suppose that a people so eminently artistic as the Greeks could for one instant tolerate a falsehood in art is to show but little knowledge of either what art is, or how the Greeks practised it. They could not be ignorant that one of the first, and indeed the fundamental canon of true art in architecture, is, that the exterior of a building shall in every part and every detail express the interior as correctly as it is possible it can be done; and that all attempts to make two or more small things look like one large one, or any building look like what it is not, or as if belonging to another age from that in which it is erected, are vicious and false, and can only result in a direct falsehood covering an ill-concealed deceit."

And again, after some remarks upon the Greek drama, he says, "It is a form, it is true, that has passed away and cannot return. But the forms of beauty are numerous as the stars of heaven; and when one sets in the west it is only that others may rise from the east not less bright than those which have disappeared; and the smallest star is a more beautiful and more sublime object to him who understands its meaning and its beauty, than is the sun itself to him who turns only an ignorant and listless gaze upon its splendid orb."]

The usual division of a church into the nave and side aisles appears to have had its origin, not in symbolism, but in fitness. In vaulted churches the span from wall to wall would be excessive, and large buttresses would be required to resist the thrust of the vaulting; and a similar difficulty would be experienced with the timber roof at a time when constructive carpentry was in a very low state. But the division of the span into three intervals removed these difficulties, and the introduction of the clerestory windows assisted the illumination of the building. The accession of dignity which was thus gained was an accidental accompaniment of this constructive excellence, not the essential feature of the design, to which economy, stability, and convenience—in a word, fitness—was to be sacrificed. If, however, we examine most of the churches built since the accession of the Tudors, we find this principle of fitness, and of the subserviency of appearances to conveniency of plan or constructive excellence, egregiously violated. St. Paul's Cathedral is a remarkable example, for here, as has been well observed, "one half of the church is built to conceal the other." Here the architect has been so faitbless to his great scientific talents, and so unaware of the source of true architectural effect, as to conceal all his constructive resources and to mask his transcendant abilities, as though he was ashamed of his glorious handiwork!

The division of the church into a nave and side aisles involves the introduction of intermediate supports—a necessary evil in those days, and but little felt in a service whose influence was so dependent upon ceremonial observances, the effect of which would be rather heightened than impaired by such an arrangement. But in Protestant churches, particularly amongst the Dissenters, the interest of the congregation is concentrated upon the pulpit and the reading desk. It is desirable, therefore, that the audience should have an unimpeded view of the officiating clergyman; and intermediate supports should be avoided, as they either conceal the pulpit from a portion of the audience, or else, if placed in the aisles, impede the passage or necessitate the loss of space. The plan adopted by Mr. Holme in St. Paul's, Prince's-park, is one way of obviating this objection: other designs for roofs present themselves to the investigator.

The introduction of the essential features of one class of religious edifices into churches whose ceremonial is independent of such accessories, is in bad taste, as suggesting discordance and controversy where harmony and unison are most desirable. In like manner, the formation of niches without statues, and where there is no probability of statues being provided at any time, is objectionable, as suggesting a feeling of incompleteness where, in fact, all is done that is intended. And thus that which is an agreeable feature when justified by its application to legitimate purposes—*i. e.* when *fitly* introduced—becomes by its misapplication evidence of the architect's want of resource and taste.

The introduction of blank windows, blank doors, blank chimneys, or shams of any kind, may be taken as *primâ facie* evidence of a want of skill in the architect. He must be very deficient in taste who has resource to make-believes, when, by the exercise of a little talent, he can avoid such deception. I would add that I consider the introduction of shams as evidence that the architect had reversed the right order of proceeding, and designed his elevation before considering his plan; unless, indeed, they be adopted on the same principle as that which induced the ladies of the last century to wear patches of conspicuous size and ugliness, in order to distract attention from comparatively minor blemishes.

The modern use of the plinth is a striking illustration of that forgetfulness of the principle of fitness which is now so common. Originally the plinth was used as a protection to the set-off occasioned by the projection of the lower part of the wall as compared with the upper; the face of the plinth was flush with that of the wall below, and the upper edge was weathered to throw off the rain. Now the external face of the wall is one plane throughout, and the plinth-course becomes an unmeaning string of great depth and without weathering.

The form of the roof has an important influence in determining the character of the exterior; and as we enjoy more choice of material than did our forefathers, so will our architecture be less peculiar; we are at liberty to introduce roofs of a much flatter pitch than they could venture to do. It must be determined by reference to convenience, expense, and appearance; but the character of the ornamental details should be modified by a regard to the climate and material. The large and greatly projecting cornice of the Italian school is scarcely suitable to this locality, as the weathering on its surface is so flat as to yield very little protection to the stone; whilst the water discharged over the face of the cornice disfigures the mouldings, and is an annoyance to passers-by, or to people waiting at the house door. The cornice of the Gothic style, on the other hand, is a better protection to the stone, and the gutter being worked in it, the quantity of water discharged over the front is much reduced. A comparison being established between the cills, strings, and other horizontal members of the two styles, will be found to establish a similar preference for the Gothic mouldings generally. At the same time there is so much that is agreeable in the Italian style, that I believe we should all regret its banishment; but if we continue its use, it must be acclimated by the introduction of such modifications as will remove these objections.

A regard to expense has its sway in fixing the character of a building, and, in connection with its size and design, legitimately determines the standing it occupies as an architectural work. Frequent mistakes are made, when the funds are but small, by undue outlay being lavished upon one portion of the building, to the injury of the remainder, inside and out, when a more equal distribution would produce a whole more perfect and gratifying. In works of art it seems indisputable that a whole of good and appropriate design is to be preferred to one of unequal character.

For illustration, compare the exteriors of the Royal Institution in Colquitt-street with that of the Royal Insurance Offices in North John-street. On the one hand, we have an edifice with the proprietors of which money was manifestly an object; the architect had no opportunity of showing his taste by the introduction of any ornament beyond a portico little better than a door-case, and cornices of an unpretending character on the main walls; but the arrangement of the parts, the grouping, is so effective, that I think it is almost impossible for any one to pass the building without pausing to look at it and carrying away a pleasant impression. In the Insurance Offices, on the other hand, the observer would naturally suppose that he was looking at a club-house, to the owners of which expense was no object; ornament is profusely lavished, stuck on and about in almost every situation it is possible to put any; and yet, with all this extravagance, the whole produced is unsatisfactory. Frittered into innumerable parts, unnecessary and senseless, it is a heavy conglomeration of many features, each struggling for notice, and depriving the design of all unity and repose. If we pass into the interior, we make the painful discovery that the lavish expenditure is all *outside*, like the apparelling of a dandy spendthrift; and were it not the property of a known wealthy proprietary, we might suppose the exterior to be some bankrupt's "folly," purchased and completed by careful, prudent men, who wished to make the most of their bargain. In the Commercial Bank, to take another illustration, we have an exterior that might have been prepared by a student member (and even then it would be thought a *young* design), with an interior handsome and costly, agreeably indicative to the customers of a wealthy company.

It is an essential element in good constructive architecture that piers should be built upon piers, and not over voids, yet there is scarcely any principle which is more frequently evaded. Look around and see the innumerable examples, where piers and openings are jumbled together in such admirable confusion that at first a careful examination is needful to ascertain whether first principles are not sometimes wrong, and if a pier is not actually supported by a void; but fractured lintels and cills, crooked reveals, shattered bricks or stone, and long straggling cracks, the accompaniments of settling, show too plainly that nature's laws will not sanction such gross deviations from the dictates of judgment and experience. Yet, day after day, is the same fault committed, as though the lesson was never to be acted upon. Shop-windows are the most glaring manifestations of this perversity, which leads men to build heavy piers on unseasoned timber bressumers, as if all the flaws produced by settlements were so many beauties, the presence of which was to be insured by every artifice the architect's talent can devise. It is certainly not impossible to make handsome shop-windows in accordance with the principles of sound architecture,—as at the Apothecaries' Hall, or Mr. Rainford's new shop in Renshaw-street,—and if they should be a little smaller, less capital will be required for their daily dressing or baiting to catch customers.

The proper application of materials is a subject which would of itself fill a paper of considerable length; I shall not enter upon it this evening further than to protest against the use, or rather the ABUSE, of cement. The practice of smearing over the exterior of a building with this composition is costly, is subversive of good workmanship, and is at variance with the dictates of common sense, because it seeks to protect the more durable material by the assistance of the more perishable.

It is well known that bricklayers do not take the same pains with their work when it is to be concealed by cement as when it is to be open to the light of day; and I am sure that Liverpool bricklayers require every incentive to improvement and excellence, and no excuse nor opportunity for making bad work. The use of cement in exteriors I conceive to be allowable only where necessary to repel damp, and where an old building is to be furbished up as good as new, or for some other temporary purpose. The habitual use of it by architects of standing must, I fancy, arise from an impatience, perhaps not wholly unnatural, to see how their works will look in old age; but they should remember that premature old age wants a charm belonging to the influence of time; and that though the senility which proceeds from natural decay is touchingly beautiful, that which is the consequence of the misapplication of talents is mean and contemptible. The ruins which are hallowed by the course of many years, and around which are entwined the recollected associations of other days, are indeed beautiful; but the mushroom inanities of rubbish and cement, which decay almost before they are finished, are paltry in the extreme; and he who trusts his reputation to such keeping must bear the odium usually attached to bad company. False and meretricious as are such paste-like imitations, the application of them, which is now so common, cannot be too deeply deplored—too severely censured.

But one shade better, or rather, I should say, but one degree less blameable, are the imitations of various materials, in which our painters and decorators are striving to excel—lavishing in the pursuit of an excellence which becomes less valuable the more nearly it is attained, that time which would be more judiciously employed in studying correct principles of colouring, drawing, and design. Surrounded, as we are, from our youth up, by sham oak, sham stone, sham marble, by scrolls and pateræ in sham relief, and by all those other shams in which the architects of our days exhibit sham taste and seek sham fame, what wonder is it if society should take its colouring from the falsities which surround us, and that we should be disgraced by sham sentiment, sham credit, and sham principles; that we find the fruit that was fabled in a former age frequently plucked in this—fair and beautiful to the eye, but within filled with ashes and bitterness, falsehood and disappointment?

And here I will conclude, though much may be said on the application of the general principle of fitness to the arrangement of buildings—their elevation, the details of their ornament, and the material; but to do justice to all these would occupy too much of your time. If, however, the principle I have laid down be adopted, its application may be readily deduced. Let it not be supposed that I consider "fitness" synonymous with beauty—far from it; it is but the framework upon which beauty is to be wrought. If the frame be shapeless, can we but regret the art which is wasted on its decoration? I do, however, believe that truth is an essential element in all-enduring beauty; and to secure truth in architecture we must first have "fitness." This principle ought to pervade every structure, however mean or noble; and where it exists it gives individuality and character. It is this which legitimately distinguishes ecclesiastical from domestic edifices, the haunts of commerce from the seats of science, the cottages of humble poverty from the abodes of wealth and luxury; and were it always allowed the influence it ought to exercise, we should have no more examples of Grecian temples applied to modern uses; of conventual buildings adapted to domestic purposes; or of barn-like erections consecrated to the Most High; but all our practice would be governed by a due consideration of the uses for which our work is intended.

FORM AND SIZE OF SEWERS AND DRAINS.*

Increased Power of the Sweep of Water gained by Alterations in the Forms of Sewers.

IT appeared on examination that accumulations were greatly influenced by the shape of sewers, where the conditions as to run of sewer water or fall were the same. The trial works prepared in respect to sewers are here adverted to as illustrative, on a large scale, of the principles of construction previously noticed. Mr. Roe, surveyor of the Holborn and Finsbury division, who made one of the earliest advances in the improvement of the construction of sewers, had shown that, by an alteration of the form of sewer from a flat segment to an egg-shape—with the same quantity of water, at the same inclination—the deposit was reduced one-half. As a point of pecuniary economy accompanying improvement in construction, it was shown that the number of bricks required to construct a sewer, with upright sides, 75 inches long, would suffice for the construction of an egg-shaped sewer, with the same sectional capacity, 122 inches long.

Other examples might be adduced of improved results obtained by variations in form, without any change of the internal capacity of sewers.† The egg-shape possesses an advantage over the circular sewer in the increased scouring action derived from the greater rapidity of flow when the stream is small, and occupies only a small proportion of the area; and this is the general condition where sewers are made large enough for men to traverse them, without reference to the quantities of sewage which they have to convey; but it should be observed, that wherever good inclinations are obtainable, and the ordinary flow would be sufficient to keep the circular form of sewer clear of deposit, that form is to be preferred. It is stronger and more economical, it presents less frictional surface, and is more capacious, with the same amount of material. The special advantage of the egg-shape diminishes moreover with the size of the sewer, so that in the smaller areas it becomes scarcely appreciable. For pipe-sewers and drains the circular form is on the whole to be preferred, because the greater risk of unevenness of form, and the difficulty of obtaining the same accuracy of joint with the egg-shape, more than counterbalance the advantage of the small increase of flow which would be acquired. For intermittent purposes, where the house-sewage occupies only a small portion of the area, but the sewer is liable to be filled with storm-water, the egg-shape is undoubtedly the best. In proportion as the flow can be equalised and adjusted, and the principles of drainage reduced by practical science to an approximation of constants, to the same extent the egg-shape must yield to the circular, as the best form of sewer, without reference to size.

Increased Power gained by Alteration of Size, as well as Alteration in Form of Sewers.

The following is an account of several trial works, and illustrates the effects of altering the size as well as shape of the channel of conveyance, with a better adaptation to the run of sewer water, and the service to be performed. It is contained in a Report of Mr. Hale, the surveyor, who was directed to make the trial.

"The main line of sewer in Upper George-street is 5 ft. 6 in. high and 3 ft. 6 in. wide, and runs from the Edgeware-road to Manchester-street, where it falls into the King's Scholars' Pond sewer. I have laid a 12-inch pipe 560 feet long upon the invert of this main line, and have built a head wall at the end of it, so that the whole of the sewage discharged by the collateral sewers above the pipe, as well as what sewage may find its way independently into the upper part of George-street, is forced to pass through the pipe. The whole area drained by the sewers running into the 12-inch pipe in George-street is 213,778 square yards, or about 4½ acres. Observations are being continually made on the work, and the

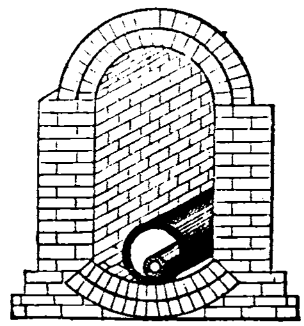
* GENERAL BOARD OF HEALTH.—'Minutes of Information collected with reference to Works for the Removal of Soil Water or Drainage of Dwelling-Houses and Public Edifices, and for the Sewerage and Cleansing of the Sites of Towns.' Ordered to be printed for the use of Local Boards and their Officers engaged in the Administration of the Public Health Act. Presented to both Houses of Parliament by command of Her Majesty. London: Eyre and Spottiswoode. 1852.

† Narrow and deep channels frequently cut by streams in the surface of the soft deposit accumulated in flat-bottomed sewers, were demonstrative of the very little observation on which eminent engineers have declared that the form of the bottom of a sewer is of no consequence. It was declared at the outset of the investigation that a sewer with upright sides and wide-spreading footings was the best and most certain form of construction. The examinations directed in the subterranean survey have proved the erroneous doctrine in extensive failures of that form of sewer when carried through slippery ground. In some instances whole lines have been found driven in at the sides.

results are as follows:—The velocity of the stream in the pipe has been observed to be four-and-a-half times greater than the velocity of the same amount of water on the bed of the old sewer.* The pipe has not been found to contain any deposit, but during heavy rains stones have been distinctly heard rattling through it. When the pipe is nearly filled, the velocity and concentration of the water are sufficient to clear away any matter which may have been drawn into the pipe from the large sewers, and much of which matter it may be presumed would never enter a well-regulated system of pipe sewers; also the force of the water issuing from the end of the pipe is sufficiently great to keep the bottom of the old sewer perfectly clean for 12 feet in length; beyond this distance a few bricks and stones are deposited, which increase in quantity as the distance from the pipe increases. Beyond a certain distance mud, sand, and other deposits occur to the depth of several inches, so that the stream there is wide and comparatively sluggish, and being dammed back by the deposit, exerts an unfavourable influence on the flow of water through the pipe. On the invert of the original sewer, which now forms the bed of the pipe, deposit was constantly accumulating, and was only partially kept under by repeated flushings. The superficial velocity of the water in the pipe is generally three, four, and five times greater than the superficial velocity which obtained *under the same circumstances*, in the original sewer, and the velocity of the *whole mass of water* in the pipe approximates much more to its surface velocity, as ascertained by a float, than does the velocity of the *whole mass* of water in the sewer approximate to its own surface velocity. On one occasion I had the sewer in Upper George-street carefully cleaned out immediately below the pipe, and then caused a quantity of deposit, consisting of sand, pieces of bricks, stones, mud, &c., to be put into the head of the pipe; the consequence was, the whole of the matter passed clear through the pipe (560 feet long), and much of it was deposited on the bottom of the old sewer, at some distance from the end. When the pipe was flowing nearly half full, two pieces of brick, one weighing one pound and three-quarters, and the other one pound thirteen ounces, were impelled by the force of the water through the whole length of pipe, and struck the legs of the man at the end of the pipe with considerable force. A live rat was also washed with great violence through the pipe, and struck the legs of a man with such force as proved the rat had no control over its own motion. When the water was only 5 inches deep in the head of the pipe, nearly a whole brick, weighing four pounds, was put in it; it was heard for a few seconds moving down the pipe, but was not caught at the end. The bulk of the stream at the head of the pipe is diminished to about half its dimensions when it arrives at the end, the velocity being greater. A great number of irregular-shaped stones, each of several ounces weight, were washed through the pipe with the same apparent ease as marbles, and the distinct rattling noise I occasionally heard them make might convey a correct notion of the considerable force with which they must have been impressed. All the foregoing results were effected when the pipe was either only half full, or less than half full of water, which has been gauged in the pipe. The house-drains connected with the experiment in George-street are in most respects like the rest of the house-drains of the metropolis; the general characters of the whole are great size, irregularity of form, and filthy and bad-smelling condition. The variations in size are from nearly half a square foot to four square feet cross section, and the different forms include the circle, the square, and square bottom and sides with semicircular top; their inclinations seem not to vary more than from horizontal to a fall of two inches in ten feet. Their condition with respect to quantity of matter deposited in them does not seem to be regulated by their inclinations. This may be accounted for by the fact, that their wide and irregular inverts spread the small streams and destroy their force, and cause matter to lodge with greater security. Many of the ends of the drains are so dilapidated, that their original form cannot easily be distinguished; but enough can be determined to know that the sum of all their areas (480) would exceed the area of a circle of 30 feet in diameter. Much of the rubbish and obstructions in the house-drains have been found to consist of heaps of pieces of brick and mortar which from time to time have fallen from the soffits and sides of the drain, as it has progressively become dilapidated. Various species of fungi shoot out from the interstices of the brickwork; and the existence of old cobwebs around the sides, and sometimes nearly covering the mouth of the drain, furnishes another proof, in some instances, that the drain has not been for a long time, if ever, half filled with water. These old drains are the special harbours of rats and other vermin."†

It may be here observed that vitreous pipe-sewers, if properly made, will bear very considerable internal pressure. The smaller-sized stoneware pipes have been tested to several hundred feet. Common redware clay pipes of 6 inches have been tested to between 100 and 200 feet of pressure. Pipe sewers and drains, properly laid, and cemented with Roman cement, may therefore be used under pressure. Experience, as well as a consideration of the difference of structure, shows that it is not safe to use sewers of the common brick and mortar construction full.*

The following is a view of a sewer in which another trial work was most carefully conducted by Mr. Lovick, surveyor, to determine accurately the amount of sewage from 1200 average-sized houses in the metropolis on the days when there was an intermittent supply of water from the different water companies.



In this sewer, which had a flat segmental bottom 3 feet wide, a sectional area of 15 feet, and an average fall of 1 in 118, the deposit from the 1200 houses regularly accumulated at the rate of 6000 cubic feet per month. But a pipe of 15 inches diameter placed along the bottom of this sewer, with a somewhat less inclination (1 in 153), kept it perfectly clear of deposit. The average flow, without rain-fall, was about 51 gallons per house per diem; the absolute drainage, apart from rain-water, from all the 1200 houses would have passed through a 5-inch tube (of the relative size of the smaller one shown within the 15-inch tubular pipe placed along the bottom of the brick sewer), or not one-third the area of the minimum-sized drain which had, up to the time of the investigation, and upon the advice of professors of architecture, been declared and enacted in the Metropolitan Building Act to be necessary for a single house—namely, one of not less than 9 inches diameter. On the same rate of flow, the whole of the mere house-drainage from all the houses in the metropolis might be discharged through a sewer of 3 feet in diameter.†

Adjustments of the Sizes of Tubular House Drains and Main Drains required for the Discharge of Storm Waters.

Whilst the drains for the discharge of soil-water from within houses are made of 3 or 4 inches diameter, the main-drains and sewers will require some enlargement (beyond the space required for the ordinary waste-water from the houses) to receive variable quantities of rain-water.

The necessity of provision for the reception of these variable quantities of water was alleged as one justification of the enormous sizes of the sewers as, until recently, constructed; but on examination the data were found to be wholly insufficient to warrant such dimensions.

* As the force of a stream is proportionate to the square of its velocity, the cleansing power of the concentrated stream in the pipe would be above twenty times as great as that in the wide sewer, consequently stones, &c., which might rest in the latter would be swept away by the more rapid flow.

† An inquiry was directed to be made as to the expense of laying down a mile of 16-inch pipe in an old sewer, with junctions of 4-inch branch pipes to every house-drain made good, when it was estimated that the expense would be 254*l.* 14*s.* 5*d.* per mile; and it appeared that in many such situations as those, where according to the views of various engineers, cleansing by flushing or hand labour would be required, such a line of pipe would keep the sewer entirely clear of deposit, and, so far as the sewer itself was concerned, clear of smell, while it would greatly diminish, if not prevent, the circulation of foul gases from the house-drains through the sewers. According to the report of Mr. Lovick, the present expense of flushing in some districts is 2*l.* 10*s.* per mile per week. In the newly-cleansed districts it was 29*l.* per annum per mile. Even this expense was owing to old accumulations now in course of removal. In the Holborn and Finsbury division, where the flushing is regular, the average expense of keeping the sewers clean by flushing, at piecework, is 17*l.* 5*s.* per mile per annum. Now, the total cost of such a tubular sewer as that above described by Mr. Hale, allowing for a 16-inch pipe instead of a 12-inch one, and spreading the payment over twenty years, would not be more than 19*l.* 8*s.* 5¼*d.* per mile per annum, if executed on a large scale at the prices therein described. Under the flushing system in the least uncleanly sewers district, the expense of flushing represents the expense of removal of 517 loads of detritus and decomposing refuse at 8*d.* per load, spread in portions over a mile of surface 3 feet wide on the average, until it is removed at weekly and fortnightly intervals. At an extra annual expense of 2*l.* 3*s.* the retention and spreading of a proportionate part of these 517 loads may be prevented in streets where there happens to be a sufficient fall.

* With respect to a great number of the recently-built and most expensive brick sewers in the metropolis, it is reported by the officers engaged in the subterranean survey, "that with one-fourth the strength of a man you may drive a searcher through the brickwork and several feet beyond; then, by using the searcher as a lever, you may shake the whole sewer for a yard round;" and that the works cannot be reasonably expected to stand for more than ten or twelve years, much less any full flows of storm-water.

† It will be obvious that by this calculation it is not intended to convey the meaning that a 3-feet sewer would suffice for the drainage of the metropolis, but merely that assuming the average of the whole of the house-drainage alone to be that which was found in this experiment, and that the whole were flowing in one channel at the same rate, a 3-feet sewer would suffice to convey it.

The greatest storm which need be considered—such a storm as occurs in England only in the course of years—would be a fall of about 2 inches in the hour, or 44,789 gallons per acre. Now, it was proved by the trial works that a *three*-inch tube, at an inclination of 1 in 120, will clear away more than this amount of rain-fall from 10 squares, space enough for three labourers' cottages, classed as fourth-rate houses under the Building Act in the metropolis; at a fall of 1 in 80 it was found that it would clear away the rain-fall from 12 squares, or one first-rate and four fourth-rate houses; at a fall of 1 in 40, from 17 squares, or five fourth-rate houses; and with a fall of 1 in 20, it would serve for 25 squares, or the space of two first-rate houses, or eight fourth-rate houses. A 4-inch tube would carry away nearly twice as much water ($\frac{16}{9}$) as one of 3 inches diameter; that size is, therefore, for such an area more than sufficient for the greatest contingency.

Observation of the flow of any outfall of storm-water, and of the tributaries from a hill-side, offers to an unscientific person some approximate conception of the sizes of the channels or tubes which would be required to convey it away; so in a town, the observation of the flow of storm-water in the rough kennels or channels of streets, where there is no under-drainage, would be suggestive of the maximum sizes of the underground sewers required for its removal. But it was found on investigation that for side streets and streets where the storm-water never rises above the side gutters, enormous sewers had been constructed of a capacity sufficient to receive water enough to cover the whole surface several inches deep, and to give it the appearance—which it never had—of a river.

The occasional bursting of large sewers has been referred to as a proof of the necessity of their large size for the discharge of storm-waters; but it appeared upon investigation that the burstings were caused by accumulations occasioned by the large sizes of the sewers, by their irregularly-constructed bottoms, their junctions at right angles, and by other causes. On the occurrence of a sudden storm, one accumulation is rapidly driven up the incline of another, occasioning a complete stoppage. When the internal condition of the sewers was examined at the places where these burstings occurred, it became a matter of surprise that such accidents had not even more frequently happened.

One plea often urged in justification of the extravagant sizes of the old drainage works, even for lines of streets in which but little extension could be reasonably expected was, that they were made so large to meet an assumed probable extension of the population. Such outlays are open to the objection that immediate and certain levies ought not to be made upon the present population to provide for contingencies remote and uncertain. It is overlooked in such expensive provisions that the reduced rates at which improved works may be constructed, as compared with former defective works, will pay for their removal within very short periods. Further, it is presumptuous to say that no improvement can be reasonably expected upon existing works, and that they will for ever be the most eligible. Moreover, the plea cannot be sustained, even as regards the future, for reason has been generally found for believing that the same lines of sewer would admit of considerable additional heads of water without any increase of size whatsoever.

The provision of extra capacity for such purposes has, however, been frequently made on the assumption that the increased area required would be proportional to the population, whereas it appeared that an additional head causes, by the increased velocity, the discharge of the additional quantity through the same sized sewer; an effect not then understood, but which was displayed in the trial works. It would be in exceptional cases only that the drainage area would be increased with increase of population.

Neither is the formation of a *whole* system of sewers of extraordinary sizes justifiable on the pretext of their being required on the occurrence of extraordinary storm-waters.

In many cases an increase in the number of the higher branch lines may ultimately necessitate an increased size in the valley-lines; but in respect to all the branch lines it may be concluded that the concentration and economy of the ordinary flow, and the most rapid and complete daily sweep of the sewers preponderates in importance over the inconvenience occasioned by extraordinary storms, occurring at intervals of many years, and sometimes only at intervals of generations, such as the storm which fell upon parts of the metropolis in 1846, of 4 inches in the hour.

Various formulæ were presented to the Commissioners for inquiring into the means of improving the Health of Towns, as furnishing the means of obtaining greater certainty in the construction of town sewers, and plans for the sanitary improvement of large town districts were prepared upon those formulæ; but the sewers thus designed were still so large, and consequently so very expensive as to offer very formidable obstructions to the extensive voluntary adoption of works of sanitary improvement. These plans were apparently thought repugnant to common and empirical observation of natural outfalls of the nature above referred to, and therefore it was found necessary that trial works should be instituted for the better determination of the proper sizes. The chief results of these trials, made with the smaller and more manageable channels for the removal of sewage or drainage water, have been already described in the evidence cited. In respect to the larger channels, the branch and main sewers, there occur elements not ascertainable by any readily manageable trial works; such could be determined only by observation from an ascertained rain-fall upon a given town area how much did really reach the outfall, and within what time.

To test compendiously the statements as to the alleged necessity of such large sizes for the removal of varying quantities of storm-water, observations were directed to the flows of water at the outfalls from large districts after rain. The following portions of an examination of Mr. Roe exemplify the course and results of these investigations:

"Has carried on a set of practical observations as to the flow of sewers of different sizes and capacities under different circumstances, ever since he has been in the service of the Commissioners of Sewers for the Holborn and Finsbury divisions. Has carried on observations as to the velocities of water in the river Fleet sewer; subsequently he extended his observations to branch and collateral sewers of different descriptions. About 4400 acres are drained by the river Fleet, of which 1888 acres are covered, or town area, and 2512 acres uncovered, or rural area. The Fleet sewer is 12 feet high and 12 feet wide, with a sectional area of 120 feet in the largest part in the Holborn and Finsbury divisions; but the capacity of the whole line varies generally according to the quantity of surface drained by each portion. With regard to its inclination, it varies from 1 inch in 100 feet to 1 inch in 2 feet, whilst some portions are on a level. The sum of the capacities of all the sewers that fall into it is about 550 feet, and they are sixty in number. The capacity of the main is about 1 to 4 of the capacity of the sewers, of which it is the general outlet. The average inclination of the sewers which fall into the Fleet in most instances varies; some of them are a quarter of an inch in 10 feet, others are 3 inches in 10 feet. If every house within the district had a drain of 9-inch diameter, the proportion the capacities of the house-drains would bear to the sum of the capacities of all the sewers would be about 16 to 1, and to the capacity of the main outfall about 75 to 1.

"Engineers and theoretical writers have set forth various formulæ as to the flow of water; and in the Second Report of the Health of Towns Commission there are some tables, by Mr. Hawksley, on the capacity of sewers required for various areas of drainage. Taking table No. 1, witness finds that the sizes recommended for sewers to drain certain portions of land are larger than the actual requirements; for instance, the quantity of acres that a cylindrical sewer 48 inches in diameter is (by the table) allowed to drain, when the inclination is 1 in 240, is 47; whereas in practice it is found that such a sewer, with that inclination, drains more than 100 acres of town area at a similar fall of rain to that on which the table is formed. Again, a sewer, with a similar inclination, to drain 129 acres of town area, should (by the table) be of the capacity of about 28 feet; but in the great storm of August 1846, the water from 215 acres of town area, and 1785 acres of rural district, occupied only 30¼ feet of the superficial area of a sewer with that inclination. With respect to larger sizes, the table shows, that at an inclination of 1 in 480, a sewer to drain 329 acres of town area should have a capacity of about 78 feet; whereas, in a sewer with a similar inclination, the area occupied in the storm of 1844 was only 79 feet; and to this sewer there drained 1181 acres of town area, and 2656 acres of rural district.

In the formation of the tables for showing the proper size of sewers it has usually been assumed that a certain large proportion of the rain falling upon a town area will flow into the sewers as quickly as it falls, and that the channels for its conveyance ought to be large enough to carry that quantity away, supposing it all to enter at the head. Mr. Roe finds from long-continued observations that a very much smaller part of the rain runs off into the sewers in the same time than has been assumed (*i. e.* that very heavy falls of rain are much shorter in continuance than the floods they occasion), and that sewers receiving along their course the confluence of many smaller channels will convey away far more water than if it all entered at the head. He consequently finds that sewers of much smaller section than the usual tables indicate are amply sufficient, and therefore that the use of such tables, or of the formulæ on which they are constructed, has led to large unnecessary expenditure.

Since Mr. Roe gave the evidence already cited, he has been compelled by illness to resign his office of chief surveyor to the Metropolitan Commission of Sewers; but he has since his retirement, and during his convalescence, occupied himself in completing for the Board a table of dimensions of sewers, founded upon his observations, in the Holborn and Finsbury district of the metropolis, of branch as well as main lines of sewers—observations the most extensive of any which have yet been made. The runs of water through the smaller-sized pipes are corroborated by the results of trial works, promoted in pursuance of the investigations directed by the Metropolitan Sanitary Commission.

The discrepancies of the formulæ adopted by various eminent authorities for calculating the run of water through pipes are well known. Some mathematicians appear to have deduced their constants from experiments on a scale so small as could be tried in a room, and to have assumed that empirical formulæ so obtained were of universal application; but the results of such calculations are frequently at variance with fact and with each other. And correct though certain formulæ may be for determining the discharges of water through simple pipes or channels under certain conditions, it is quite certain, from all the most recent and careful investigations, that the ever-varying conditions connected with the complete drainage of a town or district renders the application of any of the formulæ hitherto used not merely impracticable but productive of serious constructive error. The objections to the use of all the tables prepared from such formulæ for determining the sizes of sewers were stated in evidence before the Metropolitan Sanitary Commission. Their entire inapplicability for this purpose is strikingly confirmed by Mr. Roe's table, founded upon the only observations of considerable extent in the sewers themselves which are known to have been yet made; and the circumstances of the flow in the larger sizes, and of most extensive lines of sewers, are such as could be corroborated by no trial works obtainable with any available means, or within reasonable time and cost.

The size of a stream which would be produced by a given fall of rain upon a given area admits of calculation, assuming that all or a given proportion of the water arrives at the drain at a given rate; but it would appear that notwithstanding the enormous expensiveness of drainage works, persons directing the outlay had never determined by actual observation the greatest rate at which the water did really run off, and consequently could not know of what size drains should be made.

The proportion of the flow which actually reaches the sewers differs greatly under different circumstances of season, soil, and surface, and especially of different rates of rain-fall in a given time. In long-continued rains, and in heavy storms, for which the table is calculated, a much larger proportion reaches the sewers than on ordinary occasions, the greater flow from the covered portion of the surface usually having time to pass away before the rain falling on an absorbent surface of garden, meadow, or arable land, reaches the sewer.

The following is Mr. Roe's table, and his account of its formation:—

TABLE *showing the Quantity of Covered Surface from which Circular Sewers (with Junctions properly connected) will convey away the Water coming from a Fall of Rain of One Inch in the Hour, with House Drainage, as ascertained in the Holborn and Finsbury Divisions.*

	DIAMETER OF PIPES AND SEWERS IN INCHES.											
Inclination.	24	30	36	48	60	72	84	96	108	120	132	144
	acre	acre	acre	acre	acre	acre	acre	acre	acre	acres	acres	acres
Level	38½	67½	120	277	570	1020	1725	2850	4125	5825	7800	10100
¼ in. in 10 ft., or 1 in 480 ..	43	75	135	308	630	1117	1925	3025	4425	6250	8300	10750
½ in. in 10 ft., or 1 in 240 ..	50	87	155	355	735	1318	2225	3500	5100	7175	9550	12400
¾ in. in 10 ft., or 1 in 160 ..	63	113	203	460	950	1692	2375	4500	6575	9250	12300	15950
1 in. in 10 ft., or 1 in 120 ..	78	148	257	590	1200	2180	3700	5825	7850	11050	14700	19085
1½ in. in 10 ft., or 1 in 80	90	165	295	670	1385	2486	4225	6625				
2 in. in 10 ft., or 1 in 60	115	182	318	730	1500	2675	4550	7125				

"The table is formed from results obtained from observations extending over a period of twenty years in the Holborn and Finsbury divisions. In some instances the observations were carried on during the whole period of heavy rains, being commenced as each storm began, and continued until the effect had ceased in the sewers, the depth of water being taken every five minutes, and the velocity of the current repeatedly noted at every depth. In some instances the observations were continued day and night for several months in different years, and in others they were conducted day and night for a period of two years; rain-gauges being kept to ascertain the depth of rain that fell. The particulars from which the table is compiled fill upwards of 100 memorandum books. The first saving which these observations enabled me to make was about 4000*l.*, by lessening the size of a proposed portion of main line, by which a reduction of two guineas per foot lineal was effected in a length of nearly 2000 feet. In other sewers of smaller size, savings were effected to the amount of several thousands per annum for many years. In 1843, I was called upon to report on the best means of saving the town of Derby from the disastrous effects of floods. It was from the knowledge obtained during the course of these observations, that I was enabled to suggest the size of sewers which would convey the flood-water of the Markeaton-brook, the overflowing of which shortly before had not only caused damage to the amount of many thousand pounds sterling, but also loss of life. From the time of the completion of the sewer to this date, it has answered every expectation, no flooding having been complained of, although in August 1846, more rain fell in a short space of time than I find on record at any other period. This knowledge also enabled me to judge of the size required for a main line of sewer in the town of Birmingham some years since, and which has also answered every requirement. The necessity of carefully forming the sewers, so that no obstruction to the passage of the water may obtain, cannot be too strongly impressed on the minds of all connected with such works. At the head of the table I have named, 'junctions properly connected,' nor will the respective sewers drain the area stated, unless this important matter be duly attended to. Every junction, whether of sewer or drain, should enter by a curve of sufficient radius. All turns in the sewers should form true curves, and as, even in these, there will be more friction than in the straight line, a small addition should at curved points be made to the inclination of the sewer. I may mention a case or two in illustration. In 1844, a great quantity of rain fell in a short space of time, over-charging a first-size sewer and flooding much property. On examination, it was found that the turns in the sewers were nearly at right angles, and also that all the collateral sewers and drains came in at right angles. The facts and suggested remedy were reported to the Holborn and Finsbury Commissioners, and directions given by them to carry out the works. The turns and junctions were formed in curves of 30 feet radius, and curved cast-iron mouths put to the gully-shoots and drains; the result was, that although in 1846, a greater quantity of rain fell in the same space of time than in 1844, no flooding occurred, and since then the area draining to this sewer has been very much extended without inconvenience. In another case flooding was found to proceed from a turn at right angles in a main line of sewer. This was remedied by a curve of 60 feet radius, when it was found that the velocity of current was increased from 122 (as it was in the angle part) to 208 (in the curved part) per minute, with the same depth of water. In the winter season, on meadow ground 82 acres in area, having a clay subsoil, 3 feet per acre per minute was the greatest quantity that came at one time from a fall of rain of half an inch in depth, and this amount did not reach the sewer until three quarters of an hour after the rain had ceased. From similar ground during the summer, when a greater fall of rain took place, no water ran off the surface, and that which percolated to the land-drains did not reach the sewer until after the greatest flow from the streets and houses had passed away. In applying the table to localities where the inclination of the surface is greater than that of the Holborn and Finsbury divisions, a modification of the sizes of sewers will be required; for instance, in one case that came under my notice, where the general inclination of the surface of the streets was about 1 in 20, the greatest flow of water from a thunder-storm came to the sewer at the rate of one-third more than it did to a sewer draining a similar fall of rain from an area with a general surface inclination of 1 in 132."

In examining this table, two points of error must be guarded against, into which the ordinary calculations would lead, and which constitute the striking difference between the results here noted, and those which have been hitherto put forward for guidance; namely, the error of calculating the discharges obtained only from pipes running full at the head; and the error of assuming, without observation, that the given quantity of rain falling in a certain time would be discharged within the same period.

The effect of junctions on the line of sewer constitutes a most material difference in the discharge. The experiments and observations show, that with a pipe laid at an inclination of 1 in 60, with junctions along its line, the capacity of discharge is upwards of three times greater than if the flow were merely from a full head; and in the larger sizes it will be found that the quantity accumulated increases to upwards of eight times

Table showing the Size and Inclination of Main House-Drains for given Surfaces, and the Number of Houses of either Rate thereon, calculated from Mr. Roe's Table for a Fall of Rain of 2 inches in the Hour, as obtaining in the Holborn and Finsbury Divisions.

Surface occupied.		Number of Houses of either rate, either of which may respectively be drained.				Diameter and Inclination of Tubes.									
Acres.	Squares of 100 feet.	1st	2d	3d	4th	3-inch.	4-inch.	5-inch.	6-inch.	7-inch.	8-inch.	9-inch.	12-inch	15-inch.	18-inch.
1/8	54	1	2	3	4	1 in 120									
1/4	112	2	4	6	9	1 in 20	1 in 120								
7/16	195	3	7	10	15	. .	1 in 40								
1/2	224	5	8	13	18	. .	1 in 30	1 in 80							
6/10	265	5	9	15	21	. .	1 in 20	1 in 60							
1	448	10	15	26	36	. .	. .	1 in 20	1 in 60						
1 1/5	528	11	17	29	40	. .	. .	. .	1 in 40	1 in 120					
1 1/2	648	15	23	39	54	. .	. .	. .	1 in 20	1 in 60	1 in 120				
1 4/5	814	19	28	49	67	. .	. .	. .	. .	. .	1 in 80				
2 1/10	912	21	32	55	76	. .	. .	. .	. .	. .	1 in 60	1 in 120			
2 1/2	1094	25	38	65	90	. .	. .	. .	. .	. .	. .	1 in 80			
2 3/4	1200	27	42	71	99	. .	. .	. .	. .	. .	. .	1 in 60			
4 1/2	1970	45	68	117	162	. .	. .	. .	. .	. .	. .	. .	1 in 120		
5 3/10	2308	52	79	136	189	. .	. .	. .	. .	. .	. .	. .	1 in 80		
5 4/5	2534	59	88	150	208	. .	. .	. .	. .	. .	. .	. .	1 in 60	1 in 240	
7 4/5	3432	79	118	205	284	. .	. .	. .	. .	. .	. .	. .	. .	1 in 120	
9	3976	90	135	234	324	. .	. .	. .	. .	. .	. .	. .	. .	1 in 80	
10	4404	101	152	263	364	. .	. .	. .	. .	. .	. .	. .	. .	1 in 60	1 in 240
17	7400	169	253	439	608	. .	. .	. .	. .	. .	. .	. .	. .	. .	1 in 120
19 9/10	8700	200	300	520	720	. .	. .	. .	. .	. .	. .	. .	. .	. .	1 in 80

that which would be discharged if received only from a full head. If the area is lengthened and distant, with little inclination towards the main, and there is a considerable portion of rural area, the conveying sewer may be proportionately less. In such cases the flow from the nearer portion of the district will frequently have been discharged before that from the distant area will have reached the main, and at all times the rain-fall on the rural portion will be proportionately longer in reaching the sewers.

It should be observed, that although the actual sizes given in Mr. Roe's table would more than suffice for the drainage of the areas stated, with the houses thereon, yet in relation to the smaller sizes, for the drainage of courts and collections of houses, some modifications will be found necessary. In these cases, many of the reasons alluded to, which are seen to operate in great reduction of size of sewer for larger areas, and for space from which several connections would be formed, more or less distant, will not be in action. The rain-fall from the smaller spaces will flow more immediately to the drains, and their capacity must be equal to its discharge with corresponding suddenness. The pipes themselves, moreover, are often not of the full sizes which they are stated to be, and their greatest effect is not obtained from unevenness of form. The risk of carelessness in laying and jointing is greater also in the smaller sizes, where it is of the most importance, and operates still further in reducing the available capacity of the pipes. These points have so far influenced the practice that 3-inch tubes have scarcely been used hitherto, except for branch house-drains. For these reasons it is considered advisable to admit of greater margin in the calculation of the sizes for this purpose; and the above separate table has been prepared by Mr. Roe for special application to house and court drainage.

From this table it will be perceived, that the sewer formerly proposed as the smallest size admissible for the drainage of a "mansion," viz., 15 inches, would at a fall of 1 in 120, drain 79 of the largest mansions, or 284 of the smallest houses; that a 9-inch drain (the minimum size prescribed by the Building Act, for the drainage of a single house), would at the same gradient remove the storm-water from 21 of the largest mansions, or from 76 of the smallest houses; or, at a fall of 1 in 60, would drain nearly 100 of the smallest, or an area of nearly 2¾ acres of covered surface.

An 18-inch sewer, less than that prescribed as the minimum size into which a man might crawl for cleansing, would, at an inclination of 1 in 80, remove the storm-water from nearly 20 acres; and a sewer of 3 feet (less than the minimum size formerly recommended for the smallest street), would, at the same inclination, remove the drainage from 295 acres.

In distributing the inclinations, which a given fall in any continuous length will admit of, it should be borne in mind that it is always desirable to graduate them, so that the utmost inclination which may be practicable should be given to the upper part of the line, where there will be the less current and force of sweep. The drains should always be laid at the greatest inclinations which can be obtained; and this should always be kept in view, therefore, in selecting the sizes from the table. The sizes of the drains will require modification according to variations in the area and inclinations of the ground, and the number of houses to be provided for.

ON THE CONVERTIBILITY OF PHYSICAL POWERS.

By W. J. Macquorn Rankine, C.E., F.R.S.E.

Had I pretended (in my remarks on this subject published in the *Civil Engineer and Architect's Journal* for October) to give a complete account and explanation of the phenomena observed by Mr. Clark in his numerous experiments on the expansive action of steam in locomotives, or had I even adduced those phenomena as a definite and conclusive confirmation of results deduced from the law of the mutual convertibility of heat and mechanical power, I should have deserved the strictures contained in Mr. Clark's paper, published in November.

But so far from this being the case, my mention of Mr. Clark's experiments was merely incidental, and made solely in order to point out one reason for the difference in the phenomena exhibited by the steam in them and in the experiments of Mr. Siemens; a reason founded in a great measure on the analogy between the latter experiments and those of Messrs. Thomson and Joule, on the heating of air by the agitation of its particles. I expressly disclaimed, moreover, the considering Mr. Clark's experiments as affording more than a general verification of the conclusion, that vapours working a piston are partially liquefied by their own expansion, on the ground of our present imperfect knowledge of the bulk occupied by a given weight of steam at a given pressure and temperature.

I admit, with Mr. Clark, that where alternate liquefaction and re-evaporation occur, they are probably produced in a great measure by the alternate transference of heat to and from the cylinder; but I must still consider the expansive working as one cause of liquefaction, especially when I find it stated by Mr. Clark, that the steam in expanding falls below the temperature of the metal.

Glasgow, November 1852. W. J. M. Rankine.

SUGGESTIONS FOR ALTERING AND ENLARGING THE PRESENT NATIONAL GALLERY.

By C. H. Smith.

[*Paper read at the Royal Institute of British Architects, Nov. 15.*]

It seems to be generally admitted that a considerable enlargement of our National Gallery is indispensably required, in order to make room for the reception of the National Pictures. If a few of the rooms in the present gallery are large enough for the purpose of viewing the grandest of the pictures exhibited, they are nevertheless not sufficiently capacious to admit the number of valuable works which there is reason to believe would be presented or bequeathed to the nation, if the conviction were general that government had provided proper accommodation for receiving them. Much has been said about the pernicious and destructive influence of the London atmosphere on pictures, and much more might be asserted without proving the truth of such statements. In all cases, colours that are mixed with any kind of oil must necessarily become darker and darker by time, in consequence of the natural tendency which that vehicle has to absorb oxygen from the atmosphere; some varieties of oil, it is true, absorb it much more rapidly than others, but, sooner, or later, all fatty substances employed as menstrua in painting will certainly change to a dark brown colour. In this respect, so far as the atmosphere is concerned, precisely the same change would take place, whether the pictures were exposed to the air of Lombard-street, of Trafalgar-square, or of places far remote from the busy world's unceasing sound. Castle Howard, Blenheim, and Belvoir Castle, are baronial mansions placed in the midst of beautiful woodland scenery, at distances of eight or ten miles from any large town; they all contain numerous pictures by celebrated masters, which to the best of my recollection, are in no better state of preservation than those in the galleries at Bridgewater House, of the Marquis of Westminster, in Grosvenor-street, or the many excellent pictures that have been kept for ages in the halls of some of the companies situated in the midst of the City of London. But the best evidence that I can mention, to show that there is nothing in the situation or atmosphere of London likely to destroy or injure the beauty of pictures, is, that the nine pictures painted on canvas by Rubens, which form the main portion of the ceiling of the Chapel at Whitehall, have been exposed to the atmosphere in the very neighbourhood of the present National Gallery, during a period of between two and three centuries, without the advantage of any particular care or attention, and that they are yet even now in as good a state of preservation as if they had only been painted within the last twenty years.

We must all admit that a vast difference in the amount of our laundress's bills depends on whether we reside in town or in the country; similar remarks apply to the furniture of our houses, and to our habitations generally. To appear decent, a London house should be cleaned, or fresh painted, much oftener than one in the country, but this difference arises merely from dust or soot slightly adhering to the surface, which, in the case of pictures, may be easily washed off once in a few years, without risk of their receiving the slightest injury.

For all useful purposes, London is the only proper situation for the picture gallery of the British people; were it erected a mile or two out of the metropolis, the number of students and visitors would decrease surprisingly, in inverse proportion to the increase of distance. If there be any appreciable objection to the air of London, it must be useless to think of removing the pictures anywhere within eight or ten miles of so pestiferous a place. But convinced, after much consideration, that it will be difficult to find a better locality, or a more commanding situation for a grand public building than the north side of Trafalgar-square, I would propose, without entering upon the well-known restrictions which the architect had to contend with before commencing, and the numerous difficulties he had to overcome in carrying out the present building, to proceed at once to the question, whether the present building forming the National Gallery and the Royal Academy of Fine Arts, can be enlarged sufficiently to meet the present as well as the prospective demand for space; whether the principal elevation facing the south can be improved without great expense; whether the entire alteration and enlargement, when completed, are likely to answer the intended purpose; whether it will be worth the money it is likely to cost; or, whether it will be a waste of outlay, merely to produce a mean and unsatisfactory result.

Mr. Wilkins, the architect of the National Gallery, in his evidence before the Committee of the House of Commons in 1836, suggested that a very considerable extension of the galleries might be obtained by the purchase of the dilapidated buildings which now occupy the site westward, at the back of the new houses in Pall Mall East. This addition alone would more than double the present space in the National Gallery; but as this is not a new idea I will leave it, and call your attention to a much larger space existing on the north of the eastern half of the present site. The workhouse buildings of St. Martin's parish, situated between Hemming's-row and Castle-street, occupy at least an acre of ground, contained in a compact quadrangular, though not rectangular, figure, immediately behind the portion allotted to the Royal Academy. I am not one who would, for interested motives, turn out the inhabitants of a district merely because they are paupers, but the poor of St. Martin's parish might be much better accommodated, and certainly more healthily located, in a new building, situated in the middle of a beautiful garden, a few miles out of the metropolis, instead of being immured in the present old prison-like edifice, in a crowded neighbourhood, misnamed "*St. Martin's in the Fields.*" In this manner the trustees of the National Gallery and the guardians of the poor of the parish, might mutually be considerably benefited by the exchange, and it may be presumed that the workhouse buildings, together with the freehold site, could be purchased for a sum not exceeding their fair marketable value.

An arrangement, something like the plan now submitted, would give six rooms or galleries, each averaging above 100 feet long by 40 wide; two, 55 by 40; three, 40 feet square, and a hexagonal room, say 45 feet diameter; or, in other words, there would be about eight times the space of the present National Gallery. The whole of these rooms would be on the first-floor—that is to say, would be nearly on a level with the present exhibition rooms, consequently there would remain the entire range of rooms on the ground-floor of the proposed new building available for other purposes. With regard to the communication to be made from the present building to the proposed new galleries, I think it will be admitted that an unreasonably large space is occupied with gloomy halls, vestibules, and staircases, at the chief entrance either of the National Gallery or Royal Academy, and certainly without affording the commensurate advantage of any particularly-grand architectural feature. This central portion of the building is therefore all that I propose to disturb and re-arrange. The principal entrance doorway and the two Corinthian columns would remain as at present, while the little cupola over the pediment being taken down, would obviate the necessity for the the wall which divides the entrance from the vestibule; this alteration would give a hall about 40 feet by 22, from which steps of nearly the entire width would lead up to a new vestibule, on the site of the present Antique School or Sculpture Room, the floor of which vestibule would be on a level with the exhibition rooms in the present National Gallery and Royal Academy. From the new vestibule, doorways to the right and to the left would communicate with two new rooms, each nearly the size of the largest in the present building. These rooms would open into the present galleries without any further alteration than cutting a doorway through the north wall of the large exhibition room of the Royal Academy, to open a communication at the end of the building with the proposed new galleries.

The public footway from Castle-street, through Duke's-court, to St. Martin's-lane would remain; but in order to connect the old with the new galleries, it would be necessary to build communications over Duke's-court, which I would propose to form over the public way in two distinct places, at an elevation of probably 16 or 18 feet above the foot-pavement of the court. To whatever purpose the ground-floor of the proposed new building might ultimately be appropriated, height of the rooms would always constitute a valuable feature of the scheme; consequently, as the ground rises gradually 4 or 5 feet from Duke's-court towards Hemming's-row, I should give that much additional elevation to the floors of the new galleries, by ascending a few steps at the junction of the new and old buildings, to be formed over Duke's-court. A few broad and easy steps, to vary the level in so extensive a suite of apartments, might be considered almost an ornament rather than a defect in the general arrangement. The outline or boundary of the proposed site would be very nearly of the shape, dimensions, and relative proportions represented in the plan now exhibited; by which it will be perceived that the walls would not be square to each other, but a little contrivance in the direction and thickness of the walls might enable us to build the rooms right angled. By the arrangement of the rooms and doorways represented on the plan, a person entering from the hexagonal vestibule, and following the direction of the arrows, might visit every room without passing over the same ground a second time. Not to occupy your time by going into minute details, generalities will be sufficient for the present purpose. It must be evident that the accommodation thus proposed would certainly be sufficient for a vast accumulation of pictures; is it, therefore, advisable to build galleries so very extensive that they may probably remain empty during the next one hundred years? But suppose all the rooms suggested to be erected on the site of the workhouse should become filled to excess with fine works of art within thirty or forty years, is it not highly probable that during such interval an opportunity might offer to purchase the old buildings alluded to by Mr. Wilkins? or that the barracks, and the large piece of gound adjoining, which already belong to the Crown, might be vacated for some spot more convenient for military purposes?

The second question is, "Can the principal elevation be improved for a moderate outlay?" In my humble opinion, as a non-professional man, I am disposed to think that much might be done with the present materials if differently arranged; in which case the chief expense would be incurred for removing and refixing them. It strikes me that one of the principal objections to the existing elevation is the great number of longitudinal parts into which the front is divided. If these could be disposed in larger masses, greater breadth and simplicity would be obtained; with this impression I have tried the effect of removing the columns from the side porticos, and adding them to that in the centre; I suppose the same pediment to be elevated, elongated, and reconstructed, without further alteration; I have already proposed to dispense with the little cupola over the pediment, which may be considered almost a useless feature, neither dignified in its external appearance, nor internally convenient, as a place in which the students of the Royal Academy have to study from the living model. In lieu of this, I would propose to erect a dome of larger dimensions over the new vestibule.

To alter the elevation principally by re-arranging the old materials, according to the plan which I have suggested, would probably not exceed the sum of 3000*l.* or 4000*l.*; but should it be considered impossible to amend the present elevation, and therefore desirable to pull it entirely down, to sell off the old stone, and to erect a new façade in the Greek, Gothic, Egyptian, or Chinese style, with about the same amount of labour and materials, we should still retain possession of this fine situation, and the whole course would not even then exceed some 15,000*l.*; I have good authority for naming this sum, because I made a detailed estimate of the masonry for Mr. Wilkins, and the contract for the external stonework was taken for a trifle under that amount.

No galleries which are decidedly erected for the display of paintings should be architecturally decorated internally; plain, straight walls are most fit for the object in view. If ornament be admitted at all, it should be confined exclusively to the ceiling or covering; and in this respect many valuable hints might be taken from some of the recently-constructed iron and glass roofs at the railway stations and termini. With regard to the exterior of the proposed additional buildings, the public thoroughfares of Duke's-court, Castle-street, and Hemming's-row, are not of sufficient importance to warrant any expenditure for the display of architectural design, not even to the extent of stone-facing; therefore perfectly plain brickwork, without break or recess of any kind, would suffice.

Thus I have endeavoured to show that the present site of the National Gallery is an admirable one for such purpose; that the existing elevation may be altered, or entirely rebuilt, for an insignificant sum; that the demand for space may be supplied to almost any reasonable extent, and galleries sufficiently large to receive the grandest performances of historic art may be built. And further, I venture to say that the number of rooms and extent of accommodation could not be produced in so satisfactory a manner anywhere else for so small a sum of money. If the scheme thus merely suggested were properly carried into effect, I am disposed to imagine that the ultimate result would never be considered mean, incomplete, or unsatisfactory.

In conclusion, I beg to offer a few remarks respecting the construction of the new National Gallery, wherever it may be determined to erect it. No part of the architectural profession appears to give so little satisfaction to the great body of artists and amateurs as that by which the architect arranges the mode of admitting daylight into picture-galleries. Some of our most eminent professors have failed in this respect, and I can scarcely bring to mind any large room where the light is so admitted as to give general satisfaction to the artists who send their works for exhibition: I would, therefore, ask if this part of the subject is so difficult to determine, why not try experiments upon a large scale at full size, and in the actual building during its progress? As soon as the general plan of the edifice is settled, let me suggest that the walls of one of the principal rooms should be built up to the full height with as little delay as may be consistent with sound construction. Upon these walls place a temporary roof or covering, with a superabundance of glazed lights; let the entire roof, and, as far as practicable, every part of it, be made to admit of a variety of adjustments or alterations; —if there be too much light, it will be easy to modify it with sun-blinds where requisite. When these arrangements are ready, hang up a few large pictures to try the effect, and submit the experiment to a committee of artists, or other persons competent to form a correct judgment in such matters; if the first attempt should prove unsuccessful, try various other modes of lighting the apartment: it will be much better to spend a few hundreds, or even a thousand pounds, in experiments to ascertain the best mode of giving light to the pictures, than to finish the galleries at an immense expense, and, when they are completed, to find that the greater number of artists consider the pictures improperly lighted, and, consequently, that the building does not properly answer the purpose for which it has been especially erected. More useful information is likely to be derived from such experimental modes of procedure, than from examining and comparing plans, sections, measurements, and descriptions procured of all the picture galleries in the civilised world.

I have already stated that the New Galleries, in the plan submitted by me, are proposed to be placed on the first-floor; this arrangement would leave the entire range of rooms on the ground-floor available for other purposes, such, for example, as rooms for Archbishop Tenison's Library and School, and a Subscription Library belonging to St. Martin's parish; both these institutions now occupy part of the site, and might well be accommodated on the ground-floor, under the new galleries. The ground-floor frontage, in Hemming's-row, might be valuable for shops or warehouses. Should the objection be made that the various hazardous trades and occupations, carried on in these tenements immediately beneath the picture-galleries, would endanger the safety of the building by conflagration, I confidently submit, that it is possible, and quite practicable in these days, with all our modern improvements, inventions, and appliances, so to construct a building as to set flames and incendiarism at defiance. With brick, tile, stone, slate, iron, glass, and various cements, the entire edifice may be constructed and finished, ready for the pictures, without an atom of what is usually termed inflammable matter in its composition.* Even the furniture and fittings might, to a very considerable extent, be manufactured with incombustible materials. But if a little wood should be introduced in places for greater convenience, no very great harm could arise; a small quantity of fuel can never be kindled into a large fire; still I must maintain the assertion that it is not necessary to use inflammable substances to form any part of the building; and that the entire fabric might be erected, from the foundation to the roof, completely fire-proof.

Discussion.—Mr. D. MOCATTA, the Chairman, after expressing his opinion of the importance of the subject treated by Mr. Smith, said, that with respect to the supposed injury occasioned to pictures by the London atmosphere, although Mr. Smith had suggested that it was a question for chemists, they, as architects, were always glad to have the opinion of artists on such subjects; he therefore hoped that the artists present would favour the meeting with their sentiments on this most vital point in con-

* The pictures might be hung by means of a contrivance something like the mason's lewis: a number of cast-iron dove-tailed sockets, to receive the lewises, being inserted during the progress of the building into various parts of the walls where the pictures should be suspended, from which iron rods or bars would pass through the rings from one lewis to another, and from these rods small chains might be attached to the picture-frames wherever requisite. If the lewises, or iron rods, should be occasionally in the way, and interfere with the arrangement of the pictures, the lewis might be taken out of the socket, leaving the wall free from any projecting object, and it might be re-inserted, at a moment's notice, whenever required by changes made in the arrangement of the pictures.

nection with the proposed change in the site of the National Gallery.

Mr. Garling said that it might be doubtful whether many other causes, besides the oxygen of the atmosphere, did not combine to produce the injury complained of. Leaving, however, that important question, he begged to offer some remarks on the addition to the present National Gallery, as proposed by Mr. Smith. The plans of all public buildings should present a regular geometrical outline, without acute or obtuse angles, from which no considerations of site should induce the architect to depart. The plan exhibited by Mr. Smith was defective in this respect, but might easily be improved, without any material loss of space, by making its outline and subdivisions square. Duke's-court and the southern end of Castle-street were extremely unimportant as thoroughfares, and, as an Act of Parliament would in any case be necessary, it would be better to close them altogether, and take into the proposed addition the whole width of the latter street. In such a thoroughfare as Hemming's-row the shops proposed by Mr. Smith could not be remunerative, as they would be only fourth-rate, and he hoped that feature of the project would therefore be given up.

Mr. Scoles hoped that the act, if carried, would embrace the removal of the houses in St. Martin's-place, which would otherwise hide the new building.

Mr. Mocatta said the real question was one of site rather than arrangement. If the site were determined, it would not be difficult to provide for the reception of many more pictures than might be added for years to come to the National Collection, and certainly there was plenty of available space for enlarging the existing building. The magnificence of the present site, and its central situation, would render it highly desirable to retain it if possible. The Institute and other learned and scientific bodies would be glad to be accommodated in a building in such a situation, and therefore, the suggestion of making shops a portion of the structure might be at once abandoned. In his opinion, however, the first question was, whether the pictures really sustained any injury in their present situation? and he hoped Mr. Foggo would give the meeting the benefit of his views on that subject.

Mr. G. Foggo said that he had given much consideration to the subject, and to the evidence and reports of committees in reference to it. He regretted to say that the last Parliamentary Committee had rejected all the conclusions arrived at by previous Committees, and recommended a change of site without hearing any opinions to the contrary. Indeed, although two artists had tendered their evidence in favour of the present site, the Committee refused to hear one of them, and only received the opinions of the other on condition that they should appear as an appendix to their report. The importance of having a National Gallery in the centre of the metropolis could not be over-rated. He (Mr. Foggo) was a member of a deputation which had waited on Lord John Russell to solicit the removal of the Cartoons from Hampton Court to the National Gallery. Until about twenty years ago, the keeper or deputy-keeper at Hampton Court was allowed a stove and coals to keep the cartoon gallery dry, and the fire, with the spray from the fountain in the court-yard, had produced more injury to those valuable works than they could possibly have sustained in London. He had strongly urged upon Lord John Russell the immense importance, in an educational point of view, of rendering the cartoons more accessible to the population of the metropolis, and his lordship rather warmly expressed a similar opinion. In fact some of the cartoons had been brought to London for study at the Royal Academy and the British Institution without especial injury. Mr. Smith, he believed, was perfectly right in stating that the carbonic acid gas which settled on a properly varnished oil painting might easily be cleaned off without injury to the picture. It was well known to picture dealers that when the re-paints and varnishes were taken from an old picture, it was often found "as hard as marble;" and pictures imported from the fine climate of Italy were never supposed to sustain injury from remaining ten years or more in the shops of the neighbourhood of the National Gallery. Indeed, if there were any truth in the idea, every nobleman and gentleman in London possessing fine pictures would at once send them away. The Duke of Northumberland's gallery was even in a worse situation than the National Collection; and whilst the former was not supposed to have been at all injured, a picture by Hilton in the latter had suffered materially. Indeed, an entirely new picture with the *magilp*, which was now so frequently used, would suffer more in the three months' exhibition of the Royal Academy than would a Raffaelle in a hundred years. All pictures, indeed, changed more in the first three months than in three years; and more in the first three years than in fifty years after. A faithful copy of an old picture, in like manner, would in a very few years be much darker than the original; and if any part of a picture requiring it were repaired, the repaired portion soon became a dark spot. If in glazing a picture an excessive quantity of oil were used, the oil floated on the surface, and attracted the oxygen, as described by Mr. Smith. Mr. Farrer, in his evidence on the National Gallery, had stated that the improper use of magilp instead of mastic varnish, was the cause of their deterioration, and that the magilp was now so thick upon them, and so great was its tenacity, that if the practice were discontinued and varnish employed instead, the pictures would be torn to pieces; therefore, there was, unfortunately, no remedy for the existing evil, whilst every fresh coating of magilp made the picture darker by attracting the oxygen. The result would be the same in the country as in London. The fountains in front of the National Gallery, and the smoky chimneys around it, might be supposed to have injured the site, but he doubted whether damp or smoke were seriously injurious, and at all events those evils had been promoted by the authorities who now sought to remove the pictures from them. Some had said that the dust raised by the visitors to the gallery injured the pictures, but if that were so they should not be exhibited at all; but in truth the grand object was that these great works should be seen and criticised by all classes of men, women, and children. Pictures were subject to atmospheric influences abroad, as in England, and the situation of the Louvre, especially in November or February, was much worse than that of our own National Gallery. The pictures there were very liable to be injured by the fog, which though whiter than our own, often prevented the building being seen from the opposite quay; and there was more irregularity there in warming and ventilating than in London. The coal fires, also, which darken the London fog, maintain a greater degree of warmth and ventilation. In the dingy atmosphere of Holland the finest pictures of Van Eyck and others were preserved, even with the most beautiful glazings ever seen. More benefit would be done by offering premiums for good oils and varnishes than in building a new National Gallery. Admitting the darkening influence of the London atmosphere, Mr. Foggo contended that it was not confined to the centre of the metropolis. The sheep in Kensington-gardens and at Shepherd's-bush were as dark as in the heart of London; and when certain winds prevailed, the fog and smoke were conveyed to Harrow, Uxbridge, aud Epping-forest; whilst he had often observed that a dense evening fog in the outskirts was dispelled in the metropolis by the gas-lights. In regard to Mr. Smith's design, he thought a magnificent frontage to Trafalgar-square would supersede the necessity of other fine elevations; and if the additional apartments were spacious and regular within, the external irregularity would not be of so much importance.

Mr. Papworth adverted to the evidence of Mr. Faraday, to the effect that the national pictures were mainly damaged by the ammonia deposited upon them by the perspiration of the immense multitude of persons who visited them. Either Mr. Faraday was wrong in that conclusion, or another question arose—namely, whether such works were to be preserved unchanged as monuments of departed artists, or to be kept for the education and benefit of the people at large. In the latter case they should be allowed to do their work and perish, when they might be supplied by others.

Mr. E. T. Parris observed, that the supposed injury to pictures from the London atmosphere was rather to be ascribed to the mode in which they were originally painted. Besides the picture by Hilton, to which Mr. Foggo had referred, he (Mr. Parris) had observed that the painting by the same artist presented to the church at Newark, had cracked throughout in precisely the same way. Another picture by Hilton had actually run away, having been described to him as actually "melting;" and the meeting would no doubt remember the painting of 'Sabrina' by the same artist, in which the eye of the principal figure had fallen down upon the cheek, so that it was necessary to turn the picture upside down, in order that it might run back again. Reynolds, and other artists of his time, prepared their colours according to their own notions of chemistry; and, adopting the views of Vasari and others, they used boiled oil extensively, and with the worst effect. He (Mr. Parris) had recently restored some pictures at Norbury Park, Surrey, which, from being painted in the manner referred to, with a mixture of bitumen (pitch) had become perfectly black. The oil and bitumen being differently affected by heat and moisture, they could never coalesce. Most of Reynolds's and many of Wilson's pictures, had suffered from the same cause. The pictures at Norbury were by Pastorini, Cipriani, Barret, sen., and Gilpin; and besides the blackness which obscured them, there were cracks in them so deep, that he had found it necessary to scrape, rub and fill up, to a great extent, to get a surface. At present the preparation and mixture of colours was conducted with such skill that he believed, if they were carefully used, the pictures of living artists would be as enduring as the best of the old masters. Magilp was a mixture of drying oils and mastic varnish; the drying oils being boiled to blackness with sugar of lead, &c. The landscape by Rubens in the National Gallery, formerly the property of Sir George Beaumont, while in his possession was never varnished, but merely rubbed with salad oil to nourish it. He agreed with Mr. Foggo, that the greatest changes in pictures took place soon after they were painted, and was decidedly of opinion that the London atmosphere was not at all injurious to pictures.

Mr. Mocatta thought that the latter point was really the most important, and he hoped that the removal of the National Gallery would not be decided on till the Institute, as an important public body, had been appealed to, when it would be for them, if they thought fit, to make a stand in favour of the present site. He concurred in the view that the atmosphere of Paris was inferior to that of London for the preservation of pictures; and if the National collection were to be removed, the question was, how far should it be taken. Certainly it was important, if it could be done with safety, to retain it in the metropolis. It was satisfactory to know, as Mr. Smith had stated, that 15,000*l*. would produce an entirely new elevation for the present building.

Mr. Jennings inquired whether the sulphuric acid from the gas used in London was supposed to be injurious to pictures.

Mr. Papworth repeated that Mr. Faraday considered ammonia to be the sole cause of injury.

Mr. Parris agreed with Mr. Faraday; and considered that, if a picture were to be left without varnish (which, however, was never the case in London), the acids arising from the gas would immediately combine with the oil. Varnish being a gum, of course, resisted all the acids and salts. The Cartoons of Raffaelle which had been brought to London, were as perfect as those which had never been removed.

Mr. Foggo said that sulphuric acid could not penetrate the thinnest coat of any other surface.

Mr. Twining referred to the varying condition of the works of the old masters in this and other countries, as a proof that they were not deteriorated by atmospheric influences, but by some cause dependent on the manner in which they were painted. Even if the London atmosphere were injurious, no removal to a less distance than twenty miles could prevent the evil. He cordially approved of Mr. Smith's ingenious proposition, especially as economically improving the elevation of the present building.

Mr. Hesketh eulogised the arrangement of the additional building, as proposed by Mr. Smith, which gave the smallest quantity of external wall to be exposed to the damp, and afforded access from room to room without going again over the same ground; the necessity for doing which (as there was only one room in depth) was a serious defect in the present building.

Mr. James Bell, M.P., said that if the site of a new Gallery at Kensington had been actually secured, as had been stated, it would require the utmost vigilance on the part of the Institute to prevent the completion of the scheme. If, indeed, that plan were carried out, the Cartoons at Hampton Court would be more accessible than at the National Gallery. He would not call the proceeding referred to a job, though he could hardly describe it in other terms; and if Mr. Foggo had accurately characterised the proceedings of the last committee, the Institute would know what they might expect.

Mr. Billings congratulated the Institute that a member of the body was now in a position to look after this and similar matters in parliament. He thought nothing effectual could be done to improve the present elevation of the National Gallery, and that so many private collections would be offered to the nation, if a proper building were provided, that Mr. Smith's plan (ingenious as he admitted it to be) did not provide anything like sufficient space. If a new National Gallery were to be built, he hoped the design would be open to general competition; but, if what he had heard was correct, he thought the plans for the intended building at Kensington were already nearly prepared.

Mr. Mocatta, in proposing the thanks of the meeting to Mr. Smith, expressed a hope that Mr. Billings was misinformed, and that there might yet be an opportunity for the Institute to interpose.

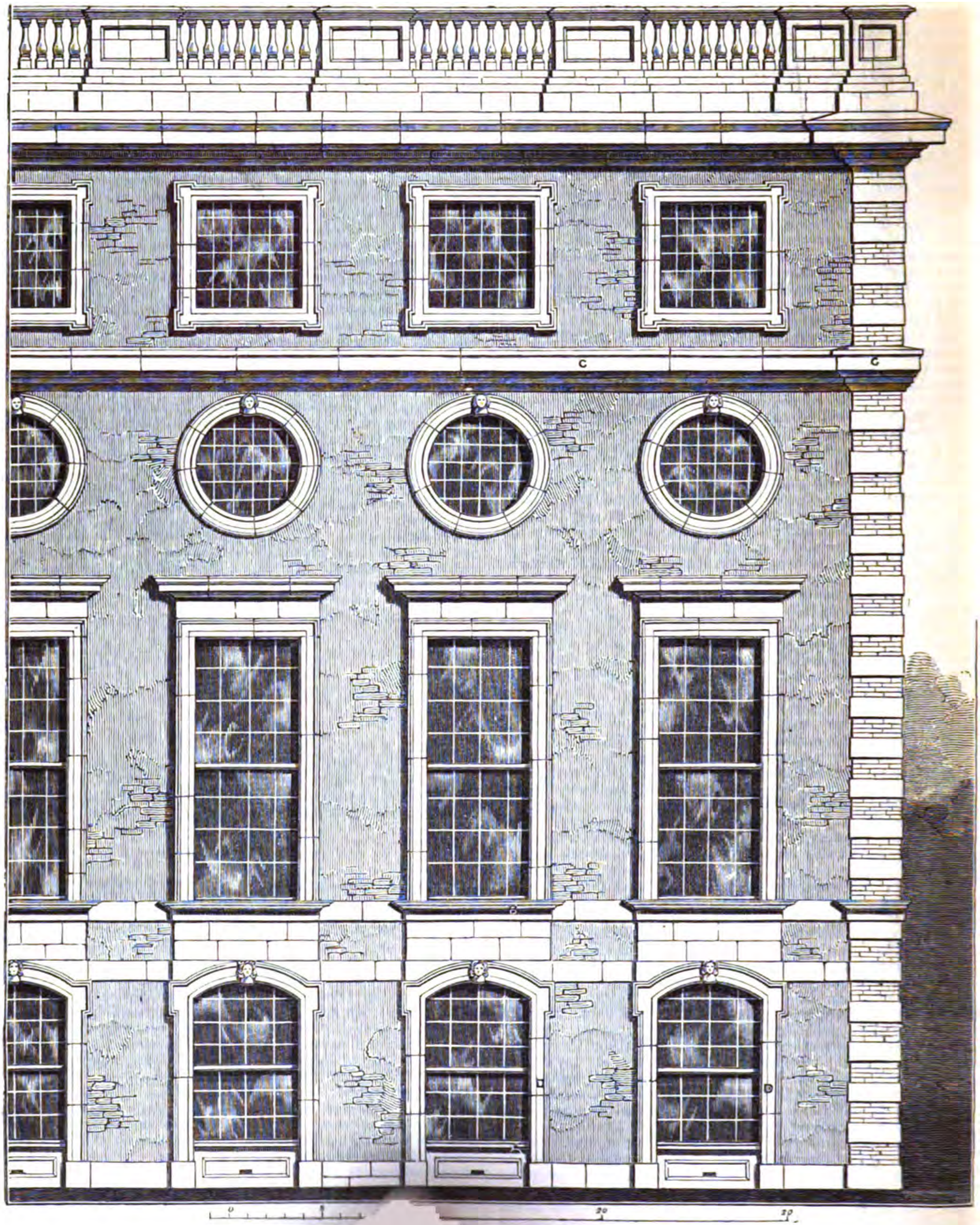
FLOATING BRICKS.

Mr. Horner has exhibited, at the Liverpool Architectural Society, some specimens of a very light description of brick, manufactured from silicious earth, found in the Tuscan Maremma, called in that country "fossil flour." The deposit of this earth, which may be, perhaps, a mile in extent, exists near Castagneti, supposed to be about the centre of ancient Etruria, and was first discovered during excavations made in search of Etruscan antiquities. Mr. Harald Srûb, of Leghorn, who furnished the descriptions from which Mr. Horner gave a translation, says—"Arrived at the pit, we turned up the surface with picks. In the first place, we came upon a stratum of vegetable earth and remains of trees, under which lies the 'fossil flour,' called by the country people 'Latte di Luna' (Milk of the Moon). This is a light, porous earth, somewhat tenacious and moist, which is dug out in lumps, and which is remarkably white, although it may sometimes be stained by infiltration from the vegetable mould. If exposed for some time to the action of the sun and air, the earth loses its tenacity, and where stained becomes pure white, showing that the accidental colouring matter was vegetable. When viewed through a strong magnifier, it appears for the most part to be composed of small, shining, needle-like crystals, not visible to the naked eye. Water being thrown upon the earth, it gives out an argillaceous smell, with a very slight steam. It is also slightly plastic. Exposed to the heat of a furnace, it remains infusible, and only loses about one-eighth of its weight. My friend, Signor Fabbroni, turning it to account in a very ingenious manner, has made bricks of it, so light that they will float in water. Quoting from memory, I give the result of this friend's analysis, viz.:—

Silica	·55
Magnesia	·15
Water	·14
Argilla (Alumina ?)	·12
Lime	·03
Iron	·01
	1·00

Its composition, therefore, is very different from that of other earth commonly called by the same name, 'Latte di Luna,' which is simply a pure argillaceous carbonate; and, not to confound this with other substances, we call it, with Signor Fabbroni, 'fossil flour.'"

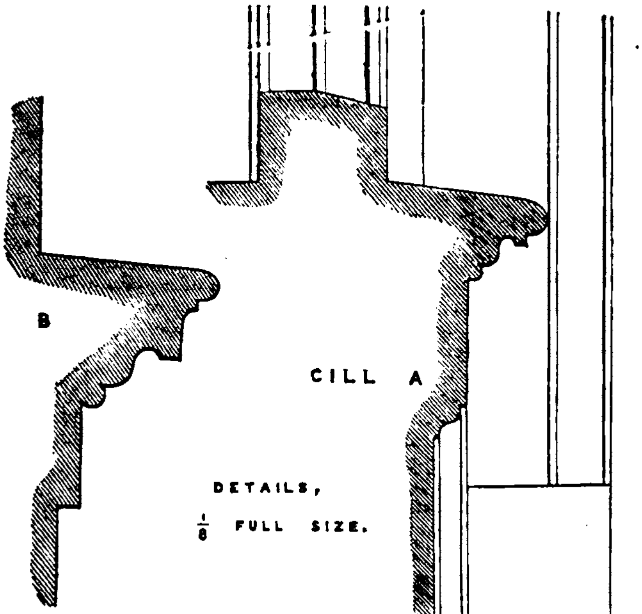
The Clyde.—Lately there was launched from the building-yard of Messrs. Tod and Macgregor a large iron steamer, for the Peninsular and Oriental Company in the Indian Seas, of a tonnage of 2300 tons. The launch was attended by circumstances exactly resembling those of the recent launch of the *Marion Moore* at Liverpool. While the men were engaged knocking away the shores or supports at the stern part of the vessel, the immense mass was suddenly seen to move, and plunged into the river; the ship did not wait for her name —the *Bengal*—but it was wafted after her. She is 10 feet longer than the *Great Britain*; but having less depth and breadth of beam, she has not, of course, the same amount of tonnage. The same gentlemen have in the course of construction in their building-yard two steamers, to be named the *Cadiz* and the *Douro*, each of 1000 tons, and they are about to lay down the keel of a magnificent steamer to be called the *Simla*, and which will be 20 feet longer than the *Bengal*. All these are for the Peninsular and Oriental Company. Indeed, when the present contracts held by Messrs. Tod and Macgregor, and other gentlemen in the neighbourhood, are finished, this company will have spent no less than one million sterling in ship-building on the banks of the Clyde.

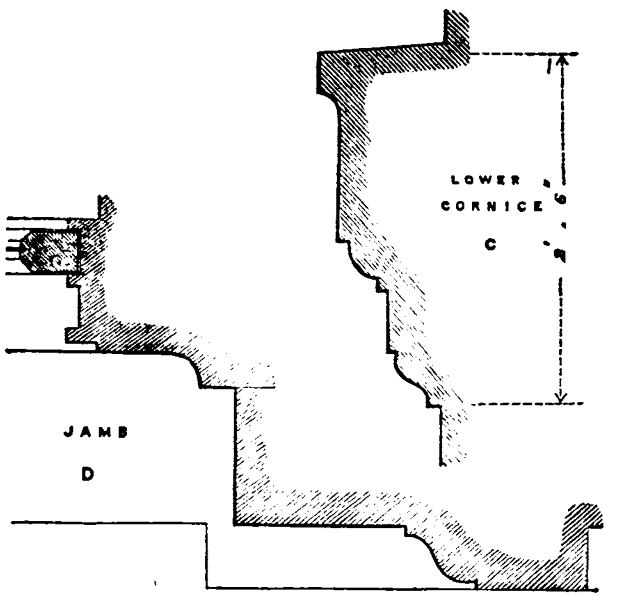


HAMPTON CO —ELEVATION OF EAST FRONT.

HAMPTON COURT PALACE.

We have already (*see* page 66, Vol. XIV.) called attention to this extensive pile of building, to the circumstances of its erection at different periods and under different auspices, and given some general remarks upon the architecture itself. On the present occasion the subject of our illustration, and of these notes, bear reference to the eastern part more particularly, the whole of which portion was designed by Wren, conjointly, it may be said, with his royal master, William the Third. It will be recollected that our former drawings alluded to were in illustration of the Fountain Court, which immediately adjoins the eastern wing, and serves as the connecting link between the Classic and Gothic portions of the edifice.





The eastern front presents a symmetrical design, of which a small portion, with its details, is shown in the annexed engravings. Documentary evidence shows that it was erected between 1690 and 1694, for the purpose of increasing the number and convenience of the state apartments. For this reason the rooms are all *en suite*, and of imposing proportions and decoration. Externally the front presents a massive, unbroken elevation, about 330 feet in length, executed in red brick; the alternate angle-quoins, the window-dressings, and ornamental accessories, being in stone. There are in all nineteen compartments in this elevation. The centre consists of an eight-column pseudo-portico of the Corinthian order, having a well-proportioned entablature and pediment, with elaborate sculpture in the tympanum. This order occupies the first-floor and mezzanine story only, for in the attics the columns are replaced by pilasters, and in the ground-floor by piers. Between these latter is the approach to the Fountain Court, already alluded to, through some peculiarly elegant iron gates, which give great completeness to the *ensemble*.

Sculptured devices are scattered freely and varied, but chiefly referring to national events, monograms, and royal initials. The keystones to the windows alone will, on examination, fully corroborate these statements. But the subject is exhaustless. Let all see and compare for themselves.

THE CATHEDRAL OF ST. ASAPH.

By J. H. Cooper, Trin. Coll. Cam.

[*Abstract of a Paper read at the Cambridge Architectural Society.*]

In the midst of the Vale of Clwyd, about seven miles from the sea, the rivers Elwy and Clwyd unite their waters. At the point of land formed by this confluence is a steep hill (according to books, "arises a gentle eminence"), or rather—for the hill is only on the north side—the level of the Vale suddenly sinks; and on the sides and base of this acclivity is scattered the city of St. Asaph, the principal street being straight up the steep hill, after the usual fashion of Welsh towns. At the summit stands the cathedral, and though on elevated ground, yet its lowly height, surrounded by its tall churchyard elms, gives an impression of but simple grandeur and modest dignity.

Mr. Cooper gave a lengthened and interesting description of the origin and early history of the city and cathedral, and having noticed the dilapidations and restorations the latter had at various periods undergone, proceeded to give an account of its more modern history, as follows:—

In 1629, after a succession of bishops, a repairer and beautifier was found in J. Owens, chaplain to Charles I. when Prince of Wales, and the first bishop to establish preaching in Welsh. He rebuilt Bishop Redman's throne, made a neat pulpit, and also set forms for the accommodation of worshippers in general. Nor did he stop here, for he gave an organ. At this time we may consider this cathedral to have been in its most perfect state; it had been repaired and adorned by the pious care of its bishops as it had never been before, nor yet has been since; but, like Solomon's Temple of old, the period of its greatest glory was short—the day of rebellion, with its attendant sacrilege and despoiling was at hand. A few years, and, instead of the notes of the organ, the neighing of horses and the bellowing of oxen resounded along the nave, calves were tied up in the choir, the holy font was turned into a pig's trough. The generous bishop had fled in exile and poverty, and his palace was converted into a beer-shop.

In 1669, Isaac Barrow, uncle to the master of Trinity, was translated from the Isle of Man, and instantly set about repairing his cathedral, and especially the choir, the east end of which is covered with the wainscoting he placed there. His tomb is just outside the west door, and has inscribed on it a prayer. In 1708, there came Bishop Fleetwood, who laid out large sums of money on the interior of the cathedral, repairing it, and painting and "beautifying" the choir. The present throne is the work of Bishop Griffith (1714), who, however, never occupied it, dying just as it was finished.

As to the present state of St. Asaph's Cathedral, in an architectural point of view, its great peculiarity is, that it has no peculiarity about it. It is more uniformly built than English cathedrals in general: any further comparison only serves to point out its defects. We look in vain for some of the most beautiful features of a cathedral church—the lady chapel, the cloisters, the chapter-house, and even the monuments. Richman describes it as a plain cross church, principally in the Decorated style; and it certainly is a singular example of what appears a paradox—viz., Plain Decorated. We have only two dates to keep in mind—1284, when the walls and pillars now remaining were erected, at which time (Edward I.) the Decorated style had just been introduced; and 1490, when Bishop Redman put in the east window, and raised the walls to the height at which they now stand, and then the Perpendicular had fully developed its distinctive features.

A close examination supplies a proof of the fact of the different periods of building, for the upper part of the nave is not of the same workmanship as the lower; and while most of the church is built of a red soft stone, the east window is of white free-stone; while the windows of the nave and transepts are Decorated, the five in the clerestory show that they owe their shape to the times of the Tudors. Let us now go round the church, beginning from the west. Here we find a very plain simple front, having a deeply-recessed Pointed door, and a really elegant (from its excellent proportions) Decorated window of six lights, with flowing tracery, which excited the admiration of Richman. On each side a plain square buttress terminates in a pinnacle panelled and crocketted; and it is to be remarked, that the buttresses about the cathedral are both few and plain; the plain cross on the gable point has been recently restored. The nave has side aisles, though the transepts and choir are destitute of them. The south aisle can boast of nothing but four plain Decorated windows, a door now closed up, and the apertures in the clerestory, hardly windows, which are square, and of Tudor work. Among the beautifyings of modern times, the clerestory has entirely disappeared from the inside. The transepts are very good features in the cathedral, presenting, as they do, some simple beauties of the late Decorated in the windows both of the north and south sides and their east walls. The north and south walls of the choir have each two late Decorated Pointed windows, now filled with stained glass by the bishop, as a memorial of the late Mrs. Short; and in the east wall is one said to be copied from a window at Tintern Abbey, filled with stained glass in 1810, by voluntary contributions, the subject being the arms of the contributors. At the intersection of the nave and transepts rises a square embattled tower of very lowly appearance, being only 90 feet high; each face possesses as its sole ornament a Late Decorated window, and up the north-east corner runs a square staircase turret to an elevation slightly above the rest of the tower.

Measurements of St. Asaph's Cathedral.

	ft.	in.
Breadth of tower between bases of pillars	30	10
Breadth of nave and aisles	67	9
South aisle from wall to pillars	13	6
North aisle from wall to pillars	14	2
West end to south door	27	0
West end to north door	15	0
Breadth of doors	4	6
Distance between pillars in nave	12	9
Square of base of each pillar	4	9
Thickness of 2 great western pillars of tower, E. and W.	5	6
Breadth of transepts	33	6
Bishop's throne, distant from altar	14	0
Breadth of choir (east end)	32	0
Height of walls of choir	33	0
Pitch of roof	45	0
Thickness of buttress at west end	4	3
Distance to second buttress	20	7
Thickness of second buttress	2	2
Distance to third buttress	18	0
Thickness of third buttress	2	3
Distance to fourth buttress	18	0
Thickness of fourth buttress	2	3
Distance to transept	16	0
Length of transept from corner to corner	40	9
Height of transept to pitch of roof	40	0
Length from west corner to transept	87	7
Square of steeple = breadth of transept		
From east end of transept to first buttress	18	0
Thickness of first buttress of choir	3	0
Distance to second buttress of choir	17	9
Thickness of second buttress of choir	3	0
Distance to east end of choir	18	0
Thickness of east buttress	3	0
Length of church from east side of transept	62	0

On entering by the west door we are met at once with a proof of the extent of mischief usually wrought in modern times by "substantial *repairs*" and "*beautifying*" operations, which seem to have but one universal rule—to destroy the character of the building, by additions as much as possible at variance with it. The nave and aisles are plain almost to meanness; the arches, indeed, are Pointed, but their pillars are without capitals; the ceiling is plain, in the worst sense of the word, consisting, as it does, of plaster vaulting, with a few lines here and there to represent tracery. In the nave this style of roof has only lately succeeded a timber one of unornamented beams and rafters. The tower rests on four Pointed arches, in the western of which is the screen and organ. The transepts are blocked up to serve the purposes (north) of chapter-house, vestry, and (south) of library. The choir is mainly "a modern re-edification, with much attempt at the imitation of ancient work, but with no real resemblance to any style, though the intention seems to have been the imitation of Perpendicular." The canopies of the stalls alone remain to attest the short-lived beauty of the original choir; they were carved for Bishop Redman, and still bear his arms. Fourteen feet from the altar is the episcopal throne, erected by Bishop Griffith in 1714; it is not above 14 feet high; but neither does it, or the pulpit, possess any features worthy of notice.

PLAIN CYLINDRICAL DRUM PROPELLER.

Professor A. CRESTADORO, Inventor.

THE patentee of this novelty in steam navigation considers the use of paddles to be a mistake, and that the best and cheapest method of improving the propeller is to use simply the plain circumference of cylindrical drums. He states that it is a natural supposition that a plain round surface should have no tractic adhesion with the water; but, on close examination, it will be found not only that such is not the case, but, what is even more surprising, the tractic adhesion of a plain cylindrical drum is far greater than that of a paddle-wheel of equal size. Taking, for instance, the steam-vessel *Atlantic*, whose paddle-wheels are 35 feet diameter, and length of paddles 12 ft. 6 in.; supposing a moderate immersion of 5-feet paddles, one pair of drums of equal size at equal immersion would displace a pair of cubic segments at about 125,361 lb. of water; or, what amounts to the same thing, a pressure of not less than 60 tons would act upon the drums as a tractic adhesion, which is by far superior to that afforded by the best method of paddle-wheels in the most favourable circumstances. Now, the cylindrical propeller has the substantial advantage that it can be, when reduced to a moderate diameter, applied as well totally immersed as if it be fitted into a semi-cylindrical case, with only such a clearance as is just sufficient to let the drum have a proper action, the other half drum or semi-cylinder projecting out of the case for the propelling action. There is no piece of mechanism which more strenuous and frequent attempts have been made to improve or supersede than the paddle-wheel, and of which there are so many different descriptions. Surely, when so many and large interests are at stake as are represented by steam navigation, those who are engaged in the large steam communications should give it a fair trial. In a heavy sea, where the rolling of the vessel is considerable, what a difference between a paddle-wheel and a plain cylinder! And the machinery of such a propeller would not require to be repaired during the passage, as is often the case with the paddle-wheels, causing a loss of time equal to what has been gained. And when we consider that each of the paddle-wheels of the *Orinoco*, *Parana*, and *Magdalena*, weighs nearly 80 tons, it is not too much to say that, with such a weight, a cylindrical propeller may be made quite gun-proof.

The patentee is of opinion that an immense advantage will also be obtained by the surface of a cylinder entering and leaving the water without a splash, in removing the great obstruction to the practicability of steam-vessels of quick velocities in canal navigation—that is to say, the agitation of the surface, and the consequent injury to the banks of the canal.

Society of Antiquaries.—At the meeting of the Society of Antiquaries on the 25th ult., the attempt to increase the subscription from two guineas to four, was defeated by a division of 51 to 39. The reduced subscription is looked upon with confidence by its promoters, as a means of restoring the Society to a position of greater utility, and of enabling the more extended co-operation of persons interested in antiquarian pursuits. The opposition seems to be based on the desire to keep up an exclusive system, and to prevent a competition with the Archæological Institute and Association, which have thriven under the exclusive *regime* of the Society of Antiquaries. Now, that the late heavy subscription of four guineas is finally abolished, we may look to the inrolment in the Society of many practical and zealous antiquaries.

DIMENSIONS AND COMPUTATIONS OF THE AMERICAN, PITTSBURG, AND CINCINNATI PACKETS, AND SOME OF THE OTHER LARGE STEAM VESSELS WHICH NAVIGATE THE OHIO RIVER, ABOVE OR BELOW THE FALLS.

By William J. McAlpine, C.E.

PARTS MEASURED, in feet, and decimals of a foot.	Pittsburgh and Cincinnati Packets.							Louisville and Cincinnati Packets.		Louisville and New Orleans Steamboats.				Steubenville and Wheel'g Packet	Louisville and Frankf't Packet
	Clipper No. 2.	Brilliant.	Keystone State.	Buckeye State.	Messenger, No. 2.	Cincinnati.	Hibernia, No. 2.	Benjamin Franklin	Telegraph, No. 2.	Bostona.	Alex. Scott.	Peytona.	Magnolia.	Cabinet.	Blue Wing, No. 2.
Lengths—															
Stem to stern	215·	227·	250·	264·	244·	242·	226·	255·	..	265·	266·	265·	295·	172·	153·
Stem to promenade deck	28·	28·	28·	28·	29·	28·	28·	..	..	25·	26·	28·	35·	27·	21·
Stem to boilers	59·	71·	73·	81·	71·	73·	73·	80·	..	75·	82·	83·	88·	55·	40·
Stem to wheelshaft	145·	157·	162·	172·	160·	157·	152·	165·	..	173·	169·	177·	186·	129·	108·
Of pilot houses	9·	8·	8·	10·	8·	8·	8·	11·	..	12·	10·	14·	16·	..	10·
Breadths—															
Of beam	32·	32·	30·	30·	31·	31·	28·	34·	..	34·	34·	33·	35·	27·	27·
Outside of guards	54·	58·	57·	56·	58·	55·	54·	66·	..	66·	69·	69·	72·	..	37·
Of pilot house	15·	15·	12·	12·	12·	12·	14·	13·	..	14·	13·	13·	16·	..	10·
Depth of hold	6·9	7·5	7·2	7·8	7·2	7·4	7·	7·	..	7·5	8·	8·	9·	5·6	5·7
Draught when light	3·2	3·5	3·3	3·5	2·9	3·3	3·5	..	3·5	4·7	3·8	..	4·4	1·8	2·7
Heights above the surface of the water when light—															
Main deck	4·4	4·0	4·3	4·5	4·2	4·3	3·5	3·3	4·2	3·5	4·	4·3	6·0	..	3·7
Promenade deck	16·8	16·	16·	16·	15·	16·	14·5	15·	17·8	15·8	16·3	18·3	21·3	..	10·
Hurricane deck	22·3	23·6	25·	23·8	22·5	23·	19·5	24·5	27·	26·5	27·	26·5	30·	..	21·
Skylight deck	25·9	26·1	27·7	26·	25·2	25·5	22·	28·7	31·2	29·	29·5	29·8	34·2	..	23·
Pilot house	45·1	46·3	46·1	45·7	45·4	45·8	40·5	48·6	50·4	49·5	50·1	43·8	56·7	..	32·5
Wheel house	26·7	30·7	30·3	30·8	28·4	32·	24·2	29·5	32·3	30·2	34·5	32·	41·5	..	24·
Cross braces	28·7	..	27·7	34·1	26·8	26·7	43·5	29·5	..	29·5	32·	30·8	38·2	..	25·3
Hog chain braces	..	51·4	..	52·4	..	..	..	..	..	..	..	..	..	..	..
Paddle Wheels—															
Diameter	25·	29·5	30·	31·3	30·	32·6	26·	27·5	30·	30·	30·	30·	40·	22·	25·
Diameter of shaft	1·	1·3	1·3	1·4	1·3	1·3	..	..	..	1·3	..	..	1·5	..	..
Length of bucket	11·3	11·4	12·	11·5	12·	11·	12·	14·7	12·	14·	15·	16·	12·2	8·3	7·
Width of bucket	2·	2·2	2·7	2·6	2·5	2·3	2·6	3·	3·	2·5	2·3	2·5	2·4	2·2	2·
Number of sets of arms	16	20	19	20	18	18	18	18	18	18	20	18	26	15	14
Revolutions per minute	22	20	19	18	19	18	19	16	18	20	18	16	16	24	23
Chimneys—															
Centre of flues ab. surf. water	9·7	9·5	9·5	10·	9·7	9·8	8·1	8·6	9·5	8·6	9·2	9·8	12·	8·2	8·3
Hinges " "	54·5	59·	27·	26·8	64·	21·9	53·7	..	..	..	..	..	..	..	23·6
Top of " "	66·7	71·5	77·5	74·8	74·	84·7	63·7	72·7	79·8	85·8	87·5	73·8	90·4	56·	55·6
Top of, above flues	57·0	62·	64·0	64·8	64·3	66·9	55·6	64·1	66·3	77·2	76·3	64·0	78·4	47·8	47·3
Distance between chimneys	..	18·5	18·	..	..	17·8	15·3	..	..	..	..	..	..	..	..
Diameter of	3·66	4·55	4·06	5·50	4·45	4·45	4·5	4·6	4·85	4·75	5·	5·1	5·	..	3·55
Width of iron rings	2·04	2·07	2·17	2·06	2·04	1·75	2·	2·0	2·0	1·92	2·	1·83	2·0	..	3·56
Boilers—															
Number	4	5	4	5	5	4	5	6	5	5	6	6	6	2	3
Length	26·2	26·5	30·8	30·2	30·	28·	27·	32·	30·	34·	31·	32·5	30·	26·	22·
Diameter	3·08	3·33	3·45	3·5	3·37	3·33	3·42	3·33	3·33	3·5	3·5	3·5	3·5	3·5	3·33
Distance from centre to centre	3·7	4·	4·1	4·2	4·2	4·1	4·	3·7	4·	4·	4·2	4·2	4·1	4·	4·
Number of flues	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Diameter of flues inside	1·08	1·29	1·45	1·45	1·33	1·27	1·17	1·17	1·33	1·33	1·21	1·25	1·33	1·33	1·25
Draft space, back end	0·83	0·70	1·	0·75	0·90	1·	0·90	0·92	0·75	0·75	..	..	..	..	..
Draft space, over bridge	0·42	0·42	0·5	0·64	0·60	0·58	0·50	0·50	0·70	..	..	..	0·83	0·46	..
Pressure of steam, in lbs.	150	140	140	140	150	150	150	130	160	145	140	125	125	135	130
Heaters—															
Number	1	2	2	2	2	2	2	2	2	2	2	2	2	2	1
Diameter	2·	2·7	2·9	2·9	2·7	2·3	2·5	1·7	2·	2·5	2·3	2·	2·9	1·5	2·2
Length	4·	8·2	8·2	10·5	10·2	8·3	7·5	6·	6·	6·	8·	8·	8·	5·	6·3
Grate Bars—															
Length	4·	4·	4·	4·1	4·1	4·	4·	4·	4·	4·	4·1	4·1	4·	4·1	4·
Thickness	0·07	0·06	0·06	0·08	0·09	0·07	0·07	0·12	0·12	0·17	0·11	0·17	0·06	0·17	0·12
Spaces, width of	0·07	0·07	0·07	0·08	0·08	0·07	0·16	0·08	0·08	0·06	0·08	0·06	0·06	0·11	0·08
Depth of, below boiler	1·75	1·54	1·62	1·58	1·50	1·67	1·67	1·83	1·67	1·67	1·83	1·75	2·	1·04	1·67
Engines—															
Number of cylinders	4	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Diameter of do.	1·33	2·19	2·12	2·42	2·33	2·	2·33	2·50	2·17	2·21	2·08	2·50	2·50	1·42	1·46
Length of stroke	7·	8·	8·	8·	7·50	7·	8·	8·	9·	9·	10·	10·	10·	5·50	7·
Cuts off at	5·25	4·	3·5	5·	4·6	3·5	5·	4·	6·75	5·	6·25	6·25	6·25	2·75	4·38
Length of connecting rods	24·	26·	26·	26·	26·	26·	24·	26·	27·	29·	30·	30·	35·	20·	22·
Size of steam ports, in sq. ft.	..	..	..	0·2552	..	..	0·1872	..	..	..	..	..	0·3886	..	·1512
Size of escape ports	..	..	..	0·3984	..	..	0·2988	..	..	..	..	..	0·4814	..	·1800
Diameter of steam valves	0·33	..	..	0·56	0·50	..	..	0·58	0·62	0·54	..	..	0·71	0·33	..
Diameter of escape valves	0·46	..	..	0·62	0·58	..	..	0·67	0·71	0·62	..	..	0·79	0·43	..
Diameter of steam pipe	2·	2·	2·	..	..	..	..	..	..	..	..	..	..	..	..
Diameter of branch pipes	0·40	0·67	0·56	0·65	0·65	0·50	0·65	0·65	..	0·67	0·67	0·70	0·67	0·34	0·50
Diameter of exhaust pipe	1·00	0·90	1·10	1·10	1·10	0·80	1·10	1·00	1·00	0·9	1·00	1·20	1·00	0·50	0·80

Dimensions and Computations of American Steam-Vessels, by W. J. McAlpine, C.E.—(*Continued.*)

[From the Journal of the Franklin Institute, U.S.]

PARTS MEASURED, in feet, and decimals of a foot.	Pittsburg and Cincinnati Packets.							Louisville and Cincinnati Packets.		Louisville and New Orleans Steamboats.				Steubenville and Wheel'g Packet	Louisville and Frankf't Packet
	Clipper No. 2.	Brilliant.	Keystone State.	Buckeye State.	Messenger, No. 2.	Cincinnati.	Hibernia, No. 2.	Benjamin Franklin	Telegraph, No. 2.	Boston.	Alex. Scott.	Peytona.	Magnolia.	Cabinet.	Blue Wing, No. 2.
Engines to work pumps—															
Diameter of cylinder	0·75	1·00	..	0·75	0·75	0·92	0·67	0·75	0·75	0·67	0·75	0·50	0·92	0·58	0·58
Stroke of do.	2·00	1·50	..	1·83	1·50	1·25	1·83	1·42	1·75	1·42	3·0	1·58	2·25	1·25	
Number of cold water pumps	2	2	2	2	2	2	2	2		2	2	2	2	2	1
Diameter of do. do.	0·46	0·46	0·52	0·54	0·50	0·48	0·42	0·58	0·44	0·46	0·67	0·46	0·58	0·33	0·37
Stroke of do. do.	..	..	..	1·42	1·29	1·50	1·00	1·50	1·75	1·17	2·0	1·58	1·67	0·71	
Number of hot water pumps	2	2	2	2	2	2	2	2		2	2	2	2	2	1
Diameter of do. do.	0·46	0·46	0·52	0·50	0·50	0·48	0·42	0·33	0·42	0·37	0·37	0·33	0·50	0·29	0·29
Stroke of do. do.	..	..	..	1·42	0·29	0·50	1·00	1·50	1·75	1·17	2·0	1·58	1·67	0·71	
Fuel consumed per trip—															
Coal, bushels	3200	4000	3000	4000	3000	3000	2500	..	..	..	..	..	..	100·	
Wood, cords	None.	50	72	50	60	20	80	..	..	660					
Average speed—															
Passage down, hours	36	36	36	30	42	38	40	9	10	132	144	..	..	3	
Passage up, do.	52	52	52	50	52	52	52	15	15	132	144	..	..	3	
Against four mile current	10	10	10	12	9	10	10	10	12	12	11	..	..	7	
Time boat commenced running	1848	1846	1850	1850	1848	1850	1847	1848	..	1848	..	..	1850	..	1850
Tonnage, carpenter's measur't	452·1	525·8	516·4	617·2	526·0	535·3	429·1	594·1	..	481·	710·	686·4	918·4	244·2	216·9
Sectional area, in sq. feet—															
Of immersion when light	96·4	107·6	94·1	102·7	82·85	..	94·0	..	..	153·9	123·3	..	150·0	46·6	68·7
Of two chimneys	20·82	32·24	38·32	47·00	30·82	30·82	31·38	33·10	36·66	34·70	38·64	40·36	..	..	19·58
Of all the flues	7·36	13·00	13·20	16·70	13·90	10·08	10·80	12·96	13·90	13·90	13·80	14·76	16·68	5·56	7·38
Over bridge wall	17·06	22·72	20·25	26·95	..	22·73	..	28·12	24·62						
Area in square feet, of—															
One bucket of wheel	22·66	25·69	33·00	30·70	30·00	25·63	32·04	44·25	35·04	35·00	34·95	40·00	29·64	19·16	14·16
Grate surface	59·2	80·	65·6	86·1	86·1.	65·6	80·	88·8	80·	80·	93·32	93·32	98·40	32·80	48·
Spaces in grate	28·36	41·64	36·25	41·16	39·11	..	53·9	23·92	30·93	20·52	41·41	25·66	47·80	12·02	18·13
Whole heating surface	1343	1927	1935	2394	2270	1614	1887	2649	2218	25·60	2667	2839	2716	786	947
Contents, cubic feet—															
Between grate bars and boilers	127	160	137	176	173	139	170	199	170	173	238	230	243	46	99
Boilers, for water and steam	569	775	718	914	889	669	919	1217	858	1125	1320	1353	1191	347	398
Ratio between—															
Buckets & immers'n of vessel	2·13	2·09	1·43	1·67	1·38	..	1·47	..	..	2·20	1·76	..	2·53	1·22	2·43
Grate and effective heating surface	1 to 14·86	1 to 15·54	1 to 18·90	1 to 17·84	1 to 16·92	1 to 15·91	1 to 15·47	1 to 19·49	1 to 17·82	1 to 20·79	1 to 16·96	1 to 17·99	1 to 17·92	1 to 15·55	1 to 12·77
Contents of boiler and effective heating surface	1 to 1·53	1 to 1·60	1 to 1·73	1 to 1·68	1 to 1·64	1 to 1·56	1 to 1·35	1 to 1·42	1 to 1·66	1 to 1·48	1 to 1·33	1 to 1·37	1 to 1·48	1 to 1·47	1 to 1·54
Distance traversed by hot air and gases	107	112	123	122	121	120	107	125	123	142	135	126	135	97	88
Fuel consumed in pounds of coal and its equivalent in wood—															
Per hour	2545	3892	3409	4281	3032	..	2989	..	..	3125	..	..	..	1166	
Per second	0·71	1·08	0·95	1·19	0·84	..	0·83	..	..	0·87	..	..	..	0·32	
Per hour on each square foot of grate surface	43·	48·65	51·97	49·72	35·22	..	37·37	..	..	39·06	..	..	..	35·57	
Nominal horse-power of all the engines —															
At 100 lb. steam, per inch	800	781	659	928	866	514	913	816	895	927	862	1104	1103	267	378
At pressure of steam, stated by engineer of boat	1200	1093	922	1300	1212	720	1279	1060	1432	1344	1207	1324	1380	360	491

REGISTER OF NEW PATENTS.

ORNAMENTING METALLIC SURFACES.

Richard Ford Sturges, of Birmingham, Warwick, manufacturer, for *an improved method or improved methods of ornamenting metallic surfaces*—Patent dated January 24, 1852. [Reported in Newton's *London Journal.*]

The improved method of ornamenting metallic surfaces, which constitutes this invention, consists in the use of designs made of wire, sheet metal, thread, lace, paper, or other fabric or material, placed between two plates or sheets of metal, and subjected to pressure between rollers or otherwise, whereby the design is impressed upon the plates or sheets.

The designs may be continuous (*i. e.* repeated an indefinite number of times upon a long sheet of metal), or central (the design being confined to one part), or partly continuous and partly central—that is, one part may be impressed upon the whole surface of the metal sheets or plates, so as to constitute a ground pattern, and the other portion may be confined to one part of the sheet or plate. Wire designs may be made by bending or working the wire into the desired pattern, either by hand or machinery. Thread designs may be worked by hand or machinery; and the designs in thread met with in commerce, such as lace, muslin, or other ornamental fabrics, may be used for impressing metallic surfaces. Designs of sheet metal or paper may be cut out or pierced by any of the ordinary methods. The patentee sometimes combines patterns or designs of lace or wire work with patterns or designs of paper or sheet metal: for example, he places upon a piece of lace the design of a shield or crest, or some central ornament, such as a group of flowers, and, by pressing the same between the plates of metal, he obtains ornamental surfaces, having a ground pattern like that of the lace, with a central ornament left more or less plain. Sometimes the patentee uses patterns or designs made of paper or sheet metal, or sheets of other substances or fabrics, on which designs have been made in relief by writing or painting; and he finds that such designs, although slightly in relief, and of but moderate hardness, may be readily impressed upon metal.

The modes of applying pressure, to effect the objects of this invention, will vary; but the methods which have been found to answer are—rolling, pressing by presses, and stamping. The metals which are suitable for being ornamented by the above process are—gold, silver, copper, iron, tin, and lead, tinned iron, and the alloys of metals called brass, German silver, and Britannia metal.

Instead of placing a pattern or design between two plates or sheets of metal, and obtaining an impression on each plate, only one plate or sheet to be ornamented may be operated upon; and the said plate, with the pattern or design placed thereon, may be passed between rollers or otherwise pressed; or the pattern may be placed between the plate of metal to be ornamented and a plate of hardened steel or other hard surface, and the whole subjected to pressure.

GAS RETORTS.

JOHN SWARBRICK, of Blackburn, fire-brick manufacturer, for *certain improvements in the method of manufacturing retorts used for gas and other purposes, and in the apparatus connected therewith.*—Patent dated May 22, 1852. [Reported in the *Mechanics' Magazine.*]

Claims.—1. The mode or means of making retorts for gas or other purposes, or moulds, in a vertical or perpendicular position, with the apparatus described for making the same; 2. The mixing of clay with coal ashes or other suitable refuse or substance, or the mixing of different qualities of clay in such proportions as the quality may require, thereby forming an improved composition for the said purpose.

The mode of manufacturing retorts adopted by the patentee is as follows:—He takes clay, as dug from the pit, and if it contains coal or other refuse, burns it until the coal is reduced to ashes; or, if no coal exists in the clay, then he mixes ashes with it, or other varieties of clay, until a suitable material for his purpose is obtained. He then grinds this with just sufficient water to produce a stiff, doughy mass, instead of adding as large a proportion of water as usual. Having taken a mould of the size required (and it is preferred that the moulds should be used in sections two to three feet long, with flanges for uniting them to each other), and placed it in an upright position, he introduces a core-bar into it, which he wedges firmly into the centre; he then rams the stiff clay into the spaces between the mould and core, and, withdrawing the wedges, fills also the space occupied by them with the clay. The core-bar is then raised by a lever or screw, another section of mould joined to the first, the wedges replaced, and the operation of running in clay repeated until the required length of retort is produced. Retorts formed in this manner are dry enough to be at once removed to the oven, and when baked will be found to be free from cracks or fissures.

SALINE AND METALLIC COMPOUNDS.

PETER CLAUSSEN, of Gresham-street, City, gentleman, for *improvements in the manufacture of saline and metallic compounds.*—Patent dated February 3, 1852. [Reported in Newton's *London Journal.*]

The first part of this invention relates to the manufacture of certain saline compounds, such as nitrate of potash, and consists in treating ammonia, and certain ammoniacal compounds evolving ammonia, in such manner that the volatile alkali may suffer decomposition and oxidation, so that certain nitracids, and especially nitric acid, may be formed;—lime, potash, soda, or other suitable base being presented to the nascent nitracid, in order that nitrate of lime, potash, or soda may be produced. To assist the oxidation of the ammonia, the patentee employs an apparatus containing pumice-stone, charcoal, coke, platinum foil, spongy platinum, or other substances which present an extended surface, possessing the property of absorbing large quantities of oxygen. The ammoniacal liquid is allowed to pass over the surface of the spongy platinum or other substance; and it is then, in its oxidated state, brought into contact with a suitable base, so as to form a nitrate of the same. The patentee states, that when using an ammoniacal salt (such as the sulphate of ammonia), he first presents to the salt some suitable body (such as lime) with which the acid will combine, setting the ammonia free: the part of the apparatus in which this change takes place must be closed, to prevent the escape of the liberated ammonia into the air. The ammonia, being absorbed by water, is allowed to drop on to the surface of the spongy platinum or other oxidating substance, and then into a solution of the base of the future nitrate. The above process may be employed in the nitrification of the ammonia obtained in the manufacture of gas from coal.

The second part of the invention relates to the manufacture of soda salts, and consists in the conversion of sulphate of soda, whether made directly or produced as a residuum, into caustic soda (hydrate of soda) and carbonate of soda. Thus, to a solution of sulphate of soda is added a suitable proportion of some substance, which, having a greater affinity for sulphuric acid than soda, will decompose that salt and set the soda free. If, for example, the hydrate of lime, baryta, or strontia be used, sulphate of lime, baryta, or strontia will be formed, and hydrate of soda be left in solution. By long exposure to the atmosphere, carbonic acid will be absorbed, and the hydrate of soda will thereby be converted into carbonate of soda. The decomposition of the sulphate of soda is facilitated by the application of heat.

It is also proposed by the patentee to manufacture hydrate of soda and carbonate of soda direct from common salt, by decomposing that substance by certain organic acids (which are afterwards decomposed by heat); or by gaseous acids; or by hydrates, oxides, peroxides, and certain metallic bases; or by certain carbonates,—carbonate of ammonia excepted.

The patentee claims, first,—the method of oxidation and combination of ammonia with alkaline and earthy bases, for the purpose of forming nitrates. Secondly,—the formation of caustic soda and carbonate of soda by the double or simple decomposition of sulphate of soda or of chloride of sodium.

RAIL AND TRAM ROADS.

PETER BRUFF, of Ipswich, civil engineer, for *improvements in the construction of the permanent way of rail, tram, and other roads, and in the rolling stock or apparatus used therefor.*—Patent dated April 29, 1852.

A metal clip, which the inventor terms a fishing key, is employed for supporting and keeping securely in position the ends of rails. The clip passes round the joint, and by the natural spring of the metal closes on it; or a wooden block may be introduced between one side of the clip and the rail. When chairs are used they should be placed within 18 inches either side of the fishing key. The second improvement is introducing longitudinal sleepers under the joints or ends. The intermediate ones being longitudinal, a transverse lateral motion is prevented, and increased durability acquired. The third improvement has relation to a mode of fastening the ends of rails on railways. These form the first claim. The second is for a peculiar combination of parts forming rail or plank-roads or ways. Longitudinal sleepers are bedded in the ground, and on these timber is laid diagonally, or two thicknesses of planking may be laid down without the sleepers; the latter are laid diagonally to each other. A covering, when necessary, is employed of gravel-ashes, combined with asphalte, kamptulicon, or any preparations of cartouch or gutta-percha. This plank-road may be in connection with an ordinary road, the planking being laid down on one or either side. The patentee calls these roads Agricultural Railways. He proposes, as a means of connecting rail or other roads through places where rails would be inadmissable, that on one side of the roads should be fixed an edge-rail with a guide-block of wood; and at the required distances a longitudinal sleeper, bar, or dished-rail should be fixed in such a manner that it will not be raised above the surface of the road. The ordinary traffic would be enabled to use the whole road, the dished-rail serving to keep it on its proper side. The third claim is for forming tyres of railway wheels with broad flat flanges, to run on flat surfaces; but they are so constructed that the crossings may be no impediment.

CHILLING CAST IRON.

EDWARD HAMMOND BENTALL, of Heybridge, and JAMES HOWARD, of Bedford, ironfounders, for *improvements in the mode of chilling cast-iron.*—Patent dated April 22, 1852.

Claim.—The mode of chilling cast-iron as set forth, in all or any of its modifications.

In casting ploughshares or other articles, on the underside of the matrix is affixed a plate, which forms a chamber; at the lower part a tube is introduced, which serves to convey air, forced in by a fan or other pneumatic apparatus, or an exhaust may be used. At the side of the chamber are vents for the entry or departure of the air; by this means the molten metal is more gradually cooled. In consequence of an equitable temperature that is kept up by the film of air, greater durability is obtained in the moulds than at present, as in order to cool them water is thrown over them, whereby they are frequently cracked. A better quality of iron is produced by the equitable cooling. Water may be used as the refrigerator, care being taken that it is caused to move actively, in order to prevent the generation of steam. In casting plough-breasts a core of a zigzag shape is made in the mould, or a serpentine tube is passed from end to end, which affords an equal cooling to all the parts. Care must be taken in casting small or complicated articles that the steam is not allowed to collect in any of the parts.

SOAP MANUFACTURE.

CHARLES THOMAS, of Bristol, soap manufacturer, for *improvements in the manufacture of soap.*—Patent dated May 1, 1852.

Claims.—1. The combination of apparatus for stirring soap; 2. The pressing of soap in the frames by means of fluid pressure.

The object of this invention in the first place is to supersede the necessity of manual labour in stirring the boiling materials, and also to prevent their boiling over; and secondly, in compressing mottled soap when cooling in the frames. The first is accomplished by having a small agitator suspended from a shaft over the pan, and driven by such shaft. As the soap boils up in the pan it comes within the range of the agitator, which breaks up the surface, and liberates the steam therefrom. The second part is to obviate the plugging of soap, by means of wooden blocks forced in or otherwise. An iron pan is fixed at the bottom of the frame, into which is forced liquor of a greater density than the soap, and thus the soap is necessarily kept in a solid mass from the surface of the liquor to the top of the frame, where a thick board is fastened, to prevent the soap being forced out.

SMELTING.

HUGH LEE PATTINSON, of Newcastle-on-Tyne, manufacturing chemist, for *improvements in smelting certain substances containing lead.*—Patent dated May 1, 1852.

The object of the invention is the smelting of the residuum arising in the manufacturing oxichloride of lead from galena, by the use of hydrochloric acid. The following is the process adopted by the patentee:—4 parts of residuum are smelted with 1 part of common salt and 1 part of granulated or disintegrated iron. They are then run into a conical mould, and when cold the lead and silver, which will settle in the bottom, may be broken off, and the slag remelted on a common slag hearth.

REMOVING HOUSES AND TREES.

STEWART MCGLASHEN, of Edinburgh, sculptor, for *the application of certain mechanical power for lifting, removing, and preserving trees, houses, and other bodies.*—Patent dated April 29, 1852.

The first portion of the invention relates to lifting and removing trees; the second to removing houses and other bodies. A trench is dug out and inside of the building to such a depth as to allow a block of wood with a rail on it to be placed under. Beams of wood are applied at each corner, and along the whole out and inside of the walls and gable, at sufficient distances from each other, with cross-bindings. The binding of the logs and the house together at the same time is done by applying screws to the inside of the logs, which prevents the walls from falling in or out. This framing is attached to a beam of wood which runs the whole length of the house, and has wheels, which run on the rails above-mentioned. Holes are then slapped through the walls, through which bars are introduced, running under the floors and foundations right through, and resting on the framing and carriage. A log of wood is laid over the side walls, projecting at either side; an iron tie runs through this, uniting it with the carriage. The whole being bound together, the carriage is moved forward by any convenient means to the required position over the new foundations. The beams are then carefully removed.

INSTITUTION OF CIVIL ENGINEERS.

Nov. 9.—JAMES MEADOWS RENDEL, Esq., President, in the Chair.

THE business of the first meeting of the present session was commenced by the announcement of the dates of the ordinary meetings; of the appointment of December 21st for the annual general meeting for the election of the President, Council, and officers; and of the 31st of May, 1853, for the President's Conversazione.

The paper read was "*On the Improvement of Tidal Navigations and Drainages.*" By W. A. BROOKS, M. Inst. C.E.

The object of the communication was chiefly to elicit observations from members, and the narration of facts which might be usefully employed hereafter in an investigation into the laws which govern the flux and reflux of the tide in estuaries. The author, after alluding to the impediments to improvement arising from the popular prejudice against such constructions as would appear by their bulk to diminish the space for the tidal water, proceeded to show with how little reason the hacknied phrases "encroachment upon navigation," and "abstraction of tidal water," were applied indiscriminately to works which the experience of engineers pointed out as adapted to ameliorate the flow and ebb of tidal waters.

He then showed that estuaries were of two classes. The first and best kind were bounded by shores, gradually receding from each other as they approached the ocean, with their navigable channels bearing a large proportion to the full breadth of the stream at high water, as in the case of the Thames, &c. The second and inferior kind had tortuous channels of uncertain and varying capacities, and with great disproportion between their relative widths at low and at high water.

The first class afforded perfect drainage to the country on account of their capacious low-water channels, in which the declination of surface was very gentle; the transmission of the tidal wave was therefore quick, and it was able to turn early and attain a head to overcome the ebb, so that the interval of stagnation or rest at sea was very short, which last was the best test for the general good state of a navigation. At the mouths of such rivers there were rarely any bars.

The features of the second class of estuaries were directly opposed to those of the first class; the body of water was generally divided into several tortuous streams at low water, their capacity being greatly disproportioned to the width of the bed, which offered an undue resistance to the flow and the ebb. There was great fall and consequent rapid loss of height in the tidal column, which caused a considerable interval of rest between the currents of the flood and the ebb, during which period a great amount of deposit took place. Numerous other features and their results were carefully pointed out and reasoned on.

The best means were then described for promoting the natural action of the tidal water in rivers of good condition, so as to combine the most efficient drainage of the country with the best state of the navigable channel. The Mississippi was then given as an instance of the effect of a large volume of water, densely charged with alluvial matter, falling into the nearly tideless Bay of Mexico—producing a delta of great extent, and so diminishing the depth of the harbours as to prevent vessels of any considerable tonnage from frequenting the coast. This led to the enunciation of the axiom, that in the improvement of rivers of the second class, although the river walls might not be raised above the level of half tide, they would suffice to determine the future condition of the bed of the estuary, behind and parallel with them, as the conversion of those reclaimed spaces into land was simply a question of time and of the amount of alluvial deposit brought down by the floods. Thus, by this system the same effect would be eventually produced as by inclosing the space with full-tide walls, it being impossible to keep open the rear space as receptacles for tidal water.

The tendency to deposit, in consequence of the formation of breakwaters, in certain situations was fully considered, with the question of the difference between the relative times of high water, as affording a true test of the condition of a river: this latter view should be received with caution, as the only certain test was the condition or progress of the tidal wave throughout the entire period of the flow. Thus the tidal wave would pass more quickly through a broad and straight reach after the sands were covered, although its progress might have been very slow in the earlier stage of the tide, in consequence of the opposition of the sandbanks, which would form for the nascent flow a restricted and tortuous course through a reach which, at high water, might appear well adapted for the ready transmission of the tidal column.

The author then described the broad principles of his own practice in training the current of a river to be based chiefly on the construction of full-tide timber groynes or jetties at right angles to the intended new line of river frontage. These structures, raised at a cost of from twelve to thirty shillings per running foot, had been aptly designated by Sir W. Cubitt "as the scaffolding for forming the new line of shore;" and as "making so much more land and bringing the shore to the form represented by a line drawn through the ends of the groynes." In practice it was found that whilst the spaces between these groynes afforded a locality for the deposit of the alluvial soil held in suspension, their action was also to produce a deepening of the main channel of the bed of the river, at a much less cost than by the construction of parallel rubble walls. In fact, the latter should not be built until the groynes had completed their work of raising the acquired land between them to the level of the bed on which the rubble walls were to be placed.

By adopting these means there was scarcely a river whose navigable capacity might not be greatly increased without any excessive outlay, aiding at the same time the general drainage of the district, which, it was remarked, had been lamentably neglected in many of the schemes promulgated for the improvement of rivers.

Nov. 16.—The evening was entirely occupied by the discussion of Mr. W. A. Brooks' paper. It was contended, that the use of groynes was advisable, as a means for the regulation of the sectional area of the channel, which could only be accurately defined by practical experience. In some cases it would be better to combine them with training walls, on opposite sides of the river. It was not considered that two classes sufficed to distinguish the differences existing between rivers, and that their several characteristics and circumstances must be minutely studied, to determine the mode of treatment. The Wye and the Avon were quoted as rapidly rising rivers, and yet being without bars at their mouths; to which it was replied, that those streams were not cases in point; that they were mere tributaries, whose mouths were traversed and swept clear by the rapid current of the Severn; and that this latter river illustrated the position assumed, as there was a great loss of tidal range between Beachley and Framilode, the channel wandering through a range of shoals. The successful improvements executed at the entrance of Newhaven harbour, by Mr. Stevens, were alluded to. The treatment of the Dee, by groynes, and the Clyde, by training-walls, was examined, and it was argued, that the inconveniences experienced in the former case, from the washing out of deep pools, at the points of the groynes, must be attributed to the injudicious extension of those structures, whence the navigation was too violently contracted, the freshes flowing over them, and removing the deposit from between them. Rennie's Report on the Clyde, in 1807, showed that the irregularity of depth at the points of the groynes previously erected by Golborne, was not anywhere 12 inches more than elsewhere in the channel. With reference to the wide expanse, or "pouch" form of the Mersey, above Liverpool, which it was urged was of utility in scouring the bar on the ebb, it was contended that the main body of water would pass off with the early ebb, without producing any beneficial effect; and it was shown, that in that part the loss of tidal range was considerable, from the great expanse covered at high water, but which was shoal at low water. The improvements of the Thames, by the removal of the shoals, and the construction of training-walls, were described, and it was suggested that it might be beneficial to use groynes in the bays which had produced the shoals, now in course of removal. Fully admitting the impossibility of generalising, in river engineering, it was still urged that there was more similarity between cases than was generally understood; and attention was directed to the inevitable effect, arising from the conflicting action, between the ebb and flood-tides at the mouths of rivers having a rapid rise of their low-water surface near their mouths, which invariably produced bars. It was suggested that the treatment of some special river should be submitted to the Institution, in order to afford an opportunity for a continuation of the discussion of this interesting topic.

After the meeting, Mr. Doull, jun., exhibited a model of, and described a system, proposed by Mr. James Forbes, for lowering and raising ships' boats, and also the construction of a *Cylindrical Ship-Life-Boat*, which latter, it was contended, approached nearer than any other construction, the qualities considered requisite for a boat of that class. The cylindrical life-boat was 30 feet long, 8 feet wide, and 2 feet deep, would carry with ease sixty persons, with provisions for a week, in the air-tight seats—could not be upset, or swamped—could be pulled either end foremost—was steered with an oar—had extra buoyancy in water-tight compartments, and was so constructed that a hole might be knocked into one or more divisions without danger to the whole—was fully stowed with masts, sails, oars, and everything complete, so as to be always ready for use on any sudden emergency. When folded up it was perfectly cylindrical, and on reaching the water opened out, and could in a minute be made a stiff boat, and the dimensions could be modified to suit any vessel. The apparatus for lowering the boats consisted of two davits, with tubular stems, down which the ropes passed, through sockets in the bulwarks, to a drum, on which they were coiled, so as to be easily wound up by a wheel and pinion, with the exercise of very little power, and in lowering, a friction-break could be used with great advantage. By this means the boat would swing out very easily, as the davits could turn entirely round, and it would be nearly impossible that a boat could be swamped, in the heaviest sea, or under circumstances of the greatest difficulty. The cylindrical form, and its lightness of construction, would enable a boat of this sort to be put over the bulwarks by six men, without tackle of any kind, and by merely cutting a lashing when in the water it would fall open, when all the stores, &c., would be found made fast within, and ready for use.

Nov. 23.—The paper read was "*On the Drainage of Towns.*" By Robert Rawlinson, Assoc. Inst. C.E.

The author, believing the subject of the drainage of towns to be so comprehensive, that its full and complete consideration within the limits of a paper, to be read in one evening, would be impossible, restricted his remarks to a few general points likely to induce discussion and to elicit criticism on former and present systems. The historical portion was limited to showing that in the now disinterred ruins of the most ancient cities remains of drains had been found, and the Cloaca Maxima formed part of the wonders of ancient Rome. Politically, the question of sewerage was very urgent, as the general health of the population influenced, to an important extent, the amount of misery, pauperism, vice, and crime existing in every city; and the increasing numbers, as shown by the census, demonstrated the necessity for providing for the extension of all large towns. In 1841, the population of 117 districts, comprising the chief towns, was 6,612,958 souls. In 1851, in the same districts, the number was 7,795,958. Disease had been rife in those districts, but it was shown that much of it might have been averted by timely sanitary precautions.

It was, however, to the social effect of town drainage that the attention of civil engineers would be most naturally directed, as under that head the leading principles of actual practice and the proposed modifications must be brought forward and discussed. The questions of forms, dimensions, fall, cost, &c., of large and small sewers were passed over, with the remark that they were matters of detail, to be fixed by the knowledge and experience of the engineer; contending, however, that the system most deserving commendation was that which enabled the greatest extent of sewerage to be well and cheaply accomplished. The position of the outlet would be governed by natural local conditions, and the dimensions would be fixed by the area and the number of houses to be drained. The material of construction was a question dependent entirely on experience and practice; earthenware pipes were, however, according to the author's views, the most economical and effective for all sewers and drains within the capacity of the material.

It was contended, that town sewers could not receive the excessive flood waters, even of the urban portion of the site; they should never receive the suburban drainage, nor be combined with watercourses; they should be adapted solely to remove the solid and liquid refuse from the houses; and that it was safer for the inhabitants that there should be no sewers at all, rather than they should be of such dimensions as to become places of deposit. Pumping could be profitably adopted in certain situations where, from the level, or the effect of tidal influence, the outlet flow might be checked. Intercepting sewers at mid-level were approved. Sewers of minimum dimensions were advocated, in connection with pumping, and they should be capable of resisting internal hydraulic pressure, in case of the water rising in them. The flow through sewers should be constant, and it was argued, this could only be secured by having small conduits. The extraordinary fall of rain at Birmingham, in July, 1845, when nearly 2 inches of rain fell in half an hour, equivalent to 9·091 gallons per square yard, or 44,000·440 gallons per acre, was used as an argument against the building of large sewers below the level of the cellars, which, to be of service, must be capable of carrying off the heaviest rain-fall. It was contended, that the *maximum* surface water could not be passed through the sewers, but the natural surface outlet should be retained, to assist in carrying off the flood waters from the streets of large cities; though the fact of town sewers not having been originally intended to receive house drainage or soil, was prominently noticed. The want of connection between the houses and the sewers, in many parts of the metropolis, the absolute disconnection at Paris, and the prohibitory law, only recently repealed, at Liverpool, being quoted. With regard to earthenware pipes, 3 inches diameter was considered too small for any drain pipes, and 30 inches diameter too large, for the material of which they were made. Pipes of 4 inches diameter would probably be found the least sectional area that should be used for house drains, and 9 inches for streets, and then not a less gradient than one in sixty. It was decided that the beneficial use of pipe sewers could not be pushed beyond certain limits; but the system should not be entirely condemned because it had been carried to extremes by those who wanted experience. The general success of the use of egg shaped pipe sewers at Manchester was given as an example of the advantageous adoption of the pipe system. The various kinds of joints were described, and it was recommended not to use pipes of larger diameter than about 15 inches, as larger sizes were apt to be fractured, from unequal bearing at the joints. The difficulty of moulding, drying, and burning pipes increased, probably, as the squares of the diameters; if large pipes were moulded too thin, they were liable to be crushed in the finished sewer; and if they were moulded of extra strength, the wet pipes collapsed with their own weight in drying, were twisted out of shape in burning, or were imperfectly vitrified. Sewers of radiated bricks, moulded for the purpose, were better and cheaper than large earthen pipes; a sewer thus constructed, 3 feet in diameter, being cheaper than one of pottery pipe of 20 inches diameter, their relative capacities being as the squares of their diameters; and there was no reason why brick sewers should not be as smooth within and as impervious as any pottery pipe.

After treating of side junctions, gulley-holes, drain traps, and ventilation, the use of cast-iron conduits, in certain bad soils, was advocated, and as a summary, it was stated that all sewers should be below the level of the cellars, and should be specially adapted to the work they had to perform. Rivers and natural streams should not form part of any system of town drainage, and in low districts the sewers should be capable of resisting internal pressure. Free outlets should be preserved, whether from intercepting or low sewers; all small drains should be circular, and large ones oval or egg-shaped; the largest radius should be adopted, and there should be extra fall in the curves; all sewers and drains should be impervious to water, and should present even and smooth surfaces; the gradient of all large sewers in steep ground should be modified, or interrupted, and the materials used should be such as would resist rapid wear and bursting; wherever it was practicable, the outlet should be very free, and in all cases complete ventilation must be provided for. All mention of cesspools was omitted, as no locality could be considered as properly drained in which they were permitted to exist, except near the outlets, for ultimate use for agricultural purposes.

The true purpose of town sewage must be considered, as the removal, with the utmost rapidity, from the vicinity of dwelling-houses, and the sites of cities and towns, all the refuse, which being liable to decomposition, could be conveyed away in water; and the more perfectly this could be accomplished the better would be the work, and the greater the credit due to the engineer.

RECENT AMERICAN PATENTS.*

Improvements in the Manufacture of Plate and Window Glass. T. Clark, Pittsburg, Pennsylvania.

The invention consists, first, in a new and improved combination of machinery for rolling plate glass; and, second, for a new and improved construction of an oven for fire-polishing the plates or sheets of glass.

Claim.—"Having thus described my improved mode of making window or plate glass by machinery, what I claim as my invention is, 1. The use of hollow chilled iron rollers, in the manufacture of window and plate glass, in connection with the mode of heating them with charcoal or other combustible placed inside; 2. the combination of the grooves with the strips and guides and the set screws, for the purpose of regulating the width and thickness of the sheet of glass; 3. The use of trucks, for carrying off the sheets of glass as they pass from the rollers as aforesaid; 4. The combination and arrangement herein before described, of the gates, flues, and furnace, in the construction of the polishing oven."

Improvement in Locomotive Engines. H. R. Remsen and P. M. Hutton, Troy, New York.

This invention relates to the employment of a locomotive engine, of three cylinders, whose cranks are arranged at angles to each other of about 120°, with valves, valve chests, steam and escape pipes, so arranged as only to admit steam to one side of the pistons when the locomotive is advancing, and the other side when it is backing, the reversal being accomplished by such change of the operation of the steam, without recourse to any of the ordinary means of reversal.

Improvement in Valves for Pumps. J. R. Bassett, Cincinnati.

The invention consists of a cylindrical box-valve, with its inducting openings, and its side or water-way openings, and its eduction openings, and of a valve chest adapted thereto, with its induction, and side or water-way, and eduction openings, corresponding to the openings in the valve-box; the whole, in connection with the usual water-ways and barrel of a double acting pump, furnishing the parts necessary to the operation of such a pump; thus obtaining from a single valve, deriving its motion from the out-flowing and in-flowing currents, the result for which several separate valves have hitherto been needed, substantially in the manner described.

* From the Journal of the Franklin Institute.

Improved Valves, or Gates, for Oblique Float Paddle Wheels. J. C. Carncross, Philadelphia.

The invention consists in placing at the edges next each other, of the obliquely arranged paddles of the wheel, a series of radial gates, turning on journals, and having right-angled wings at their axes, for keeping them closed when they pass through the water, to prevent the water being moved laterally by the oblique paddles.

Improvement in Lead Pipe Machinery. B. Tatham, New York.

An improvement upon the method of making pipes from set or solid lead, by a patent granted to T. Burr, of Shrewsbury, in Shropshire, England, dated the 11th April, 1820.

Claim.—"Having the core so that it shall not be affected by the vibrations of the ram; connecting the core with the ram, by means of an universal joint, or its equivalent, so that the core shall be retracted with the ram, in combination with the cylinder and die of a machine for making pipe by pressure, from lead or other soft metal, run into the cylinder and on to the said core in the molten state, substantially as specified, whereby the core is retracted with the ram, and held in position while the charge is poured in, and during the operation of forming the pipe, the vibrations of the ram do not practically affect the central position of the core in the dies, as herein specified."

Improvement in Locomotive Boilers. J. W. Farrel, Reading.

Claim.—"Isolating the lower portion of the water-space surrounding the furnace from the upper portion, and connecting it by a free and constantly open communication with the tank of feed-water, in such manner that the feed-water of the tank will circulate without being forced by a pump in contact with the fire-plates, to cool them, and to be itself heated, preparatory to being pumped into the boiler."

Improvement in Stone Dressing Machines. S. W. and R. M. Draper, Boxborough.

Claim.—"Hanging the arm carrying the pick upon a shaft, which receives a vibratory motion through a cam, driven by a mill spindle, or other spindle provided for the purpose, and giving the said arm a motion lengthwise along the said shaft."

Improved Wrought Nail Machinery. D. Dodge, Keeseville, New York.

The invention is such a combination and arrangement of the cutter, gripers, and hammers, that when a rod of suitable dimensions is introduced into the machine, a piece of sufficient length to form a nail will be cut off, caught into gripers, and passed under a series of hammers, receiving one stroke from each, as it progresses, and revolving during its transition from one hammer to another, so that its different sides may be acted on alternately, until it has passed the entire series and is reduced to the requisite size and form, after which it is discharged.

Claim.—"1. I claim the combination of a series of hammer faces with gripers, having both a rotatory and progressive motion, and so arranged as to convey the blank between the several pairs of faces successively, at the same time revolving it so as to present different sides successively to the hammers; 2. The several hammer faces, which act successively upon the blank, with regard to the distance of the lines in which they respectively move from the line in which the gripers move, that when the gripers move forward in said line, thereby conveying the blank from one pair of faces to another, the successive strokes which it receives, will fall on different points, thereby reducing different parts of it, successively, to the required size; 3. An arrangement of the faces, with respect to the gripers, such a graduation, in the nearness with which the several pairs respectively approach, when they strike, that the several parts of the blank, upon which they respectively act, will be reduced to different sizes, and that the combined effect of the whole will be to reduce the nail to the proper form; 4. The combination of the two kinds of faces, broad and narrow, with gripers so arranged as to present the blank to the action of the narrow ones, until it is suitably elongated, and subsequently to that of the broad ones, to receive a finish; 5. The arrangement of a set of gripers upon the interior of a circular hub or frame, in combination with hammers placed in or near the centre of the circle in which they are arranged; 6. Adjusting the gripers, by means of a spring, or its equivalent, so arranged as to press them towards the hammers to their proper place, allowing them to recede as far as the lengthening of the nail requires, while the hammers are acting, and causing them to return again when the hammers are withdrawn.

THE AUSTRALIAN BOMERANG PROPELLER.*

The *Liverpool Albion* has given an account of the trial trip of the steamer *Keera*, fitted with Sir Thomas Mitchell's propeller, which combines the parabolic and cycloidal curves; equilibrium, gravitation, the laws of hydrostatics relating to pressure on oblique surfaces under water; and, more particularly, that remarkable law by which the area must be governed—namely, that the area of working surface should never exceed the supplement of the spiral surface over the section taken at right angles to the shaft.

The screw is a modification of the wedge; the bomerang propeller is a rotary oar, so made and attached by gearing obliquely to the axis of rotary motion, as always to present its narrow surface to the plane of the spiral, and a narrow edge in direction of its motion, but obliquely to the resistance. Every part of this edge cuts the water so as to form an angle with the radius, but, on one side, concave, like a sickle; on the other, convex, like a sabre. The two halves of the bomerang perform, distinctly, different functions in rotation, but yet equally; or so that the fore-half takes hold of the water with exactly the same force as that with which the stern-half throws it back. By this means an equilibrium of resistance is preserved, which belongs to no other kinds of propeller. It may be necessary to point out that the action of the bomerang weapon through the air is horizontal; whilst that of the bomerang propeller through water is vertical; that the force of the savage arm in the one case is represented by steam in the other; that gravitation and air afford the resistance in the first case, which in the second is derived from steam power acting on water. This method of converting the equilibrium exhibited by the bomerang's motion on air, while resisting the effect of gravitation, into an equilibrium of resistance in the water, with velocity enough to act on that element as a wedge, is quite new, and was much wanted, to enable us to employ powerful steam machinery with sufficient effect against the well-known powerful resistance of water.

The cylinder of water under the action of any propeller comprises the resisting medium on which that propeller acts. With the bomerang form this water is acted on by one screw, and no more. The three-bladed propeller consists of three perfectly similar portions, placed all in the same plane; consequently, the back parts necessary to complete the spiral to any of them are all wanting; and these three similar parts of a spiral not only have to act on the same cylinder of water, but on the same section thereof, revolving in a plane at right angles to the axis. To such a form of screw lateral resistance is inevitable; and this was so obvious and well-known to the able engineers who constructed the engines for the *Keera*, that they adapted them to this lateral resistance. That these separate bits of spirals so placed as to act on the same cylinder of water, should do about even half as much as *one* spiral when truly applied, shows what a splendid medium has been given by the Supreme Power to man as well as to fishes for purposes of rapid locomotion.

*The specification and an illustration of this invention were given in the *Journal*, Part 156, Vol. XII. (1849), p. 23.

Appointments.—Henry Charles Mules, Esq., is appointed one of the three Chief Commissioners of the Tithe and of the Land Inclosure Commission for England and Wales, in the room of Captain Wentworth Buller, R.N., deceased. Mr. Mules was formerly Secretary to the Inclosure Commission, and has acted in the same capacity to the United Board ever since the consolidation of the Tithe Commission.—Frederick Goodall, Esq., has been elected an Associate of the Royal Academy of Arts, London.—Captain Galton, R.E., has been appointed Government Inspector of Railways, in the room of Captain Laffan, R.E., who has been elected M.P. for St. Ives.—Major General the Hon. George Anson, M.P., has been elected Chairman, and Mr. Robert Benson, Deputy Chairman, of the London and North-Western Railway.

THE INUNDATIONS.

The late floods have been attended with unexampled catastrophes to engineering works, and will be as remarkable in this respect as in any other of their phases of desolation. It will be seen that the destruction has affected not only the small local works, single arches, and highway bridges, but has extended to some of the largest railway viaducts. We have therefore thought it necessary to record some particulars as to these casualties, although we cannot embrace the whole. Although the flood seems to be without precedent in its extent and violence, we cannot but believe that its effects have, to some degree, been promoted by insufficient capacity of works. Within the last few years the great river-basins have been operated on in a two-fold direction, tending to increase the power of the waters. The great lines of communication thrown across the country have in some cases deepened portions of the water-courses, or straightened them, and in others contracted them. The operations of agricultural drainage have likewise given greater means of throwing rapidly into rivers the rain-fall on the land. In the lower parts of the rivers new weirs, bridges, locks, and channels, have been constructed, bringing the tidal influence higher. Thus what is going on upon the Thames from various causes, is to be witnessed in the other basins; and with the progress and tendency of engineering improvement, it may be looked upon as an essential condition in all new bridges and viaducts, wherever situated, to carry down the piers much lower than hitherto, and greatly to increase the waterway. As so many works have been destroyed, and their re-construction is to be proceeded with, we earnestly recommend our professional friends to avail themselves of the present opportunity to carefully investigate the causes and extent of the floods in their localities, and ascertain what operations are in progress, or probable, which may affect their constructions, and so provide against the repetition of catastrophes by which the traffic of the country has been impeded, and so much damage done. Greater waterway must be provided, and solidity of construction is less to be sought in strength of materials, than in judicious location of the members of the works. At the present moment it would be very useful to the profession to bring before the Institution the condition of individual basins; and papers on such subjects would not only afford information directly available to many individuals, but would promote discussions in which the general principles of construction would come under consideration.

NOTES OF THE MONTH.

Builders' Benevolent Institution.—An election of five pensioners will take place on February 22, 1853, at the London Tavern. Applications of candidates must be sent in by the 9th inst. The Builders' Ball, in aid of the funds, is to take place at Willis's Rooms on the 3d of February.

Putney Bridge.—A company has been provisionally registered, having for its object the removal of the present and the erection of a new bridge and pier. The Chelsea Waterworks Company will carry their mains over the Thames by this means, otherwise they would have to erect an independent aqueduct. Mr. Simpson, F.R.S., and Mr. S. Clegg, F.G.S., are the engineers engaged.

Stephenson Monument.—A meeting of the committee appointed to make arrangements for erecting a suitable monument to the late George Stephenson, was held lately. Nearly 3000*l.* has been collected. This sum includes a very gratifying feature—subscriptions from upwards of 3000 workmen, whose contributions ranged from 1*d.* to 5*s.* 178 subscribers had contributed 2550*l.* 15*s.* 6*d.*, and 3150 workmen had given 285*l.* 2*s.* 7*d.*, so that the total amount subscribed is 2853*l.* 18*s.* 1*d.*

Liverpool.—The shipbuilders of this town have come to the wise resolution of helping themselves, instead of calling upon Hercules to pull their wheel out of the clay, and the consequence is, that the trade of shipbuilding is coming back again to Liverpool. First in this movement is Mr. Laird, whose efforts in relation to iron shipbuilding have deservedly advanced his reputation, and brought him a cloud of commissions to build other ships. In addition to the extensive yard at Birkenhead, Mr. Laird has taken the yard next the Dingle, formerly occupied by Messrs. Vernon and Son, but which of late years has been lying idle.

At the Birkenhead yard Mr. Laird is at full work building the African screw steamers; and at the Dingle yard he has commenced operations, having erected some machinery and furnaces, and a number of men are already employed in this yard laying down the keel blocks and erecting the scaffolding for a large iron screw steamer, which will be forthwith commenced, and this long-neglected place will gradually be transferred into a scene of the busiest industry. Next comes the yard of Messrs. Vernon and Son, which is equally alive with iron work for the Danube boats. And last of all come Messrs. Jordan and Getty, who have brought their iron ship up to the last two courses of plates. They are also deepening the *Iron Prince* screw steamer 3 feet. This vessel will be remembered as sailing between this port and Wales a year or two ago. It has been found that this vessel can be safely enlarged to that extent, which will add materially to her carrying powers, and of course make her a more profitable vessel. These builders have further taken the contract for the hull of the new Woodside boat from Messrs. Forrester and Co., the latter gentlemen making the engines. This boat will be laid down immediately. The dimensions are 110 feet long, 20 feet beam, and 8 feet deep. She will differ very little from the other boats, but she will be somewhat better finished, and possibly have a cabin for ladies. It is proposed to place the steering-wheels in the centre of the ship, the steersman occupying an elevated position; and as some platform will be required for this purpose, it would be well to consider whether a deck-house something like that on the *Satellite* could not be erected as a place of shelter in wet weather. At the same time there might be a contrivance introduced by which passengers could step on and off a platform level with the landing-stage, instead of the awkward method at present in use. But to return to iron shipbuilding. There is every reason to believe that it is likely to be conducted on a larger scale than ever at this port. It is more probable that iron shipbuilding will gradually supersede wood, and that the screw, in some modified form not yet discovered, will substitute the use of sails. If we are to believe all we hear, the great obstacle to the use of iron in ships—namely, "fouling," has been overcome. Should this prove to be correct, the question of iron or wooden ships will be at once settled. If an iron ship be sent to China or any other long voyage, she is almost sure to come home with her bottom covered with barnacles, which impede her progress, injure the iron, and make the vessel expensive to be kept clean. But remove this evil, and the only obstacle to the general use of iron is taken out of the way. Many minds are directed to this subject, and it may be that more persons than one will discover the remedy simultaneously. But whoever finds it out will have nothing to do further to make his fortune.—*Liverpool Courier.*

FOREIGN RAILWAYS.

France.—The Paris and Strasburg Company are said to be about to construct a railway from Rheims to Givet. Rheims will then be the centre of three branch lines—one from Epernay to Rheims, a second from Rheims to Douai, and a third from Rheims to the Belgian frontier.——Three additional miles of the trunk line of the Sambre and Meuse Railway were opened on the 8th inst.—viz., from Walcourt to Silenreux, where it joins the great high road from Philippeville to Beaumont. The works of this section have, we are informed, been well executed, and do credit to the contractors. The further works are being pushed forward with much energy. On the main line Mr. Brassey has collected his material, and will be in a position in the course of a few days to considerably increase the force he has already upon the ground, and thus carry on the works at the tunnel at Senzeilles, and along the line. On the branches the contractors have made very great progress—in fact, all appears proceeding very satisfactorily, and promises well for the completion of the line and branches.

West Flanders.—It appears by the Directors' report that the affairs of the Company are in good condition. The Poperinghe line is being made for a sum within the estimates, and this month the first section, namely, from Courtrai to Werwicq, is to be opened, when the Company comes into the receipt of one-fourth of the government guarantee of 16,000*l.* a-year.

Italy.—We learn from Florence that the works for the completion of this line are already commenced. It will form, with the Maria Antonia and Lucca to Pisa lines, a communication between Florence to Leghorn. In addition to this, the Central Italian Railway will join this line, which will secure to the Lucca and Pistoja Railway all the advantages resulting from the traffic between the Port of Leghorn and the towns and important countries through which the central line runs, and *vice versa*. It is, we learn, proposed to issue 34,000 preference shares of 150 Florentine livres, or 5*l.* each, in order to complete the section from Pescia to Pistoja. These shares will produce an interest of five per cent. per annum guaranteed by the Tuscan government, and they will besides share in the profits of the railroad with the primitive shares. The line is to be open to the public in less than two years.

Egypt.—The railway works have been greatly advanced within the last few weeks, and 8000 men are now employed in throwing up the embankments along the shores of Lake Mareotis, the coast line of which it traverses for twelve miles, or nearly its entire length. The foundation has proved more secure than was expected, and it is highly probable, from the exertions that are being made, that by the end of 1853, trains will be passing with passengers and merchandise between the Mediterranean at Alexandria, and the Nile at Kafi-Lais.

OBITUARY.

Buchanan.—Lately. George Buchanan, C.E., of Glasgow.

Creuze.—23d ult., at Sydenham, Augustin F. B. Creuze, F.R.S., principal surveyor to 'Lloyd's Register,' aged 52.

Decaisne.—Lately. Henri Decaisne, aged 53.

Hassell.—3d ult., at Lancaster, Edward Hassell, Member of the Society of British Artists.

Mantell.—12th ult., Gideon Algernon Mantell, LL.D., F.R.S., F.S.A., the renowned geologist, aged 63.

Morgan.—29th ult., William J. Morgan, landscape painter.

Ramey.—Lately, aged 57, C. Ramey, the sculptor, Professor and Member of the Academy of Fine Arts, Paris.

Seguin.—Lately, in France, aged 59, Camille Seguin, the well-known engineer. He introduced the system of suspension-bridges into France, and constructed eighty-six of them in France, Spain, and Italy. He also brought to a successful termination several other great public works.

LIST OF NEW PATENTS

GRANTED IN ENGLAND FROM OCTOBER 21, TO NOVEMBER 25, 1852.

Six Months allowed for Enrolment unless otherwise expressed.

Robert McGavin, of Glasgow, Lanark, North Britain, merchant, for improvements in the manufacture of iron for shipbuilding.—October 23.

Henry Needham Scrope Shrapnel, of Gosport, for improvements in extracting gold and other metals from mineral and earthy substances.—October 23.

James Lamb, of Kingsland, Middlesex, gentleman, and Joseph Menday, of the same place, engineer, for improvements in the construction of kilns for burning or calcining cement, chalk, limestone, and other substances requiring such process, and in the application of the heat arising therefrom to the generation of steam.—October 23.

Joseph Walker, of Dover, Kent, merchant, for improvements in treating cotton seeds, in obtaining products therefrom, and in the processes and machinery employed therein, parts of which improvements are applicable to distillation. (A communication.)—November 2.

Patrick M'Anaspie, of Liverpool, gentleman, for a new manufacture of Portland stone cement and other compositions for general building purposes and hydraulic works.—November 2.

John Crowther, of Huddersfield, York, for a self acting hydraulic crane or engine for lifting weights, such weights when lifted to be used as motive power; as also for loading and unloading vessels and vehicles.—November 2.

Louis Arnier, of Rue du Loisir, Marseille, France, engineer, for certain improvements in steam boilers.—November 6.

Pierre Armand Lecomte de Fontainemoreau, of South-street, Finsbury, English and foreign patent agent, for certain improvements in the manufacture of certain articles of dress. (A communication.)—November 6.

Charles Liddell, of Abingdon-street, Westminster, Esq., for improvements in electric telegraphs.—November 11.

John Weems, of Johnstone, Renfrew, North Britain, for improvements in the manufacture or production of metallic pipes and sheets.—November 11.

Andrew Fulton, of Glasgow, Lanark, hatter, for improvements in hats and other coverings for the head.—November 11.

William Petrie, of Woolwich, Kent, civil engineer, for improvements in obtaining and applying electric currents, and in the apparatus employed therein; part or parts of which improvements are applicable to the refining of certain metals, and to the production of metallic solutions and of certain acids.—November 13.

Auguste Edouard Loradoux Bellford, of Castle-street, Holborn, for improvements in the construction of springs for railway and other carriages.—(A communication.) November 25.

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END OF VOLUME XV.