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The Locomotive.

PUBLISHED BY THE

HARTFORD STEAM BOILER INSPECTION AND INSURANCE CO.
HARTFORD, CONN.

NEW SERIES.

Vol. XVI.

HARTFORD, CONN.

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The Locomotive.

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NEW SERIES — VOL. XVI. HARTFORD, CONN., JANUARY, 1895. No. 1.

Cracked Plates.

There are certain classes of defects in boilers that boiler owners know about, and endeavor to avoid. Among these are the deposit of sediment and scale, leakage around tube-ends and along riveted joints, and overloaded safety-valves. These defects rather force themselves on the attention of the owners; but there are many other kinds of defects that are not so obvious, though they may be fully as dangerous. Among these less patent defects are cracked plates.

Frequently cracks start from the edge of the plate. opposite a rivet hole, in the girth-joint that comes over the fire. Such cracks are often due to distress at the joint arising from an improper arrangement of the feed-pipe; for if the comparatively cold

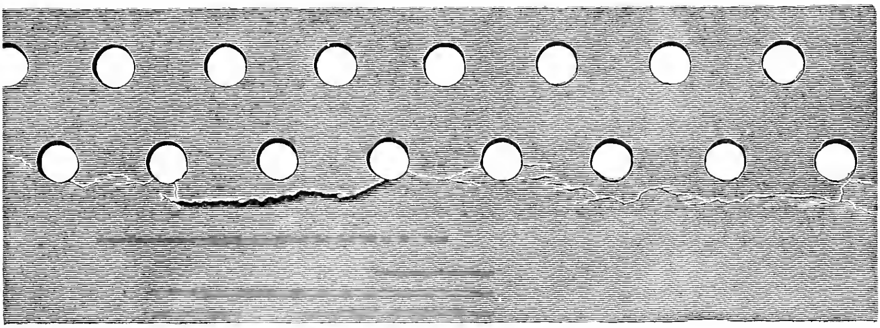

FIG. 1. — A CRACKED PLATE.

feed-water is discharged on or near the fire-sheet, it chills the shell in that vicinity, and produces a powerful local contraction of the metal, which is quite sufficient to start the joints, or, under some circumstances, to even crack the solid plate. But whatever the cause of the cracks, they are likely to first appear at the edge of one of the fire-sheets, and to extend gradually inward. Often they are stopped by running into the rivet-hole, and do not extend further. Frequently, however, they run past the rivet-hole, or cross it and extend into the sheet on the further side of it. It then becomes very important to check their further progress. This may often be done by drilling a small hole through the sheet at the very extremity of the crack. This hole may afterwards be filled with a rivet, or it may be tapped and filled with a screw plug.

Besides these fire-sheet cracks there are numerous other kinds, due to different causes. For example, the strength of a plate may be injured by overheating, or "burning," so as to develop a serious crack under the ordinary running conditions, without any assignable reason except that it has become too weak to withstand the strain that comes upon it in ordinary usage. Cracks are often discovered, too, along flanges

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that have been turned to too short a radius. Careless flanging is apt to start small cracks through the skin of the iron, and these frequently extend inward and eventually become dangerous. Incipient cracks on the inside of a boiler sometimes develop into deep grooves, the slight yielding of the shell, under varying pressure, opening up the interior of the metal to the corrosive action of the water. Defects of this kind usually occur along the edge of lap-joints, or near stay-bolts, where the shell is partially stiffened, and the buckling action of the plates more pronounced.

The accompanying wood-cut (Fig. 1) shows a crack due to a different cause, and it ought to carry with it a useful lesson. It represents a piece of plate that was cut from a boiler in active service, and which was believed to be in good condition. The boiler from which it was taken was 48 inches in diameter, with tubes 15 feet long; and the plates were of steel, $\frac{1}{4}$ of an inch thick. The piece of plate shown in the cut formed the edge of one of the sheets, where two sections of the shell were united by a longitudinal, double riveted lap-joint. It was taken from the upper part of the boiler, and was not exposed to the fire. It contained one well-marked crack extending completely through the plate, besides many other shorter ones running into one another in all sorts of ways, some of them extending through the plate, and others not quite through it. All these cracks were entirely covered by the inside lap of the joint, so that they could not be seen from the interior of the boiler; and on the outside, the boiler was covered at this point by a thick layer of non-conducting asbestos covering. We mention these points in order that the reader may understand how easy it would be to overlook this defect. Yet it would not be putting the case too strongly to say that although the boiler appeared to be in good condition, it was actually on the verge of explosion. For a considerable distance along the joint the strength of the plate was entirely destroyed; and at other places it was held together by the merest skin of metal, as was afterwards shown by breaking the plate across along the line of the cracks. The fractured area was almost entirely black, though bright spots were noticeable at intervals of two or three inches or so.

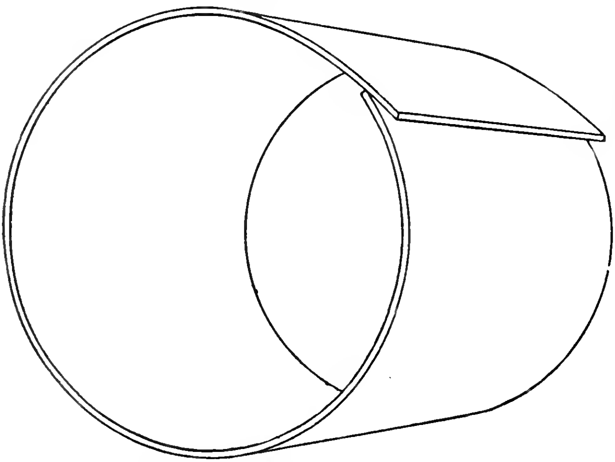
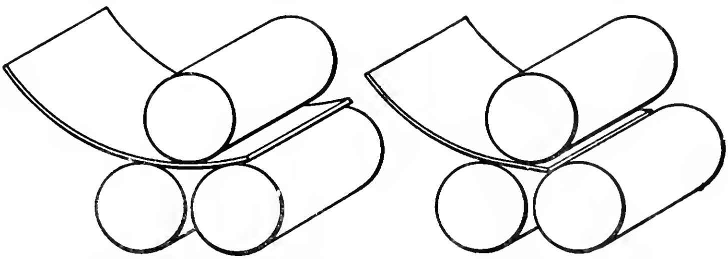


FIG. 2.—ILLUSTRATING THE "OFF-SET" OF THE LAP.

The cause of this defect will be sufficiently obvious to those who are familiar with the processes of boiler making. In rolling plates into the cylindrical form, preparatory to riveting them up into shells, it is customary to bend one end of the plate to what is judged to be the proper radius, by the use of the sledge-hammer. The plate is then run through the rolls and rolled into shape, the end that was previously bent being introduced first. When the plate has been rolled all but the last five or six inches the last end slips off of the first roll, and the rolls can no longer "grip" the sheet. The result is, that the last end of the sheet is not bent to the proper radius, but remains straight or nearly so. The shell (if rolled from one sheet) then looks something like Fig. 2, one end of it "standing off" from the rest of the shell. In order to make this action more evident we also present two diagrammatic views of a set of rolls in operation. In Fig. 3, the sheet has been rolled nearly to the end, and in Fig. 4 the end has passed over the first roll, the sheet is no longer "gripped," and the end has sprung back again so that it is nearly straight. In order to bring the outer lap to the proper curvature, it is customary for one man to hold a sledge against the projecting edge of the lap, while another workman strikes the shell on the inside. In this way the lap is bent down into place, and after the shell has been brought to conform with the "sweep" or templet, in every part, it is ready for riveting.

Now it will be seen that the treatment required for bringing the laps together in this manner is rather violent; and it follows that nothing but the best of materials will stand it without being greatly distressed and permanently weakened. Under the sledging oper-



FIGS. 3 and 4. — DIAGRAMS ILLUSTRATING THE ACTION OF THE ROLLS.

ation the material is likely to be strained beyond its elastic limit, unless it possesses great ductility. The greatest strain on it comes on the outer lap, at or near the line where it touches the inner one in Fig. 2, or along one of the lines of rivet-holes, where the plate is weakened by the loss of material. We have no doubt that the cracks shown in Fig. 1 were started in this way, and that they afterwards crept into the plate gradually as the boiler yielded slightly under varying pressures, until they reached the highly dangerous state described above.

If the sledging were done while the sheet is hot, it would not be so objectionable; but the great majority of boiler-makers will not attempt to heat the plate before sledging the lap down, because when the sheets are hot they are apt to buckle out of shape, and give great trouble. If the sheets are to be sledged cold, the proper way to do it is to bend each end to the proper radius before beginning the operation of rolling. A convenient way to do this is to lay the ends of the sheet *over the upper roll*, and bring it down to the proper radius very gradually.

In the early days of steel boilers, before the manufacture of that material was understood as well as now, plates were much more apt to be injured by sledging than they are at present. Steel having a high tensile strength is almost certain to be deficient in ductility; and for this reason it is customary, in the specifications sent out from this office, to make the maximum allowable strength of plate 65,000 pounds to the square inch, when such plate is to be exposed to the fire. We also specify that the steel used shall show an elongation of twenty-five per cent. in a length of eight inches, that it shall show a reduction of area of not less than 56 per cent., and that its elastic limit shall be at least fifty per cent. of its ultimate strength. The plate should also be capable of being bent double and hammered, when either hot or cold, without showing cracks; and it is also desirable that it should stand this same test after being heated and quenched in water. Steel that possesses these qualities makes excellent boilers, and it will stand a great deal of abuse, in the boiler shop, without developing defects in after service.

In conclusion, we may say that cracked plates are not so uncommon as the average reader might suppose. This may be seen by glancing at our inspectors' reports, as published from month to month in THE LOCOMOTIVE. Thus we find that during the year 1892, our inspectors discovered no less than 2,646 plates that were cracked in one way or another, of which 658 were considered to be dangerous. During 1893 the number of plates classified as "fractured" was 3,532, and of these 640 were reported to be dangerous.

[This article is reprinted, with some slight changes, from THE LOCOMOTIVE for November, 1893, because the importance of the subject is so great that we desire to bring it before the public, and before our own inspectors, too, in as emphatic a manner as possible. Cracks along a row of rivets on the outer lap are especially dangerous because they can be overlooked so readily; and although the earlier grades of steel were more liable to them than those made at present, the danger is still very great, and should never be forgotten. Only a short time ago we found just such a crack as is shown in Fig. 1, *in a new boiler, not more than six months in use!* The case reported by our foreign correspondent on page 186 of THE LOCOMOTIVE for December, 1894, in which the aggregate length of the crack was fourteen feet, was also probably due to the cause we have outlined in the foregoing article.— ED.]

Inspectors' Report.

NOVEMBER, 1894.

During this month our inspectors made 7,681 inspection trips, visited 15,852 boilers, inspected 5,485 both internally and externally, and subjected 638 to hydrostatic pressure. The whole number of defects reported reached 10,592, of which 881 were considered dangerous; 53 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	826	37
Cases of incrustation and scale,	1,623	63
Cases of internal grooving,	160	6
Cases of internal corrosion,	516	58
Cases of external corrosion,	654	38
Broken and loose braces and stays,	147	51
Settings defective,	309	50
Furnaces out of shape,	439	12
Fractured plates,	318	54
Burned plates,	286	25
Blistered plates,	276	9
Cases of defective riveting,	1,383	83
Defective heads,	122	11
Serious leakage around tube ends,	1,823	164
Serious leakage at seams,	416	28
Defective water-gauges,	391	58
Defective blow-offs,	167	42
Cases of deficiency of water,	22	17
Safety-valves overloaded,	60	15
Safety-valves defective in construction,	87	26
Pressure-gauges defective,	473	29
Boilers without pressure-gauges,	2	2
Unclassified defects,	92	3
Total,	10,592	881

Boiler Explosions.

NOVEMBER, 1894.

(265.)— On October 26th a boiler exploded in the Ogden Coal Company's mine, at Ogden, near Boone, Ia. Mr. Emil Lewis was fatally injured.

(266.)— A boiler exploded at the Pittsburg & Tennessee Copper Company's plant, at Ducktown, near Knoxville, Tenn., on October 26th. Superintendent Carl Henrich was slightly injured. [The preceding explosions were received too late for insertion in the regular October list.— ED.]

(267.)— A slight boiler explosion occurred on November 2d in the Edison Electric Light plant in Cincinnati, O. Considerable damage resulted, and Daniel Blackburn was killed.

(268.)— On November 3d a boiler exploded in Foust's grain elevator at Grover Hill, near Van Wert, O. The son of the engineer, McDown, was killed, and the engineer himself and Mr. Foust were fatally injured. The building was completely wrecked.

(269.)— About November 5th a boiler exploded in the electric light plant in Urbana, O. The town was in darkness for several weeks.

(270.)— C. C. Rummel & Company's saw mill at Duff, Ind., was completely demolished by a boiler explosion on November 5th. Mr. Rummel was instantly killed, and his son and two other men were badly injured.

(271.)— Mr. Cato Gripon was seriously scalded on November 8th by a boiler explosion at Taylor's Bayou, on the Rice Farm of Mr. J. J. Burrell at Beaumont, Tex.

(272.)— A boiler exploded on November 8th at the Congo fire clay plant, at Toronto, O. The building was completely wrecked, and parts of it were blown 150 yards.

(273.)— A stationary boiler in the Wabash machine shops at Decatur, Ill., exploded on November 10th. Engineer Burrows was blown through a glass door and was seriously cut and scalded.

(274.)— On November 12th a blow-off pipe blew out of a boiler in the Empire Cordage Company's works at Champaign, Ill. Mr. A. Hughston was fatally scalded, and died a short time afterwards. Patrick Gillen and A. J. Freeman were also seriously injured.

(275.)— A slight boiler explosion in the Grape street school at Springfield, Mass., on November 12th, necessitated the closing of the school for a few days.

(276.)— A boiler exploded at the Charlestown Gas Company's plant, Charlestown, Mass., on November 13th. Thomas O'Malley was seriously burned about the arms and face, and received a concussion of the brain. He may recover.

(277.)— The boiler of locomotive No. 78 of the Concord & Montreal Railroad exploded on November 15th, near Nashua, N. H. The two front sheets of the boiler were blown off and the boiler tubes were twisted into fantastic shapes. Engineer F. W. Clifford escaped with slight injury, but Fireman N. F. Bean was severely scalded about the body.

(278.)— A mud drum exploded on November 15th at Muncie, Ind., in the muck bar mill. A shower of hot mud, boiling water, and steam was thrown along the length of the mill, and five men were scalded. John Gainer was terribly scalded over his hands, face, chest, and legs. He cannot recover. It is thought that the other men will not die.

(279.)—The boiler that supplies the steam that runs the pump at the Martsolf shaft on the McAntire & McKees lease of the James Bolen land at Spring City, Mo., exploded on November 15th, seriously injuring George and Charles Bailey and Daniel Reed. It was thought that Reed and George Bailey must die, but later advices say that they are improving. The boiler was blown over 100 feet from the engine-house, and the building was literally torn to kindling-wood.

(280.)—Three boilers exploded on November 15th at the Stockton colliery, near Hazelton, Pa. The boiler-house and an adjoining building were blown to pieces. Michael Keesha and James Hudaka were seriously injured. The middle boiler of the battery buried itself in a culm bank.

(281.)—One of the boilers at the electric power-house at Elwood, Ind., exploded on November 16th, demolishing the building and the adjacent street car barns. Twenty or more residences were also injured. The property loss to the power company is estimated at $60,000, and the damage to the residences will probably amount to $10,000 more. Norman Clark, the night engineer, was killed. Frank McDonald was buried in the ruins, but was not seriously injured.

(282.)—A boiler explosion occurred at the Stella sugar-house of Messrs. A. & S. R. Jacobs of Donaldsonville, La., on November 18th. No one was killed.

(283.)—A boiler exploded on November 19th on a pump-boat at Pittsburg, Pa. George Hullihan, Peter Berry, and James McClusky were painfully scalded. Hullihan will die, and it is doubtful if Berry recovers.

(284.)—On November 19th a boiler exploded in John Malcolm's cotton-gin at Cale, I. T. Charles Malone and William Robbins were killed, and Mrs. John Malcolm, wife of the owner of the gin, will die. Hal Morris, George Townsend, Alexander Jenkins, William Creel, and another man whose name we could not learn, were seriously injured.

(285.)—On November 20th a boiler exploded in Capt. Halliday's cotton-gin at Leland, Ark. The gin was a large one, and the damage to machinery, buildings, and cotton will probably reach $10,000.

(286.)—The crown sheet of a locomotive on a Chicago elevated railroad blew out on November 20th, and William Aldrich, the fireman, was injured.

(287.)—A boiler exploded on November 21st in the basement of J. R. Stout's barber shop, 603 West Taylor street, Chicago, Ill. P. H. Fleming, Geo. W. Holmes, Charles A. H. Miller, J. D. Murphy, James W. Sheridan, J. R. Stout, and Mrs. J. R. Stout were injured more or less seriously. Holmes is likely to die. The property loss to Mr. Stout is about $2,500, and the damage to the building, which was owned by Ferdinand Arndt, was about $800 more. The force of the explosion may be estimated from the fact that a passing street car was blown from the track.

(288.)—By the explosion of a boiler in a saw-mill at Monticello, near Orangeville, Ont., on November 21st, Robert McQuarrie and Alexander Darraugh were killed, and Otto Hendrickson and James Powers were seriously hurt. Two men named Walker and Cooper received lesser injuries. The mill was blown to atoms.

(289.)—A boiler exploded on November 22d in Liston Staley's mill, near Moulton, Ia. The mill was utterly destroyed and fragments of it were found a quarter of a mile away. Benjamin O'Neal was fearfully crushed and scalded and cannot recover.

(290.)—A boiler exploded on November 22d in the basement of the Center school at Uxbridge, Mass., under the floor of the primary department. The floor was completely torn up, and desks and seats were broken in pieces. Bricks were thrown through the floor as high as the ceiling. Thirty pupils were in the room at the time, and many of them were hurt in the panic which followed.

(291.)—A heating boiler exploded in Hartford, Conn., on November 23d, in the residence of a well-known citizen. The explosion occurred in the middle of the night, and nobody was injured, but a considerable amount of damage was done to bric-a-brac and other perishable articles in the room above.

(292.)—A boiler exploded about November 24th in Kelleher's mills at Bradford, Pa.

(293.)—On November 24th a boiler exploded at the Conway cotton-gin at Bryan, Tex. The boiler-room was wrecked, and Engineer Henderson lost his eyesight and was terribly scalded about the head.

(294.)—A boiler exploded on November 25th at the Burbeck coal bank, near Wadsworth, O. The attendants had left it only two minutes before, and nobody was injured.

(295.)—On November 26th a boiler exploded near Pottsville, Pa., in the Blackwood colliery, owned by the Lehigh Valley Coal Co. Fireman George Copeland was injured in the back, and George Sherock was badly hurt about the legs.

(296.)—By the explosion of a boiler in a mill at Danby, near Ithaca, N. Y., on November 26th, William Bierce and Fred Vanloon were killed, and Harry Beardsley and Fremont McFall were scalded so badly that they will probably not recover. Edward Martin and Charles Grant also received injuries that were painful, but not fatal. Both of Bierce's legs were blown off.

(297.)—A boiler exploded on November 26th in the Loyal street school at Danville, Va. As the accident occurred about five o'clock in the morning nobody was hurt.

(298.)—By the explosion of a boiler in a power-house at Sharon, near Pittsburg, Pa., on November 26th, travel was suspended on the Chenango Valley electric railway. The damage was repaired in a day or two and traffic resumed.

(299.)—A heating boiler exploded on November 27th at the residence of Henry Withington in Lawrence, Mass. Parts of the house were wrecked, but no one was injured. The loss is estimated at $1,000.

(300.)—A boiler used to run a steam peanut roaster in Scranton, Pa., exploded on November 27th, and the flying peanuts and pieces of iron caused great destruction — especially the peanuts.

(301.)—Joseph Oliver was scalded to death on November 30th by the explosion of a boiler at Green Hill, near Bowling Green, Ky.

(302.)—On November 30th a fearful explosion occurred on the farm of Henry Leihold, near Cedar Rapids, Ia. A gang of men with a steam thresher were hulling clover, when the head of the boiler blew out. George Leihold was instantly killed.

(303.)—On November 30th the safety-valve casting on a boiler in the Briggs rolling-mill, in Findlay, Ohio, was blown bodily off. No person was injured, and the damage that was done was repaired next day.

Do Incandescent Lamps Start Fires?

A few very simple experiments that any one can make will answer this question in a fairly conclusive way and will furnish an interesting demonstration of the extent of incandescent lamp fire risks under certain conditions. Those who lack the opportunity to make the trials for themselves will find the results which they undoubtedly would have obtained in a report submitted a short time ago to John Lindsay, chief of the St. Louis fire department, by A. J. O'Reilly, supervisor of city lighting. The investigation which Mr. O'Reilly made was prompted by a recent fire in that city, supposed to have been started by an incandescent lamp lying against a couple of wooden poles, and his conclusions, which have since been borne out by similar tests repeated several times, are decidedly to the effect that an incandescent lamp may, under favorable circumstances, cause a fire.

Where the ignitable material was in a vertical position and the lighted lamp simply rested against it, Mr. O'Reilly found that in the case of white pine a spot one inch in diameter and having a light brown color appeared after about four hours. In the case of varnished oak, well seasoned, the varnish became blistered in three minutes and blackened in about fifteen minutes. The wood had the appearance of being charred at and near the point of contact, but was not ignited. A dry, white pine board began to smoke after forty minutes, but, through the breaking of the lamp, the test stopped at that point. With a lamp incased in two thicknesses of muslin, the latter commenced to scorch in one minute, in three minutes gave off considerable smoke, and at the end of six minutes, when the muslin cover was removed from the lamp and fresh air reached its interior, it burst into flames. Where a lamp was laid on inflammable material, the effect seemed to be more rapid, owing, probably, to the pressure exerted by the weight of the lamp. A newspaper was, in this way, carbonized in three minutes, and ignited in forty-five. The lamps used in the trials were all of sixteen-candle power, and the results satisfied Mr. Lindsay, as they will probably satisfy many others, that fires may sometimes be very properly ascribed to what has generally been regarded as an absolutely safe form of light. — *Cassier's Magazine.*

[The bulb of an incandescent lamp is ordinarily at such a temperature that one can just about bear its contact with the hand. If the radiation (and convection) of heat from the bulb is lessened in any way, say by covering the lamp with muslin, as suggested above, the temperature at once rises, and its ultimate value will depend upon how perfectly the heat is retained by the covering. It is a matter of common observation, especially in sick rooms, that it does not do to shade a portion of the apartment by throwing a dark cloth over the lamp; for even if the cloth does not take fire, the heat developed is likely to melt the rubber key by which the lamp is turned on and off. The ignition of cloth and wood by causes of this kind does not appear to be *directly* due to the high temperature produced by the lamp itself. The organic materials near the lamp are partially carbonized, the charcoal so formed condenses a considerable amount of air within its pores, and the heat given out by the air in its compression is added to that due to radiation from the lamp. By this double action the temperature may sometimes be raised to the point of ignition. A similar action may occur in wood-work near a stove-pipe or any other conductor for hot gases, and doubtless many of the so-called "mysterious fires" that originate near the heating apparatus of dwellings and other buildings can be ascribed to the same cause. The fact that freshly prepared charcoal can absorb (or "compress" within its pores) a considerable quantity of air or other gas is well known to all students of physics and chemistry, and many lecture-room experiments have been devised to illustrate the action. The medical fraternity recognize the same fact when they give dyspeptic patients charcoal tablets to absorb the gases formed in the stomach and intestines (although we question the efficacy of the remedy, because the charcoal becomes *wet*, as soon as it is swallowed). The affinity of charcoal for gases is probably due to the porous nature of the substance. *All* solids are known to carry a film of condensed air (or other gas) upon their surfaces, and the makers of Geissler's tubes and other high-vacuum apparatus are obliged to take special precautions to remove this film from the glass of which their tubes are made — otherwise an almost perfect vacuum would be sooner or later destroyed by the gradual "evaporation" of the layer of condensed gas on the inner surface of the apparatus. The condensation of gas upon solids is a *surface* phenomenon, and it is especially noticeable in porous bodies (such as charcoal), because their total surface is so enormous. Spongy platinum exhibits the same phenomenon in a marked degree, and if a jet of hydrogen gas be directed against a piece of it, the gas is absorbed so rapidly that the temperature of the platinum immediately rises to a red heat, and the jet of hydrogen is ignited. This ancient experiment is sometimes employed, by dabblers in science, for making "chemical cigar lighters." — Ed.]

Injury to Boilers by Grease.

It has often been observed that small quantities of grease in combination with deposits lead to boiler accidents. This compound gets deposited on the plates, and the most violent water circulation is sometimes insufficient to remove it. The plates, in consequence, get overheated and accidents result. The introduction of grease inside the boiler should be avoided, especially where the water from the condenser is used for feeding the boiler, by the use of a sufficiently large feed-water filter. The Berlin Boiler Inspection Society had the following case brought under its notice: Two single-flued boilers, 4 feet 8 inches diameter, 23 feet long, flues 18 to 22 inches diameter, pressure 12 atmospheres, were used to generate steam for a 150-horse power engine with surface condenser. The installation had only been at work since July, 1893. A considerable portion of the flue of the left boiler had collapsed. This could not be attributed to shortness of water. On examination it was found that nearly all over the boiler a fatty brown slime had been deposited, which, being placed on a red-hot iron, burst into flame. The feed-water pump got its water from a large open tank over which a small filter was placed. The condensed water was led to this filter in order to have the grease removed. Unfortunately, the arrangements were so bad that a considerable portion of the grease found its way into the boiler. A similar case was recorded by Mr. Abel at the last meeting of the Markisch Society for Testing and Inspecting Steam Boilers. Four boilers, the feed water of which was heated by the exhaust steam from a Westinghouse engine, after being in use about six weeks, were so damaged that one boiler had to be completely removed; the other three had to receive extensive repairs. An examination of the boilers showed that the flues were covered with a deposit of fatty slime. An analysis of this showed that about 52 per cent. of it consisted of mineral oils and paraffine, and 27 per cent. of animal fat. It is strongly advised, therefore, that feed water shall always be filtered so as to remove any oils or grease. — *Scientific American.*

The Locomotive.

HARTFORD, JANUARY 15, 1895.

J. M. ALLEN, *Editor.* A. D. RISTEEN, *Associate Editor.*

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As the heating apparatus in the gymnasium at Madison, Wis., was being tested under pressure for the first time (on November 9th), a violent explosion occurred, which shook the whole building. When the steam cleared away it was found that a large elbow had given way, a piece of which, after passing completely through a partition and tearing a door from its hinges, had passed along a hallway for a distance of 80 feet, and burst open the two heavily-bolted front doors. Workmen were standing near, but fortunately they all escaped injury. If this account be true (we get it from a newspaper), we should like to know what kind of a pressure the Madison people use to "test" heating systems with.

The Shamokin Explosion.

The following extract from the *Scientific American* may be of interest to our readers, in connection with the great boiler explosion at Shamokin, Pa., which was discussed in our last issue :

At a recent meeting of the Engineers' Club, Philadelphia, Mr. John L. Gill, Jr., exhibited and explained a table showing the energy stored in boilers of different types, dimensions, and horse powers, and the height to which this energy could throw the boiler, with its weight of water, if allowed to act through an explosion. The explosion which occurred recently at Shamokin, Pa., in a plant of 36 boilers, arranged in nests of 3, whereby 27 of the boilers exploded and were thrown to a considerable distance from their original resting places, was possibly due to gas having collected under one or two of the boilers, and by its explosion breaking the branch connection to the main pipe, thereby causing others to explode: or it may have been occasioned by one set of boilers running out of water, the latter cause being the more probable [?]. Mr. Gill then explained, by means of the projecting lantern, a number of photographs which had been taken in the neighborhood on the day after the explosion. All of the boiler shells were broken circumferentially, and many of them had been thrown with such force that they had been embedded many feet in the side of a culm bank, some distance from the boiler house.

"As stated by Mr. Gill," said Mr. James Christie, "the boilers at Shamokin were horizontal cylinders, about 44 feet long, and were suspended by rods 11 feet from each end. Hence they were not only subjected to internal pressure, but also to unequal strains at the top and bottom, due to this manner of mounting, and the latter strains must have been very great. In long boilers like these there is also unequal strain, due to the differences in temperature between the bottom and top, the latter in this case being open to the air."

"When I was connected with the Edge Moor Iron Company," Mr. Henrik V. Loss said, "I remember to have made some experiments whereby we found that the differences between top and bottom strains in some cases might be as much as 5,800 pounds per square inch."

Mr. John Overn, chief boiler inspector for Philadelphia, referred to his examination of the remains of the Shamokin boilers as follows: "I examined the boilers at Shamokin on the day after the explosion and there was not a single case which showed any longitudinal strain. Each boiler shell was composed of 13 plates, and all but one of those which exploded broke in the section to which the suspension rods were attached. By the use of a blower the heat under the boiler cylinders was made very great while the top of the boilers was cool. After inspecting boilers for many years, I have noticed that there are comparatively few exploded because of low water. The disturbance at Shamokin, I think, was due to unequal elongation on opposite sides of the boiler shells, and to the very poor quality of iron used in their construction."

In *Cassier's Magazine* for January, an extract from which is given elsewhere in this issue, we find a series of articles of unusual interest — which is saying a great deal, for *Cassier's* is always bright, instructive, and artistic. There is nothing in it that will not well repay one for perusal. Mr. Nelson W. Perry's article entitled "The Feats of the Magnetic Girl Explained," although not strictly on an engineering subject, is nevertheless of interest to engineers, because it tends to clear up certain points in the mechanics of girls and chairs and broomsticks that are very confusing to the laity in general, and also, without doubt, to many of the mechanical profession. Mr. Perry says that the tricks of the so-called magnetic girls "seem, at first sight, to involve either the possession of superhuman strength, or else some occult power. As a matter of fact, however, they involve neither. The strangest part of them is that they are all within the ability of any of my readers to perform. Furthermore, it will be found that the very mechanical laws which these tricks appear to set at defiance are the ones upon which they depend for their success, and the chief reason why they have remained mysteries to those who have witnessed them is that they have not tried to repeat them themselves upon the first opportunity afforded." It is impossible to give a clear idea of the explanations that Mr. Perry offers in particular cases, without reproducing his illustrations; but he claims that all the tricks can be easily learned and performed, by anyone who is interested enough to try them.

"Kitchen Boiler Explosions."

We desire to acknowledge the little book on *Kitchen Boiler Explosions*, which the author, Mr. R. D. Munro, M.I.M.E., has kindly sent us. Mr. Munro is chief engineer to the Scottish Boiler Insurance and Engine Inspection Company, Limited, of Glasgow, Scotland, and is probably well-known to many of our readers through his book on *Steam Boilers*. His attention was specially directed to the explosion of kitchen boilers by the unusual succession of such accidents that occurred in England and Scotland during the early part of last January. (A list of thirty-eight of these explosions, which occurred during five days of cold weather, and which resulted in twelve deaths and in injuries to thirty-three persons, will be found in The Locomotive for March, 1894, on page 38.)

Many theories were put forth to account for these explosions, prominent among them being the usual low-water and "spheroidal state" hypotheses. Mr. Munro has undertaken to dispel the haze that enveloped the subject, and to find out the true cause of the explosions, by actual experiment. The general method of carrying out the experiments is described elsewhere in this issue, in an article taken from *Engineering*. It may be well to say that the kind of boiler contemplated by Mr. Munro is not very common in this country; it consists of a wrought-iron vessel with a capacity of from 10 to 20 gallons, so placed that the gases from the kitchen range pass under and around it on their way to the chimney flue. In this country the "water-front" is more frequently used, except where considerable quantities of very hot water are wanted; but as Mr. Munro's results have a direct bearing on boiler explosions in general, his book will undoubtedly be received by engineers in this country, as well as in England, as a valuable contribution to our knowledge of the larger and more destructive explosions that occur in boilers used for the generation of power. Of the conclusions reached by Mr. Munro, the following will be of special interest to our readers: "(1) The experiments prove that water will flow into a red-hot boiler although there is no free outlet, and, also, that a steam-pressure can be attained under such circumstances sufficient to cause rupture of the strongest boilers in use. (2) Although a very high steam-pressure may be generated in a red-hot boiler by the sudden injection of cold water, it was clearly demonstrated that a disaster cannot thus be produced, and that the internal pressure is dissipated almost instantaneously, upon the occurrence of a very small rupture or leakage. (3) It was also clear that an explosion, in the true sense of the word, cannot occur unless the boiler contains water as well as steam; and that the force of the explosion will be in proportion to the quantity and temperature of the water in the boiler immediately before rupture." Mr. Munro points out that a cubic foot of *water*, at a temperature equal to that of steam at 60 pounds pressure, has a total energy of 133 foot-tons, while the energy in a cubic foot of *steam* under the same conditions is only about one-third of one foot-ton. This fact, which has long been known, of course, fully accounts for the comparatively slight damage done by "low-water" explosions. "(4) The experiments, as a whole, proved conclusively that kitchen boiler explosions, like all other explosions, are due to simple and preventable causes. The outlets become blocked by ice or other obstruction, and, in the absence of a safety-valve, the pressure will rise more or less rapidly, according to the condition of the fire, until the strength of the boiler is exceeded, and explosion occurs."

Mr. Munro's little book is published by Charles Griffin & Co., Limited, of London.

Early Steam Heating.

The following letter appeared some time ago in the *Heating Engineer*, and will doubtless interest our readers, now that steam and hot-water systems are so common. The original, we believe, is in the possession of Mr. S. D. Tompkins, of Jersey City, N. J.

HARTFORD, Sept. 16, 1819.

ROGER M. SHERMAN, ESQ.,
Fairfield, Conn.,

DEAR SIR: — Yours of the 14th inst. lies before me, with the contents noted. You anticipate warming your dwelling-house with steam, and desire of me a particular account of the machinery necessary to the object. I shall be happy to give you all the information I possess on the subject, but at present decline doing it by writing, under the belief that it would not be done to your satisfaction or my own, even if accompanied with diagrams. Could I see you, sir, I have no doubt it would be in my power to give you more information in an hour than would be possible with the pen in two or three days. If, however, you have not business to call you hither, and still wish me to give a written description of the machinery, please to signify it, and it shall be done. It is perhaps proper for me here to state that my object in making the experiment last winter was simply to test the principle, whether steam can be advantageously used for heating rooms or not, and I am satisfied it can, under some if not all circumstances. My boiler was not of a kind, or set in a manner, to show the economy with which the thing may be done, but a boiler was afterwards constructed for a different application of steam which, I think, would clearly show that it is economical. The most successful experiments with which I am acquainted have been made in England, within a year or two, and apparently with great approbation. The differences of climate, I think, should be taken into consideration; it may be questioned whether it will answer as well in a climate so cold as ours, as in theirs; my experiments have not been such as to satisfy me entirely of the facts, but should say any desirable temperature may be obtained and kept up, even in our climate. If I am correct in my position, there cannot be a question but the advantages of using steam for warming rooms are so great as to demand its immediate introduction, to the exclusion of all other methods.

I am, sir, very respectfully yours,

Lorenzo Bull.

Domestic Boiler Explosions.

When a fallacy is once promulgated, its vitality is something amazing. Owing to our mediæval system of education, the average middle-class man knows nothing of physics, and is thus not in a position to express an opinion on the accuracy of any of the many marvelous theories of the universe and all that in them is which are not infrequently thrust upon him by his daily paper.

The word electricity seems to have the same soothing effect on people of this class as the word Mesopotamia had for the old lady of the story. If a phenomenon is only said to be electrical, everything is considered to be explained, there being an inherent love of the marvelous in the run of mankind, which makes a straightforward and simple explanation much less to its taste than a more involved and mysterious one ; and when one of these occult explanations has once gained a fair degree of acceptance, its refutation may be compared to the labors of Sisyphus. The error may be clearly established by experiment, and for the moment its supporters are silenced or convinced; but a few months later the same old fallacy is again making the rounds of the papers, and the work of refutation has to be gone through again. One of the most persistent of these errors has been the theory that under certain conditions a safety-valve is useless on a boiler, owing to the alleged fact that it is possible to generate steam so quickly in an ordinary boiler that the valves would be unable to pass it and to prevent a very serious rise of pressure.

At the beginning of last year we republished a description of experiments made by the Manchester Steam Users' Association in 1867, which showed pretty conclusively that it was impossible to make a kitchen boiler explode by heating it to redness and then turning in cold water. No arrangements were, however, made to measure the pressure developed in these experiments, though it was known that it did not exceed 35 pounds per square inch, for which the safety-valve was loaded. In some later experiments made by the same association on a Lancashire boiler, this omission was made good, and in this instance it was found that on turning water on the top of the red-hot flues of the boiler a pressure of 27 pounds was reached. Naturally, it was not possible to heat any large proportion of a large Lancashire boiler to redness, and hence the red-hot surfaces were small in comparison with the cubic capacity of the boiler. It was, therefore, only to be expected that higher pressures would be developed if the experiments were repeated on a kitchen boiler, of which a large fraction of the whole surface could easily be made red-hot. This has now been done by Mr. R. D. Munro, the chief engineer to the Scottish Boiler Insurance and Engine Inspection Company, Limited, who has recently published a small volume,* giving the results of his experiments, which fully confirm the view that it is impossible to make a boiler "explode" by raising it to a red heat and turning cold water into it. It may be cracked, or a side may open, but no explosion in the proper sense of the term takes place, a very small aperture being sufficient to pass all the steam generated.

For the purpose of these experiments, a wrought-iron cylindrical shell, about 20 ft. long and 6 ft. 6 in. diameter, was prepared and erected with its axis vertical. The boiler to be tested was placed inside this, so as to prevent damage being done if an explosion did occur. A furnace was fitted inside this shell, and over it was placed the boiler to be tested. The boilers experimented upon were taken from the general stock of the different makers, and were fair samples of the ordinary domestic boiler. As a preliminary, a series of experiments were made to determine the size of safety-valve necessary to prevent a rise of pressure above that corresponding to the load on the valve. With a so-called "boot" boiler having a capacity of 14 gallons, and weighing 160 pounds, it was found that a dead-weight safety-valve, $\frac{1}{2}$ in. in diameter, was capable of passing all the steam which it was possible to generate. In making the experiments with the "red-hot" boiler, it was found that a suitable safety-valve was again effective in preventing any serious rise of pressure, even when fully three-quarters of the whole surface of the boiler was raised to a red heat.

In the first of these experiments the safety-valve was loaded to 10 pounds, and, on turning on the water, the pressure due to the steam generated by the hot surfaces rose to 12 pounds, after which it fell again to 6 pounds, which was that due to the head of water in the supply pipe. The steam produced apparently cleared the boiler of water, but in a few seconds a second supply of water gained access to the boiler, sending the pressure up again to about 12 pounds, after which it fell below that due to the head. The "geyser" action again recurred, a larger supply of water reaching the plates than in the previous case, with the result that a pressure of 16 pounds was indicated on the maximum gauges.

In the second experiment the valve was loaded to 20 pounds, the head in the supply pipe being raised to 12 pounds per square inch; and in this case the boiler was made nearly white hot. On turning on the water, the pressure rose to 44 pounds, but then fell steadily, and at the end of 22 seconds was below the safety-valve load. On withdrawing the fire, the boiler was found considerably distorted, and a stay between the front and back plates was started. Very similar results were obtained on repeating the experiments on other boilers, and it was evident that the safety-valve, having a discharge area of but $\frac{1}{5}$ square inch, was too small for the work, though, of course, the

* [See page 11 in this issue.—ED.]

conditions were much more unfavorable than they would be under any conceivable conditions in practice.

In the next series of experiments the boilers were fitted with a safety-valve of double the diameter, and, at the same time, the supply pipe was fitted with a non-return valve. The head causing flow into the boiler was 40 ft., or 18 pounds per square inch. With this arrangement, the pressure never rose above that due to the valve loading, the valve being able to pass easily all the steam generated. The pressure, however, always rose to the safety-valve load, and thus there is a difference between these experiments and those made by the Manchester Steam Users' Association on a Lancashire boiler, where the pressure never rose above 27 pounds per square inch. This, of course, is to be attributed to the much greater ratio which the heated surface bore to the internal volume.

To complete the experiments, the safety-valves were locked fast, and the boiler heated as before. On turning on the water, the pressure gradually rose up to a maximum of 118 pounds per square inch, when a part of the boiler gave way. There was, however, no explosion, a weld simply opening and letting the steam out quietly. The experiment was then repeated with a second boiler, which failed at 90 pounds per square inch. As before, there was no explosion, there being no reserve of highly heated water to keep up the pressure, as is necessary for a true explosion to occur. The boilers were not even shifted on their beds.

These experiments seem to prove conclusively that a boiler explosion cannot be caused by simply making the boiler red hot and turning water in. As Mr. Munro points out, in many towns a domestic boiler is quite as likely to run dry in summer as in winter, owing to the water supply being intermittent; but he has only found one case of a domestic boiler exploding in summer, and that was proved not to be due to shortness of water. In winter such explosions are frequent, and, in view of all the experiments which have now been made, it can hardly be doubted that they arise simply and solely from the plugging of the outlets, and that a suitable safety-valve forms a perfect guarantee against danger.— *Engineering.*

It was reported, a short time ago, that a boiler exploded in the rubber works at Akron, Ohio, about November 21st. According to the Akron *Democrat*, the rumor was untrue.

The United States revenue cutter *Rush*, which left San Francisco on November 28th, to determine, if possible, the fate of the missing ship *Ivanhoe*, returned to port next day in a disabled condition. She had not proceeded far on her way when one of her steam pipes burst and she was compelled to return for repairs.

Here is what the Bushnell (Ill.) *Democrat* says about a presumably esteemed contemporary: "The Warsaw *Pilot* is now run by wind, for sure. It was not so very long ago that the steam boiler in the office blew up, and all but blew the editor into another world, so that he has erected a wind-mill over the office, and runs his presses with that."

Incorporated 1866.

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HARTFORD, CONN.

Charter Perpetual.

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The Locomotive.

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Boiler Settings.

The past few years have witnessed great changes in the practice of steam engineering, the sharp competition in all branches of business causing a decline in the prices of the products of mill and shop. This has made the cost of production a matter of great importance to the manufacturers, and one to which they have given much study. The cost of power, especially where steam is used, is a very important factor in the case, and it has received much attention; the general result being that the simple high pressure and condensing engines that were formerly considered good enough are being replaced by the best types of compound and triple-expansion condensing engines. Foreseeing

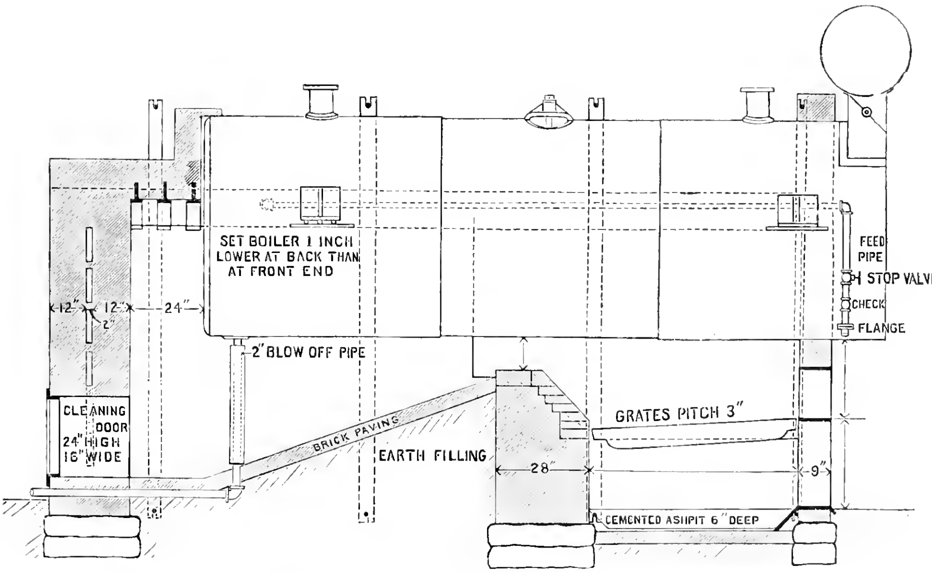

Fig. 1. — Side Elevation of Setting.

the necessity of better economy in the generation of steam, and of greater durability in the plants, the officers of the Hartford Steam Boiler Inspection and Insurance Company were led, after a careful study based upon years of experience, to prepare improved plans for the setting of externally fired boilers of the plain cylinder or tubular types, these being the prevailing forms of boiler that are used in this country. Increased capacity and economy seemed quite feasible with this class of boiler. The proportion of grate area to heating surface and to the tube area were carefully considered, as well as every other detail of the setting. The ratio of grate area to heating surface was considerably reduced in comparison with the ratio in general use at the time the company's setting was designed, and it is also less than is used by many designers at the present day. The width of the furnace in the settings advocated by this company is six inches less than the diameter of the boiler. Beginning just above the grate, the side walls batter at such angle as to make them 3″ clear of the boiler at the center, where the walls project inward and close against the boiler. This batter gives greater stability to the walls, and another special feature of it is, that it allows the heated gases to rise without impinging against the walls of the setting, and they flow away from the wall and distribute themselves evenly over the whole heating surface of the shell. The removal of soot and ash from the shells is also facilitated, and, moreover, it is found that these deposits do not form so readily when the walls are battered as they do when the walls are straight, and the space between them is correspondingly contracted. The batter also increases the volume of the combustion chamber, and allows of a more thorough mixing of the oxygen and furnace gases, the result being that complete combustion of the fuel is greatly facilitated. The bridge-wall slopes back from about four inches above the grate, at an angle of 40°, in order that the radiant heat from the fire may be diffused over a large portion of the boiler shell. The flame bed back of the bridge-wall slopes down to the level of the boiler-room floor. It is paved for easy cleaning, and the combustion chamber is large enough to make examinations and repairs to the boiler comparatively easy. The cleaning door in the rear wall is placed on a level with the flame bed in order that ashes may be readily removed, and as it is below the currents of highly-heated gases loss by radiation through the door is largely prevented. The loss or waste of heat from this cause is often very great and it has not generally received the attention it deserves. Another point that demands more attention than it usually receives, is the liability of *leakage* of cold air through the walls of the setting, with the resulting reduction of furnace temperature. To avoid loss of temperature from this cause heavy double walls are constructed in this company's settings, the outside walls of a battery having a two-inch air space between them. The division walls between two or more boilers should have a half-inch clear space between them, to allow free and independent expansion of the walls. With a solid wall and one or more boilers of the battery stopped, one side of the wall separating a boiler in use from another one out of use would be hot and greatly expanded, while the other side of it would be cool; the result being that the bonded or solid wall must necessarily be severely strained or injured, and the joints in the masonry quite probably broken by the unequal expansion. Excessive leakage of air is likely to follow. These criticisms apply to all solid-built boiler settings. While the heavy double walls are somewhat more expensive in first cost, the increased economy and capacity of the boilers, as well as the greater durability of the settings, fully warrant

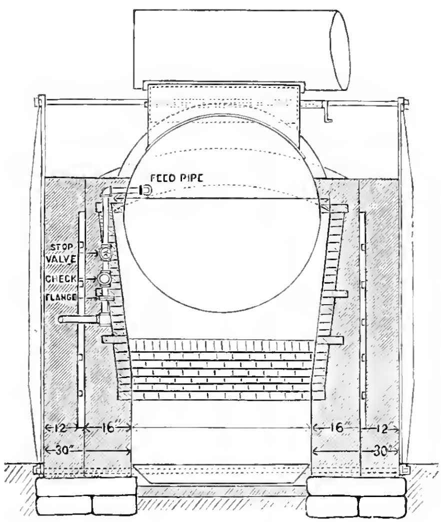

FIG. 2. — SECTION THROUGH FURNACE.

their construction. The results obtained in many large plants fully sustain this statement.

The exposed portions of the boiler shells above the settings are covered with plastic non-conducting covering $2\frac{1}{2}''$ thick. This is much lighter than brick, is a better non-conductor, and does not exert a sensible thrust upon the setting walls as a brick arch does. If leaks occur along the joints of the covered part of the boiler, they are quickly noted by the discoloration of the covering, and may be stopped before injury from corrosion occurs. The illustrations give the general arrangement of the settings above described, in which it is desired to combine durability with simplicity in design and construction, and at the same time to obtain good results from the boilers, both in economy and in capacity. To obtain the maximum economy in the combustion of fuel, we should obtain the highest temperature possible in the furnace, and the lowest temperature in the chimney — that is, in the chimney we should have a temperature not greatly in excess of that due to the pressure carried in the boilers, and we should admit to the

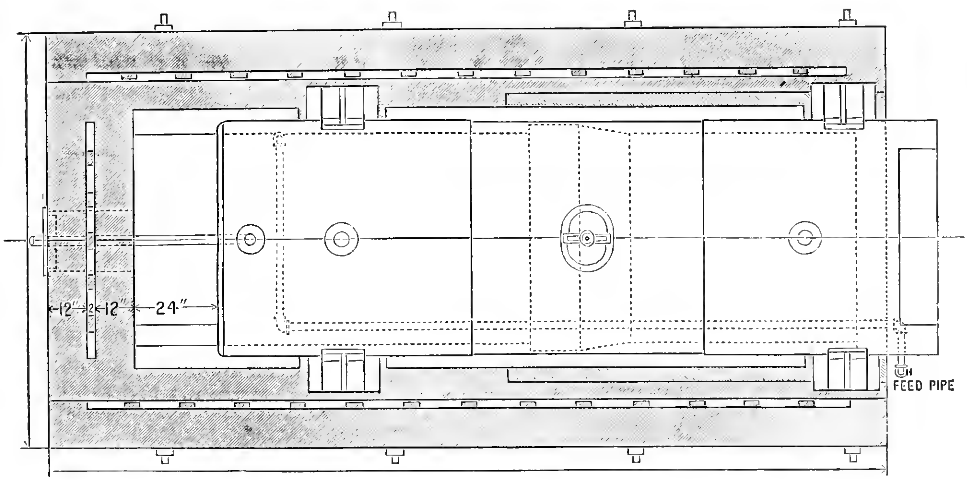

FIG. 3. — PLAN VIEW: SECTION THROUGH CENTER OF BOILER.

furnace the smallest quantity of air that will insure complete combustion of the fuel. With these ends in view, the relative proportions of grate area and heating surface, and of all other areas and proportions of the settings, have been placed within certain limits determined by experience. It is well known that the intensity of heat produced by the fuel varies with the rate of combustion; and if a temperature of 2,200° to 2,500° can be obtained in the furnace, and the heat can be distributed over the heating surfaces, and can be so absorbed that the chimney temperature does not exceed 400° to 450°, the percentage of heat lost through the chimney is very small. It is possible to obtain such results with well-proportioned plants. Where a careful daily record of boiler duty has been maintained for several years with boilers of a *nominal* capacity of 100 horse-power each, and set in accordance with this company's designs, such boilers have shown an evaporation of $12\frac{1}{2}$ pounds of water from and at 212°, per pound of combustible, and an *actual* capacity of 130 horse-power. When running at full capacity such boilers frequently develop 175 horse-power, with an economy of nearly 11 pounds of water evaporated per pound of combustible, for a week's run of daily duty in the mill. The flue temperature observed in such cases ranges from 400° to 500°. Economy and capacity in the generation of steam are not to be found in the most complex systems, but in those which are simple and which are constructed in harmony with the laws of nature.

Inspectors' Report.

DECEMBER, 1894.

During this month our inspectors made 7,914 inspection trips, visited 16,834 boilers, inspected 6,499 both internally and externally, and subjected 772 to hydrostatic pressure. The whole number of defects reported reached 12,409, of which 1,610 were considered dangerous; 79 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	842	44
Cases of incrustation and scale,	2,042	107
Cases of internal grooving,	101	19
Cases of internal corrosion,	669	37
Cases of external corrosion,	789	49
Broken and loose braces and stays,	175	58
Settings defective,	351	30
Furnaces out of shape,	457	19
Fractured plates,	291	83
Burned plates,	238	47
Blistered plates,	222	8
Cases of defective riveting,	1,437	224
Defective heads,	136	12
Serious leakage around tube ends,	2,645	640
Serious leakage at seams,	571	46
Defective water-gauges,	459	71
Defective blow-offs,	178	40
Cases of deficiency of water,	33	12
Safety-valves overloaded,	133	18
Safety-valves defective in construction,	112	20
Pressure-gauges defective,	457	20
Boilers without pressure-gauges,	4	4
Unclassified defects,	67	2
Total,	12,409	1,610

Summary of Inspectors' Reports for the Year 1894.

During the year 1894 our inspectors made 94,982 visits of inspection, examined 191,932 boilers, inspected 79,000 boilers both internally and externally, subjected 7,686 to hydrostatic pressure, and found 595 unsafe for further use. The whole number of defects reported was 135,021, of which 13,753 were considered dangerous. A summary of the work by months is given below, and the usual classification by defects is likewise given:

SUMMARY, BY DEFECTS, FOR THE YEAR 1894.

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	10,446	587
Cases of incrustation and scale,	23,000	923
Cases of internal grooving,	1,277	125
Cases of internal corrosion,	7,679	458
Cases of external corrosion,	9,543	638
Defective braces and stays,	2,128	649

Nature of Defects.	Whole Number.	Dangerous.
Settings defective,	4,289	452
Furnaces out of shape,	5,274	236
Fractured plates,	3,655	692
Burned plates,	3,087	293
Blistered plates,	3,153	175
Defective rivets,	15,828	922
Defective heads,	1,400	222
Leakage around tubes,	22,355	4,221
Leakage at seams,	5,869	412
Water gauges defective,	4,610	760
Blow-outs defective,	2,032	548
Cases of deficiency of water,	239	122
Safety-valves overloaded,	835	267
Safety-valves defective,	1,159	378
Pressure gauges defective,	6,053	438
Boilers without pressure gauges,	200	200
Unclassified defects,	910	35
Total,	135,021	13,753

Summary by Months.

Month.	Visits of inspection.	Number of boilers examined.	No. inspected internally and externally.	No. tested hydro-statically.	No. condemned.	Number of defects found.	Number of dangerous defects found.
January,	9,334	17,973	6,430	525	79	10,615	1,110
February,	7,347	15,515	5,769	456	47	10,273	1,333
March,	7,915	16,700	6,512	527	63	11,324	1,181
April,	7,646	16,003	7,061	642	44	11,355	1,071
May,	8,142	15,966	6,893	735	35	11,613	1,123
June,	7,467	13,931	6,702	706	25	11,308	976
July,	7,698	15,151	8,242	630	61	11,160	1,102
August,	7,325	14,730	6,309	656	31	10,757	1,261
September,	7,824	15,253	6,542	652	31	11,292	1,195
October,	8,509	18,024	6,556	747	47	12,323	910
November,	7,861	15,852	5,485	638	53	10,592	881
December,	7,914	16,834	6,499	772	79	12,409	1,610
Totals,	94,982	191,932	79,000	7,686	595	135,021	13,753

The following short table shows the increase in the work of our inspectors during the past year:

Comparison of Inspectors' Work during the Years 1893 and 1894.

	1893.	1894.
Visits of inspection made,	81,904	94,982
Whole number of boilers inspected,	163,328	191,932
Complete internal inspections,	66,698	79,000
Boilers tested by hydrostatic pressure,	7,861	7,686

	1893.	1894.
Total number of defects discovered,	122,893	135,021
" " of dangerous defects,	12,390	13,753
" " of boilers condemned,	597	595

We append, also, a summary of the work of the inspectors of this company from 1870 to 1894, inclusive. The years 1876 and 1878 are omitted, because the data that we have at hand for those years is not complete. The figures, so far as we have them, indicate that the work during those years was in good accordance with the regular progression observable in other years. Previous to 1875 it was the custom of the company to publish its reports on the first of September, but in that year the custom was changed and the summaries were made out up to January 1st, so as to agree with the calendar year. The figures given opposite 1875, therefore, are for sixteen months, beginning September 1, 1874, and ending December 31, 1875.

SUMMARY OF INSPECTORS' WORK SINCE 1870.

YEAR.	Visits of inspection made.	Whole number of boilers inspected.	Complete internal inspections.	Boilers tested by hydrostatic pressure.	Total number of defects discovered.	Total number of dangerous defects discovered.	Boilers condemned.
1870	5,439	10,569	2,585	882	4,686	485	45
1871	6,826	13,476	3,889	1,484	6,253	954	60
1872	10,447	21,066	6,533	2,102	11,176	2,260	155
1873	12,824	24,998	8,511	2,175	11,998	2,892	178
1874	14,368	29,200	9,451	2,078	14,256	3,486	163
1875	22,612	44,763	14,181	3,149	24,040	6,149	216
1877	......	32,975	11,629	2,367	15,964	3,690	133
1879	17,179	36,169	13,045	2,540	16,238	3,816	246
1880	20,939	41,166	16,010	3,490	21,033	5,444	377
1881	22,412	47,245	17,590	4,286	21,110	5,801	363
1882	25,742	55,679	21,428	4,564	33,690	6,867	478
1883	29,324	60,142	24,403	4,275	40,953	7,472	545
1884	34,048	66,695	24,855	4,180	44,900	7,449	493
1885	37,018	71,334	26,637	4,809	47,230	7,325	449
1886	39,777	77,275	30,868	5,252	71,983	9,960	509
1887	46,761	89,994	36,166	5,741	99,642	11,522	622
1888	51,483	102,314	40,240	6,536	91,567	8,967	426
1889	56,752	110,394	44,563	7,187	105,187	8,420	478
1890	61,750	118,098	49,983	7,207	115,821	9,387	402
1891	71,227	137,741	57,312	7,859	127,609	10,858	526
1892	74,830	148,603	59,883	7,585	120,659	11,705	681
1893	81,904	163,328	66,698	7,861	122,893	12,390	597
1894	94,982	191,932	79,000	7,686	135,021	13,753	595

The following table is also of interest. It shows that our inspectors have made nearly a million visits of inspection, and that they have made over a million and three-quarters of inspections, of which nearly seven hundred thousand were complete internal inspections. Of defects, over a million and a third have been discovered and pointed out to the owners of the boilers; and nearly one hundred and seventy thousand of these defects were, in our opinion, dangerous. Nine thousand boilers have been condemned as unsafe, good and sufficient reasons for the condemnation being given in each case.

Grand Total of the Inspectors' Work Since the Company Began Business, to January 1, 1895.

Visits of inspection made,	891,707
Whole number of boilers inspected,	1,771,992
Complete internal inspections,	687,786
Boilers tested by hydrostatic pressure,	109,881
Total number of defects discovered,	1,341,330
" " of dangerous defects,	168,502
" " of boilers condemned,	9,001

Boiler Explosions.

December, 1894.

(304.)— The boiler in Pinkerton Misenheimer's saw-mill, Cabarrus county, N. C., exploded on December 1st. The engineer, Milas Misenheimer, was scalded so badly that he died shortly afterwards.

(305.)— A small boiler exploded on December 1st, in Louisville, Ky. Otto Shrieck was badly scalded about the face, arms, and breast, and William Kirk, an assistant, was painfully bruised. Both men will recover, but Mr. Shrieck will be permanently disfigured.

(306.)— The boiler of locomotive No. 187, of the Norfolk & Western railroad, exploded on December 3d, at Nolan Station, near Kenova, W. Va. Fireman A. M. French was badly scalded, and one of his legs was broken. It is feared that he cannot recover. Engineer G. W. Croky escaped without serious injury.

(307.)— A boiler exploded on December 3d, in Greene, a village in the northwestern part of Coventry, R. I. John A. Brown and Lyman Scott were instantly killed, and John E. Gladding, William Cushman, and Levi Remington were seriously injured. The shell of the boiler was found in a swamp, 250 feet from its original position. The building in which the boiler stood was wrecked. The explosion appears to have been caused by simple over-pressure, as the steam-gauge is said to have indicated 129 pounds a few moments before it occurred. The boiler was built of quarter-inch iron.

(308.)— A boiler exploded at Gray's elevator, Sabina, O., on December 5th. Nobody was hurt. The boiler landed 300 feet from its original site, and in its flight it tore the side out of a box car.

(309.)— The boiler in H. D. Richardson's cotton-gin at Elmo, Texas, exploded on December 5th. Mr. Richardson was injured, but will recover.

(310.)—On December 7th a boiler exploded near Carey, O., injuring Nicholas Goesche so badly that he died a few hours later.

(311.)—A boiler exploded, on December 7th, in Danby, Tompkins county, N. Y. William Bierce and a man named Van Lieu were killed, and Henry Beardsley and Fremont McFall were scalded so badly that they cannot recover.

(312.)—On December 8th a boiler exploded at Highland Village, near Lanesboro, Minn. Anton Simmons and a young man named Ellestad were scalded badly. Edward Overland was struck on the head by a piece of iron, and it is thought that he will die. At last accounts he was still unconscious.

(313.)—Ex-Mayor E. M. Short's steam saw-mill, at Washington, N. C., was wrecked on December 10th, by the explosion of one of a nest of four boilers. The exploded boiler was shattered into a thousand pieces. Mr. Short was killed, and so also were the engineer, two firemen, and a teamster. Two other operatives were injured.

(314.)—A boiler exploded on December 11th, at the Vincennes Novelty Works, Vincennes, Ind. The boiler room and plating room were completely wrecked, and the property loss is probably between $2,000 and $3,000. Harry Lane, a boy who was playing in the neighboring school-yard, was stunned by a brick, and although the extent of his injuries is not known, his physician did not consider them to be necessarily fatal. Charles Hodapp, another boy, was also struck in the head in the same manner, but his injuries were not serious.

(315.)—A boiler exploded at Whalen, Minn., on December 12th, and wrecked a neighboring dwelling-house belonging to Eben Gilles. Six persons were injured, but none of them fatally.

(316.)—One of the boilers in Willy & Co.'s flouring mill, at Appleton, Wis., exploded on December 15th. Engineer John Steinel and a laborer named Joseph Kreuzer were instantly killed. Two other persons were injured, and the property loss was about $12,000. A similar explosion occurred in this same mill on January 13th, 1894. (See THE LOCOMOTIVE for March, 1894, page 36, explosion No. 13.)

(317.)—Four men were injured, on December 16th, by the explosion of a boiler in Bronson township, Ohio.

(318.)—By the explosion of a boiler at Happly Hollow, Schoharie county, N. Y., on December 16th, William Hanson and Harry Tremont were fearfully scalded, and a man named Van Allen was badly injured. All three of the men may die.

(319.)—The boiler of an illicit still exploded in Quebec, Ontario, on December 17th, and nine persons were badly burned. It transpired that the still was owned by a sergeant of the city police!

(320.)—A boiler exploded on December 18th, in Russell Bros.' mill, at West Bay City, Mich., John Calcutt, George Pfund, Albert Heubenbecker, Albert Rahn, and John Braun, were killed, and Charles Doege, Roe Hudson, and Fred Wildanger were injured. Mr. Doege's injuries were quite serious, but he will live. The boiler house, the dry-kiln, and the east end of the factory were wrecked. The property loss is variously estimated at from $5,000 to $12,000.

(321.)—A boiler exploded in Peabody's mill, Paris, Ill., on December 19th. Benjamin Johnson, D. B. Peabody, and Samuel Richmond were seriously injured; Johnson died three days later, and Peabody is not expected to live. Part of the boiler was found 600 feet away. It had passed through a house in its flight, but none of the occupants were injured.

(322.)— A large kitchen boiler exploded in Gallipolis, Ohio, on December 19th. The building was considerably damaged, cooking utensils were thrown in every direction, and a servant in the kitchen was severely scalded.

(323.)— On December 19th a boiler exploded in Highland, near St. Paul, Minn. The boiler was constructed of steel, and the State inspector allowed the owners to carry a pressure of 120 pounds to the square inch. At the time of the explosion the gauge showed 165 pounds. The fusible plug, it was found, had been filled with babbitt metal instead of with tin, as required by law.

(324.)— A boiler exploded on December 21st in Trainor's mill, four miles north of Bellmont, near Mt. Carmel, Ill. George Trainor (a son of the proprietor) was killed instantly. Braden Myrick, the engineer, was bruised and scalded so badly that he died of his injuries within 24 hours. John Trainor, the owner of the mill, was seriously injured, but may recover. Zion Lambert, an employe, was scalded severely but not fatally. The boiler had no steam gauge, and our account says that the "pop-off" was set at 100 pounds, but that it was so defective that the boiler may have been carrying as much as 200 pounds.

(325.)— A saw-mill boiler exploded on December 22d, at Bonayr, Barren county, Ky. Robert Bird and a man named Spann were killed outright, and Claude Deering, Mr. Spann's son, and another man whose name we could not learn, were fatally injured. The mill was almost totally destroyed.

(326.)— A boiler exploded on December 23d in a tile factory at Elgin, Ill. The explosion did considerable damage, but nobody was hurt.

(327.)— On December 25th two boilers exploded in the Chewalla cotton mills, near Eufaula, Ala. One man, who was in the boiler room at the time, was injured quite badly, but he will recover. The mills were considerably damaged.

(328.) — A flue collapsed on December 27th, in a boiler in the basement of the Midland hotel, Kansas City, Mo. John Alba, a fireman, was injured so badly that he died next day, and Engineer Fred C. Patton was injured internally, and is expected to die. Riley Mowen was badly burned, but it is believed that he will recover. Fireman Henry Gable was also slightly injured. The damage to the hotel was small.

(329.)— A small boiler exploded in Springfield, Mass., on December 28th. Crayton Billings, the fireman, received painful injuries, and a young Italian boy was slightly hurt. At last accounts, Mr. Billings was on the road to recovery.

(330.)— A boiler exploded in Carter's mill, near Hinton, W. Va., on December 29th, killing George T. Hall instantly, and seriously injuring Edward Carter and several others. Six years ago a boiler exploded in the same mill, killing five men and injuring eight.

(331.)— A kitchen boiler exploded on December 30th, in the residence of Mr. W. J. Barnes of Tuscaloosa, Ala. The kitchen range was completely demolished, and furniture was blown through the ceiling of the room. Mr. Barnes was struck by a fragment of iron and painfully injured.

The Locomotive.

HARTFORD, FEBRUARY 15, 1895.

J. M. ALLEN, *Editor.* A. D. RISTEEN, *Associate Editor.*

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Papers that borrow cuts from us will do us a favor if they will mark them plainly in returning, so that we may give proper credit on our books.

IN these *fin de siècle* days we look to the theater to give us faithful representations of saw-mills in action, of mountain torrents, of earthquakes, of volcanic eruptions, and of whatever other startling thing the fertile imagination of the manager can conjure up and the stage carpenter can construct. We confess, however, that we had not looked for a genuine boiler explosion; and yet, behold! it has come to pass. An advertisement in an esteemed contemporary notifies us that this very thing is given "in the new Uncle Hiram" (whatever that may be), six evenings in the week, with Saturday matinées; and the further advice is given, "Don't fail to see it at the Opera House."

A BOILER in England burst recently, and, at the inquest held upon it, a person testified that he had examined the boiler all over — or at least where he could get at the parts without trouble — and found it safe. He had never examined a boiler before, but he thought he was quite capable of it, and presumed the whole boiler was safe because he did not see any defects in a cursory inspection; his opinion was that "black heat" caused the explosion. It only remains to add that this gentleman was ordered to pay $50 towards the cost of the inquest, not, possibly, because of his "black heat" opinion, but to teach others to be more careful in future. — *The Engineer* (New York).

Fast Living.

The most remarkable instance of rapid growth is said to be recorded by the French Academy in 1729. It was a boy of six years of age, 5 feet 6 inches in height. At the age of five his voice changed, at six his beard had grown, and he appeared a man of thirty. He possessed great physical strength, and could easily lift to his shoulders and carry bags of grain weighing two hundred pounds. His decline was as rapid as his growth. At eight his hair and beard were gray; at ten he tottered in his walk, his teeth fell out, and his hands became palsied; at twelve he died with every outward sign of extreme old age. — *Times and Register.*

[This reminds us strongly of the precocious baby whose brief but eventful biography is given in Mr. W. S. Gilbert's *Bab Ballads.* After giving numerous illustrations (with both pen and pencil) of the extraordinary sophistication of this infant, Mr. Gilbert tells us that

"He died, an enfeebled old dotard, at five."

— ED.]

The Importance of Ductility in Boiler Plates.

The evidence given at the inquest on the fatal explosion which occurred on Dec. 17th, at the Henry Rifled Barrel and Small Arms Factory, Hoxton, [Eng.,] and by which two men were killed and half a dozen seriously injured, shows once more the importance of steam-users insisting upon the employment of nothing but the very best material in the construction of steam boilers.

It is not sufficient for boiler plates that they are capable of standing a considerable tensile stress. Measured by this standard alone, steel and iron may appear to be fairly satisfactory, and yet as boiler materials they may be utterly worthless. What is of far more importance than tenacity is, that the material shall be *ductile* — that is to say, capable of being drawn out before breaking. In virtue of this property the structure is capable of adjusting itself to the various stresses that are imposed on the material during the process of construction, as well as those arising from unequal expansion and contraction when the boiler is set to work. How serious and complex the nature of these stresses is, only engineers who have made a special study of the working of steam boilers adequately realize. The boiler in the explosion under notice was of the externally fired type, a class which . . . is specially liable to stresses from the action of the fire, and therefore one in which the employment of a good ductile material is the more necessary.

In the absence of the detailed report of the Board of Trade, which will, however, be issued in due course, we cannot state precisely the cause of the disaster. It would appear most probable, however, that it arose from a rip at one of the longitudinal seams. But of one thing there is no doubt, and that is that the wretched character of the material of which the boiler was made contributed largely to the result. In the course of the inquest, evidence was given which clearly proved this point. Test strips of the plates, which were of iron, gave a tenacity of 21.97 tons pulled in the direction of the grain, and 18.89 tons pulled across the grain. As a tensile strength this may seem fairly good, and it is only when we turn to the percentage of elongation that we clearly realize the wretched character of the stuff. This on a length of 10 in. was only 4 per cent. and 1.9 per cent. respectively. The two samples named were taken from plates exposed to the action of the fire. These results were fully confirmed by two other specimens cut from a plate away from the fire, which gave a strength of 19 tons per square inch, and 17 tons per square inch with the grain and across the grain respectively, the corresponding elongations being 3.7 per cent. and 1.4 per cent. in a length of 10 inches. How miserably deficient the material was in the all-important property, *ductility*, will be realized when it is stated that similar test pieces of good iron boiler plates would give an elongation of something like 7 to 10 per cent., while mild steel would afford an elongation of upwards of 25 per cent. The material was what is technically known as "best" iron. As a matter of fact, it was about the worst quality that could possibly be used, and utterly unfit for boilers. With such brittle plates and punched holes, it is easy to understand that the use of a drift, which would be almost inevitable (since some of the rivets were not fair in the holes), would go a long way towards establishing cracks in the first instance, and that it would only be a question of time for such incipient flaws to develop into open rupture.

We have stated that the quality of the plates was that known as "best" iron. The use of this phrase by makers of iron plates is very misleading to steam-users who have no technical knowledge, and, therefore, it may not be out of place if we explain that the qualities of iron plates are roughly designated in the trade [in England] as "best,"

"best best," and "treble best." Thus the brand designated as "best," is in reality the worst that can be employed, and its use in boiler construction should, in our opinion, be made criminal.

At the inquest the usual verdict of "accidental death" was returned, the jury stating that they agreed with the engineer of the London County Council, who gave evidence, and stated that in his opinion the explosion was due to the brittleness of the material, coupled with bad riveting and the unequal strain induced by external firing, adding that the disaster was not the result of any special act or circumstance.

When a boiler explosion is clearly proved to be due to bad workmanship and worse material, it cannot, in our opinion, be regarded as accidental. Surely someone is, or ought to be, responsible for the material and workmanship employed in the construction of a steam boiler. Happily, the matter will not be allowed to rest where it is; the Board of Trade will, no doubt, make an inquiry in due course, and the question of responsibility for the defects that have been proved to exist, will probably be brought home in a highly unpleasant manner to the parties concerned.—*Practical Engineer* (Eng.).

Thick Fires.

It is the prevailing opinion with some that it is necessary when a boiler is worked to a high rate of capacity to maintain correspondingly heavy fires. It is argued that thin fires are well enough for slow rates of combustion, but as the call for steam increases it must be met by an increased thickness in the bed of coal on the grate. Where heavy fires are carried it is a common thing for the fireman to shovel in all the coal that he can conveniently supply, going so far as to almost fill the opening at the fire door, leaving little if any room for a future supply until that already in has been pushed back to make room for more. The ordinary fireman is apt to favor this method, for the reason that he can introduce large quantities at a firing, and afterwards he is not obliged to give the fires much attention for perhaps an hour's time, when he will again fill the furnace full in the same manner as before. This method of firing with most of the high-class bituminous coals in use in the Eastern States requires from time to time the use of the slice bar for breaking up the bed of coal. It has always seemed to the writer that whatever necessity there may be according to the popular idea for carrying heavy fires, in the matter of the amount of labor involved it is in reality more laborious for the fireman than it would be if the fires are kept comparatively thin and small quantities of coal supplied at each firing. As an explanation, however, of the favor which this method receives, it is probable that the class of labor which is generally employed considers the muscular effort required much less of a task than the more frequent and careful attention which is needed when the fires are kept at medium thickness.

As regards a comparison between thick and thin fires, the fact is that more capacity can be obtained from a boiler when a fire of medium thickness is carried and proper attention is given to its condition than can be realized by any system of management when the fires are exceedingly heavy, and advocates of thick fires, who take the ground that they are a necessity when boilers are forced, are entirely mistaken. As to the economy of the two, some persons maintain that heavy fires give the most economical results, but this is questionable. Valuable information on the subject has recently been brought out by the results of two evaporative tests, which we give below. They were made on a 72-inch return tubular boiler having 1,000 $3\frac{1}{2}$-inch return tubes, 17 feet in length. The heating surface amounted to 1,642 square feet, and the grate surface to 36 square feet, the ratio of the two being 45.6 to 1. On the thick fire test the depth of the coal on the grate varied from 8 to 20 inches, being heaviest at the rear end and lightest at the front end. On the thin fire test the depth was maintained uniformly at about 6 inches. The fuel was New River semi-bituminous coal. The difference in the results as appears from the figures is an increased evaporation due to thin fires amounting to 15.6 per cent.

	Condition as to thickness of fires.	Thick fires.	Thin fires.
1.	Average boiler pressure, pounds,	131.6	130.4
2.	Average temperature feed water, degrees,	39.6	43.5
3.	Average temperature flue gases, degrees,	484	487
4.	Average draught suction, inches,	0.17	0.18
5.	Per cent. moisture steam, per cent.,	0.25	......
6.	Coal per hour per square foot grate, pounds,	13.72	12
7.	Per cent. ashes, clinkers, per cent.,	5.1	5.7
8.	Horse power developed on basis 30 pounds from 100° and at 70 lbs., horse power,	140.3	144.4
9.	Water evaporation per pound coal, pounds,	8.517	9.457
10.	Equivalent evaporation, per pound of combustible from and at 212 degrees, pounds,	10.985	12.234

— *Scientific American.*

Molecules.

For the past 2,000 or 3,000 years, philosophers have taken special delight in theorizing about the nature of matter. Their theories, until recently, were not based upon a study of nature, but were evolved from their inner consciousnesses, and were the products of meditation rather than of experiment. Some of the views of these early philosophers have turned out to be surprisingly near the truth, while others are absolutely absurd and ridiculous. Nowadays the physicist pursues a very different method. He studied the properties of matter as they are manifested in his laboratory and elsewhere, and strives to discover the simplest constitution of matter that would suffice to explain these properties. He always checks himself carefully by the facts, and his theories are accepted or rejected according as they agree with these facts or disagree with them. They are also judged according to their intrinsic reasonableness. It is easy enough, comparatively, to find out whether a theory agrees with the facts or not, but it is not so easy to say that is reasonable or unreasonable; for this will depend to a large extent upon the state of knowledge at the time and upon the year of grace in which the theory is propounded. It is a notorious fact that things that are absurd to one generation are often mere commonplaces to the next one.

The sound and healthy growth of our knowledge of the constitution of matter can fairly be said to have begun with the present century. In 1805 Dalton, a celebrated English chemist, called attention to the fact that when substances combine with one another they do so in certain definite proportions; and he felt that the easiest way to explain this was to assume that all bodies consist of small particles, which come together in pairs, or in threes, or fours, when these bodies combine. This would explain the law of definite proportions, a law which is difficult to account for by any other hypothesis. There are many other reasons for believing that matter is not homogeneous, as it often appears to be to our senses, among which may be mentioned the dispersion of light by a prism. It is difficult to understand why a light of one color should be refracted either more or less than one of another color, unless we suppose that the transparent substance composing the prism really has a grained structure, and that the distance between its particles is comparable with the wave-length of the light. The high vacuum tubes constructed by Mr. Crookes afford a most convincing proof of the molecular constitution of gases, but we cannot dwell upon them, interesting as they are, in the present article.

All bodies may be classified in general as solids, liquids, and gases. This classification is by no means perfect, because there are many substances, such as tar and certain kinds of wax, which are brittle, and are apparently solids, but which nevertheless will flow like a liquid *if we give them time enough.* According to the present views of physicists, solid bodies are believed to consist of molecules that are relatively fixed, so far as their positions are concerned. They may be vibrating, or rotating, or oscillating to and fro, but they never depart very far from their average positions unless constrained to do so by the application to the body of some external force. In liquids, as well as in solids, the molecules are believed to be very close together, and well within the range of their mutual powers of attraction. They are not believed to be fixed, however, but are thought to weave their way in and out among one another perpetually, so that in the course of time any given molecule may pass throughout the entire mass of liquid in which it occurs. Gases are believed to differ from liquids in having their molecules further apart, so that the effects of intermolecular attraction are barely perceptible. The molecules of gases are also believed to be traveling with speeds greatly in excess of those which occur in solids and liquids.

It has been found easier to investigate the properties of gases than those of solids and liquids, on account of the simplicity of the physical laws to which they are subject; and hence the molecular theory of gases has been developed much more than the corresponding theory of other bodies. Many of the results that mathematicians have obtained by studying the inter-action of flying molecules are extremely interesting, but we can touch only upon one or two of the most rudimentary of them. It has been shown that the "absolute temperature" of a gas is proportional to the square of the average speed of its molecules. As the molecules strike against the walls of the vessel containing them, they act like so many rubber bullets fired out of a gun, and as they are extremely numerous they produce the effect which we call "gaseous pressure." When a liquid is allowed to evaporate, the action is believed to be something like this: The molecules within the liquid are attracted equally in all directions, but those which are at the surface are attracted only downward. Now if a molecule, in the course of its wanderings, comes to the surface of the liquid, it will continue its upward motion for a certain distance, and may even pass away from the liquid altogether. As soon as it has left the liquid, however, the attraction which the liquid exerts upon it is wholly *downward*; and if the escaped molecule is moving slowly, it may not be able to rise very far before the pull of the liquid stops it and makes it fall back again. On the other hand, if it is moving with considerable speed it will be merely slowed down a little, but will continue in its upward course with reduced velocity, and after it has risen to a height of one five-thousandth of an inch, or so, it will no longer feel the attraction of the liquid, but will have become a permanent addition to the vapor above. This explains why liquids do not fly into vapor instantly. It also explains why evaporation *cools* the liquid; for it is only the swiftest molecules that escape, and hence the tendency is to continually reduce the average speed of those that are left. If the liquid is enclosed in an air-tight vessel the evaporation will not go on indefinitely, but a state of equilibrium will be attained when the vapor over the liquid acquires a certain density; because, although molecules continue to escape from the liquid as before, yet as the density of the vapor increases a larger and larger number of molecules will happen to fall back into the liquid again, and get entangled within it — the apparent equilibrium being attained when the number of molecules that leave the liquid in a given time is precisely equal to the number of those that chance to plunge back into it out of the vapor.

The pressure that the gas exerts against the vessel containing it being due to the molecular bombardment of the walls, it is an easy matter to calculate the speed that the molecules must have in order to give the observed pressure. It is found, for example, that molecules of air under ordinary conditions of temperature and pressure have an average velocity of about 2,000 feet per second. The speed is even higher in hydrogen gas, whose molecules travel, on an average, more than a mile in one second. Of course there must be frequent collisions between the flying molecules of gases; and it has been shown that the average distance that a molecule of the air travels between two successive collisions with its neighbors, is about three one-millionths of an inch. It is easy from these data to show that the number of collisions experienced by a molecule of air in one second is about five thousand millions.

When we come to consider the sizes of molecules, and the absolute number of them in a given volume of gas, we find that molecular science is not yet able to give us a very precise answer. Many methods for finding the sizes of molecules have been proposed, but a general discussion of them would be out of place in this article. One of the simplest of them is known as the "method by camphor movements." If camphor scrapings be dropped upon an absolutely clean water surface, they will at once exhibit surprisingly vigorous movements. This experiment is easily performed, but the most absolute cleanliness is essential to its success. The least trace of oily matter on the water will stop the movements entirely. We need not enter upon the explanation of the astonishing behavior of the camphor particles, further than to say that it is a "surface phenomenon" entirely, and that the molecules of water below the surface have nothing to do with it. As soon as the water is covered by an oil film, however thin, the movements cease, as we have said. By using a large tank of water, and allowing a very small but known quantity of oil to spread over it, it has been found that the camphor particles are brought to rest by a film of oil about .00000006 of an inch thick. We do not know that this film of oil is precisely one molecule thick, but we *do* know that its thickness cannot be *less* than that. Other methods, entirely different in principle and based upon experiments of very different kinds, give substantially the same results; and hence we conclude that the figure just given is of about the right order of magnitude for the diameters of molecules. By compressing gases strongly, so that they begin to deviate from Boyle's law, it is possible to show what proportion of the volume of the gas is actually filled by molecules, and what proportion of it is empty space. In hydrogen gas, for example, we find that only about $\frac{1}{3000}$th of its volume, under ordinary conditions, really consists of matter — the rest of it being empty. Knowing in this way the total volume of the molecules, and having found by other methods the diameter of a single molecule, we can find how many molecules there are in a cubic inch of the gas. Thus it is found that in all gases, at atmospheric pressure and at the freezing point, there are about 100,000,000,000,000,000,000 molecules in each cubic inch.

Such numbers as this, obtained from a study of things that surround us on all sides, put to shame the boasted big numbers of astronomy. It is impossible to conceive them, and an illustration will perhaps serve to make their significance a little easier to grasp. If the molecules contained in a cubic inch of hydrogen were placed in contact in a straight line, they would reach 32,000,000 miles, or about one-third of the way from the earth to the sun. (This seems like an impossibility, but it can be easily shown to be true.) To gain a further idea of the number of molecules in a cubic inch of gas, it may be said that if these molecules were spread out on a plane so that the average distance from one molecule to its neighbor was the same as the average distance between the centers of the letters on this page, the sheet thus formed would wrap around the entire earth, and cover it completely.

Incorporated 1866.

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Charter Perpetual.

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The Locomotive.

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NEW SERIES — VOL. XVI. HARTFORD, CONN., MARCH, 1895. No. 3.

On Boilers with Single Fire Sheets.

Some few years ago it was quite common to build boiler shells with short courses of plates, the rings, in many cases, being not more than three feet long. The reason for this mode of construction was that it was very difficult at that time for the rolling mills to turn out larger plates that were both uniformly good in quality and cheap enough to compete in the market with the smaller ones. With the gradual improvement of methods of manufacture, and the introduction of larger and better machinery in the plate mills, the various objections to large plates lost their cogency, and at the present day boilers with three courses (or four courses, at the most,) are almost univer-

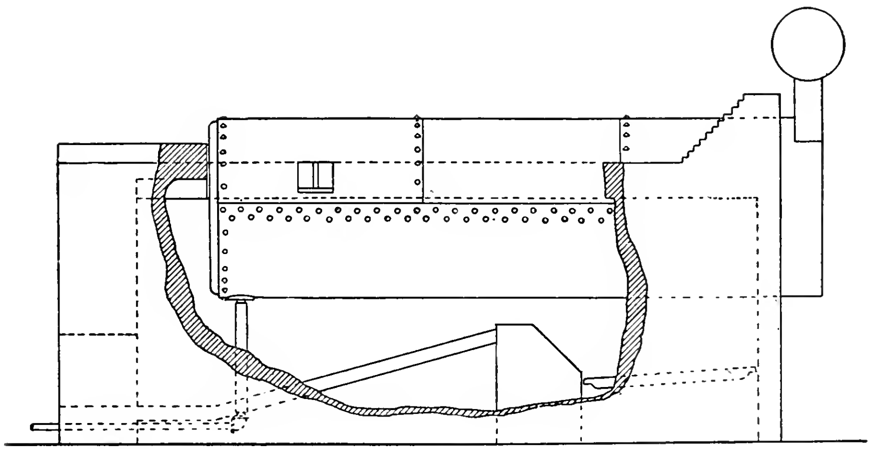

FIG. 1.— ELEVATION OF A SINGLE-SHEET BOILER.

sal. The effort to make larger and larger plates has by no means ceased, and to-day we find many large boilers constructed as shown in Figs. 1 and 2, the lower half of the shell being composed of a single sheet of unusual size, while the upper half is composed of three courses of smaller plates, as before.

The single fire-sheet is used with the idea that much is gained by keeping the girth-joints up out of the fire, and undoubtedly the construction in question is good, so far as this one point goes. We have no desire to condemn these big, single-sheet boilers — in fact, we have repeatedly accepted them for insurance, and shall probably continue to accept them so long as they are otherwise well-designed and well-made — but we wish to explain why we are not as enthusiastically in favor of them as their advocates have expected us to be.

In the first place, we hold that since the longitudinal joints are always subject to greater strain than the girth-joints, it is much more important to protect the former from the fire than the latter. If the reader will carefully observe Figs. 1 and 2, he will readily understand the point we wish to make. Putting aside all question of the greater liability to defects that the big single sheets may have, the fact remains that these sheets, *when used on large boilers*, are not wide enough to allow the builder to carry the longitudinal joints above the fire line. These joints are located below the lugs or brackets that support the boiler, and are, therefore, subject to the unobstructed and intense heat of the furnace; so that, although the new construction does away with *girth* joints in the furnace, and in this respect is an improvement, as we have already admitted, yet it involves the grave defect of exposing the *longitudinal* joints to the fire. We have long maintained that boilers should be so constructed that all longitudinal joints will be well above the fire-line, and covered in by the brick-work. Figs. 3 and 4 illustrate the construction that we have recommended for this purpose. There are three rings of plates, as will be seen, and the longitudinal joints are well protected.

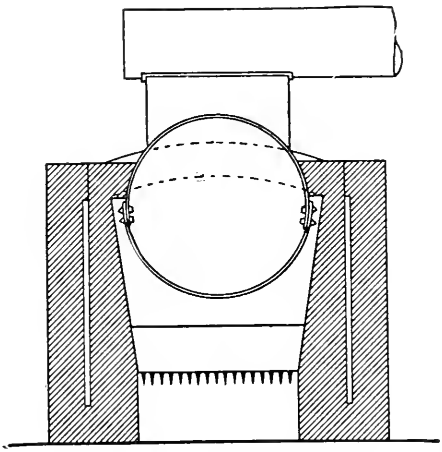

FIG. 2.— SINGLE-SHEET BOILER.

The single bottom plate has been used for some years in the construction of boilers of comparatively *small diameter*, to be used at ordinary pressures; but in these cases the plate has been wide enough to carry the longitudinal joints above the fire-line — a point of difference well worth serious consideration. It does not follow, from the admitted excellence of these earlier and smaller boilers, that the same principle of construction is advisable for the large, high-pressure boilers that our modern compound, triple, and quadruple expansion engines require.

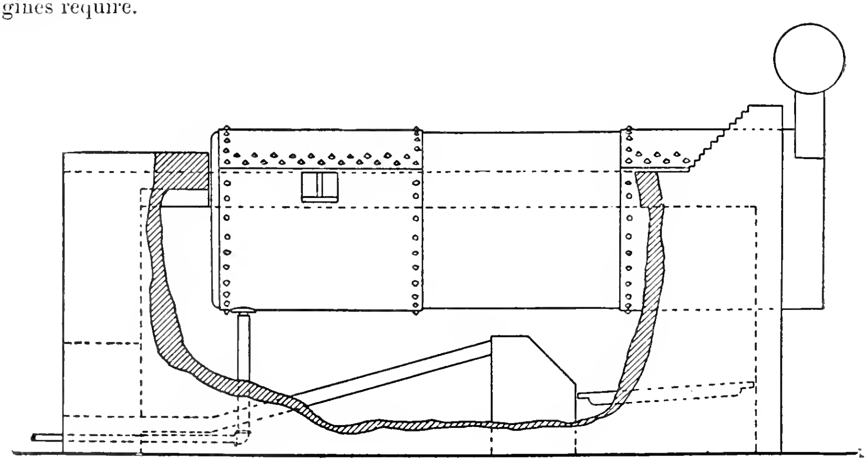

FIG. 3.— ELEVATION OF A THREE-RING BOILER.

Another point to which the attention of boiler-makers and steam-users is earnestly called is the fact that in the new construction the longitudinal joint extends without a break from one end of the boiler to the other. The principle of "breaking joints" is observed in carpentry, masonry, bridge-building, and other constructive arts: we do not see why it is not also applicable to boiler making.

We wish to move with the times in the matter of boiler construction, and we have no desire to "be the last by whom the old is laid aside"; but at the same time we feel that there are two sides to the single-sheet question, and which of them is right can only be finally settled by experience. If it be urged that the new design works well in practice, we can only reply that such a conclusion is hardly yet warranted by the data at hand. We must wait until many more such boilers are built, and until they have been fully tested under actual running conditions, before any final and trustworthy conclusion can be reached. We may say, however, that we have known of trouble from the single sheet already. Fig. 5, for example, represents a boiler of this kind that recently exploded in an electric light plant, with disastrous results. This boiler was 66 inches in diameter and 16 feet long, with 54 four-inch tubes. It was made of steel, $\frac{3}{8}$ of an inch thick, and the longitudinal joints were double riveted. As will be seen from the cuts, there were three courses on the top, and a single sheet on the bottom. The lines of fracture are indicated in the cut, and there was every indication, both from the final disposition of the fragments of the boiler and from a study of the reduction in area along the torn edges of the plates, that the initial rupture was at the point indicated by the arrow. There was also good reason for believing that the explosion was primarily due to the

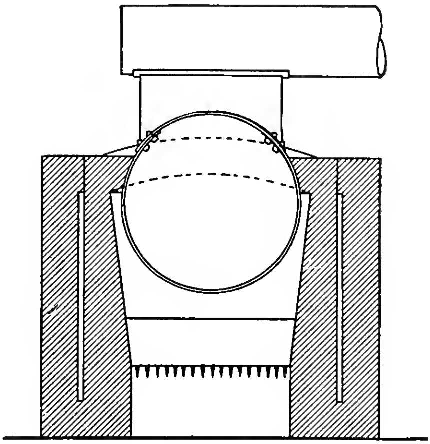

Fig. 4.—Three-Ring Boiler.

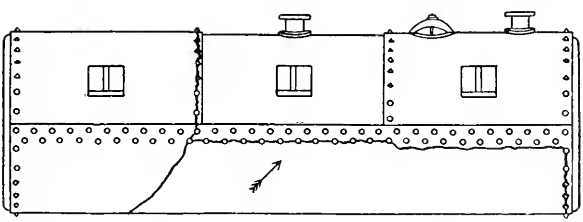

Fig. 5.—Showing Lines of Fracture in a Single-Sheet Boiler.

single-sheet construction, and the consequent exposure of the longitudinal joint to the fire. Two persons were killed by this explosion, and three seriously injured, and the property loss was estimated at $50,000.

Inspectors' Report.

MARCH, 1895.

During this month our inspectors made 8,308 inspection trips, visited 17,504 boilers, inspected 4,355 both internally and externally, and subjected 539 to hydrostatic pressure. The whole number of defects reported reached 10,726, of which 990 were considered dangerous; 37 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	815	52
Cases of incrustation and scale,	1,753	73
Cases of internal grooving,	85	5
Cases of internal corrosion,	576	32
Cases of external corrosion,	712	45
Broken and loose braces and stays,	224	104
Settings defective,	315	24
Furnaces out of shape,	383	16
Fractured plates,	381	47
Burned plates,	212	28
Blistered plates,	231	8
Cases of defective riveting,	1,482	57
Defective heads,	106	16
Serious leakage around tube ends,	1,833	227
Serious leakage at seams,	418	38
Defective water-gauges,	304	85
Defective blow-offs,	147	42
Cases of deficiency of water,	18	11
Safety-valves overloaded,	82	26
Safety-valves defective in construction,	80	27
Pressure-gauges defective,	391	23
Boilers without pressure-gauges,	3	3
Unclassified defects,	85	1
Total,	10,726	990

Boiler Explosions.

JANUARY, 1895.

(1.)—On January 1st a boiler exploded in Salzenstein Bros.' rendering works, near East Peoria, Ill. Superintendent Jackson James was blown 150 feet and instantly killed, and the works themselves were almost totally wrecked.

(2.)—A small boiler belonging to William Kirkwood, at Pinoak, near Oil City, Pa., exploded on January 3d. The boiler-house was wrecked, but Kirkwood, who was the only one about the place at the time, escaped without injury.

(3.)—By the explosion of a boiler in Metz, Mo., on January 4th, C. B. Wilson and W. W. Smith were fatally injured. Mr. Wilson was scalded and bruised about the head, and Mr. Smith had an arm and a leg broken, and was scalded severely and injured internally. P. C. Smith and E. Gillespie were also scalded and bruised about the head and shoulders.

(4.) — A boiler exploded on January 4th at Rosston, ten miles east of Lebanon, Ind. No one was in the building at the time, but five men who were in the yard had narrow escapes from death. The mill was completely wrecked, one side of it being blown bodily out and carried a distance of 200 feet.

(5.) — On January 4th a boiler exploded in the Fordville Coal Company's shaft-house at Ford, Iowa. The boiler was thrown about 200 yards, and all the framework and elevators caught fire and were destroyed. Engineer Solomon Bailey was injured, but not fatally. About fifty men were thrown out of employment, and the loss is estimated at from $4,000 to $5,000.

(6.) — A japanning boiler in the factory of Conchares, Schreiber & Co., at Dubuque, Iowa, exploded on January 7th, causing a fire which damaged property to the extent of about $5,000. Foreman William Dougherty was killed.

(7.) — A boiler exploded in Tench's mill, near Hilda, in Sussex Co., Va., on January 8th. Nobody was injured, and the property loss was not great.

(8.) — A boiler exploded at the works of the Joplin Gas Company, at Joplin, Mo., on January 9th. The power-house was wrecked and the buildings took fire, but the flames were controlled after a desperate fight. The explosion blew the engineer through a window, but it does not appear that he was hurt.

(9.) — A boiler exploded at Convent, La., on January 9th. Joseph Adams had both legs broken.

(10.) — A boiler exploded on January 11th in the electric light plant at Highland Park, near Waukegan, Ill. Nobody was hurt.

(11.) — On January 12th a water-back exploded in the residence of Mr. J. M. Neal of Davenport, Iowa. The entire front of the range was blown off, but fortunately there was no one in the kitchen at the time.

(12.) — Two boilers exploded on January 16th in the thirty-inch mill of the Carnegie steel works at Homestead, Pa. John Greka was firing one of the boilers and Harry Brenneman was standing near him. Both men were hurled across the room, and Brenneman was instantly killed by the concussion. Greka bore few marks of injury, but the shock that he had sustained was so severe that he died shortly afterwards. John Baraak, who was some distance from the exploding boilers, was dashed against a beam, and although it is believed that his skull was fractured, some hope is felt that he may recover. William Banks, who was passing through the boiler-room at the time, received a severe shock and was badly scalded. The property loss is estimated at from $8,000 to $10,000.

(13.) — A small boiler exploded on January 17th near Portland, Ore. The boiler-house was blown to kindling wood, but the engineer, who had just stepped outside, escaped with a black eye. The greater part of the boiler was blown to a distance of 500 feet, striking a derrick in its flight, cutting the boom (a timber sixteen inches in diameter) squarely off, and carrying the butt a distance of 150 feet. There was plenty of water in the boiler, and the safety-valve was in good order.

(14.) — On January 17th a boiler exploded in a cotton gin at Grifton, near Greenville, N. C. Theodore Bland (the proprietor) and John Smith were instantly killed, and another man was painfully but not dangerously injured.

(15.) — A boiler exploded on January 17th in the plow-handle factory at Lebanon, Ind. The entire plant was wrecked. The engineer had noticed something wrong about the boiler, and had just left the boiler-room to inform the foreman. To this circumstance he owes his life.

(16.) — A terrible boiler explosion occurred at the Van Buren saw-mill, eighteen miles southwest of Rusk, Cherokee county, Texas, on January 17th. William Lewis, Alexander Lewis, Tobias Richardson, Alexander Hamilton, and Abner Lee were instantly killed. Emanuel Hamilton and Ashton Miller were injured so badly that they cannot recover, and Nicholas White, Peter Van Buren, Andrew Ross, and Richard Loftin received injuries from which they may recover. Everybody about the mill was killed or wounded, except two boys, who escaped unharmed, although they were standing within a few feet of the boiler.

(17.) — A boiler in Shallmar's mill, near Rison, Ark., exploded on January 19th. J. T. Sumerow was instantly killed, and Charles Valentine, the engineer, died two days later. The engineer's son, Edward Valentine, was so badly scalded that he cannot possibly live, and James McCullough and William Gray were scalded and bruised so that their recovery is doubtful. The property loss is estimated at $30,000.

(18.) — A boiler exploded on January 21st at Indian Camp, fifteen miles northeast of New Concord, Ohio. W. M. Dickson was instantly killed, and Albert Morrow was fatally injured. Elmer McCullough and Oma Evilseizer were also injured, but it is believed that they will recover.

(19.) — One of the boilers in Brownlee & Co.'s saw-mill on the River Rouge, near Detroit, Mich., exploded on January 21st. Frank Collian, the engineer, was instantly killed, and Henry Setske had one arm and one leg torn off, and may die. The property loss was probably about $3,000. Mr. John N. Brownlee, president of the company, said: "I am wholly at a loss to find a cause for the accident. The boiler that exploded was seven years old and was one of a battery of four. The boiler-room had every known appliance for safety. Each boiler was provided with a separate locomotive pop safety-valve and a steam gauge. The boiler that exploded was thoroughly overhauled less than a year ago, and was believed to be in perfect condition. The fireman states that there were three gauges of water in the boiler less than half a minute before the explosion occurred."

(20.) — A boiler exploded on January 23d in Parson Bros.' saw-mill on Sugar creek, six miles southwest of Springfield, Ill. John C. Parsons was killed and the mill was destroyed. The property loss is estimated at $8,000.

(21.) — On January 24th a boiler exploded in the Johnson-Brinkman grain elevator at Rosedale, near Kansas City, Mo. Pieces of boiler-iron were scattered about the neighborhood for blocks. The walls of the engine-room were razed to their foundations and not a brick was left in its original position. Débris of all kinds was thrown high into the air, falling in a shower upon the surrounding roofs. The property loss was about $5,000. There was nobody in the building at the time of the explosion.

(22.) — The main building of C. Henning & Son's brewery, Mendota, Ill., was destroyed on January 25th by a fearful boiler explosion. Adam Biersheid, Samuel Deshazo, David Gheer, John Kennedy, Henry Pearl, Christopher Seifert, David Wells, and William Long were killed, and James Love, H. Freeman, A. McLeod, George Parker, Charles Reed, Frank Henning, and Henry Varmore were more or less seriously injured. The property loss was estimated at $100,000.

(23.) — The large boiler of the extensive green-houses owned by Mr. Augustus Doll of East York, Pa., exploded on January 26th. A considerable amount of damage resulted.

(24.) — A boiler exploded on January 27th at the Enz brewery, Allegheny, Pa. The boiler was torn into a dozen pieces, and nothing was left of the boiler-house but the foundations. A large hole was made in the side of Mr. Enz's house, which adjoins the brewery, and Mrs. Enz and her youngest child were painfully injured. The boiler was new and was tested hydrostatically a short time before.

(25.) — A steam boiler used in the government distillery of Mr. T. G. McCowan, Culloden, Ga., exploded on January 28th, scalding Mr. Derwood Sanders so badly that he died later in the day. George McCowan was also fearfully injured, and one of the accounts we have received says that he was killed. Henry Shellworth had both hands blown off and Thomas M. McCowan was badly scalded.

(26.) — A boiler explosion, followed by a panic, took place in the Exchange building at the stock-yards in Chicago, Ill., on January 28th. The exploded boiler formed part of the heating apparatus in the sub-basement. Considerable damage was done in the sub-basement and on the floor immediately above. About twenty-five persons were in the restaurant at the time. They were badly frightened by the shock and the noise, and fled precipitately for the street, overturning tables, chairs, and other furniture, and all joining in a general chorus of howls and screams. They were much more scared than hurt.

(27.) — On January 30th a boiler exploded in the electric power house at Denver, Col. Conrad Bitzer and Frank Walrod were killed, and Edward Stanley, Hugh Ellis, and John Brown were painfully injured. The boiler-house was completely wrecked, and the property loss is estimated at $50,000.

(28.) — John Reedy, a fifteen-year-old boy living in Etna, near Pittsburgh, Pa., was quite seriously injured, on January 30th, by the explosion of a copper boiler connected with a small steam engine of his own make. The boy's head and face were badly scalded, and his eyes were nearly destroyed.

(29.)—A boiler exploded on January 30th, in the windmill factory at Columbus, Neb., tearing out the north wall of the engine room, blowing off the roof, demolishing two walls, and wrecking the machinery. The steam gauge registered ten pounds at the time of the accident. The engineer had left the room about two minutes before the explosion, and nobody was injured.

Poets and philosophers are fond of marveling at the wonders of the human heart, but they usually confine themselves to homilies on its ceaseless activity, and some of the things that are most wonderful of all escape their attention entirely. One of the most remarkable things about the heart is the *amount* of the work it does. Considering the organ as a pump, whose task it is to deliver a known quantity of blood, against a known "head," it is easy to show that in 24 hours a man's heart does about 124 foot-tons of work. "In other words," says a contemporary, "if the whole force expended by the heart in 24 hours were gathered into one huge stroke, such a power would lift 124 tons one foot from the ground. A similar calculation has been made respecting the amount of work expended by the muscles involved in breathing. In 24 hours these muscles do about 21 foot-tons of work."

Finding Squeaks and Knocks in Machinery.

John H. Cooper.

I once sent a boy to find a squeak in a lathe counter-shaft; he returned to me, saying he could not find it. I asked him whether he used his eyes or his ears to hear with. Not understanding me exactly, I then said to him: "Let us go and see if we can find a pulley that makes the same number of turns per minute as the squeaks we hear." We soon found one. "Do you see that?" pointing to the desired pulley. "Yes, sir," he replied. "Now step up to it and oil its shaft." He did so, and silenced the squeak. "Let me now impress this upon your mind so that you will remember it as a lesson well learned," I said; "in future, when you are sent to find a machine-shop squeak, be sure to use your *eyes* as your *ears*." This little incident, which happened forty years ago, I have turned to good account many times since.

Knocks in engines can be found very easily in the same way, by synchronizing the sight and sound of them. Every one knows that the sounds of working machinery are carried to almost every fixed and working part of the same, and unless there are some means known of locating them by coincidence of motion their discovery is very difficult. The fact is generally observed that sounds are loudest where they are made, but we cannot always say, in truth, that sounds gradually decrease in loudness as we withdraw from the sounding body; surrounding objects may have the effect of dispersing or concentrating the waves of air, which carry sounds, so to speak. A concave body will collect the promiscuous sound waves about us, rendering them audible, which, without some special device, would pass by us unheard. So children say: "Put a sea-shell to your ear and hear the ocean roar." In the philosophy of echoes the existence of surfaces which collect and return to us the expanding sound waves are included, but we are at or near the focus of these rays in order to get the benefit of the many vibrations, which, without concentration, would be lost to us. The increase of sound in one locality and its decrease in another diverts the attention, confuses the ear, and makes the locating of its origin difficult in the engine room; therefore it is necessary for the ear to have the aid of the unerring eye to fix the exact place of it and find the cause.

I have often proved the necessity of *seeing* as a strong aid to *hearing*, by pacing back and forth many times the full length of the engine, as a method of locating a "thump," often finding little or no difference in the loudness of the sound, wherever I might be; but as soon as I discovered a concordance of sound and motion, then at once the solution came — there was no uncertainty afterwards. So Schelling says: "In order to see aright one must know to look." The study of acoustics and its illusions is deeply interesting by the peculiar phenomena presented and the startling disclosures made. The flight of sounds, followed by their repetition without apparent cause, as with echoes, and their diversion from original sources, completely deceiving the listener, as shown by the art of the ventriloquist, are familiar and eloquent examples of the extraordinary behavior of sounds, which prove the necessity of aiding the ear in order to obtain correct knowledge. The noises of the engine room swell and fade away and come again as if by magic, putting you all out in your search for their source. Of course we do know that knocks in engines are as numerous in variety as the engines themselves, and that they arise from many more sources than the numbers and handling of the same. One prime source of knocking is want of alignment; for, say what we will, an engine in motion under steam is in a very different condition, with regard to its lines, from the same engine when standing. Under severe and reversed strains, every part yielding more or less to the pressure imposed, the certainty of maintained alignment is not secured, and the extent of the departure of some essential organs of the power transmission while at work, from the mathematical exactness intended, is not known till the engine speaks in tones which the intelligent engineer ought to understand and answer. Heavy oil and oil with pulverized and purified graphite, will often cushion the bearing and cure a mild knock in shafts which are acted upon by reciprocating forces. Sliding pieces of machinery frequently knock after long use, when a change of its stroke has been made by adjustment of connected parts; a shoulder has been formed and the moving part strikes it. The amount of metal in the way is often astonishingly small, as I have found by experience in cross-head guides and steam cylinders.

The ways of some knocks are well nigh past finding out, deceiving and defying the very elect. I had a case of knock in a vertical engine once that outwitted two of our best machinists. They both took the engine completely down and re-erected it, but failed to find the cause of the knock. A bystander declared the follower of the piston was loose, for he had a long hunt in his engine and found the knock at last, as he stated: therefore, it must be in the piston. But, my dear sir, there is no follower to this piston, it is a solid one with rings sprung into its peripheral grooves. Another informed me that after diligent search everywhere, as he thought, he finally discovered the crank-pin to be loose in the crank—impossible of application to our case. This engine shaft has a solid forged center crank, all in one piece. Other causes were discussed and explained away; there was certainly no precedent for the knock we had in hand. So dismissing all critics and adjusting properly all the working parts, "Now, John," I said, "let's see her run." And sure enough, there was that same unvanquished knock, occurring every time the cranks passed the top center. "Now John, run her slow — as slow as you can." We now have two knocks instead of one, at the same place in the turn. Here is something to reason out; two knocks at slow speed, one at high. What part of an engine can do that? It must be at the place where the parts under the intermitting action of the steam join the continuous running wheel; for at high speed the wheel does not outrun the shaft, but the steam is quicker than the wheel and turns the shaft ahead, pressing it against the key; in the other case, when the engine creeps, the crank will hardly pass the top center without help; but the wheel, being heavy, keeps on in rotation, crowding the key and driving the shaft over the top center; when the steam comes on it sends the shaft quickly ahead, pressing against the other side of the key. Now, if the key is not tight, these knocks can be accounted for. This mystery being cleared up, I tell John what's the matter: the fly-wheel key is loose. "Stop the engine and hit the key a tap with your hammer, please." And when we started again a quieter running engine was never seen.

You sympathize with the long-suffering engine-driver who for months can't trace the "knock" to its source, and silence it. He comforts you with his justifiable (?) remark that it has been in the engine from the first. *You*, mayhap the busy engine-builder, step in on call, hear the knock at the moment you open the door of his engine room, take up a wrench from the window sill, give a tap-bolt on the cross-head a slight twist, throttling the said knock, bid the engine room good-bye and pass out and down the street, wondering whether it is or is not included in the curriculum of the engine-man's studies and duties to seek for and to gain and to apply some knowledge of knocks — their cause and thei. remedy.— *Machinery*.

The Locomotive.

HARTFORD, MARCH 15, 1895.

J. M. Allen, *Editor.* A. D. Risteen, *Associate Editor.*

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A fearful accident occurred in the harbor of Rio Janeiro, Brazil, on January 7th. The boilers of the *Port Nictheroy* exploded, setting the steamer afire, and the excursionists who were aboard were obliged to jump into the sea to escape the flames. About 120 of them were drowned.

Some of the would-be legislators in this broad land of ours have peculiar ideas. In one case it was proposed "to require insurance companies to insure boilers on tests made by the State!" Why not require life insurance companies to insure on examinations made by the board of health?

The Mills block, in Patchogue, R. I., was shaken up somewhat, on February 2d, by the explosion of a vulcanizer in the office of Dr. J. R. Furman, a dentist. The room in which the vulcanizer stood was badly wrecked, and a piece of the cylinder went through a wall, carrying a set of false teeth with it.

The Associazione fra gli Utenti di Caldaie a Vapore, of Milan, Italy, has very kindly sent us the three volumes of their reports for 1891, 1892, and 1893, and also two interesting little volumes by Chief Engineer Guido Perelli, entitled, respectively, *Instructions to Locomotive Engineers* and *Instructions to Firemen.*

We learn with regret that the private laboratory of Mr. Nikola Tesla, the famous electrician, was destroyed by fire on March 13th. All of the apparatus that it contained was ruined, including several nearly completed inventions relating to electric lighting. Mr. Tesla feels his loss keenly, and he will have the sympathy of a wide circle of friends.

The St. Louis *Globe-Democrat* gives another example of the antiquity of all sub-solar things. "A tubular boiler 1,800 years old has been discovered in Pompeii," it says. "It is made of sheet metal, probably copper, in the shape of a large amphora, or two-handled jar, with a hollow space running half-way up the center of the jar. In this space was placed a cylindrical fire-box resting on five fire-bars, which are tubes three-quarters of an inch in diameter, connecting with the water space. The fuel seems to have been charcoal."

On January 8th, Mr. William Jackson lost his life by an accident in the boiler room of the pumping station at Selma, Ala. One of the boilers, known as the "reserve boiler," had only fifteen pounds pressure upon it, while the others in the battery had about eighty. Jackson opened the stop-valve on the "reserve boiler" too suddenly, causing the steam in the hot boilers to rush into the cooler one with great speed. Doubtless there was more or less water in the steam pipe, and it is probable that some sort of a water-hammer action resulted. At all events, the stop-valve at which Jackson was standing burst, and the unfortunate man was killed instantly. His skull was fractured, and he was terribly scalded. This accident is only one of a large number of the same sort, which are continually occurring. It ought to emphasize, strongly, the danger of opening a stop-valve suddenly.

We read of another one of those black conspiracies to blow up boilers, this time in an esteemed western contemporary. "The timely discovery by an engineer that something was wrong with the boiler in a planing mill this morning," says the account, "prevented a disastrous explosion. During the night water was removed from the boiler under which was banked a fire, causing the burning of the plates, the plotters contemplating an explosion when water was turned on to the dry boiler after the fire was made. The belt used to move the machinery had been cut, and every preparation made for the dare-devil exploit." Our esteemed contemporary does not explain why the dare-devil exploiters cut the belt, if they "contemplated an explosion when water was turned on to the dry boiler;" nor does it furnish a certificate that the blow-off was shut tight the night before when the fireman got through with it.

Boiler Explosions and Dynamite.

The recent terrible boiler explosion at Mendota, Ill., (see No. 22 in the list of January explosions in this issue) was of such extreme violence that many of those who viewed the ruins found it hard to believe that such havoc could be wrought by a steam boiler. The senior member of the firm owning the boiler said at the inquest that "he did not believe the disaster was caused by the bursting of a boiler," because he thought such an explanation inadequate. Another member of the firm "believed that the disaster was caused by dynamite." He did not believe that the heavy ice engine, weighing upward of twenty tons, could have been completely overturned, anchorage and all, and then shattered to pieces simply by the explosion of either of the boilers; also that the ground would not have been rent by a boiler explosion, *which has an upward tendency.* He is borne out in this opinion by two expert boiler inspectors from Chicago and one from La Salle, "who have been at work upon the matter the last two days." "Some of the facts discovered by the latter," the same account continues, "have created a decided sensation. Mr. Henning would not state whether he thought the dynamite was placed in the brewery by designing persons, or whether it might have been some that was being used by the well diggers."

There is a dark hint here of a mysterious plot against the property of the owners of the brewery and the lives of the unfortunate victims of the explosion; but there was no basis whatever for such an insinuation, except that a great amount of damage was done. (The coroner's jury rightly took this view of the case.) An exploding boiler is a terrible engine of destruction, and quite competent to do as much damage as a reasonable quantity of dynamite can do. In fact, we never hear of dynamite theories except from persons unfamiliar with the dreadful possibilities of boiler explosions. Of course, the italicised reference to the *direction* of such explosions has no basis of fact. It is bad physics, and there is no evidence to support it.

The New Element, "Argon."

In The Locomotive for July, 1893, we published the contents of a circular issued by the Smithsonian Institution to the scientists of the world. In this circular various prizes, known as the "Hodgkins Fund Prizes," were offered for treatises and essays upon atmospheric air. The principal offer was "a prize of $10,000 for a treatise embodying some new and important discovery in regard to the nature or properties" of air. The time-limit for this treatise expired on December 31, 1894. We do not know that the prize has yet been formally granted, but there is no doubt that it will ultimately be awarded to Lord Rayleigh and Professor Ramsay, who have discovered that a remarkable and hitherto unknown gaseous substance, which they call "argon," forms a constant constituent of the air.

The history of the discovery of argon is very interesting. Several years ago Lord Rayleigh, in the course of some experiments on nitrogen, observed that the density of that gas is greater when it is obtained from the air than it is when obtained from nitrogenous compounds. After satisfying himself that the difference in density was real, he proceeded to investigate its cause. Naturally enough, he suspected that there might be an unknown "allotropic form" of the gas present, either in the air or in the supply obtained by chemical means. This explanation appeared the more probable, inasmuch as a number of the other elements that occur in organic bodies have allotropic forms — for example, oxygen, carbon, sulphur, and phosphorus. This point was tested by methods that we cannot discuss in the present article, and the results were negative — the difference in density did not appear to be due to allotropism. It was next thought possible that the "chemical" nitrogen was contaminated with traces of hydrogen, some slight amount of that gas coming through the purifiers in which any of it that might be present was supposed to be absorbed. To test this point, hydrogen was purposely added to the "atmospheric" nitrogen, and the mixture was run through the same purifiers. The absorption of the hydrogen was perfect, the density of the nitrogen returning precisely to the original value. This indicated that the lightness of "chemical" nitrogen is not due to the accidental presence of slight quantities of hydrogen. Various other possible explanations of the difference in density were examined, but always with negative results. Finally, a considerable quantity of "atmospheric" nitrogen was brought in contact with red-hot magnesium, the result being that the greater part of the gas united with the metal to form a nitride; but there was always a small residue of gas left, which could not be made to combine with the magnesium. When the residue so obtained from a considerable quantity of "atmospheric" nitrogen was collected in a glass tube and examined by passing electric sparks through it before a spectroscope, it was seen at once to be quite different from nitrogen. Its spectrum was unlike that of any other known body.

As soon as the new gas had been isolated, great interest was aroused in the scientific world to know whether or not it was an *element*. To determine this question attempts were made to cause the gas to combine with something; but, so far as we are aware, every experiment of this kind has utterly failed, and the new substance appears to possess the unique property of being well enough satisfied with itself, and unwilling to combine with any other body, under any circumstances whatever. In this respect it is diametrically opposed to fluorine, which is by far the most ready of all the elements to form compounds with other substances. The atomic weight of the new gas is thought to be about 40. This is only inferred from the density of the gas, however, and nothing certain can be learned about the atomic weight until chemists have succeeded in inducing the gas to combine with something.

Among the various physical properties of "argon" that have been determined is the ratio that its specific heat at constant pressure bears to its specific heat at constant volume. We do not know the precise value that has been obtained for this ratio, but we understand that it is in the neighborhood of $1\frac{2}{3}$. Now, it is known from the kinetic theory of gases that if the ratio of the specific heats is as great as this, the molecules of the gas must be extremely simple. It is upon this fact, combined with the character of the spectrum of the gas, that the belief in the elementary nature of "argon" is based.

In conclusion, we must say that, although Lord Rayleigh first observed the discrepancy in the density of nitrogen as obtained from different sources, the prestige of the discovery of "argon" does not rest with him alone. Professor Ramsay has also given great attention to the problem, and the two experimenters succeeded in isolating the new gas at almost exactly the same time, and by the same method. The present plan is, we believe, to divide the honor between the two men, and let their names be both handed down to posterity with equal distinction.

Margins of Safety in American Boiler Practice.

The following quotation from our esteemed English contemporary, the *Practical Engineer*, should be of interest to all our readers:

"Allowable steam pressures in America are generally understood to be very much in excess of anything allowed in this country, but we are not aware that anything has ever been published here showing to what extent there is foundation for this belief. It may be stated that pressures are based very much upon the Rules and Regulations of the Board of Supervising Inspectors of Steam Vessels, which are set forth in a pamphlet known as 'Form 2101,' and in this are very fully set forth the pressures that may be used for both boiler shells and flues. To a certain extent, boiler pressures are upon a more certain basis than with ourselves. American boiler plate is stamped by its makers with its ultimate tenacity in pounds per square inch of section, and, according to this stamping, a boiler is allowed a corresponding steam pressure. Should plates not prove when tested to be of the strength stamped upon them, they may be re-stamped to the figure found by the testing inspector. In addition to strength, steel plates must elongate 20 per cent. in a length of 8 in.

"The tables of allowable pressures that are printed in Form 2101 include shells from 36 in. to 96 in. diameter, increasing by 2 in. up to 48 in., and by 6 in. for the remainder. The plate thicknesses are given from .1875 in. to .375 in., increasing by no special rule as follows: .21, .23, .25, .26, .29, .3125, .33, .35 — in all, ten thicknesses. Taking a shell of 84 in. diameter and $\frac{3}{8}$ in. thick, we find that for plates of 45,000 lbs. tensile strength the pressure for single riveting is 66.96 lbs., and for double riveting it is 20 per cent. higher, or 80.35 lbs. Now, as the 45,000 quality is about equal to 20-ton iron, we may compare this final figure with the allowance for a 7 ft. double-riveted Lancashire boiler of $\frac{3}{8}$ in. plate — *viz.*, 65 lbs. at the most — and we see that American practice allows a little higher pressure upon a single-riveted shell than English practice allows for double riveting. The rule is given thus: 'Multiply one-sixth of the lowest tensile strength found stamped on any plate by the thickness — expressed in inches or parts of an inch — of the thinnest plate in the same cylindrical shell, and divide by the radius or half diameter — also expressed in inches — and the sum [quotient] will be the pressure allowable per square inch of surface for single riveting, to which add 20 per cent. for double riveting.' The allowance for hydrostatic pressure test is 50 per cent. additional — quite enough, too, for it gives a test pressure higher than the very usual English test, which prescribes 75 per cent. addition to the working pressure.

"Some few years ago — the rule was in force to the writer's knowledge in 1887, but has since been repealed — there was a special pressure allowance for the boilers of freight and towing steamers on the Mississippi River and its tributaries, and under this rule the pressures allowed were most alarming. Thus, taking the example of the 84 in. shell, $\frac{3}{8}$ in. thick, the rules would give $112\frac{1}{2}$ lbs., the standard pressure being 150 lb. on a 42-in. shell, $\frac{1}{4}$ in. thick; and we are not even enlightened as to whether the riveting is other than single; neither are we told why the Mississippi River is so specially favored in the matter of pressure.

"With such facts as these officially before us, need we wonder at the frequency of American boiler explosions? Rather, should we not be surprised that there are so few?

"Presumably, this Mississippi law being repealed, all boilers are on the same footing; but we believe that American boiler insurance companies have to contend against the excessive pressure of boilers thus fostered by the government itself. Curiously enough, too, in some cities of America — New York, for example — the inspection of boilers is undertaken by the municipal authorities as a police function; but we believe that this resolves itself into little more than an application of the hydraulic test, in a manner far removed from what safety would dictate. Speaking generally, then, we should say that steam pressures are excessive, and we should not omit to emphasize that for higher qualities of steel the pressure allowed is correspondingly increased, so that for steel of 70,000 lb. tensile resistance the 7 ft. boiler, only $\frac{3}{8}$ in. thick, and double riveted, is allowed to carry 125 lb., single butt strips must be as thick as the plates, and double strips not less than $\frac{5}{8}$ of the plate thickness. Braces and stays must not be stressed beyond 6,000 lb. per inch of section, unless of steel specially tested, when they may even be allowed 9,000 lb. on their smallest section.

"Tubes for external pressure seem to have equally heavy pressures allowed. Thus, a 40 in. lap-welded or riveted tube, $\frac{1}{2}$ in. thick, in sections of 30 in. in length, is allowed 107 lb. pressure, which seems heavy, though for corrugated flues the rule is $\frac{14000\ t}{D}$, which would give the pressure of 175 lb. to a 40 in. flue of half plate. It is difficult to realize that with such excessive pressures as we have quoted plain flues and shells can endure long. We believe that the Hartford Steam Boiler Inspection and Insurance Company has for a long time been adverse to such dangerously heavy pressures, but with the weight of government authority against them, no doubt they find it difficult to effect very much. Probably our English practice borders on the over-cautious. Certainly it has practically abolished boiler explosions, and English steam-users send boilers to the old boiler yard which would be granted certificates in America for a pressure in excess of what they were permitted to bear when brand new in England. With such facts before us, we can no longer wonder at the compound explosions such as that of Shamokin. In a heavily-stressed shell, a very small extra provocation may easily lead to an explosion."

We do not propose to discuss this question of comparative practice at all exhaustively at present, but we must call attention to one or two things that are suggested by the most superficial perusal of the foregoing article. In the first place, it is obviously wrong to compute an "allowable pressure" with no further knowledge of the joint than that it is single-riveted or double-riveted, as the case may be. We have striven for many years to fix this point in the public mind, and it is only fair to say that we have met with some considerable success — though there is still room for many more sermons on the same text. Every one who has had a wide experience with the joints that are put into boilers will know that a poor double-riveted joint is often far inferior in strength to a good single-riveted one; and before deciding what pressure shall be allowed, it is certainly imperative to know the proportions of the joint, and its efficiency. Any rule that does not take these things into account is misleading, and, in many cases, exceedingly dangerous.

Another point that we wish to consider is that the rules established by the United States government do not apply to boilers in general, but only to such as are subject to government inspection — that is, chiefly to *marine* boilers. We are not aware that the proportion of marine boilers that explode is larger in this country than elsewhere, and hence we are inclined to question the validity of the deduction that our contemporary draws with respect to the relative total number of boiler explosions in this country and in England. Most of the boilers that explode in the United States are land boilers, to which the government rules do not apply; and in many cases of marine explosions it is easy to show that the disaster is not due to the imperfection of the government rule, but to other causes that are usually not hard to find. See, for example, the account of the explosion of the *Rambler's* boiler, in THE LOCOMOTIVE for July, 1894.

We heartily agree with the *Practical Engineer*, however, that many boilers are run in this country with too small a factor of safety. We believe that 5 is the proper factor for shells exposed to the fire; but we know that many boilers are running with a factor of not over 3½, and we believe that the wonder is, as our contemporary says, not that there are so *many* explosions, but that there are so *few*. Knowing, as we do, the conditions prevailing in boiler practice, we do not understand why more boilers are not blowing up every minute.

WE have received from the Yorkshire Boiler Insurance and Steam Users' Company, Limited, of Bradford, Eng., a copy of Chief Engineer Waugh's report on an explosion that recently occurred in Staffordshire. The manhole had presumably been leaking; at all events, the boiler attendant was screwing up the nuts on the two main bolts at the time the accident occurred, and the result was that a great strain was thrown upon the internal flange that held the cover. The failure occurred by the stripping of this flange, the remaining part of the cover being blown bodily out. The attendant was killed. The report says that calculation showed the cover to be strong enough to withstand any steam pressure that could come upon it, as well as any reasonable additional strain from the screwing up of the nuts. "The inquiry has resulted in a consensus of opinion that cast-iron is not a suitable metal for the purpose, and the object of printing this report is to make it known to steam users that it would be better to have all cast-iron manhole covers in use replaced by either wrought-iron or cast-steel ones."

The Hartford Steam Boiler Inspection and Insurance Company has long strenuously advocated the use of wrought-iron or steel, both for manhole covers and for the frames.

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The Locomotive.

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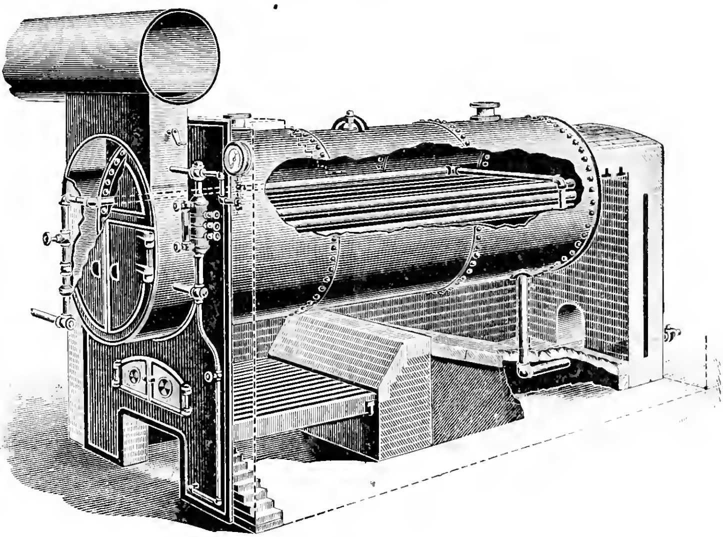
Boiler Settings.

The article on boiler settings published in the February issue of THE LOCOMOTIVE having aroused a considerable interest among our readers, and elicited a number of letters of inquiry concerning various points not touched upon in that place, we present herewith a perspective view of the setting advocated by this company, in the hope that it may make the general design somewhat clearer to those not familiar with mechanical drawings. (The side wall of the setting is supposed to be removed, in order to expose the other parts to view.)

The boiler here shown has an "overhanging front"; that is, the dry sheet projects



PERSPECTIVE VIEW OF SETTING.

outward beyond the cast-iron front-piece of the setting. We prefer this style of front because there is no possibility of burning the dry sheet. Others prefer the "flush front," urging that some heating surface is lost by setting the boiler as here shown, and that the projecting front is in the way of the fireman. We do not consider these objections to be very weighty, but we are quite ready to admit that flush-front boilers work well when the setting is properly designed and built, and we make specifications for them when our patrons prefer them. (The different forms of boiler-fronts in common use will be found illustrated in THE LOCOMOTIVE for September and December, 1890.)

The boiler itself consists of three rings of plates. In some cases, when the boiler is long, it may be necessary to use four rings, but in most cases three will be quite sufficient. The longitudinal joints, which are not shown in the engraving, should be high enough up to be entirely outside of the furnace; and the design and proportions of these joints should be carefully considered in connection with the pressure that it is desired to carry. The weight of the boiler is borne upon lugs riveted to the shell. The lugs are not shown in the present cut, but are indicated in the illustration given in the February issue. Three pairs of lugs are often provided, but we believe that two pairs are quite sufficient except when the boiler is very long; and two pairs can be brought to a good bearing more readily than a larger number can. The boiler should be "anchored" by the front pair of lugs, and the rear pair should be provided with rollers so that the boiler may expand and contract freely, without producing strains in the setting or in itself.

The course of the feed-pipe is indicated quite plainly in the engraving. If there are several boilers set in a battery, the main feed-pipe runs along the fronts, just under the projecting ends of the boilers. From this main feed-pipe a branch pipe is taken off for each boiler. The branch pipe is taken off on the left-hand side of the boiler, and near the main pipe it is provided with a ground union, or with a flanged connection. Immediately above the union there is a check-valve, and above this is the globe valve which controls the feed. The feed-pipe rises until just above the level of the tubes, when it turns to the right and enters the front connection as shown. It then turns again and enters the boiler just inside the root of the flange of the head, and passes down the boiler on the inside, nearly to the back end. It then crosses over to the right-hand side and discharges downward between the tubes and the shell. It is found by experience that when the feed is introduced in this way it becomes heated almost to the temperature of the water in the boiler before it is discharged, so that the annoying and often dangerous effects that are produced when the shell is chilled by cooler feed-water are entirely avoided. In many parts of the country, where the water used in the boilers is muddy, some form of top feed is often preferred. We have no objection to the top feed when it is properly designed and constructed. (A form that has been found to work well is shown in The Locomotive for March, 1891.) On boilers 60 inches or more in diameter the diameter of the feed-pipe should be at least 1½ inches. On boilers 36 inches in diameter, or less, the feed-pipe should be at least one inch in diameter. On boilers of intermediate sizes — say from 42″ to 54″ inclusive — the feed should not be less than 1¼ inches in diameter.

The blow-off pipe should be located at the rear end of the boiler, as shown in the illustration. It is very important that the shell should be *reinforced* where the blow-off enters it. The neglect of this precaution has led to many serious accidents. As the blow-off is exposed to the action of the fire, it is also highly important that it should be encased in a protecting sleeve of some kind, as indicated by the dotted lines. A piece of larger pipe, slipped over the blow-off, is frequently used for this purpose. An asbestos rope, coiled about the blow-pipe, is also satisfactory; and in The Locomotive for September, 1891, a special form of cast-iron sleeve is shown, which has certain advantages over either of these devices. The blow-off pipe is often so arranged that the elbow comes in the combustion chamber; but we believe that this is bad practice, and we strongly recommend that it be carried straight down until it passes below the floor of this chamber. The elbow is then well protected from the fire, and the horizontal portion of the blow-off passes out through the rear wall of the setting, under the center of the cleaning door, as shown. The blow-off pipe should be 2″ in diameter under ordinary circumstances, but where the water is bad 2½″ may prove to be a better size, and in some rare cases it may advantageously be as large as 3″. It is important that there should be a very rapid discharge through the blow-pipe when the cock is open, in order that fragments of scale or other obstructions may be swept out with certainty. If the pipe is larger than we have indicated above, it is difficult to realize this effect. Plug cocks or gate valves should always be used on blow-off pipes; globe valves are very apt to trap pieces of scale. (This point was discussed in THE LOCOMOTIVE for October, 1894.)

We recommend the use of a water-column of some kind. The chamber of the column should be at least four inches in diameter internally, and the pipes by which it is connected to the boiler should not be less than 1¼ inches in diameter. We also recommend that the connections used in attaching the water-column should be *four-way tees* instead of elbows. It will then be possible to clean the connections out thoroughly by removing the plugs in these tees, and running a straight rod of suitable diameter through the piping. A small drain-pipe should be provided at the lowest point of the water-column attachment, in order that sediment may be blown out readily. It is convenient to have this drain-pipe discharge into the ash-pit, as shown in the engraving. The try-cocks and gauge-glass are attached to the water-column, and the lowest try-cock must be at least three or four inches higher than the upper side of the top row of tubes. The steam-gauge is attached to the steam connection of the water-column. It must be provided with some form of water trap, in order that the hot steam from the boiler may not come in contact with the Bourdon spring. If this is not attended to the gauge will not give correct readings, and it is very likely to be entirely ruined. The requisite water trap is commonly provided by forming the steam-gauge pipe into a U, or by bending it around an entire circle. This form of trap is objectionable, because although it performs its function perfectly when everything is in proper condition, it can be cleaned out only with great difficulty. As there is little or no circulation in the water-trap, sediment, carried over by particles of water in the steam, or in some other manner, is liable to lodge in it, and we often find gauge-connections entirely stopped up from this cause. It is much better to attach the gauge by means of nipples and fittings, as shown in the engraving. In case of choking, it is then easy to take the trap apart and clean it thoroughly. A small cock should always be provided at the lowest point of the trap, so that the fireman can readily draw the water off when the boiler is put out of service.

Inspectors' Report.

FEBRUARY, 1895.

During this month our inspectors made 7,131 inspection trips, visited 14,576 boilers, inspected 3,991 both internally and externally, and subjected 414 to hydrostatic pressure. The whole number of defects reported reached 9,892, of which 1,297 were considered dangerous; 66 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	768	48
Cases of incrustation and scale,	1,453	65
Cases of internal grooving,	70	17
Cases of internal corrosion,	413	41
Cases of external corrosion,	642	61
Broken and loose braces and stays,	111	23

Nature of Defects.	Whole Number.	Dangerous.
Settings defective.	250	23
Furnaces out of shape,	389	15
Fractured plates,	251	63
Burned plates,	245	30
Blistered plates,	142	7
Cases of defective riveting,	1,420	35
Defective heads,	84	16
Serious leakage around tube ends,	1,866	571
Serious leakage at seams,	496	42
Defective water gauges,	418	72
Defective blow-offs,	158	43
Cases of deficiency of water,	27	5
Safety-valves overloaded,	74	31
Safety-valves defective in construction,	86	49
Pressure-gauges defective,	414	39
Boilers without pressure-gauges,	1	1
Unclassified defects,	114	0
Total,	9,892	1,297

Boiler Explosions.

February, 1895.

(30.)— A boiler exploded, on February 1st, at the electric light company's plant at Washington, Tazewell County, Ill. The building was totally wrecked, and the machinery was ruined. Five men were in the building at the time. Berry Huddlestone was fatally injured, and Daniel Donahue, Isaac Macdonald, Isaac Holland, and William Sopenbaugh were also injured more or less seriously. One large section of the boiler was blown nearly half a mile. Two adjacent buildings caught fire, but the flames were subdued before much damage resulted.

(31.)— A boiler exploded at Reeves's mill, Duck Hill, Miss., on February 1st, killing a man named Newell, and breaking both of Reeves's leg, and injuring him otherwise.

(32.)— A steam-heating boiler exploded, on February 3d, in one of William J. Snow's greenhouses, at Waterbury, Conn. Jacob Snyder, who was in charge of the boilers, was painfully scalded. One of the greenhouses was demolished, and Mr. Snow's loss is estimated at $1,000.

(33.) — One of the boilers in Gray Bros.' factory, at Muskegon Heights, Mich., exploded on February 3d. The boiler-house, engine-room, and dry kiln were wrecked. John Thompson, the watchman, was blown through a twelve-inch brick wall and instantly killed. The property loss is variously estimated at from $4,000 to $12,000.

(34.)— On February 3d a boiler exploded at the Cincinnati Ice Company's plant, at Amanda, near Hamilton, Ohio. There were but 30 pounds of steam on the boiler at the time, and the fire had gone out. Nobody was hurt.

(35.)— A heating boiler exploded, on February 4th, in the residence of H. R. Bowlen, at Canton, Ohio. The Cleveland *Press* says that "the explosion tore out the brick chimney, broke every pane of glass in the house, and knocked three doors off their hinges. Furniture and carpets worth $500 were ruined. Two ladies heard the noise, and ran from the kitchen, barely escaping the dining-room door, which came flying after them. Four persons were in the house, but the only fatality was the killing of the house cat."

(36.) — Another heating boiler exploded, on February 4th, in the residence of Mrs. W. H. Hopkins, Baltimore, Md. A slight fire ensued. The adjoining house, belonging to H. M. Clabaugh, was also slightly damaged.

(37.)—Charles Miller was badly injured, on February 4th, by the explosion of a boiler in Muncie, Ind. The boiler was heated by natural gas, and the owner, John W. Schaffer, had turned the gas very low upon leaving the boiler at night. About ten o'clock young Miller turned it on again to warm himself, and it is supposed that he forgot it and fell asleep. Schaffer's property loss will be small.

(38.)— William Routt was badly scalded, on February 4th, by a boiler explosion at Milford, near Augusta. Ky.

(39.)— A boiler exploded, on February 4th, at Carpenter's Ice House, Providence, R. I. Patrick Hehir and John Hehir were killed instantly, Martin Deery died within an hour, and William Morton died shortly afterwards. The others who were injured are Herbert Smith, Thomas Casey, Charles Brayton, Thomas Nelson, Martin Ryan, Henry Butler, Philip Lynch, Michael Tierny, and George M. Downing. At last accounts Casey was very low, and was not expected to live. The other wounded men are doing well. A considerable amount of damage was done. The engine was blown high into the air, and landed some 400 feet from its original position. It crashed through 13 inches of ice, and now lies at the bottom of the pond.

(40.)— A heating boiler exploded, on February 6th, in the residence of Mrs. E. C. Homans, New York city. "The explosion dismantled almost every room in the five-story structure, and created sad havoc with the costly furniture and elegant decorations. Fortunately, not one member of the household was injured, though one of the servants (the porter) had a narrow escape. . . . . Every gas and water pipe throughout the building was either burst, torn, or twisted, so as to be rendered useless. The stairway was split up the middle, while supporting iron columns on the various floors were badly bent. . . . The hall doors, massive and elegant in their construction, were torn from their hinges and blown into the hall. . . . Nothing was left of the boiler, save small bits of iron." A slight fire ensued, which did about $100 damage. The property loss due to the explosion itself is estimated at $10,000.

(41.)— A heating boiler exploded in St. Patrick's Church, at Fort Hamilton, N. Y., on February 6th. We have not seen an estimate of the damage.

(42.)— On February 6th a heating boiler exploded in the basement of the West Side Public School, at Elyria, Ohio, during the noon recess. The northern wall of the building was blown out, and a fire resulted, which did much damage. Had the explosion occurred fifteen minutes later, when the 200 children had returned, a frightful loss of life would have occurred. The damage to property is variously estimated at from $7,000 to $14,000.

(43.)— A boiler exploded, on February 6th, in the Frontier House, Niagara Falls, N. Y. We have not received particulars.

(44.) — A locomotive boiler exploded, on February 6th, at Curve, a station on the New River Division of the Norfolk & Western Railroad (Virginia). Engineer John King was thrown a long distance, and injured so badly that he died about an hour later. Fireman Dean Henry was killed instantly.

(45.) — A heating boiler exploded, on February 7th, in a Wagner sleeping car at Huron, S. D. The car, which was side-tracked at the time, was wrecked.

(46.) — A heating boiler exploded, on February 7th, at the drill hall of the Academy, at Highland Park, near Waukegan, Ill. Considerable damage was done, but nobody was injured.

(47.) — The boiler of the steam laundry at El Paso, Tex., exploded on February 7th. W. A. Williams and Geronimo Ortiz were killed. W. C. Harvie, the proprietor, was fearfully scalded and bruised, and will probably die. Juan Obrebos will also die. Hillario Sierra, the fireman, was slightly injured. A section of the boiler, weighing a hundred pounds or so, fell through the roof of Coffin & Secton's grain warehouse, two blocks away. Another section crashed into the Sheldon dining-room, still further away. Burge's art parlors, situated near the laundry, were badly damaged.

(48.) — A new boiler, used for heating Nathan & Son's store at Lancaster, Wis., exploded on February 7th, doing a great deal of damage. John Stephens, William Benn, and Arthur Benn were also scalded more or less severely, but not dangerously.

(49.) — A section of the heating boiler in the High School at Duluth, Minn., exploded on February 8th. The damage was not great, and nobody was injured.

(50.) — A boiler exploded on the steamer *Cyclone*, on February 8th, while she was steaming down the St. Francis river, some four miles east of Forest City, Arkansas. We have not learned particulars.

(51.) — A boiler exploded at an oil well in Brownsdale, Pa., on February 9th. William Williams, a driller, was killed.

(52.) — A heating boiler exploded on February 12th in the High School building at Shamokin, Pa. Fortunately nobody was injured.

(53.) — A boiler explosion occurred at Crockett, Houston county, Tex., on February 12th. We have been unable to obtain details, beyond the fact that nobody was injured.

(54.) — A rotary bleaching boiler exploded on February 12th, at the works of the American Straw Board Company, at South Kenton, Ohio. Isaac Schooler was seriously and perhaps fatally injured. The loss of property was estimated at from $1,000 to $2,000.

(55.) — On February 12th, a boiler exploded in Martin & Dreibholz's mill at Bay Ramos, La. One man was killed and several others injured. The property loss was about $15,000.

(56.) — A boiler exploded at the Spencer Coal Company's colliery at Dunmore, near Scranton, Pa., on February 14th. Fireman Reuben Jones was terribly burned and scalded.

(57.) — A slight boiler explosion occurred on February 14th, in the woolen mills at Lisbon, Ohio. Nobody was near the boiler at the time, and there were no personal injuries. The property loss was small.

(58.) — A boiler exploded on February 15th, in the rear of Deibel's meat market, at Youngstown, Ohio. The building was wrecked and John Price, Albert Apple, and M. L. Cook were badly scalded.

(59.) — A boiler in Conklin & Peterson's lumber mill at Lumberton, eight miles south of Xenia, Ohio, exploded on February 15th, killing Howard Street instantly. Street was the only person in the building at the time of the explosion.

(60.) — On February 15th, a boiler exploded in the Cobb saw mill, near Towanda, Pa. Theodore Pencil and John Mack were instantly killed, and Frank Myers was fatally injured. The mill was completely wrecked, and everything in the vicinity was destroyed.

(61.) — The boiler at Gilbert Bryant's slaughter house, at Parkersburg, W. Va., exploded on February 15th, " tearing the building into kindlings." The boiler alighted in a field, several hundred yards away. Charles Bryant was caught under some of the falling timbers, but was not dangerously hurt.

(62.) — A boiler exploded on February 16th, at Holloway's oil lease, about eight miles from Bradford, Pa. James Frazier and Alfred McQuiston were killed.

(63.) — A slight boiler explosion occurred on February 16th, in a roller mill at Campbell, Hunt county, Tex. Mrs. J. M. Reily and her two little daughters were seriously scalded. They will recover.

(64.) — A boiler exploded in Prime's shoe factory, in Rowley, Mass., on February 18th. The explosion is said to be due to the weakening of the boiler by corrosion. Nobody was injured.

(65.) — On February 18th a heating boiler exploded at the Spring Valley Water Company's plant, San Francisco, Cal. R. J. Sweeney, J. G. McKenzie, and John Taylor were injured. The damage to property was not great.

(66.) — A boiler exploded at the Emery Candle Works, Cincinnati, Ohio, on February 19th.

(67.) — A boiler explosion occurred on February 19th, in the elevator of J. G. & J. P. McCord, at McCordsville, near Scranton, Pa. The engine and boiler room were completely wrecked. The accident happened at the noon hour, and nobody was hurt.

(68.) — A small hot-water boiler exploded on February 19th, in C. E. Hornberger's drug store, Providence, R. I.

(69.) — A locomotive boiler exploded on the New York & New England railroad, near Danbury, Conn., on February 21st. Alfred Deitweiler, the fireman, was blown from the cab into a snow-bank. He was badly scalded. The engineer escaped unhurt. The train was running at about fifteen miles an hour when the explosion occurred.

(70.) — A small boiler exploded on February 21, in John F. Smith's wood shop, at Biddeford, Me. Nobody was injured, but the property loss will amount to about $1,000.

(71.) — A tube collapsed on February 22d, in the boiler of a freight engine on the Chicago & Grand Trunk railroad, near Imlay City, Mich. Timothy McCarthy, the head brakeman, was fearfully scalded, but it is believed that he will recover. The engineer and fireman were slightly injured also.

(72.) — On February 25th, a boiler exploded in John J. McLaughlin's mineral and aerated water factory, at Toronto, Ont. "The whole front of the substantial, double-fronted two-story brick and stone building fell outward, and, with the roof and a portion of the walls, scattered into an indescribable wreck of dèbris across the entire roadway; while the remainder of the structure collapsed on either side, until scarcely one stone was left upon another." The property loss probably exceeds $10,000.

(73.) — A saw-mill boiler exploded on February 26th, at Adelphi, fifteen miles from Chillicothe, Ohio. The mill was operated by Jacob Weltz and his two sons, Curtis and William. Both of the sons were fatally injured, and died within a short time. The father escaped without injury.

(74.) — Oliver Lockwood and Albert Dougherty were fatally scalded, on February 25th, by the explosion of a boiler in the Nottingham township oil field, near Portland, Ind.

(75.) — A boiler exploded on February 27th, at Clark & Cowles's factory, Plainville, Conn. Nobody was injured, and the damage to property was slight.

Boiler Explosions during 1893 and 1894.

It has been our custom, until recently, to give, each year, a summary of the boiler explosions of the year before. This practice was discontinued in 1894, for it seemed doubtful if such summaries were of sufficient interest to our readers to require publication. We have recently received a number of letters, however, asking for the number of explosions, and for the number of killed and injured, during the past two years, and we therefore present this information in the accompanying tables.

The total number of explosions in 1894 was 362, against 316 in 1893, 269 in 1892, and 257 in 1891. In some cases more than one boiler has exploded at the same time. When this has happened, we have counted each boiler separately, as heretofore, believing that in this way a fairer idea of the amount of damage may be had.

Summary of Boiler Explosions for 1893.

Month.	Number of Explosions.	Persons Killed.	Persons Injured.	Total.
January,	39	29	42	71
February,	29	20	35	55
March,	26	35	30	65
April,	28	29	31	60
May,	23	37	36	73
June,	14	9	13	22
July,	18	17	17	34
August,	29	43	34	77
September,	22	28	26	54
October,	29	22	36	58
November,	33	33	49	82
December,	26	25	36	61
Totals,	316	327	385	712

The number of persons killed in 1894 was 331, against 327 in 1893, 298 in 1892, and 263 in 1891; and the number of persons injured in 1894 was 472, against 385 in 1893, 442 in 1892, and 371 in 1891.

The greatest explosion of the year 1894 — the greatest, in fact, that has ever occurred, so far as the *number* of the bursting boilers is concerned — occurred at Shamokin, Pa., on October 11th, and was illustrated and described in our issue of last December. In this great disaster twenty-seven boilers exploded simultaneously, six persons were killed, and three others were injured.

Summary of Boiler Explosions for 1894.

Month.	Number of Explosions.	Persons Killed.	Persons Injured.	Total.
January,	30	27	39	66
February,	26	24	27	51
March,	20	19	34	53
April,	23	32	36	68
May,	22	22	42	64
June,	22	22	20	42
July,	25	28	12	40
August,	37	37	54	91
September,	28	35	48	83
October,	62	35	55	90
November,	39	18	51	69
December,	28	32	54	86
Totals,	362	331	472	803

It is difficult to make out accurate lists of explosions, because the accounts of them that we receive are often unsatisfactory. We have spared no pains, however, to make these summaries as nearly correct as possible, and in some cases we have gone over as many as eighty accounts of a single explosion, in order to extract such information as we could concerning the injuries and the loss of life involved. It may be well to add, too, that these summaries do not pretend to include *all* the explosions of 1893 and 1894. In fact, it is probable that only a fraction of these explosions is here represented. Many accidents have doubtless happened that were not considered by the press to be sufficiently "newsy" to interest the general public; and many others, without doubt, have been reported in local papers that we do not see. Our country is big, and it is hard to keep it all under the editorial eye.

By an unfortunate typographical error, the "Inspectors' Report" given in our March issue was stated to be the report for *March*, 1895. It should have been headed *January*, 1895.

Professor E. E. Barnard, of the Lick Observatory, reports that the "new star" in the constellation *Auriga* is still visible, though very faint, and that it has not changed in physical appearance since the autumn of 1892. It remains perfectly stationary with reference to the neighboring faint stars that surround it.

The Locomotive.

HARTFORD, APRIL 15, 1895.

J. M. ALLEN, *Editor.* A. D. RISTEEN, *Associate Editor.*

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Papers that borrow cuts from us will do us a favor if they will mark them plainly in returning, so that we may give proper credit on our books.

A BOILER in a distillery at Itzkany, Roumania, exploded on March 3d, doing great damage to the building and causing a loss of twelve lives. One workman, who was sleeping in a room over the boiler, fell into a tank of spirits and was shockingly scalded and burned.

Two boilers in the new addition to the American Tin Plate Factory, at Elwood, Ind., were blown up by a natural gas explosion on February 24th. The boilers were thrown from their settings, and the surrounding walls and machinery were considerably damaged. Nobody was injured, but about 200 men were temporarily thrown out of work.

As we have to rely upon the newspapers, to a large extent, for the details that we present in our regular monthly lists of boiler explosions, it occasionally happens that we do not get the facts correctly; though in every case we do the best we can. These remarks are elicited by a note we have received from Mr. Savage, a United States inspector in Boston, concerning an explosion that is alleged to have occurred on the tug-boat *Sam'l Little* on October 24, 1894. (See THE LOCOMOTIVE for December, page 184, explosion No. 258.) Mr. Savage informs us that there was no such explosion, and that the report probably originated from the fact that there was a slight fire forward, which was put out by one of the deck hands.

We make the correction with pleasure.

Kitchen Explosions in February.

A considerable number of explosions of kitchen boilers and water-backs occurred during the cold snap in the early part of February. These domestic explosions are rarely mentioned in the papers; but in a single issue of the New York *Herald* (that of February 7th) we find mention of no less than five, which all occurred on the morning of the day before. Mr. S. Garnett, of Brooklyn, N. Y., was one of the victims. The water-back in his kitchen stove burst, and the entire front of the stove was blown out. A blaze followed, but it was extinguished without much trouble. Nobody hurt. A similar accident happened in Mr. John Campbell's residence, on Raymond street, New York. The damage done at this place is estimated at $150. Another water-back burst in Mrs. O'Brien's house, on Belmont avenue, demolishing the stove and damaging a considerable amount of furniture. A more serious accident of the same nature occurred in Mr. William Fitzgerald's residence, on Washington Avenue. Owing to the intense cold Mr. and Mrs. Fitzgerald ate breakfast in the kitchen. During the meal the water-back burst, blowing the stove to pieces and throwing boiling water and fragments of iron all over the room. Mr. Fitzgerald was struck about the head and painfully injured. His wife, who was nearer the stove, and who therefore fared much worse, was very badly scalded. A still more serious explosion occurred on Garside street, Newark, N. J., in the home of Mr. and Mrs. Jacob Searing. Mrs. Searing, who is 75 years old, noticed steam coming from the water-back, and was leaning over it to see what was the matter when it exploded with extreme violence, blowing the stove to fragments, and scattering live coals all about. Mrs. Searing was badly scalded, and her clothing also took fire, and she was terribly burned. It was thought that she could not live. The damage to the house amounted to about $250.

Similar reports come from various parts of the country. Toronto was visited on February 6th by a water-back explosion, in James Murray's house, which did about $100 damage, and sunny Virginia was represented on the 8th by a similar explosion in Judge S. W. Howerton's residence, at Roanoke, the Judge being severely bruised and scalded.

Most of these explosions (all of those, in fact, of which we could learn the particulars) were due to the freezing of the supply pipes. There being no way in which the pressure in the water-back could relieve itself, it accumulated steadily until it became great enough to blow the stove to pieces. Special care should be taken during cold snaps to see that there is free communication between water-backs and the city mains; for if such free communication exists, the formation of steam in the water-back will do no harm, and the pressure, which might otherwise be disastrous, will easily relieve itself by forcing some of the water back into the mains.

"Fin de Siecle Science."

Under this heading the New York *Sun* of March 14th discusses the exhibition that was given, on the 13th ultimo, in the galleries of the American Fine Arts Society, of New York city, to show the progress science has made within the past year or so.

"It was the second show of the sort," we are told. "The separate booths were presided over by the respective experts in the different branches which they represented, and President John Krow Rees exercised a sort of general supervision. Cards had been sent out to all the academy's friends, and the rooms were crowded.

"The exhibits were strikingly arranged. The corner of the large room in which Dr. Carlton C. Curtis had his botany booth was especially effective. A long obtuse-angled table held a number of microscopes, interspersed with potted palms and hanging electric lights. On the walls behind were stuck up sheets from herbariums. Nearly all of these were studies of undescribed and little known species. Some of the species were brand new, and many of the visitors had their first chance to see the new kinds of North American leguminosæ and saxifragaceæ, and the new Japanese characeæ, with microscopic preparations of their oöspores.

"Some of the most interesting exhibits were in the photographic department. Many pictures made by the recently contrived processes of color photography decorated the walls. There were prints of Turkish rugs, of book bindings, and of paintings, in which the coloring was exactly reproduced. The negatives are made on specially prepared plates corresponding to the three primal colors, red, yellow, and blue. When the red plate is exposed a screen is placed before a camera to shut out the green and yellow constituents, and the same process is observed with the other two. In making the reproduction an imprint is taken mechanically from the red plate with red ink, and the blue print and yellow print are superposed in the same way. The result is a copy of the original in all its colors and shades.

"The same principle was used in the construction of an exhibit called a photochromoscope, which is soon to be placed on the market, together with a camera for making the triplicate negatives. The photochromoscope is somewhat like a stereoscope, except that the views appear in their natural colors. A box of mixed candies which was shown last night was startlingly realistic. A still further application was shown in an adjoining room in the shape of colored stereopticon views which were almost perfection. A man wearing a blue shirt and a red moustache and some views of the Palisades and the surrounding woodland in gorgeous autumn hues were especially satisfactory.

"Dr. T. M. Cheesman's bacteriology booth was brought clear up to date by a specimen of diphtheria anti-toxin and the corresponding toxin. There were also bacteria of every sort in abundance, and with names in inverse proportion to their sizes. One of these, the bacillius prodigiosus, was the true cause, so the scientists say, of the miracle of the bloody host. The bacillus, they assert, grew upon the wafer or altar bread after its exposure in the church during the consecration of the host.

"L. P. Gratacap of the mineralogy booth turned up with six brand new varieties. In the anatomical and physiological departments there any number of things in bottles. Among examples of up-to-date taxidermy in the zoölogical division was the late lamented Chiko, formerly of Central Park, who died last year and was mounted in January by Z. Rowley of the American Museum of Natural History. Chiko looked as natural as he ever did in his cage, and next to him was another chimpanzee, showing the better grade of commercial work of ten years ago, for purposes of comparison.

"In the electrical department the process of electrolysis, as employed in making disinfectants out of sea water, was shown in operation. The disinfectant, made on the spot, was sprayed upon a glass slide fairly alive with microbes while the observer looked through a microscope and saw them stop short and shrivel up almost as quickly as if they had been suddenly frozen in.

"The new illuminating gas which is made from calcium carbide was also made on the spot. The process is a very simple one. The carbide is a by-product of certain electrical furnace processes. It is put in a jar, water is poured on it, and the gas is evolved. The cost is said to be ten cents a thousand cubic feet, and a burner consuming a foot an hour, and giving a flame of the usual size, makes a light three times as bright as an ordinary incandescent electric light.

"When the visitor was tired of looking at these things, and the exhibits in the departments devoted to geology, palæontology, mechanics, psychology, and astronomy, he could go and have his voice photographed in the department of physics. The contrivance for accomplishing this feat was exhibited by Dr. Floyd S. Mackey and Dr. W. Hallock. The victim was instructed to sing into an orifice and attune his cry to a fork which sounded the bass C. Inside the contrivance were resonance tubes set for C and for seven overtunes, or harmonics. Behind each of these was a drum, which vibrated for the tone of a harmonic. These connected by rubber tubes with little jets of gas, so that the latter jumped up and down when the drums vibrated. The lights were photographed by a camera which was swung quickly past them, the resulting records being in the form of wavy lines. Each line represented the tone, or an overtone, and showed their relative presence in the voice tested. The stronger the tone was, the wavier the line. The object of the apparatus is to ascertain what proportion of overtones is desirable in a singing voice. Specialists have never been able to tell a throat belonging to a good singer from any other. Several famous singers have had their voices photographed with the new apparatus, and these will be compared with ordinary and unmusical voices. The difference in voices once determined in this way, the different throat structures may be better studied, and we may yet have specialists advertising to furnish ambitious young women with first-class operatic voices by simple alterations in the structure of their throats."

A Wonderful Mushroom Opera House.

For some months past the people of Colfax have heard wild rumors of the intention of the band to erect an opera house some time in the near future, but no three persons outside of that organization suspected until yesterday morning that there had been any definite shape to their many plans; but now the institution is an astonishing reality and one of which the city will be proud for many years to come.

On Wednesday night there seemed to be something wrong with the electric light plant, and the streets were in total darkness. Inquiries were answered with the intelligence that the engine was out of order and the plant could not be operated. The people were satisfied with this reply and but little comment was made. Now, it seems to have been part of a plot on the part of the band to hide their scheme. Street loungers had noticed for several days the beginning and progress upon the work of putting in the foundation of the new building on the Codd and Stravens lots north of the First National Bank, and in the last few days immense piles of brick and lime had been hauled to the street in front of the place, but it caused little suspicion.

Soon after it got thoroughly dark Wednesday night a force of about seventy-five men were brought in from Spokane on a freight train, and, unloading near the Main street bridge, armed with hods and trowels, marched to the place and silently began the work of laying the brick upon the new building. As that side of the street was obstructed and the night a dark one no one passed near the building and the ruse was not discovered. Stealthily the men passed up and down and along the walls and rapidly they sprang upward through the night. By daylight the outside walls were finished, and before any one was astir on the streets yesterday morning the scaffolding was taken down, and there stood in magnificent eloquence the proudest opera house in the Northwest.

Men, women, and children thronged down the street dumb with astonishment and admiration. It seemed that nothing short of magic could have erected such a structure without causing suspicion of what was going on.

Just before daylight the masons finished their work and silently departed, while their places were filled with as many carpenters, plumbers, decorators, painters, etc., and all day the work went noiselessly on inside the walls. The heavily curtained windows and closely fastened doors were besieged all day by anxious people, but revealed nothing. At 10 o'clock a bill poster, armed with a paste brush, came down the street, and stopping in front of the building, put up bills announcing that the Colfax Dramatic Company would star their old-time favorites, George J. Joyce, W. J. Bryant, and C. E. Irwin, in the drama "Hick'ry Farm," at the Colfax Opera House. Last night, when the announcement was recognized by the anxious and excited crowd, a long cheer of approval went up. The good news spread like wildfire, and when, at 7.30 last night, the building was thrown open, the streets were crowded from the Colfax hotel to the court house.

Marshal Mackay had to call out his entire force of one other man besides himself, to maintain order. The jam at the box office was almost suffocating, but the crowd was served and seated in the beautiful and capacious auditorium by 8.30, and the curtain rose amid thundering applause, which was repeated at intervals all through the evening. When the curtain had fallen on the last act, and the villain was finally and securely dead, the audience would not be pacified until the act had been thrice repeated for their benefit. — *Spokane Spokesman.*

A Kitchen Boiler Explosion in Scotland.

The following extract from the Glasgow *Weekly Mail* of February 16th is of interest in connection with the kitchen-boiler question that has agitated England and Scotland for the past year or two.

"An explosion of a kitchen boiler, attended with great destruction of property, and with the serious injury of two domestic servants, occurred about five o'clock on Thursday afternoon, in the house of Mr. Wm. Fleming Russell, coal merchant, at 1 Montgomerie Street, in North Kelvinside. From the information in the possession of the Maryhill police, it appears that the cold and hot water pipes throughout the house, which consists of ground floor and sunk flat, having been frozen for a week past, a plumber was engaged on Wednesday putting two new ribs into the kitchen range, and he offered the advice that a small fire should be lit in the grate. Without doubting the wisdom of this counsel the cook put on a fire as advised, and kept on increasing it until Thursday, when she had it roaring. Shortly before five o'clock in the afternoon the noise of escaping steam was heard, and before anything could be done in the way of prevention an explosion took place. The noise created was terrific, and the havoc done in a moment almost beyond description. The boiler itself was blown through the kitchen roof, tearing a large hole in the floor of the drawing-room, which is situated directly overhead, and, still ascending, struck the ceiling of this apartment, and afterwards fell back, otherwise wrecking the room and its contents. In addition to this, by the force of the concussion, a partition wall in the kitchen was laid low, no fewer than eleven windows were blown out, and the vestibule and main door of the house situated on the ground flat, and several yards distant from the kitchen, were burst out towards the street. The cook (Margaret Young) and the nurse (Esther Longbottom), who were in the kitchen at the time, miraculously escaped with no more than a severe shock to the nervous system, and after having been examined by Dr. Whyte, assistant to Dr. Hay, casualty surgeon, were sent to the Western Infirmary in a cab. The fire brigade were called out, but their services were not required.

"Detective John M'Phail of the Maryhill division, who has been investigating the affair, informed the representative of the *Mail* that the boiler which burst was situated above the kitchen range, and was not the ordinary hot-water boiler, which lay at the back of the range. This upper boiler had a flat end on which it rested, and another end in shape like the rounded bottom of a common lemonade bottle. They hadn't discovered yet the plumber who gave the cook the rather peculiar advice in the circumstances to put on a fire in the range with frozen pipes under treatment, but at any rate the girl acted on the advice on Wednesday, and the fire had been kept on until it was roaring on Thursday. Of course the gas and the steam accumulated in the circulating boiler above the range, and, the pipes being frozen, there was no escapement for the steam, with the consequence that the inevitable burst occurred. The boiler itself was wrenched from the flat end on which it sat and went smashing through the ceiling, tore through the floor of the drawing-room and crashed against the ceiling of that room, again cutting a hole in it, and fell back amongst the furniture. As to the appearance of that interior, after the disaster, the furniture of the drawing-room was left a perfect wreck. Sofas, tables, and chairs were hurled and heaped one on top of the other, and to make confusion worse confounded the place was strewn with bricks and lime, and there was a gaping void in the floor several feet in diameter. Half of the partition wall where the boiler was situated was blown down, and bricks and lime littered the kitchen in every direction. As showing the tremendous force of the concussion, Mr. M'Phail mentioned that eleven of the windows had been blown right into the street, and the vestibule door, although a strong one, and at the other end of the house, distant several yards from the seat of the explosion, and on the upper flat, was carried clean off its hinges, and carried into Montgomerie Street. Even a door round the angles of the lobby in the sunk flat had its panels smashed to pieces. In the interior of the kitchen itself to move about one had to climb over piles of brick, lime, and furniture. The residence throughout, it is scarcely necessary to add, is rendered uninhabitable, and on Thursday night a constable was left in charge. It is instructive to note that the lady of the house was apprehensive of danger before the accident. At least twenty minutes prior to the explosion she went down to the kitchen and warned the domestics of the fear she entertained. They paid no heed, however, and she actually took the children to an upper flat and kept them there at the other end of the house. Had they been in the low flat it is fearful to speculate what the consequences might have been. When the explosion took place the girl Longbottom was standing opposite the scullery door, and she was carried off her feet and blown into the scullery. The other girl was near the table at the time, and she was hurled across the apartment and against the opposite wall. She is unable to speak, but the doctors are of the opinion that apart from severe shock the girls have sustained no injuries. Having been so near the seat of the explosion it is really astonishing how either of them escaped with their lives. The report was so great that it was heard at the Great Western Road, almost a quarter of a mile away."

The oldest known fire engine for pumping water is probably the one mentioned in the "Spiritalia" of Hero, about 150 B. C. This engine, it is said, was contrived with two single-acting pumps with a single beam pivoted between the two for working the plungers. The streams of water united in a single discharge pipe and passed up a trough having an air chamber, and out of a nozzle which might be turned in any direction as desired. Fire engines appear also to have been used extensively by the early Romans, who furthermore organized regular fire brigades.

In the early part of the sixteenth century a fire engine known as a "water syringe" was introduced, which, in a measure, resembled the modern form of fire engines. This was mounted on wheels and the water pumped by levers. This form of engine was very generally used in Germany. In England, about the same time, large brass syringes were used. These held several quarts of water and were operated by three men, two of them holding the syringe at each side with one hand and directing the nozzle with the other, while the third operated the plunger. It was necessary, after having discharged the water from the syringe, to refill it from a well or cistern near the fire or from buckets. The syringes were later fitted to portable tanks of water.

The first successful fire engine was probably the Newsham engine, and this was the pioneer of manually operated fire engines. The pumps in these engines were built on many different designs, but in most cases they were operated by levers. Fire engines similar in form to the Newsham engine were in use up to the year 1850. — *Public Opinion* (London).

Incorporated 1866.

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HARTFORD, CONN.

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The Locomotive.

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The Woburn Explosion.

An already large list of Monday morning explosions has been further increased by a very destructive one to life, limb, and property, which happened at the tannery of Mr. F. A. Loring (operated by J. M. Jones & Co.), at Woburn Highlands, Mass., on April

FIG. 1. — GENERAL VIEW OF THE RUINS.

1st. Five lives were lost by it, and serious injuries were inflicted upon about a dozen other persons. The aggregate property loss was probably $20,000.

The steam plant consisted of a battery of four horizontal tubular boilers, the exploded one being known as "No. 4." During the previous day Nos. 3 and 4 had been put out of service for the purpose of having them inspected, steam being meanwhile maintained on Nos. 1 and 2, which had been inspected the week previous. Under these circumstances the stop-valves on the boilers Nos. 3 and 4 were of course closed; and this was the state of affairs when we inspected these two boilers, as already described, on March 31st. The report of that inspection was promptly made, and it states that there was some accumulation of scale upon the heating surfaces — nothing serious, however — and recommends that this scale be removed. It was also noted that there was some local corrosion of the sheets, though not enough to make the boiler dangerous at the pressure under which it is operated, — 80 pounds. The report certifies that the safety-valves, steam gauges, and other safety appliances, were examined and tested, and the boilers were pronounced safe for 80 pounds of steam under the conditions under which they were operated.

At the time our inspectors made their examinations, — that is, on March 15th, March 24th, and March 31st, — they found Michael Lally acting as head fireman in charge of the boilers, and thought him a very competent and experienced man. Indeed, so far as this company is informed, and so far as we could learn by our own investigations, his character, ability, and fidelity are unquestioned. It is said that he had three years' experience as a fireman in the U. S. Navy, with additional experience at other steam plants. If this be true we think there can be no doubt that he could have passed a creditable examination, and obtained license papers as an engineer, or head fireman, had it been required by law.

After boilers Nos. 3 and 4 were examined as described, it devolved upon the management to prepare them for service again by properly replacing the man-hole and hand-hole plates, filling the boilers with water, and starting the fires. When steam was gotten up to the same pressure, in Nos. 3 and 4, that existed in the other boilers (carefully noting the behavior of the steam and water gauges and safety-valves during this time), then, *and not till then*, should the stop-valves have been carefully opened, and the connections made with the remaining boilers of the battery. This operation of getting up steam after boilers have been out of service, is one which requires the exercise of the greatest skill and judgment; this is especially true when part of the boilers of a battery have steam upon them at the time. Our company does not contemplate that this important duty shall be performed by other than the most competent and experienced men.

The judicial inquiry made since the explosion has established the fact that on this particular night of March 31st, the duty of getting up steam, and connecting all the boilers together, devolved upon two men, one of them being a night watchman, who had been a yard laborer until some two weeks before, and who was utterly ignorant of the duty to be performed, and the other a night fireman, also without adequate experience, and perhaps without experience at all, who had been hired two nights before. These men were not questioned as to their knowledge of the duty to be performed (as it was not known by our company that they were to be entrusted with it), and they claim that they received no special directions from the managers or superintendent of the works. This inquiry also established the facts that from about ten o'clock P. M. (the time of starting fires upon boilers Nos. 3 and 4), until the explosion of No. 4 boiler, just before 7 A. M., when the engine was started and the whistle blown, the men had been in trouble, and had sought the assistance of acquaintances in the neighborhood; that they had hauled fires and started them again, that they had had trouble getting water into No. 4, that the watchman at about 3 A. M. had called the superintendent (who did not then respond), that steam was heard to blow off violently at 5.15 A. M., and that before the superintendent was called the fires were burning and the water had fallen considerably below the lower gauge in No. 4 boiler. Inasmuch as the fusible plug was known to be intact the day before, and was found partly fused after the explosion, the inference seems conclusive that this plug was fused at that time; and probably no one conversant with steam boilers who heard or read the testimony in this case was surprised that an explosion occurred. Whatever there is of wonder, it is that the whole battery was not blown up.

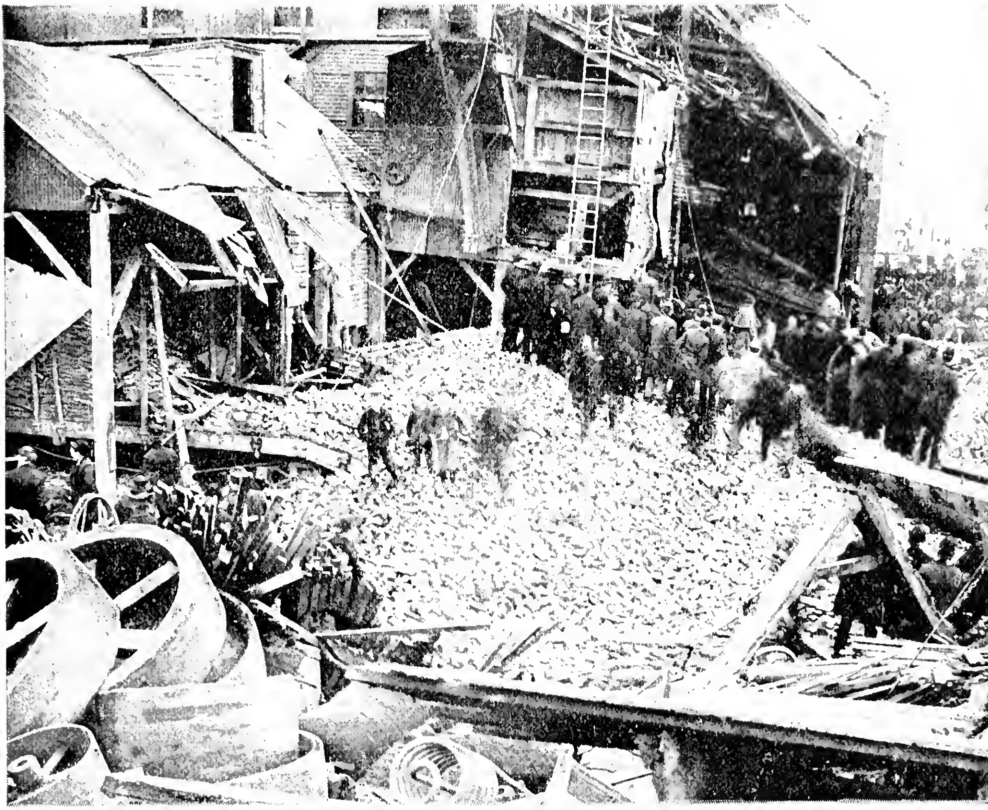

FIG. 2.—GENERAL VIEW OF THE RUINS.

Owing to this plant having changed ownership several times during the past twenty years, it has been difficult to determine positively the age of boilers Nos. 3 and 4. It is reported that they were built by Messrs. Wm. Allen & Sons, boiler-makers, of Worcester, Mass. They were constructed of steel plates, $\frac{5}{16}''$ thick, and consisted of four rings of plates, double riveted along the horizontal seams. They were supported by three cast-iron lugs on each side. The heads were of steel, $\frac{3}{8}''$ thick, well stayed. They were 60″ in diameter, and 16 feet long, and they contained 54 four-inch tubes. According to the United States tables of pressures, such boilers might have been allowed a maximum steam pressure of 124.99 pounds, when new. Taking into consideration their age, condition, and service, this company allowed 80 pounds, at which pressure it is admitted by the United States inspectors, and by the State steam-boiler inspectors, as well as by various expert engineers, that they were absolutely safe, when properly handled. No boiler, however good and strong, is safe in inexperienced hands!

Judging from the way in which the pieces were projected, the initial rupture of No. 4 boiler occurred near the juncture of the girth and horizontal seam on the left-hand side of the fourth ring of shell plates; the break then following the line of greatest weakness, — *i. e.*, running between the rivet holes of the horizontal seam. The sheet was stripped off from the other part of the shell, and also from the back heads; it was straightened out, and it probably struck the chimney or some part of the building a heavy blow, as it was deflected to the left, and when recovered was some three hundred feet from its starting point. Had its course not been thus modified, it would probably have done even greater damage to the buildings to the right of the boiler-house, perhaps with greater fatality to the workmen who were in those buildings, preparing to commence their day's work. The forward part of this boiler, with the front head and three courses of the shell, was driven endwise about 35 feet into the second floor of the tannery, demolishing everything in its path. This portion of the boiler, so far as can be determined, was the chief cause of the loss of life and injury to person that resulted.

The 54 four-inch tubes belonging to this boiler were hurled to the rear in a right and left direction, for some 400 or 500 feet around. No. 3 boiler, adjacent, was turned end for end and upside down, and had apparently been thrown high in the air. No. 2 had its connections all stripped off and its setting demolished, while No. 1, except for the shattering of the brick setting and the carrying away of the steam and water connections, was not seriously injured. The destruction of the boiler, buildings, chimney, pipe connections, and fittings, was so complete as to leave no doubt in the minds of any one conversant with such matters that the pressure that exploded this boiler must have been a very considerable one. Self-preservation is said to be the first law of nature, and as boiler explosions are commonly the result of negligence on somebody's part, those who have a knowledge of the affair, and survive, are generally more inclined to add to the mystery than to attempt to clear it up by telling, to their disadvantage, their own part in it. Hence, in such an investigation we must depend more upon a careful examination of the remaining parts of a boiler, its attachments and fittings, and the mute testimony they afford, than upon admissions to be obtained from the survivors. Just what occurred in that boiler-house on the night preceding the explosion, or the order in which it occurred, will possibly never be known. The stories of the survivors (the night watchman and night fireman), are very conflicting, and are not reconcilable with what has been made public through other channels; but fortunately we know they were seeking aid wherever they thought they could get it, and it may be assumed that they naturally would not let the superintendent know of their failure to do what was expected of them, so long as it could be concealed.

An examination of all the available information shows that No. 4 boiler, at the time of explosion, was in good condition for a pressure considerably in excess of 80 pounds. Therefore there are the best of seasons for assuming, inasmuch as it did explode, that something out of the ordinary occurred in its management, by which its strength was impaired. This would be the natural result of the distortion of the horizontal lap seam, if it were overheated while the water is admitted to have been low (*i. e.*, at the time the fusible plug was partly melted); and it is probable that the bursting pressure of this boiler was considerably reduced, at the weakest part, by an injury of this sort. It appears that the partial melting of the fusible plug has not attracted the attention, in some quarters, that it deserves; nor has the true significance of what occurred, during the night, been appreciated by those of limited experience, who reason more from a theoretical standpoint than from a practical knowledge of such matters. It is within the observation of those who have had much to do with fusible plugs, that even when they are refilled periodically, they fuse completely, or partially, with a greater or less exposure. It is not contended by this company that the water was so extremely low in No. 4 boiler as to bulge that part of the back head in which the fusible plug was

Fig. 3. — Some Details of the Wreckage.

placed; it is evident that the heat fell short of that. To cause such a bulge the water would have had to be even lower than it is claimed to have been, judging from the appearance of the plug and the shell of the boiler. It is evident, though, that there are *degrees* of overheating, and an overheating sufficient to distort and greatly injure a lap-riveted seam in the fire might not appreciably injure the plates in the head or the sheets. Seams are always the first to suffer, and they suffer the worst because a double thickness of plate at the lap throws the boiler out of the cylindrical form at this point, and the first effect of the stress due to overheating under great pressure (such as is assumed to have occurred), when combined with the effort of that part of the shell to assume a circular form, is to either rupture or distress the joint, according to circumstances. If this assumption be true, it certainly was more than probable, under the circumstances, that the strength of the boiler under consideration would have been so reduced by the injury it suffered, that it would explode disastrously at a much lower over-pressure than would its mate, No. 3, or than it would have required, itself, previous to the injury.

Our illustrations are from photographs taken shortly after the explosion.

As some criticism has been elicited by the fact that the boiler at Woburn exploded the day after it was inspected, it is proper to call attention to the foregoing article as showing that inspection is no guaranty against carelessness and ignorance of the proper management of steam boilers. A boiler in perfect condition may explode in two hours after inspection, if put under the management of an ignorant, incompetent man. The Hartford Steam Boiler Inspection and Insurance Company carried 57,000 boilers through the year 1894, and only 9 of them exploded,—that is, only one boiler in 6,333, or less than $\frac{1}{63}$ of one per cent. of those insured. The company employed during the same year 140 inspectors, all of whom are constantly engaged in this particular department of the company's business, and all of whom are capable men, with wide experience in mechanical and steam engineering. This department alone of the Company's business cost, during the year 1894, nearly $300,000; and it is to its efficiency that the low loss-ratio is to be attributed. Those insured with us reap the benefit of the advice of this corps of practical experienced men, and know it to be valuable. We were somewhat amused, recently, at receiving a copy of a trade paper published in Boston, in which was an article entitled, "*Does Inspection Inspect?*" The article was mainly devoted to a criticism of the Hartford Steam Boiler Inspection and Insurance Company and its methods. Cases of exploded boilers were cited, which were never inspected nor insured by us. There were tears and blood in the eye of the person who wrote the article. His disturbed equilibrium and venom pervaded every line. And why? An agent of this trade sheet called at our office several times to secure an advertisement from us, a short time before the Woburn explosion, and he didn't get it.—*Hinc illæ lacrimæ.*

Boiler Explosions.

March, 1895.

(76.)—A traction-engine boiler exploded, on March 1st, at Jacksonville, Ill. John Seymour and Howard Seymour were terribly injured.

(77.)—A boiler exploded, on March 2d, at Gibsonville, twelve miles east of Adelphi, Ohio. Three men, named Snyder, Brown, and McBride, were blown to pieces, and another man, named Smith, received a fracture of the skull, from which he died. John McCrooms and —— Augsberg were also horribly crushed, but not killed. The building in which the boiler stood was blown to atoms. This is the fifth boiler explosion that has occurred within a radius of twelve miles during one year. The five explosions referred to (one of which happened on February 26th of this year) resulted in a loss of twelve lives.

(78.)—A locomotive boiler, on the Central Railroad of Georgia, exploded, on March 2d, near Weems, Ala. Engineer F. A. McGuire and Fireman William Reeves were instantly killed. The locomotive and three cars were totally demolished, nothing being left of the locomotive itself but the wheels.

(79.) — A safety boiler exploded at the Laurel Hill colliery, Hazleton, Pa., on March 3d. John Sherman was badly bruised about the face and head, and one of his legs was broken.

(80.) — A boiler exploded, on March 6th, in Runkle, Rowley & Co.'s mill, at Runkle's station, near Piedmont, S. D. William E. Warren and Andrew Dillehay, Thomas Collins, Robert Repass, and Amos Wright were painfully injured. The boiler was literally blown to atoms, and the building was almost completely wrecked. Pieces of the machinery were thrown fully three hundred feet. The property loss is variously estimated at from $2,000 to $5,000.

Fig. 4. — A Section of the Exploded Boiler.

(81.) — A boiler exploded at the B. F. Goodrich company's rubber works, at Akron, Ohio, on March 7th. John Vance, a machinist, was struck on the head by a flying fragment, and died in about ten minutes. John Somerville, who was working with him, was severely burned and scalded, and several other employes received lesser injuries from the falling walls. A number of surrounding buildings were injured by the explosion. We have seen no estimate of the total damage done.

(82.) — On March 7th, a boiler exploded in A. M. Kinney's mill, five miles east of Hillsdale, Mich. Mr. Kinney was killed, and his son and another workman received painful burns. The mill was torn to atoms, and large trees, eighty or ninety feet away, were twisted and splintered by the flying pieces of the boiler.

(83.) — A portion of the sectional heating boiler in the schoolhouse at Menekaune, Wis., burst on March 8th. Nobody was injured, and the scholars had a day's vacation.

(84.) — James McGrew and Emmet Ford were badly injured by a boiler explosion at Winchester, Ohio, on March 8th. McGrew was fearfully scalded, so that he died during the evening. Ford was badly cut and bruised by flying debris, but his injuries are not fatal. The building in which the boiler stood was demolished, and the stack was also blown down.

(85.) — The locomotive of the Pacific express, leaving Harrisburg for Altoona, Pa., on the Pennsylvania Railroad, at 3.10 A.M. on March 9th, was destroyed by a boiler explosion at Cove Station, near Harrisburg. Fireman John H. Peffly was injured so badly that he died within five minutes. Engineer John A. Funk was severely injured also, but it is thought that he will recover. "We left the Union Station [at Harrisburg] on time," said Mr. Funk, "and ran along at the usual rate of speed. At Marysville I saw that there was plenty of water in the boiler, and shut off the injector from Marysville Tower to Perdix. At Cove Station I looked at the steam gauge and saw that there was a steam pressure of about 175 pounds, and that the water gauge indicated a boiler three-fourths full. The injector was on. I got up and saw that the white light was displayed at the tower, and remember nothing more of what occurred until I heard those about me in the car speaking. I asked Assistant Road Foreman Clemson 'What's the matter?' 'No. 926 has blown up,' he answered. 'Then,' I said, 'she went up with plenty of water in her boiler.'"

(86.) — A boiler used in connection with an illicit still exploded at Bay Side, L. I., on March 12th. The still was operated by a man named Stile, one of whose children was fatally injured. Stile, his wife, and two other children were also seriously injured.

(87.) — On March 13th, a boiler exploded at Pennington & Winckler's cotton gin, at La Crosse, a station on the Atlantic & Danville Railroad, about twenty miles east of Boydton, Va. The engineer and fireman were killed instantly. The explosion shook the earth for six miles around, so that the people of the surrounding country thought an earthquake had occurred.

(88.) — A boiler expoded near Chuckaluck, McMinn County, Tenn., on March 15th. Nobody was killed, but a boy name Carpenter was seriously bruised about the head and face. The machinery of the mill was ruined.

(89.) — A boiler exploded, on March 16th, at the Lawrence Steam Dye Works, Lawrence, Mass. It is said that it was designed for 60 pounds pressure, and that at the time of the explosion it was carrying but 35 pounds. None of the employés were near at the time, and nobody was injured.

(90.) — On March 17th, a boiler exploded at the South Village mill of the Slater Woolen Company, at Webster, Mass. The engine-house and the dry-room, two large one-story brick buildings, were completely demolished. In the dry-room were 200 bales of wool, valued at $1,500, which were ruined. In the engine-house there were two engines, one of them a 200 horse-power Corliss, valued at $5,000, and the other a 150 horse-power Green engine, valued at $3,000. These engines, together with the dynamos used for lighting the plant, were ruined also. It is said that the total damage, including buildings and machinery, will amount to $75,000. The front head of the boiler blew out, and the reaction of the issuing steam and water caused it to start "cross country" like a rocket. In its course it passed endwise through a 10′×12′ parlor in one of the neighboring tenement-houses. Rosa Domi, a young girl, was in the room at the time, and how she escaped instant death is beyond comprehension. The entire floor of the room was torn away from under her, and she fell into the basement below. Her fall resulted in numerous bruises, but otherwise she was not injured. As the explosion occurred at noon on Sunday, nobody was injured about the plant itself.

(91.) — Six men were killed and five others seriously wounded, on March 19th, by the explosion of a boiler at Hall's mill, 33 miles south of Marshall, Tex. The shock of the explosion is said to have been felt at Marshall. We did not learn further particulars.

(92.) — The boiler of an agricultural engine exploded, on March 20th, near Bucyrus, Ohio. John Wirtz (the owner of the boiler) and a hired man were badly injured. The engine was blown into a barn, setting it on fire, and totally destroying both barn and contents.

(93) — One of the six boilers in S. T. King & Co.'s lumber mill at Kingsville, about four miles from St. John, N. B., exploded on March 20th. Wellington Smith was killed, and Henry Conwell, Fred LeBlanc, Charles McGuire, James Murphy, John Murphy, James Landers, and Matthew Galbraith were more or less severely injured. A lad named Keefe was also slightly injured. The boiler-house was completely wrecked, and the mill itself was considerably injured.

(94.) — A boiler exploded, on March 20th, in the stave factory at Mt. Pleasant, Maury County, Tenn. We have not learned particulars.

(95.) — A boiler exploded, on March 26th, in Amos Hutchins' mill, near Van Wert, Ohio. Blakely Shaw and Fred Hutchins were killed, and Melville Storz, Isaac Bowman, and Neil Fassett were badly injured. The mill took fire, and was destroyed.

(96.) — On March 27th, a boiler exploded in Johnson's mill, on Sugar Creek, about five miles from Shelbyville, Tenn. Elijah Cunningham was killed, and Humphrey Cunningham, his brother, was blown a considerable distance and severely injured. Several other men received lesser injuries. The engine-house was completely demolished, and several small structures near it were likewise destroyed.

(97.) — A boiler exploded, on March 27th, in the Langston saw-mill, at Apple Valley, near Harmony Grove, Ga. William Goode, John Langston, and a negro woman were killed. Edward Churchwell, F. M. Langston, and ——— Holbrook were severely injured. The explosion was heard five miles away. The boiler was hurled 150 yards up a hill, mowing down a number of trees in its passage.

(98.) — On March 28th, a boiler exploded in the basement of Gerdes' Hotel, Cincinnati, Ohio. The explosion was slight. Nobody was injured, and the damage was small.

(99.) — The boiler in Williams' saw-mill, in Dunklin County, near Dexter, Mo., exploded on March 28th, killing John Waynick, the fireman, and injuring Elijah Warner, William Snipes, John Foley, John Gowan, and Charles Warner. The machinery was literally torn to pieces. A section of the boiler was blown through two walls of a gin-house, and into a field seventy-five yards away. Fragments of the boiler-house and pieces of machinery were thrown 2,000 yards from the site of the mill.

(100.) — On March 29th, a boiler exploded on a steamboat used by a dredging party near Beardstown, Ill. William May was instantly killed, and Alonzo Bollinger was seriously i ijured.

(101.) — The boiler in D. J. Ingersoll's mill at East Leon, near Randolph, N. Y., exploded on March 29th. D. J. Ingersoll and Denziel Ingersoll were instantly killed. Mrs. D. J. Ingersoll and Davillo Hunt were badly injured. The mill was demolished.

Inspectors' Report.

MARCH, 1895.

During this month our inspectors made 8,479 inspection trips, visited 18,136 boilers, inspected 6,284 both internally and externally, and subjected 569 to hydrostatic pressure. The whole number of defects reported reached 12,154, of which 1,396 were considered dangerous; 85 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	897	45
Cases of incrustation and scale,	1,987	65
Cases of internal grooving,	119	9
Cases of internal corrosion,	695	55
Cases of external corrosion,	859	72
Broken and loose braces and stays,	223	82
Settings defective,	318	44
Furnaces out of shape,	459	26
Fractured plates,	360	71
Burned plates,	287	33
Blistered plates,	206	15
Cases of defective riveting,	1,504	72
Defective heads,	102	33
Serious leakage around tube ends,	2,018	450
Serious leakage at seams,	531	52
Defective water-gauges,	452	80
Defective blow-offs,	199	64
Cases of deficiency of water,	17	11
Safety-valves overloaded,	93	26
Safety-valves defective in construction,	148	35
Pressure-gauges defective,	570	36
Boilers without pressure-gauges,	20	20
Unclassified defects,	90	0
Total,	12,154	1,396

THE ratio of the specific heats of the new element, argon, is said to be 1.66.

Our Country's Progress, as Seen by a Foreigner.

The English statistician, Michael G. Mulhall, publishes, in the June number of the *North American Review*, an article on "The Power and Wealth of the United States." Mr. Mulhall's conclusion is that:

"If we take a survey of mankind in ancient or modern times as regards the physical, mechanical, and intellectual force of nations, we find nothing to compare with the United States in this present year of 1895, and that the United States possesses by far the greatest productive power in the world."

Mr. Mulhall shows that the absolute effective force of the American people is now more than three times what it was in 1860, and that the United States possesses almost as much energy as Great Britain, Germany, and France collectively, and that the ratio falling to each American is more than what two Englishmen or Germans have at their disposal. He points out, by a careful comparison between the conditions in these different countries, that an ordinary farm hand in the United States raises as much grain as three in England, four in France, five in Germany, or six in Austria. One man in America can produce as much flour as will feed 250, whereas in Europe one man feeds only thirty persons.

Mr. Mulhall calls special attention to the fact that the intellectual power of the great republic is in harmony with the industrial and mechanical, eighty-seven per cent. of the total population over ten years of age being able to read and write.

"It may be fearlessly asserted," he says, "that in the history of the human race no nation ever before possessed 41,000,000 instructed citizens."

The post-office returns are appealed to by Mr. Mulhall in support of this part of his statement, these showing that, in the number of letters per inhabitant yearly, the United States are much ahead of all other nations.

According to the figures of Mr. Mulhall the average annual increment of the United States from 1821 to 1890 was nine hundred and one millions of dollars, and he adds that "the new wealth added during a single generation — that is, in the period of thirty years between 1860 and 1890 — was no less than forty-nine milliards of dollars, which is one milliard more than the total wealth of Great Britain."

Classifying the whole wealth of the Union under the two heads, urban and rural, Mr. Mulhall finds that rural or agricultural wealth has only quadrupled in forty years, while urban wealth has multiplied sixteen-fold. Before 1860 the accumulation of wealth for each rural worker was greater than that corresponding to persons of the urban classes; but the farming interest suffered severely by reason of the civil war, and since then the accumulation of wealth among urban workers has been greatly more than that among rural workers, a fact which Mr. Mulhall thinks explains the influx of population into towns and cities.

In a series of figures Mr. Mulhall shows that the "rise in wealth and increase in wages came almost hand in hand." In dealing with the development of farm values, he makes the following statement:

"If the United States had no urban population or industries whatever, the advance of agricultural interests would be enough to claim the admiration of mankind, for it has no parallel in history."—*Scientific American.*

A FITTING burst, recently, on the main steam pipe in the Broadway cable power house, at Sixth avenue and Fiftieth street, New York. The pipe was carrying steam at a pressure of 100 pounds to the square inch. The main stop-valve was closed as quickly as possible, and repairs were begun at once: too soon, in fact; for one of the workmen was scalded by hot water that spurted from the broken pipe.

The Locomotive.

HARTFORD, MAY 15, 1895.

J. M. Allen, *Editor*. A. D. Risteen, *Associate Editor*.

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The twentieth annual *Report* of the Märkischer Verein zur Prüfung und Ueberwachung von Dampfkesseln, of Frankfurt, Germany, is at hand.

Messrs. John Wiley & Sons, of 53 East Tenth street, New York, have kindly sent us a copy of Mr. William Kent's *Mechanical Engineer's Pocket-Book*. We confess that when we examined this work we had no great hope that it would prove to be of especial importance. We did not question the ability of the author, nor the judgment of the publishers; for we have the greatest respect both for Mr. Kent and for Messrs. Wiley & Sons. The field that the book covers simply seemed to be exhausted, and we did not think it probable that a new work could be written which would have distinct advantages over those of the same sort that were in existence. In this we were pleasantly mistaken, for Mr. Kent's book proves to be a valuable addition to the literature of mechanical engineering. It contains 1,070 pages, and covers nearly everything that a mechanical engineer wants to know. In most cases, too, the treatment is very clear. A particularly satisfactory feature is the large number of references to the original papers and books from which the rules and other information are taken. We heartily commend Mr. Kent's *Pocket-Book* to all mechanical engineers.

Effects of Temperature on the Strength of Wrought-Iron.

The pioneers of mechanical engineering, men who had never seen a tensile test made in the whole of their experience, had very little doubt but that iron and steel were less reliable in winter than in summer. As is frequently the case, however, this view was not confirmed by the earlier of the investigations directed towards this point. The first experiments on the subject were, perhaps, those of Sir William Fairbairn, but they were directed mainly to ascertaining the strength of iron at the temperatures at which it is likely to be exposed in boilers, rather than at temperatures below freezing. Still, his experiments, so far as they went, did not indicate a loss of strength, and Knut Styffe, who investigated the matter with much care, confirmed this, and also concluded that the extensibility did not suffer either. Other experimenters, however, got somewhat discordant results, some finding the strength and extensibility both to be increased at low temperatures, while in other cases a slight decrease has been noted in the percentage elongation; others, again, have noted absolutely no difference in the behavior of the metal under test while the temperature ranged from freezing to boiling point. It has long been known that rail breakages are more frequent in winter than in summer, and the same is also true of car axles, but it has been pointed out that in those countries in which this phenomenon is most marked, the winters are very severe, and in consequence the road-bed gets out of shape, and the shocks and concussions to both rails and axles are consequently much more serious in the winter season. This in itself ought to account for a large proportion of the differences in the amounts contributed to the scrap pile by the two seasons respectively. Still, in spite of this, and of the absence of any indication in laboratory tests of a loss of endurance from a reduction of temperature, many practical men still maintained the opinion that iron and steel were really more brittle in winter than in summer.

For certain purposes the rough workshop tests of material give more accurate information as to its value, and with greater ease, than the refined laboratory tests, which require large and expensive plant. By means of the common bending test, Mr. Strohmeyer was enabled to show conclusively the great loss of ductility occasioned by working steel at a blue heat. Tensile tests made afterwards confirmed the result, but its first establishment was due to the common bending test of ductility, which can be carried out by any workman that can wield a hammer. Another favorite workshop test, and one which will probably never be abandoned for certain purposes, is the impact test, invariably used for rails, tires, and axles. For these purposes it has the great advantage of being of the same nature as the shocks and concussions to which failure of these parts is commonly due in practice, and further, it is easy to conduct the tests on full-sized specimens, so that there is less risk of such errors as may arise when experiments are confined to specimen bars, differing possibly in constitution from the finished article. A very extensive series of experiments of this nature, which has been continued over several years, at great cost of time, money, and personal exertion, has been recently completed by Mr. Thomas Andrews of the Wortley Iron Works, Sheffield. These experiments go to show that the indications as to the comparative endurance of iron at a temperature below freezing point and at 212 degrees Fahrenheit, obtained in the ordinary tensile tests, are unreliable, and that there is in fact a decided loss of ductility and of capacity for enduring punishment at the lower temperatures. Mr. Andrews' experiments were made on full-sized railway car axles, made out of "best best" iron at the Wortley works. The axles in question were 7 ft. 3 in. long over all, $5\frac{1}{8}$ in. in diameter at the shoulders, and $4\frac{1}{2}$ in. in diameter at the center, the weight being 423 lb. The metal used had an ultimate strength of about $21\frac{1}{2}$ tons per square inch, with an elongation of between 18 and 20 per cent. on 10 in. The following analyses show the chemical characteristics of the metal. They referred to different samples, but are of the same nominal quality of metal:

Combined Carbon.	Silicon.	Sulphur.	Phosphorus.	Manganese.	Iron (by Difference).
0.068	0.158	0.007	0.108	0.360	99.299
0.038	0.117	0.019	0.246	0.112	99.468

The first series of experiments were made some ten years ago, and consisted in breaking 42 of the above axles by the impact of a falling weight; some of which were broken at a temperature of 7 deg. to 10 deg. Fahr., while the others were heated to 212 deg. Fahr. The axles to be tested were immersed for $2\frac{3}{4}$ hours or more in a tank containing either a mixture of snow and salt, or hot water, as the case might be. The temperature of the metal was obtained from a second similar axle drilled near its center with a hole for a thermometer. This axle was placed in the tank and removed from it at the same time as the axle to be tested. This latter was, when ready, supported on a couple of cast-iron blocks secured to a heart-of-oak bedplate, located immediately under the tripod with which the falling tup was manipulated. This latter was of chilled cast iron, and was of rounded form, weighing 1 ton, and was allowed to strike the axle direct without the interposition of any saddle. The clear span of the axle between bearings was 3 ft. 6 in. After each blow the permanent deflection was measured and the axle re-immersed for 15 minutes in the heating or cooling tank, as the case might be. It was then placed in position for a second blow, being turned half round, so that alternate blows were struck on opposite sides. The total of the permanent sets gave, of course, a measure of the work done on the material. Some of the results obtained in this first trial are given below:

Number of Axle.	Height of Fall.	Temperature.	Permanent Deflection caused by Blow Number													Total Permanent Deflection.
			1	2	3	4	5	6	7	8	9	10	11	12	13	
	(Feet.)	(Fahr.)	in	in	in	in	in	in	in	in	in	in	in	in	in	(Inches.)
2	10	7° to 10°	$1\frac{7}{8}$	$2\frac{1}{4}$	2	..	..	..	..	..	..	..	..	..	..	$6\frac{1}{8}$
12	10	7° to 10°	$2\frac{5}{8}$	3	..	..	..	..	..	..	..	..	..	..	..	$5\frac{3}{8}$
4	10	212°	$3\frac{3}{4}$	$2\frac{7}{8}$	$2\frac{1}{8}$	$2\frac{1}{4}$	2	..	..	..	..	..	..	..	..	13
5	10	212°	$3\frac{7}{8}$	3	$2\frac{3}{8}$	$2\frac{1}{8}$	$2\frac{7}{8}$	2	$1\frac{7}{8}$	..	..	..	..	..	..	$18\frac{1}{8}$
7	10	212°	$3\frac{3}{4}$	3	$2\frac{3}{8}$	$2\frac{3}{8}$	2	2	2	2	$1\frac{7}{8}$	$1\frac{7}{8}$	$1\frac{7}{8}$	$1\frac{7}{8}$	$1\frac{7}{8}$	$28\frac{7}{8}$
8	15	7° to 10°	$3\frac{7}{8}$	$4\frac{3}{8}$	..	..	..	..	..	..	..	..	..	..	..	$8\frac{1}{4}$
9	15	7° to 10°	4	$4\frac{1}{4}$	..	..	..	..	..	..	..	..	..	..	..	$8\frac{1}{4}$
10	15	120°	$4\frac{1}{2}$	$4\frac{1}{8}$	$3\frac{1}{2}$	..	..	..	..	..	..	..	..	..	..	$12\frac{1}{8}$
11	15	120°	$4\frac{5}{8}$	$3\frac{7}{8}$	$3\frac{1}{2}$	$3\frac{3}{8}$	3	..	..	..	..	..	..	..	..	$18\frac{3}{8}$

The remaining tests showed results of a practically identical nature, the amount of punishment the axles were capable of standing being much greater at a high temperature than at one below freezing point. There were, however, a few exceptional cases. Thus, axle No. 1, tested with a drop of 6 ft. at a temperature of 7 deg. Fahr., stood 47 blows, the accumulated permanent deflection amounting to no less than 62 in. Axles 3 and 6, tested at the same temperature, with a drop of 10 ft., stood, in the first case, 22 blows, and in the latter 34, the accumulated permanent deflections being respectively $54\frac{3}{8}$ in. and 86 in. When, however, the broken halves of these axles were again tested — one at a temperature of 70 deg. and the other at 100 deg. Fahr. — the warm half showed the greater endurance. The fracture in the cold tests was more crystalline than in the warmer ones. Some peculiar phenomena were observed as regards the rate of cooling of an axle immersed in the freezing mixture. Two and three-quarters hours were required to reduce its temperature to 0 deg. Fahr., and though left for 17 hours in the mixture, no lower temperature was reached, though the temperature of the mixture used was —4 deg. Fahr. This anomaly is not easily comprehensible provided due care was taken in making the readings. Experiments made to determine the difference between the outer and central layers of the axle when immersed in the freezing mixture showed that at no time was this difference great, the maximum divergence noted being 4 deg. Fahr.

The results obtained by this preliminary series of experiments showed that though there were many points requiring further investigation, there was on the whole a decided loss of ductility in the axles tested at the lower temperatures. No explanation of the behavior of the exceptions to this rule has, however, yet been attempted, and it would be interesting to have a chemical analysis of the metal in these cases, with a view to ascertaining whether it differed in any marked degree from the rest of the batch. As is well known, exceedingly small differences in the chemical composition of iron may make enormous differences in its physical properties, thus affording a remarkable instance of the importance of those "next-to-nothings" on which Sir Frederick Bramwell once so pleasantly lectured. The mode of testing adopted seems unimpeachable, the precaution of turning the axles half round after each blow being obviously necessary, as otherwise the resistance of the axles would have been enormously increased, owing to the plastic flow of the metal, after the first blow or two, equalizing the stresses on the cross-section in the same way as when a beam is strained beyond its elastic limit in an ordinary transverse test. If the experimenters, through inadvertence, had omitted to turn axles 1, 3, and 6 round between the blows, the exceptional behavior of these three could easily be accounted for. Such a mistake, however, is practically impossible, as, apart from the security afforded by Mr. Andrews' high reputation as a careful experimenter, the axle itself forms a record of the direction of the last blow, its permanent set showing this in an unmistakable manner.—*Engineering* (London).

Four Hundred Below Zero.

Four hundred and twenty-four degrees Fahrenheit below zero! Just what this means it is almost impossible to imagine, and yet it is one of the temperatures which have been reached and used in laboratory research, and has been made the subject of some highly interesting experiments and explanations by Professor Dewar before the British Royal Institution. Four hundred degrees below zero is not an everyday temperature, nor can it be reached by more everyday means than the expansion of liquid air, which latter Professor Dewar has succeeded in producing in comparatively large quantities.

The tensile strength of iron at 400 degrees below zero, is just twice what it is at 60 degrees above. It will take a strain of sixty instead of thirty tons to the square inch, and equally curious results have come out as to the elongation of metals under these conditions. It was an idea of Faraday that the magnetism in a permanent magnet would be increased at very low temperatures, and experiments with comparatively low temperatures had rather negatived Faraday's suggestion, but Professor Dewar has completely verified the opinion of the famous savant, having shown that a magnet at the extremely low temperature made possible by the liquid air had its power increased by about 50 per cent.

Very low temperature was shown also to have a remarkable effect upon the color of many bodies. For example, the brilliant scarlet of vermillion and mercuric iodide is reduced under its influence to a pale orange, the original color returning with the rise of the temperature. Blues, on the other hand, are unaffected by cold, and the effect is comparatively small upon organic coloring in matters of all tints. — *Cassier's Magazine.*

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The Locomotive.

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NEW SERIES — VOL. XVI. HARTFORD, CONN., JUNE, 1895. No. 6.

Water Columns, Gauge Glasses, and Steam Gauges.

IN a recent issue of THE LOCOMOTIVE we briefly described the settings of externally fired horizontal tubular boilers, and we shall now review, in a similar manner, the fittings and connections, which are quite as important as the setting.

The water column, which should be provided with three try-cocks and a glass gauge, should be connected by solid-drawn brass tubing, iron pipe size and thread. A

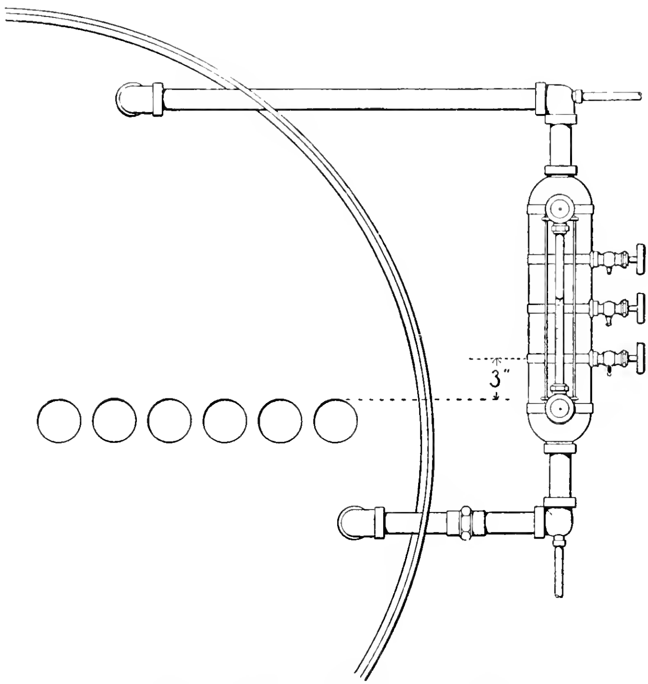

FIG. 1. — SHOWING HOW TO CONNECT THE WATER COLUMN.

ground brass union is placed in the water connection, so that the column can be readily disconnected, and the piping examined and cleaned.

In the cut we show the parts connected up by elbows, in the usual manner. Some engineers prefer to use double tees in place of the elbows, as shown and described in THE LOCOMOTIVE for February, 1895, in order that the pipes may be cleaned by merely removing the plugs from the tees, and running a straight rod through the pipes. Either construction is satisfactory.

The pipes connecting the water column to the boiler should not be less than one inch in diameter, and when the water contains much sediment we prefer them to be an inch and a quarter in diameter. A half-inch or three-quarter inch drain pipe runs from the elbow (or double tee) in the water connection, to the ash pit. This allows the water column to be blown off, so as to prevent the accumulation of sediment in it. For the sake of neatness, a drip pipe should also run to the ash pit from the gauge-cocks.

The water column should be so placed that the lower try-cock is at least three inches above the top of the upper row of tubes, and the water level should be carried, as a usual thing, a little above the second gauge. If these points are attended to, the boiler will not be liable to injury from overheating, for even if the pump or injector should fail entirely, with the water level at the lower gauge-cock, there will still be ample time to draw the fires and put the boiler out of service, before the upper row of tubes is exposed by evaporation.

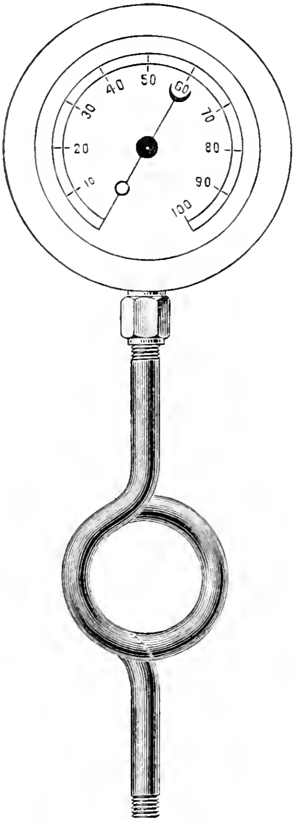

Fig. 2. — The Circular Siphon.

In connecting steam gauges the chief points to be considered are these: The gauges should be so placed that they are not liable to injury from the heat of the steam, nor from the heat radiated from the boiler front or uptake; and provision should be made for removing the gauge while the boiler is in service, in case it should be desirable to do so, and also for blowing out the piping without disturbing the gauge.

Some engineers, when erecting boilers, attach the steam gauge directly to the uptake, or to that portion of the boiler which forms the front connection. This is a grave mistake, as the heat is almost certain to injure the spring, so that the gauge will give erroneous readings, and will perhaps be entirely ruined. It is far better to attach the gauge in such a manner that air may circulate about it freely and keep it cool. It may also be carried to one side and secured to the brick setting, or it may be secured to the boiler front if a suitable thickness of non-conducting material is interposed to protect it.

In order to prevent injury from the direct contact of hot steam with the spring, some form of siphon should be interposed between the gauge and the boiler, in which water of condensation can collect and serve as a protection. Fig. 2 shows a form of siphon in common use for this purpose. We cannot recommend this form, however; for although it accomplishes its purpose of protecting the spring from direct contact with steam, it cannot be cleaned without disconnecting the gauge. Moreover, a bent pipe of this kind is especially difficult to clean, under any circumstances; for it is impossible to drive a cleaning rod through it. It is also impossible to clear a siphon of this type of water, which is an important consideration when the boiler is to be shut down in cold weather. If the water in it freezes, the spring is very likely to be ruptured.

The form of gauge connection shown in Fig. 3 works well in practice, and is in every way superior to that shown in Fig. 2. It is built up of nipples and fittings, as shown, and the gauge is provided with a stop-cock and a ground union. There is also a small cock at the lowest part of the siphon, for blowing out such sediment as may lodge in the bend. If the boiler is out of service, the water may be removed from the siphon by merely opening the "air cock"; but if it is desired to blow the pipes out while the boiler is in service, the stop-cock in the vertical pipe should be closed first, so that the gauge may not be injured. After the siphon has been blown out, the gauge

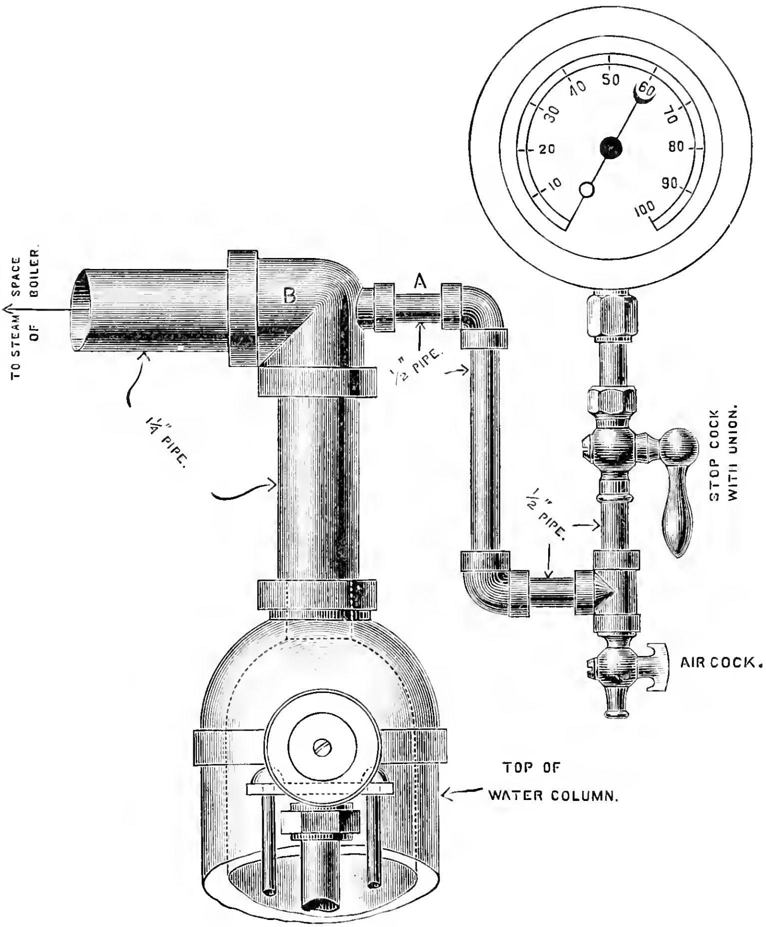

Fig. 3. — Details of the Gauge Connection.

should not be again connected with the boiler until it is judged that a sufficient amount of water of condensation has collected in the siphon to replace that which was blown out.

The form of siphon shown in Fig. 3 is easily blown out, as we have said; and in case it gets plugged so that simple blowing does not clean it effectually enough, it can be readily taken apart, and cleaned by the use of a straight rod of suitable diameter.

The main pipes connecting the water column to the boiler are shown in Fig. 1 without stop-valves. Some engineers prefer to use such valves, so that in case a gauge glass should break, or a try-cock need cleaning, the water column could be temporarily shut off. We do not entirely favor this plan, because it introduces what we consider to be another source of danger to the boiler.

The valves in question would have our hearty approval, if there were any way to make sure that they should always be open when they ought to be. There is always more or less likelihood of forgetfulness or carelessness on the part of the attendant, and if one or both of the valves should remain closed when the boiler was put into service, either through oversight on the fireman's part or through the meddling of unauthorized persons, the gauge glass would give an erroneous reading, and an accident from low water would very likely follow. Such accidents are not mere possibilities. They frequently occur; and it seems to us unwise to give the fireman unnecessary things to think of and look out for. Of course, the expert would quickly discover the true state of things if the valves were closed, either from the absence of condensation drops trickling down the glass, or from the unvarying position of the apparent water level, or from the failure of the try-cock to work, or in some other way; but, nevertheless, we think it is a bad plan to invite danger unnecessarily. The gauge glass is always provided with valves that can be closed in case the glass breaks, and we consider these to be quite sufficient.

Inspectors' Report.

APRIL, 1895.

During this month our inspectors made 6,923 inspection trips, visited 14,833 boilers, inspected 6,242 both internally and externally, and subjected 621 to hydrostatic pressure. The whole number of defects reported reached 11,859, of which 1,085 were considered dangerous; 83 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	931	33
Cases of incrustation and scale,	2,183	74
Cases of internal grooving,	211	12
Cases of internal corrosion,	730	37
Cases of external corrosion,	828	52
Broken and loose braces and stays,	132	33
Settings defective,	309	33
Furnaces out of shape,	495	16
Fractured plates,	304	49
Burned plates,	315	29
Blistered plates,	314	11
Cases of defective riveting,	1,590	305
Defective heads,	143	16
Serious leakage around tube ends,	1,525	151
Serious leakage at seams,	411	17
Defective water-gauges,	399	70
Defective blow-offs,	210	57
Cases of deficiency of water,	13	4
Safety-valves overloaded,	65	18
Safety-valves defective in construction,	91	26
Pressure-gauges defective,	547	31
Boilers without pressure-gauges,	5	5
Unclassified defects,	108	6
Total,	11,859	1,085

Boiler Explosions.

April, 1895.

(102.) — On April 1st, a boiler exploded at Woburn Highlands, Mass., in F. A. Loring's tannery, which was operated by J. M. Jones & Co. Five lives were lost, and about a dozen persons were injured. The boiler-house was in charge of inexperienced men at the time of the explosion, and it appears that the main stop-valve on the exploded boiler was closed. For some reason the safety-valve did not operate, and steam accumulated until the boiler burst. An illustrated account of this explosion will be found in the May issue of The Locomotive.

(103.) —A boiler in the old G. B. Wiggins mill plant in Saginaw, Mich. (recently purchased by Emery & Simpson), exploded on April 1st, with terrific force. Frank Kelley, a laborer, was instantly killed. John Hartel was cut about the head, and received a severe concussion of the brain, from which he died later in the day. Frank Carpenter was bruised, but soon recovered consciousness, and is now doing well. The mill was almost totally wrecked, and the property loss was about $10,000.

(104.) —A boiler exploded, on April 4th, in James Rainsburg's box factory, on Mill Street, East Lockport, N. Y. Joseph Weiner, who was the only person in the factory at the time, was severely scalded. "The frame structure that contained the boiler was reduced to condition of kindling wood."

(105.) — On April 10th, a boiler exploded in Matthew Stevenson's tile mill near Veedersburg, Ind. John Dawson, an employe, was seriously scalded. The explosion "totally destroyed the building, together with a large amount of fine machinery."

(106.) — A terrific boiler explosion occurred, April 10th, in Labahn's brick factory, at Lansing, Ill. Fireman Joseph Seaman was killed, and the engine-room and boiler-house were completely demolished.

(107.) —A boiler in Hillerman & Son's feed mill, three miles northwest of Watkins, N. Y., exploded on April 11th. Gilbert S. Hillerman, who was standing near the boiler, was injured so badly that he died three hours later. William Osterhoudt was also seriously bruised and scalded. "The mill building was undermined by the explosion, and the roof fell in."

(108.) — On April 12th, a small boiler exploded in Louisville, Ky. David Taylor, the engineer, had a narrow escape from death.

(109.) —A boiler exploded on April 12th, at the wire cloth factory, in York, Pa. We did not learn particulars.

(110.) —A boiler exploded on April 15th, in Louis Emmons' mill at Foraker, Ind. James Stein and John Mathias were killed, and Joseph Mason, H. S. Emmons, and George Emmons were badly injured. Mason is not expected to live. "The explosion tore the mill entirely to pieces, and was heard ten miles away."

(111.) — One of the nest of boilers at the Corbin colliery, Shamokin, Pa., blew up on April 15th, wrecking the boiler-house.

(112.) — The boiler of a locomotive exploded, on April 16th, at San Jacinto, Cal. Engineer John Mills was killed. Fireman Jackson was scalded about the legs, and Brakeman Augustus Matthews was thrown about fifty feet, and painfully bruised. The wrecked engine proceeded about 500 yards down the track before coming to rest. Castings, tubes, piping, and fragments of all kinds were thrown in every direction, and the engine was twisted into an indescribable mass.

(113.) — On April 20th, a boiler exploded at the New Venice Lumber Company's plant, near Scranton, Miss. The explosion occurred at 5 o'clock A. M., and the fireman and watchman, who were the only persons about, had just gone out of the boiler-house. The building was demolished.

(114.) — A hot-water boiler at "The Egnew" hotel, Mt. Clemens, Mich., exploded on April 22d. It passed up through the roof of the building. There were a number of narrow escapes, but nobody was hurt.

(115.) — The boiler in John Frank's egg-case and cheese-box mill, near Richland, Iowa, exploded on April 22d. A man named Condon was seriously scalded. The mill and its machinery were destroyed.

(116.) — A boiler exploded on April 23, in a mill owned by Peter P. Batte, near Petersburg, Va. Nobody hurt.

(117.) — On April 25th, fire broke out in the boiler-house of the Forty Fort Colliery of the Wyoming Coal Company, at Wilkesbarre, Pa. During the course of the fire one of the boilers exploded. The combined loss due to fire and explosion will reach $10,000.

Saturn's Ring.

In giving below, at the request of the editor of the *Courant*, an account of some recent observations of Saturn at the Allegheny Observatory, I have thought that a brief glance at the previous history of the subject would be of interest as an introduction: such a review is, indeed, necessary, in order that the reader may correctly understand the significance of the results which have been obtained at this place.

The hypothesis that the ring of Saturn is nothing more or less than a multitude of small bodies, revolving around the planet in circular orbits, is a very old one. It was suggested by Roberval in the seventeenth century, and was revived by Jacques Cassini in 1715, but in those days of course it had no better basis than mere speculation. These suggestions were forgotten, and when the great mathematician Laplace took up the question he regarded the rings as solid bodies. He arrived at the result that such rings could not exist in their actual form unless they were unsymmetrically weighted, and left the problem in this unsatisfactory state. At a later date Professor Peirce of Harvard showed that the rings could not be solid, and regarded them as composed of some fluid denser than water. Finally, the English physicist, Clerk Maxwell, discussed the whole matter thoroughly in a prize essay submitted to the University of Cambridge in 1857, and showed mathematically that the rings could be neither solid nor liquid, and that stable equilibrium would be impossible unless they were made up of separate bodies of no great size — "a shower of brickbats," he was in the habit of calling them.

It was indeed proved before Maxwell's time, by Edouard Roche of Montpelier, that a body of considerable size cannot revolve within a certain limiting distance of a planet, as it would be torn to pieces by the strain due to unequal attraction; but Roche's investigations were long overlooked. In the case of Saturn this "Roche's limit," as it is now called, is just outside the ring, and hence it follows that the ring must be made up of separate small bodies.

Thus it will be seen that the accepted hypothesis rested on a mathematical demonstration that no other constitution of the ring is possible according to the laws of mechanics, and although the mathematical proofs are conclusive to those capable of appreciating them, a proof by direct observation was regarded as having so much importance that the results obtained at the Allegheny Observatory attracted the widest notice.

If there were any spots on the ring, the matter would have been settled long ago; but there are none, and the motion of the ring was measured at Allegheny for the first time by means of a spectroscope. According to a well-known optical principle, a line in the spectrum of a heavenly body is displaced toward the violet if the body is approaching the earth and toward the red if the body is receding. Now, as Saturn's ring rotates, one side is continually moving toward the earth and the other side away from it. Hence the lines of the spectra in opposite sides of the ring are displaced in opposite directions, and by photographing the spectrum, and measuring the displacement on the photograph, we can determine the velocity in miles per second. The moon has no motion in the line of sight, and by photographing its spectrum on the same plate, without disturbing the apparatus, we have a starting point from which the displacements can be reckoned.

But this is not all; the velocity of different parts of the ring will differ according to the way the ring is made up. A satellite must move in obedience to Kepler's third law, and a consequence of this law is, that the velocity of the satellite varies inversely as the square root of its distance from the center of the planet; the nearer a satellite is to the planet, the faster it moves. It is easy to calculate that, if the ring is made up of satellites, its inner edge must move at the rate of 13.06 miles per second and its outer edge at the rate of 10.65 miles. If, on the contrary, the ring is solid, its outer edge must move faster than its inner edge, just as the tire of a wagon wheel moves faster than a point nearer the hub. The outer edge would in fact move more rapidly by about five miles per second.

Now let us see what the photographs say. Here are the main results obtained from the measurement of the two different plates:

Velocity of the middle part of ring, 11.2 miles per second.

Velocity of inner edge greater than that of the outer edge, 2 to 3 miles per second.

Comparing these figures with those given further above, we recognize that the photographs contain a proof that the ring is made up of independent bodies, revolving as satellites.

Perhaps I need hardly say that such results are not obtained as easily as they are described. Some idea of the delicacy of the observations can be formed when I state that a velocity of one mile per second causes a displacement on these plates of only one twenty-five thousandth part of an inch, and that the image of Saturn, which the telescope casts on the slit of the spectroscope, must not move much more than one three-thousandth of an inch during the long exposure of two hours. The plates are measured under a microscope, and while it is impossible to be certain of the fraction of an inch, an accuracy sufficient to decide in favor of the meteoric hypothesis of the constitution of Saturn's rings is quite readily attained.—Prof. James E. Keeler, in the *Western University Courant.*

The torpedo boat built at the Germania wharf at Kiel, Germany, for the Turkish government, was making her trial trip to Eckernfoerde, on May 27, when her boiler exploded. Six of the crew were instantly killed and four were mortally injured.

The Locomotive.

HARTFORD, JUNE 15, 1895.

J. M. ALLEN, *Editor.* A. D. RISTEEN, *Associate Editor.*

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Papers that borrow cuts from us will do us a favor if they will mark them plainly in returning, so that we may give proper credit on our books.

WE desire to acknowledge receipt of the twenty-fifth annual *Report* of the Norddeutscher Verein zur Ueberwachung von Dampfkesseln, of Hamburg, Germany.

WE have received from the Sulzer-Vogt Machine Company of Louisville, Ky., an illustrated pamphlet on "Electric Elevators," which discusses the system used by this firm. The pamphlet is issued as a supplement to their elevator catalogue, and copies of it may be had on application.

Perpetual Motion.

The search for perpetual motion is not so popular to-day as it used to be, but, nevertheless, it still goes on, and the United States patent office still receives applications for patents on devices that imply the solution of this famous problem.

In the days when the fundamental principles of mechanics were unknown, and it was believed that heavy bodies fall faster than light ones, even in a vacuum, there was nothing unreasonable in the hope that a machine might be devised which should furnish energy enough not only to keep itself going forever, but to run other machines also, and thus do useful work. Further study of the behavior of bodies and forces led to the discovery of certain laws of motion which clearly indicated the impossibility of solving the problem of perpetual motion by any combination of cranks and levers and gears, or by any arrangement of water-wheels and pumps. It is true that these laws have never been *proved*, and they cannot, from their very nature, be proved by any such rigorous process of reasoning as that employed, for example, in building up the science of geometry. It is safe, however, to judge them by their fruits — to take the position, in other words, that figs will not grow on a thorn tree. Looking at the question in this light, we see that all the great advances in mechanical arts have been based upon the assumption that the laws of motion, as now stated, are correct; and it is suggestive to note that whenever a machine is constructed so that it violates one of these laws, it does not work.

But the mad seekers after the elusive perpetual motion did not abandon their labors altogether when the new state of things came to pass. Some of them worked on, in sheer ignorance of the principles that had been discovered, and complained bitterly because better educated men would not listen to them, not argue with them. Others took refuge in the more recondite forces of nature. Driven from the field of simple mechanics, they sought, in the less explored fields of physics and chemistry, for principles that would accomplish what they began to perceive it was useless to search for in better explored regions. Electrical devices, in particular, were invented in great numbers. A favorite object of search was some sort of a shield that should be impermeable to *magnetism*, and motors were exhibited in which it was fraudulently claimed that such a screen had been discovered and applied. Even the usually astute editors of *Harper's Magazine* were deceived, a few years ago, by an invention of this sort, and they printed accounts and discussions of the discoveries of one Gary, until finally convinced of their error by an overwhelming weight of evidence from men educated along these lines.

As time has gone on, and the search has been prosecuted by thousands of men in every imaginable field of investigation, it has become increasingly evident that the problem is impossible. Although there may be nothing intrinsically unreasonable in it, thoughtful men have come to the conclusion that there is something about the perpetual motion which is incompatible with the general principles that underlie the universe as it is actually constituted. This is only another way of saying that it is as impossible to create or destroy *energy* as it is to create or destroy matter.

Thus we see that the search for the impossible perpetual motion has not been without fruit. The longed-for device has not been found, it is true, but in the course of the search the grand fact of the CONSERVATION OF ENERGY has been discovered. The search for the philosopher's stone, which should transmute baser metals into gold, and the equally vain search for the elixir of youth, were alike unsuccessful, so far as their avowed objects were concerned; and yet the alchemists who labored so patiently over these problems laid a substantial foundation for the modern science of chemistry. The old astrologers, too, who sought to trace human destinies in the configurations of the planets and the stars, were the pioneers of astronomy; and the indefatigable race of would-be squarers of the circle did good work in fostering the study of geometry and the infant science of trigonometry. Each of them strove for the unattainable, and yet their united labors were not lost. So, too, with the seekers for perpetual motion. They have studied, devised, and contrived for centuries upon centuries, and always with uniform failure; but they have contributed in no small degree to the establishment, upon an unshakable foundation, of the great doctrine of the conservation of energy — the grandest generalization of this century, or, perhaps, of any other.

Photography in Colors.

THE Royal Society gave its "ladies' soirée" on June 12th. The apparatus and experiments exhibited were of the usual variety and interest, but we shall confine our attention at present to Dr. Joly's exhibit, as described by our esteemed contemporary, *Engineering*.

"The greatest novelty in the rooms," says this journal, "was a set of photographs in natural colors, prepared by Dr. J. Joly of Dublin. The negatives are taken in the camera in the ordinary way, except that a ruled glass screen is interposed before the sensitive plate. This screen is ruled in fine ink lines in the three fundamental colors, red, violet-blue, and green, alternating all across the plate at the rate of 200 or more lines to the inch. The selective action of the screen makes itself felt on the negative, the result being that, except where pure white light falls, it also is divided into lines. From the negative a positive transparency is prepared, and when this is viewed through another screen ruled similarly to the first, but with somewhat different colors, the image is seen in the tints of the original object. It will make the matter clearer, perhaps, if we take a very simple instance. Let us suppose a photograph is taken, on a color-sensitive or isochromatic plate, of a sheet of paper of pure spectrum-red color. The red lines in the screen would allow the light reflected from the paper to pass, while the other lines would blot it out completely. When the negative was developed it would present a series of lines of clear glass, corresponding to the blue and green lines in the screen (through which no light proceeded), and a series of black lines of half the width, corresponding to the red lines in the screen. The positive would, of course, be the opposite of this; the red lines would be represented by clear glass, and the other colors by dark deposit. Now, if a three-color screen were placed at the back of such a transparency, with the red color superposed exactly on the clear glass and the two other colors on the opaque parts, it is evident that the plate would give a general red effect all over, provided that the lines were so fine that the eye could not divide the red and black streaks. Evidently the red of the last screen must be a different shade from the original paper, since the original color has been weakened by the action of the two screens. It is an easy step to go from a simple example like this to a geometrical pattern in three fundamental colors; and once the idea is grasped, it will be seen how the ordinary colors of nature can be portrayed, always provided (we should imagine) that photographic plates of uniform color-sensitiveness can be found. The process appears to be founded on the same idea as Mr. Ives's, but instead of three color-screens being used to produce three negatives, the screens are divided, so to speak, into fine shavings, the various colors being laid side by side to build up a single screen of alternate strips of red, blue, and green. Mr. Joly's photographs were shown in the lantern during the evening."

In referring to the soirée the New York *Sun* says, that Dr. Joly "exhibited a large number of photographic transparencies upon glass plates, representing various objects in natural colors. That every range of color and texture could be dealt with was evident upon examination of the subjects portrayed. The portrait of a gentleman seated on a garden seat showed the flesh tints of the hands and face with great naturalness. The straw hat upon the knee, the buff lining partly revealed within, as well as the faint green reflection on the rim where this caught the greenish light reflected from the foliage among which he sat, appeared reproduced with fidelity and realistic effect. Pansies of brilliant yellow and brown, deep purple, black, pale blue, snow white, and velvety brown, grouped in a painted china vase, appeared with equal fidelity in another picture. Other photographs showed the exterior of the red brick building of Trinity College, Dublin, fronted by a lawn with hawthorns, and above the greenish slates of the roof, the pale blue sky; the reproduction of a water color drawing of an Irish peasant girl wearing a red handkerchief over a blue dress, the warm and somewhat sunburnt flesh tints matching the original drawing with almost faultless fidelity, the original being placed above for comparison; a delicately colored Indian china and blue china lacquered; a brass microscope with highly reflecting German silver and copper lacquered finishing, and a thin uranium green glass tumbler with a subtle play of green and yellow light."

The screen used by Dr. Joly in taking most of the photographs referred to had 200 lines to the inch upon it. This ruling was found to be too coarse for some purposes, and he afterwards prepared screens with 300 lines to the inch. A group of flowers, photographed with this finer set of lines, was exhibited.

A KITCHEN boiler exploded at Minneapolis, Minn., on March 17, doing considerable damage. There were no personal injuries.

Effects of Temperature on the Strength of Wrought-Iron.

In our issue for May, we quoted, from *Engineering*, an account of some preliminary experiments made by Mr. Andrews, F. R. S., on the strength of iron axles subjected to an impact test at different temperatures. We are indebted to the same journal for the following account of Mr. Andrews' further experiments on the same subject:

In this second series of experiments a much smaller drop was adopted, and at the same time precautions were taken to cool the axles to be tested in a gradual manner. For this purpose the axle was placed inside an iron grating or cage, which prevented it coming into direct contact with the freezing mixture. The height of drop adopted was 2 ft. 6 in., while the weight used and span between bearings of axles were the same as in the previous experiments. For the warm tests the axles were placed in a water bath and slowly raised to 100° Fahr., and kept at this temperature for one hour before proceeding to break them. In each case the axle was after every blow replaced for 15 minutes either in the water bath or cold cage, as the case may be. The results obtained are given in the table:

TABLE OF RESULTS OF THE TESTS.

Cold Tests, 0° Fahr.						Warm Tests, 100° Fahr.					
No. of Axle.	Total Deflection in Inches.	No. of Blows Causing Fracture.	No. of Axle.	Total Deflection in Inches.	No. of Blows Causing Fracture.	No. of Axle.	Total Deflection in Inches.	No. of Blows Causing Fracture.	No. of Axle.	Total Deflection in Inches	No. of Blows Causing Fracture.
44	$4\frac{13}{16}$	8	77	$21\frac{5}{8}$	29	45	$13\frac{5}{16}$	23	74	$25\frac{15}{16}$	34
46	$5\frac{3}{4}$	8	78	66	84	47	$11\frac{7}{8}$	15	75	$12\frac{1}{16}$	16
48	$\frac{3}{4}$	2	79	$58\frac{3}{4}$	76	49	$19\frac{7}{8}$	23	76	$17\frac{1}{4}$	25
50	$6\frac{5}{8}$	8	80	$49\frac{7}{16}$	64	51	$14\frac{7}{16}$	17	81	$17\frac{3}{4}$	22
52	$8\frac{11}{16}$	11	83	$25\frac{7}{8}$	34	53	$21\frac{11}{16}$	22	82	$23\frac{3}{8}$	35
54	$38\frac{1}{16}$	44	84	$30\frac{1}{16}$	42	57	$71\frac{1}{16}$	107	89	$24\frac{1}{2}$	32
55	$4\frac{1}{2}$	6	87	$25\frac{1}{4}$	32	63	$9\frac{1}{16}$	12	85	$34\frac{3}{8}$	35
56	$6\frac{15}{16}$	10	88	$3\frac{3}{8}$	5	64	$31\frac{3}{8}$	49	86	$10\frac{5}{8}$	56
58	$7\frac{3}{16}$	9	90	$16\frac{1}{8}$	20	65	$32\frac{1}{8}$	44	111	$34\frac{5}{8}$	53
59	$5\frac{5}{16}$	7	91	$35\frac{7}{16}$	48	67	$40\frac{7}{8}$	54	98	$52\frac{3}{4}$	78
60	4	6	92	$8\frac{9}{16}$	12	69	$17\frac{15}{16}$	24	113	$30\frac{7}{16}$	45
61	$10\frac{5}{16}$	14	93	$7\frac{7}{16}$	10	70	$16\frac{7}{16}$	22	120	$23\frac{1}{16}$	32
62	$5\frac{9}{16}$	8	94	$3\frac{3}{8}$	5	71	$47\frac{1}{2}$	66	103	$34\frac{1}{2}$	49
66	$25\frac{3}{4}$	33	95	3	5	72	$43\frac{13}{16}$	62	121	$25\frac{15}{16}$	40
68	$26\frac{1}{4}$	32	96	$31\frac{1}{4}$	43	73	$37\frac{1}{2}$	57	108	$41\frac{1}{8}$	54
Averages of cold tests,				18.20	23.8	Averages of warm tests,				27.91	37.1

The tup weighed 1 ton, and the height of fall was 2 feet 6 inches.

It will be seen that on the average the warm axles were able to withstand about 50 per cent. more punishment than the cold ones; and that while of the warm axles no single one was broken under twelve blows of the tup, one of the cold ones was broken at the second blow, and about half of them broke with less than 12 blows. The best warm test is also much better than the best of the cold ones. The most remarkable feature of the test is, perhaps, however, the want of uniformity, considering that the quality was supposed to be the same throughout. Had steel axles, in an inspection test, shown such variation, there would have been good reason to reject the lot; but engineers in general are prepared to put up with variations in the quality of iron which would cause them to scrap the whole invoice, if of steel. This is, of course, justifiable enough, as there is no excuse for non-uniformity in the case of steel, the process of manufacture being so thoroughly under control. The difference in the two materials was very marked when the change from iron to steel became general in the boiler and ship yards. The percentage of plates rejected for defect fell at once.

In order to investigate more particularly the effects of sudden chilling, Mr. Andrews made a number of experiments in which iron forgings were slowed heated to different temperatures, and then rapidly chilled by being plunged in water. It was found that even when the range of temperature through which the sudden chilling took place was but 100° Fahr., there was a considerable difference in the bars cooled slowly and those rapidly chilled as described. This is a result which would, we imagine, have scarcely been anticipated, as most people would have expected the temperature range to be too small to show any material difference. As a matter of fact, however, the annealed forgings stood on an average of 23 experiments 31.7 blows each, with an average accumulation of the permanent deflections amounting to 18.83 in. The chilled forgings, on the other hand, stood on an average of 23 experiments 20.7 blows, with an average accumulation of deflections equal to 12.07 in. As before, individual results varied greatly. One of the chilled axles, indeed, stood 98 blows, while the best of the annealed ones stood but 71. Hence it is evident that a considerable number of experiments are necessary to get reliable indications. When the temperature from which the metal was chilled was equivalent to a red or white heat, the detrimental effects became very marked. In one case the forging failed at the first blow, while the strongest only stood 14 blows, and the average of 31 experiments was 2.42 blows only. The forgings used in these experiments were round bars 4½ in. in diameter, and 3 ft. 6 in. long between bearings. As before, the tup weighed 1 ton and fell 2 ft. 6 in.

It will be seen that none of Mr. Andrews' experiments have been made on steel, and until this metal has been examined in a similar way, it will remain a moot point as to how far the conclusion arrived at for iron will hold for steel. Every one is familiar with the important changes in the physical characteristics of a metal which may be caused by a small percentage of a foreign body. Thus ½ per cent. of lead added to gold renders the whole mass brittle, and iron is, if anything, still more sensitive to the action of small quantities of foreign bodies. Hence it must remain to a certain extent doubtful as to whether steel axles would act in a similar way to the iron ones. Certainly one would expect the results, whether favorable to the use of steel or the reverse to be very much more uniform, and not to show such extraordinary variations in the resistance of different specimens, as is exhibited in the above table. Considering the importance of the matter, and also the fact that steel is so rapidly replacing iron for axles, as well as for nearly everything else, it is to be hoped that some of our large steelmakers may see fit to continue Mr. Andrews' work, and extend his results to the more popular metal.

Mr. Webster's experiments, described in the minutes of the Proceedings of the Institution of Civil Engineers, Vol. LX, hardly cover the ground sufficiently, as the number of specimens of each particular metal tested was somewhat limited. The conclusion arrived at was that, in so far as ordinary tensile tests were concerned, both iron and steel were more ductile at low temperature, while their breaking strength was not reduced. With cast-iron, however, tested transversely, a diminution both in strength and flexibility was observed. With the impact tests, however, all the metals tried proved to be both weakened and less ductile at low temperatures. Colonel Greck, who spoke in the discussion following Mr. Webster's paper, stated that the Russian Government requires all acceptance tests of rails to be made at a temperature of about 2° below zero, Fahr. This gentleman also gave a table showing the results of some tests made at the Osnabruck Steel Works on 35-lb. rails, and it is interesting to note how much more uniform were the results obtained than in the experiments of Mr. Andrews. The maximum difference in the deflection of the specimens tested under similar conditions was, in the Osnabruck experiments, only some 8 per cent., instead of 35 per cent. or more, as in Mr. Andrews' experiments on wrought-iron. It is true that the results given by Col. Greck are only 12 in number, and perhaps greater differences would have been shown on a more extended investigation, but certainly we should be surprised if anything like the same amount of variation were found with steel as Mr. Andrews has observed in the case of iron. Whether iron or steel suffers the most from cold must be left for some future investigator to determine, and till then there is bound to be considerable difference of opinion between the makers of the two metals. Since, however, steel has suddenly displaced iron for railway axles, as for everything else, there is little doubt that our locomotive superintendents have concluded that it is now the more reliable of the two. The substitution in America has been hastened by the fact that iron-makers there have, it is stated, found it necessary to reduce the quality in order to compete with cheap steel, and complaints have been rife among the master mechanics of the great American railroads as to the difficulty of securing iron of the same quality as that furnished 16 or 20 years ago.

Acetylene.

The gas known as acetylene was first systematically examined by the French chemist Berthelot, in 1849, but until within a year or two it has been regarded more as a chemical curiosity than as a substance useful in the arts. This was because it could not be produced cheaply enough in useful quantities. In 1888 Mr. T. L. Willson began a series of experiments on the reduction of metallic oxides by carbon, in the fierce heat of the electric furnace. In the course of these experiments (which extended over a number of years) it was found that carbon and lime would unite at a high temperature, producing a substance which is known as carbide of calcium.

In a paper read before the Franklin Institute on March 20th of the present year, Mr. Willson gives some account of this body, and also of the now famous gas, acetylene, which is obtained from it. Carbide of calcium, he says, is a dark brown, dense substance, having a crystalline metallic fracture of blue or brown appearance, and a specific gravity of 2.262. In damp air it evolves a peculiar odor, but in dry air it is odorless. It is not inflammable, and can be exposed to the temperature of an ordinary blast furnace without melting. When exposed to the flame of a Bunsen blast lamp it can be heated to a white heat without suffering decomposition except on the surface, where it is reduced to lime. Its most striking property is, however, that notwithstanding its apparent stability and inertness, it decomposes water, at all temperatures, with great facility. The carbide consists of carbon and lime, and water consists of oxygen and hydrogen. When the two substances are brought together, the oxygen of the water combines with the lime of the carbide to form common slacked lime. This process liberates carbon from the carbide, and hydrogen from the water; and the interesting and commercially important fact about the reaction is, that the hydrogen and carbon thus set free immediately combine to form the hydrocarbon gas, acetylene. It is said that Mr. Willson discovered this reaction accidentally, through throwing a piece of hot carbide into a bucket of water, to cool it. We cannot say how this may have been. It really makes little difference whether the discovery was the result of accident, or of carefully planned experiments; for it is of great value in either case.

One pound of calcium carbide, when placed in water, produces nearly six cubic feet of acetylene (measured at the ordinary temperature and at atmospheric pressure). Mr. Willson states that the gas is colorless, and that it has "a penetrating, pungent odor somewhat resembling garlic, which is of great importance in its application to household illumination, as it renders the slightest escape of gas in a room easily detectable. It has a specific gravity (compared with air) of 0.91, and burns with a luminous, sooty flame." It can be liquefied without much difficulty. At a temperature of −116° Fah., it condenses under atmospheric pressure; and at 67° Fah. it liquefies at a pressure of about 40 atmospheres. The critical point of the gas (see The Locomotive for November, 1891) is about 98.7° Fah. If the liquefied gas be allowed to evaporate freely, the process of vaporization cools the remaining liquid so powerfully that it congeals into a snowy solid, whose melting-point is about 118° Fah. below zero.

According to Mr. Willson's figures, a thousand feet of acetylene will produce as much light as 12,500 feet of ordinary coal gas. This fact indicates very plainly the importance of the new process of manufacture. So far as the expense of working the process is concerned, we may say that Mr. Willson gives some highly seductive figures which tend to show that the manufacture of the gas by his method would be exceedingly profitable. We shall not discuss these figures, but we may say that they indicate that the process might be carried out commercially with a fair profit.

Considering the convenience of the gas, we shall expect it to come speedily into use. Of course it can be distributed in pipes, as coal gas is; but it possesses peculiar advantages for isolated places, such as country residences, since the calcium carbide can be transported in casks or otherwise, and all that is necessary to produce the gas is to wet the carbide. We see no reason why lamps could not be constructed, whose reservoirs should contain water, into which fragments of the carbide could be dropped when light was desired. Such lamps would give a brilliant light, and would be free from most of the objectionable features of those oily nuisances that consume kerosene. Such a lamp was in fact suggested by Mr. Willson himself.

Some Facts about Glass.

The most scientific glass workers of to-day are no more proficient in their art than were the craftsmen of ancient Thebes 4,000 years ago. These remarkable artisans, many of whom were priests high in authority, were well acquainted with glass staining, and displayed the highest artistic skill in their tints and designs. The colors were perfectly incorporated with the structure of the vitrified substance and were equally clear on both sides. The priests of Ptah, at Memphis, had a factory for the manufacture of ordinary glass, and also devoted their attention to imitating precious stones, succeeding so well that specimens now found require an expert to distinguish them from the real gems. They were also acquainted with the use of the diamond for cutting glass. A specimen of beautifully stained glass, now in the British Museum, has the cognizance of Thothmes III engraved upon it.

Spun glass was first brought into practical use about fifty years ago by Jules de

Brunfaut, a French chemist, although the art of spinning glass was practiced long before that time. He made a thorough study of the subject in Vienna. He first succeeded in softening the hard, shiny effect of the glass fabric, giving it a silky effect that was much more pleasing. Next he endeavored to reduce its brittleness by making a spun glass, whose threads were much finer than those of silk, and whose texture was much like that of wool. This glass could readily be woven and all kinds of articles were made of it. Among other things it was found especially suitable for surgical use, owing to its antiseptic properties and its cleanliness. The fact that glass is unattacked by most acids made the fabric useful for laboratory filters, and nearly all well-equipped establishments of the kind now use them. The cloth is, besides, non-combustible and a poor conductor of heat. As the individual fibers are perfectly non-absorbent, grease spots and stains can be readily removed. For this same reason the cloth cannot be dyed, but it can be spun of colored glass and the color is absolutely fast and unchanging.

Up to the beginning of the sixteenth century the glass used in stained glass work was what is known as "pot metal," that is, it was colored in mass through its entire substance. Painting was only used to bring out the shading and fine line work, and the paint was always brown, and was afterward "fired" into the glass. During the sixteenth century a rich yellow stain, obtained by the use of silver salts, came into use. It was also used upon blue glass to produce green effects. Shortly afterward the irregular depths of tint in the glass were first utilized to give modeling. The ruby glass used at this time was made by placing a thin layer of ruby "pot metal" upon the surface of a sheet of white glass and welding the two together by heat, as the ruby alone became opaque as soon as any thickness was reached. It soon occurred to some one to cut or grind away the ruby surface to produce white figures on the red ground. By staining the exposed portions, they were also able to get rich yellow and red contrasts. This led to extending the practice to other colored "pot metals," until a great variety of beautiful effects were produced.

When glass contains little or no lime it shows a marked tendency to become opaque upon cooling, probably owing to minute crystalization throughout its structure. The so-called alabaster glass is made by reheating glass of this kind and allowing it to cool slowly. Opalescent glass is that which possesses the same tendency in less degree. A good "mix," as it is called by glass workers, for alabaster glass is 100 parts of quartz sand, 45 parts of potash, 3 parts of calcined borax, and 5 parts of silicate of magnesia. —*Scientific American.*

In our esteemed contemporary, *Electrical Engineering*, we find the following parable, attributed to one Zambri, a Parsee :

"It is a waste of valor for us to do battle," said a lame ostrich to a negro who had suddenly come upon her in the desert; "let us cast lots to see who shall be considered the victor, and then go about our business." To this proposition the negro readily assented. They cast lots — the negro cast lots of stones and the ostrich cast lots of feathers. Then the negro went about his business, which consisted in skinning the ostrich.

All of which is supposed to illustrate the homely and familiar fact that a business agreement, although apparently equitable, may admit of a hidden construction which shall prove disastrous to one of the contracting parties.

Incorporated 1866.

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The Locomotive.

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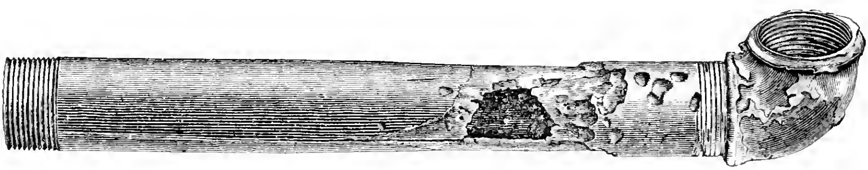
A Corroded Feed Pipe.

We present, herewith, a cut illustrating a remarkable case of corrosion that recently came to our notice. The pipe was of brass, an inch and a quarter in diameter internally, and about an eighth of an inch thick where the thickness was not reduced by corrosion. The feed-pipe entered the boiler from the top, through a bushing, and the brass pipe here illustrated was screwed into this bushing on the inner side of the boiler, so that it stood in a vertical position, with its lower end (to which the elbow is attached) below the water line and just above the tubes. A horizontal iron pipe, screwed into the elbow of the brass pipe, then conducted the feed-water toward the rear of the boiler, the rest of the piping being arranged as recommended by this company. The brass pipe was very much corroded, as shown in the illustration, and yet the iron pipe that was screwed into it was quite unaffected.

The boiler in question was situated in a shoe-shop in Massachusetts, in a part of the state where the water is more or less hard, soda-ash and kerosene being used to prevent the accumulation of scale. The boiler was three years old, and the brass pipe had been in use for the same length of time.



CORRODED BRASS PIPE FROM THE INTERIOR OF A BOILER.

The feed-water was drawn from the town supply, and was heated by a coil heater, by exhaust steam. It was metered, and naturally enough an effort was made to economize in the consumption of it, so far as possible. The drips from the shop were all returned to the feed-tank, together with the condensed water from the heater. As a result, a considerable quantity of greasy matter was introduced into the boiler along with the feed, and some trouble was experienced through the starting of the girth joint over the fire. The drip from the heater was then disconnected from the feed-tank, and allowed to run to waste. This prevented the introduction of grease, so that the boiler became much cleaner, and no further trouble was had with the joints. The change was made last January, and the boiler was not inspected internally at that time, so far as we are aware.

The large hole in the corroded brass pipe came just at the usual water line, and the natural inference would be that the destruction was due to the corrosive action of the floating grease, which would be gradually decomposed by the heat, with a corresponding liberation of the fatty acids it contained. There are several objections to this hypothesis, however. In the first place, the pipe was in good condition when the last internal inspection was made, a year ago, although it had then been exposed to the grease two years. Twenty-four months of exposure had not noticeably affected it, and yet the seven months that elapsed between the last inspection and the disconnection of the heater had entirely destroyed it (assuming the grease theory to be correct). Again, there is another boiler in the same room, eight years old, which also has a brass pipe in it, arranged in the same way. There is no observable difference in the conditions under which the two boilers are run, nor in the manner of feeding them; and yet the brass pipe in the second boiler, which is five years older, is far less affected, although it does show signs of the same action. The shell-plates along the water line are perfectly sound in both boilers, with no indications of pitting or corrosion.

It has also been suggested that the action was of electrical origin, and that it was due either to the dynamo in the next room, used for lighting the shop, or to the simpler fact that the feed-pipe was constructed of two metals, brass and iron, which would naturally produce a galvanic couple when submerged in the water of the boiler. In support of the first view it is alleged that the corrosion dates practically from the time the electric lights were introduced; and yet it is hard to understand how an electric action from such a cause could take place within the closed conductor formed by the boiler shell.* If the corrosion were of electrical origin, it seems more likely that the source of the electricity was *within* the boiler; but in that case we fail to understand why it was not observed before.

As may be inferred from what has been said, we are not prepared to offer any conclusive theory with regard to this particular case of corrosion. The brass pipe here illustrated has been replaced by an iron one, while the corresponding brass pipe in the neighboring boiler has not been disturbed. The conditions under which the two boilers are run have not been otherwise changed, and it will doubtless be instructive to observe the subsequent course of events.

In conclusion we may say that in our judgment brass should never be used, either for *internal* feed-pipes, or for blow-offs. It does very well for external feed-pipes, which are not exposed to heat, but in other places it cannot be recommended. Iron is much better.

A good example of the absurd kind of talk that is sometimes addressed to royal personages is given by an esteemed contemporary. A chemist was lecturing before a king, and at a certain stage in one of his experiments he paused and said, "These gases will now have the honor of combining before your majesty."

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* [Faraday made elaborate investigations of the electrical condition of the interior of a conductor which was charged on the outside with electricity. In the course of one of his experiments, he built a large hollow cube, twelve feet square, and covered it all over, on the outside, with copper wire and tin foil. He took delicate electroscopes into the cube, but could not detect any electricity at all, even when the outside was strongly charged. "I went into the cube and lived in it," he says, "and using lighted candles, electrometers, and all other tests of electrical states, I could not find the least influence upon them, or indication of anything particular given by them, though all the time the outside of the cube was powerfully charged, and large sparks and brushes were darting off from every part of its outer surface." (*Experimental Researches in Electricity*, by Michael Faraday, Vol. I., page 366.)]

Inspectors' Report.

May, 1895.

During this month our inspectors made 8,316 inspection trips, visited 15,960 boilers, inspected 6,946 both internally and externally, and subjected 755 to hydrostatic pressure. The whole number of defects reported reached 12,046, of which 1,092 were considered dangerous; 82 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	978	52
Cases of incrustation and scale,	2,140	92
Cases of internal grooving,	118	22
Cases of internal corrosion,	785	36
Cases of external corrosion,	846	56
Broken and loose braces and stays,	128	60
Settings defective,	328	31
Furnaces out of shape,	473	32
Fractured plates,	328	55
Burned plates,	267	61
Blistered plates,	264	14
Cases of defective riveting,	1,162	49
Defective heads,	129	16
Serious leakage around tube ends,	2,110	257
Serious leakage at seams,	533	36
Defective water-gauges,	437	77
Defective blow-offs,	193	64
Cases of deficiency of water,	12	5
Safety-valves overloaded,	46	12
Safety-valves defective in construction,	76	14
Pressure-gauges defective,	598	43
Boilers without pressure-gauges,	8	8
Unclassified defects,	87	0
Total,	12,046	1,092

Boiler Explosions.

May, 1895.

(118.) — As the train on the W. C. & C. R. R. was within about three miles of Conway, S. C., on May 2d, the boiler the locomotive exploded. The fireman jumped from the engine and broke his leg; but the engineer, who remained within the cab, was not injured. The locomotive was practically destroyed.

(119.) — A large boiler at the Knoxville rolling mills, Knoxville, Tenn., exploded on May 4th, doing great damage to the property. Fortunately, nobody was killed.

(120.) — A boiler exploded, on the morning of May 7th, in John Bennett's saw-mill, near Kokomo, Ind., just as the men were beginning work in the morning. The engineer, James Catt, was killed, and Frank Downing, Fred. Phillips, and John Bush were injured. Downing's injuries are fatal. The mill was blown to fragments, and the boiler was thrown 500 feet. A schoolhouse across the road was injured also.

(121.) — A heating boiler exploded, on May 7th, in the basement of St. Mary's School for Girls, at Concord, N. H. The foundations of the building were injured in several places, the floors were bulged upward, the windows were shattered, and the furniture was thrown all about. Miss Gainsforth, principal of the school, who was in her room when the explosion took place, was thrown to the floor, and fainted with fright. Twenty-five young women were asleep in the building at the time of the explosion, and it is considered remarkable that none of them were injured.

(122.) — The boiler of a traction engine exploded in the yard of Walter S. Trew, of Quaker Neck, near Chestertown, Md., on May 8th. The men were at dinner when the explosion occurred. The engine was completely wrecked, and a meat-house, twenty feet away, was moved about six feet. Other property was also damaged.

(123.) — The boiler of a locomotive attached to a freight train on the Pan-Handle-Chicago line, exploded May 13th, near Winnimac, Ind. John Long, a brakeman, who was riding in the cab, was dangerously scalded. P. J. Kinner, the fireman, was also severely injured, but A. W. Knight, the engineer, escaped without material harm.

(124.) — The river steamer *Unique* left Detroit, Mich., for Port Huron, on May 13th. When about nine miles from Belle Isle, on Lake St. Clair, one of the tubes in her safety boiler failed, and clouds of steam and soot were driven up through the hatches with terrific force. Engineer George Robinson, who was sitting on the port rail at the time, was blown overboard. Life preservers were at once thrown to him, but as the boat was going at full speed they did not come within his reach. A boat was lowered as soon as possible, and a thorough search for him was made, but he could not be found. When the steam had cleared away sufficiently, the officers of the boat went down to the boiler-room. On the floor lay Anthony Case, a coal passer, who was killed outright, and near him was John Plant, who was fearfully burned.

(125.) — A boiler in the thirty-three inch mill at Homestead, Pa., exploded on May 14th, fatally scalding Theodore McHenry and seriously injuring James Anderson. The men were both scalded and bruised by flying debris. The buildings near by were damaged to a considerable extent. Parts of the roof and walls of the boiler-house were blown in all directions, some large pieces of the roof being carried 100 feet from their original positions.

(126.) — The boiler in the electric light plant at Sleepy Eye, Minn., exploded shortly after midnight, on the morning of May 14th. The plant was in the basement of the high school building, a fine structure which cost over $27,500. All that now remains is a shapeless mass of ruins. The engineer of the electric plant had left the building at 11.45 P. M., with 60 pounds of steam in the boilers, and the explosion occurred 35 minutes later. The concussion was felt more or less for a radius of three miles. The building took fire immediately, and nothing was saved from it. The electric light apparatus, which cost about $9,000, was entirely ruined.

(127.) — On May 14th a boiler exploded near Coudersport, Pa., in the saw-mill of Peck, Haskell & Cobb Bros. Claude English, James Mowers, Eugene Merrick, Lyman Perry, and Charles Grover were instantly killed, and Caleb Converse, John DeGrote, and Adelbert Gudley died within a few days. Several persons were also injured and the mill was wrecked. Thirteen men were employed in the mill, and at the time of the explosion the mill was shut down while a belt was being repaired. "Nobody paid any attention to the boiler, which was making steam at a prodigious rate. It was nobody's business in particular to look after the boiler, everybody took a hand occasionally in firing, and except when the engine was started or stopped, little or no attention was paid to the steam. Suddenly there came a boom as if a cannon had been fired, followed by a cloud of steam, dust, and smoke, which rose high in the air. Four of the victims were torn limb from limb, and were recognizable only by their clothing. The mill was almost entirely demolished, and parts of the boiler were blown hundreds of feet."

(128.) — On May 14th a boiler exploded on the steamer *Rescue* as she was going up the Monongahela River, near Pittsburgh, Pa. The accident happened just as the *Rescue* was passing through lock No. 1. The explosion consisted in the collapse of a flue. The engineer, George McGinniss, and the fireman, Claude Schoonoder, were fearfully scalded, and it is believed that McGinniss will die.

(129.) — A small hot-water boiler in John Maginty's barber shop on Washington Street, Boston, Mass., exploded on May 15th. The barber shop and a kitchen in the rear of it were wrecked, but, as the explosion occurred at about 2 o'clock in the night, nobody was hurt.

(130.) — A blow-off pipe blew out, on May 15th, in Wherry Bros.' mill at Overton, Rusk Co., Texas. Mr. M. L. Wherry, one of the owners of the place, was severely scalded.

(131.) — A boiler exploded on May 16th, at the Green Ridge colliery, near Mt. Carmel, Pa. Engineer James Brennan, Fireman Joseph Boluta, and a laborer named George Rolala were badly burned about the face, hands, and back.

(132.) — Charles Pickett was killed, on May 16th, by a boiler explosion in Hiram Reynolds' quarry at Medina, N. Y. He was in the engine-house repairing a valve, and was struck on the head by a fragment of the boiler.

(133.) — A well was being drilled at Charles Peterson's residence, Attica, Ind., on May 17th, and during the progress of the work the boiler that was operating the drill exploded. William Smith was instantly killed, and Frank Peterson received injuries from which he died within twenty minutes. Leonard Stambaugh was also fearfully scalded, and cannot live. J. W. Hamar, Alexander Hamar, and Henry Shumar received lesser injuries.

(134.) — A boiler exploded, on May 19th, at the Mederia Coal Company's plant at Vinton, near McArthur, Ohio. The engineer had left the building about two minutes before the explosion. The boiler-house was completely wrecked.

(135.) — One of the boilers in the electric light plant at Valdosta, Ga., burst on May 22d. Nobody was hurt.

(136.) — A serious accident occurred on May 27th, about a mile from Labadieville, in the parish of Assumption, La. Messrs. Elfert and Delmonte, who were working a tract of land on the Tete plantation in rice, had erected a pump for irrigating the fields. On the day referred to the boilers exploded and were thrown in every direction. Charles Elfert had his jaw broken, and received other injuries about the head and face. Emile Adam had an arm broken. Lestain Hebert was slightly scalded, and a Mr. Maillet was thrown into Bayou Lafourche, from which he came forth without injury.

(137.) — On May 27th one of the four big boilers in Strickland, Wesley & Co.'s mill at Point Washington, Fla., exploded and was carried about 200 feet. The account we have received says that "not one of the fifty men in the mill was hurt, and even the ancient mule that furnishes the motive power for the sawdust cart, though almost hidden for a time by flying ashes, mortar, and brick-bats, only switched her tail in probable wonderment at the extraordinary size of the mosquitoes, and pursued the even tenor of her way."

(138.) — A boiler exploded, on May 28th, in a mill owned by Messrs. Killian & Teague of Lenoir, near Taylorsville, N. C. Edward Deal, Pender Oxford, and Gordon Oxford were instantly killed, and Reuben Jones was hurt so badly that he died five hours later. Two other men were seriously bruised, but will recover.

(139.) — Engineer Charles Mitchell was horribly scalded and otherwise injured, on May 29th, by the explosion of a boiler at Upson's coal works, Shawnee, Ohio.

(140.) — The large boiler in A. J. Collinsworth's mill, two miles west of Humboldt, Tenn., exploded on May 29th, making a complete wreck of the whole place. Several men were at work in the mill at the time, but no one was hurt.

(141.) — A boiler exploded on May 29th in the office of the Garrettsville *Journal*, Garrettsville, Ohio. Editor Charles B. Webb was injured seriously, and perhaps fatally. Miss Nellie Bosley was also slightly hurt. The building was badly shattered, and the machinery about the place was considerably damaged.

(142.) — A mud-drum on one of the boilers in Blythe & Co.'s mill at Monongahela, Pa., gave way on May 30th. John Webb was severely scalded about the head and body. Anson Hillman was also seriously scalded, but both men will recover.

(143.) — A boiler exploded on May 30th in a brickyard near Abita Springs, La. Two men were killed, and several others were injured. We did not learn further particulars.

THE boiler of the Ecuadorean gun-boat *Sucre* exploded at Guayaquil, Ecuador, on the night of May 30, killing the commander and fourteen men, and injuring seventeen more, thirteen of them fatally. At the time of the explosion she was carrying troops to Machala to attack the rebels.

A BOILER exploded, on June 22, at Kiel, Germany, on a steam launch belonging to the United States cruiser *San Francisco*. Three men were injured.

SEVEN persons were also killed, and several others wounded, on June 28, by the explosion of a boiler on a steam launch belonging to the German war-ship *Kurfuerst Friedrich Wilhelm*, at Holtenau.

A BOILER explosion at the Red Car iron works, near Guisborough, Yorkshire, England, on June 15, resulted in the instant death of six persons, and serious injury to eighteen others. Three of the injured persons died later in the day, making a total of nine killed. Thirteen out of the fifteen boilers exploded. The brickwork of the settings was hurled in every direction, and an immense volume of boiling water was discharged over the workmen. The damage done will amount to about $250,000. The latest reports from the scene of the disaster indicate that, in addition to the nine persons killed, *twenty* were seriously injured. Four hundred men were also thrown out of work.

The Locomotive.

HARTFORD, JULY 15, 1895.

J. M. Allen, *Editor.* A. D. Risteen, *Associate Editor.*

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Papers that borrow cuts from us will do us a favor if they will mark them plainly in returning, so that we may give proper credit on our books.

This world is a difficult world indeed,
And the people are hard to suit;
And the man who plays on the violin
Is a bore to the man with the flute.

And I myself have often thought
How very much better 'twould be,
If every one of the folks I know
Would only agree with me.

But since they will not, the very best way
To make this world look bright,
Is never to mind what people say,
But to do what you think is right. — *South Wales Echo.*

The camel is the animal that is oftenest mentioned as an example of one in which thirst is the longest endured. But Mr. S. M. Gorman of Cambridge, Mass., writes to *Nature* that more striking cases of prolonged endurance are found in a number of small rodents that inhabit the arid plains in the vicinity of the Rocky Mountains. These animals live for weeks and months without meeting with a single drop of water. The sand is torrid, the entire vegetation is burned up, and yet they resist. This is not the result solely of observations in nature, for direct experiments, pointing to the same conclusion, have also been made. Some common mice were put apart on the first of last October in cages in which they received nothing but perfectly dry food, such as Indian corn and grass seeds. On the seventeenth of January they were in perfect health and seemed as if they would continue thus for a long time, although they had not received a single drop of water or of any other liquid in the interim.—*Scientific American.*

Some one has called the mule the best soldier we had in the war. It is certain that the service he rendered is beyond calculation. Some teams were conspicuous, as witness the history of the following : It was fitted out in Berryville, Md., in April, 1861. A year later it was transferred to Washington, and in May was sent to Fort Monroe to join McClellan's army. It followed the latter up the Peninsula, was at the siege of Yorktown, the battle of Williamsburg, and in the swamps of the Chickahominy. Participating in the Seven Days' battles, it finally brought up at Harrison's Landing, whence it went back to Washington. It then hauled ammunition for the second battle of Bull Run, followed the army to Antietam, and from there to Fredericksburg. When General Hooker took command of the army it went with him through the Chancellorsville fights. In 1864 we find it at City Point with Grant. It served with him until the war closed, and a year later was in Washington as ready for duty as ever. The team was frequently without a bite of hay or grain for four or five days at a stretch, and nothing to eat but what it could pick up by the wayside. There were times also when it went without water for twenty-four hours. Those mules should have been tenderly cared for during the rest of their lives, and never worked except for exercise.— *New York Sun.*

The Growth of Plants.

Many persons who have but little taste for science in general derive much pleasure from the study of botany. This is partly because the beauty of the flowers commands attention even from those who are ordinarily thoughtless of Nature, and partly, no doubt, because of the stimulus given to such study by Asa Gray. The works of this eminent man, although wonderfully profound and complete in their way, have had the unfortunate result of directing popular study towards the least interesting of all the branches of botany; for we find ninety-nine out of every hundred of its devotees so absorbed in the identification and classification of plants, that they give scarcely a thought to anything but *morphology*. When the average student has examined a flower and observed the arrangement and form of its leaves, the structure of its calyx and corolla, the number and mode of insertion of its stigmas, the geometry of its buds, and a few other things of this sort, he pronounces its name with a certain degree of satisfaction, and (if his enthusiasm goes so far) he squeezes the life out of it in a press, gums its dried remains upon a card, and looks about for his next victim.

Such work is doubtless useful, but we cannot say that we find it particularly interesting. Generations of students might pass by without materially advancing our knowledge of the plant world, if their study were all of this kind. The true secrets of botany must be unraveled from the *living* plant. How does it grow? Why is it green? Why does it blossom? How are its seeds scattered abroad? and how and why do they sprout? These are some of the multitude of questions that press upon us for solution; and none of them can be answered from the herbarium. They lead us rather into the fields and the woods, and into the laboratory.

We cannot answer any of them, yet, with anything like completeness. We know, however, that the great law of the conservation of energy is as true for the vegetable kingdom as it is for the mineral kingdom; and this fact must ever be our guiding light in the study of botany in its broader sense. We know that plants are combustible, and that by burning them under boilers we can generate steam, and run engines. We know, too, that we cannot do this with the soil and carbonic acid gas of which they are built up. It follows, therefore, that the plant has contrived somehow to *gain energy*. It cannot manufacture energy, any more than a wind-mill can; and hence it must have absorbed it from something else. Several sources of energy are available, but all the higher plants obtain their supply directly from the sun, by means of the green coloring matter (chlorophyll) in their leaves; and thus we see that the prevailing tint of our vegetation is no mere accident, but that it is a consequence of the law of the conservation of energy. If the leaves of a green plant are examined under a microscope, it will be seen that the coloring matter is not diffused throughout the tissue, but that it occurs only in little bright grains, which are called chlorophyll corpuscles. When the sun is shining these corpuscles absorb the energy of the sunlight in some way which is not yet understood, and by means of the energy so obtained they are enabled to perform marvelous chemical feats, only the simplest of which can yet be imitated in our laboratories.

Carbonic acid gas, which is produced when coal or wood are burned, and which is also thrown off from the lungs of animals, is always present in the air to some extent. This gas is greedily seized by the chlorophyll corpuscles with which it may come in contact as the breezes blow through the foliage of the plant, and is split up into its constituent parts by means of the energy which the chlorophyll is meanwhile absorbing from the sun. The carbon of the gas is retained, and the oxygen is allowed to escape again into the air. Carbon and oxygen are bound together most powerfully in the molecules of carbonic acid gas, and in order to separate them the chemist has to use the utmost resources of his laboratory; yet the chlorophyll corpuscles of the plant, by the aid of the supply of energy obtained from the sun, are enabled to effect this most difficult separation with the greatest ease.

It will be seen that in sunlight green plants are constantly absorbing carbonic acid and giving out oxygen, while in animals the action is precisely the reverse. In the night-time, however, it is found that plants absorb oxygen and give out carbonic acid, and it is thought probable that both of these actions go on together in the daytime, the liberation of carbonic acid being masked, however, during sunshine, by the more copious liberation of oxygen. It is practically certain that no life can exist under any circumstances without being accompanied by the continual oxidation of carbon ; the energy made available by this oxidation being that which produces the phenomena of life itself.

The leaves are the laboratories in which the substance of the plant is built up. They have many functions to perform, in addition to the decomposition of carbonic acid, which we have just considered. For example, they serve as an evaporating surface. It is difficult to realize how great this surface is, in the case of trees especially. In a good-sized oak tree the united area of the leaves probably amounts to thousands of square feet, and as the leaves are hung up in the breeze, it is easy to see that they are very efficient in promoting evaporation. As the moisture in them dries out, it is highly important that more water should be supplied to them from the tree itself ; for otherwise they would quickly wither, and before long would become dry and dead. The water which is thus necessary in order to keep them in good condition, is absorbed from the ground by the roots of the plant, and carried up to the leaves by conduction along the wood-fibres.

It was formerly thought that the sap of the plant was carried upwards from the roots by means of capillary attraction. This view is no longer tenable, because it is easy to show that in the case of tall trees like the red-woods of California, the capillary passages would have to be far smaller, in order to raise water to such a height, than any which exist in the structure of the red-wood tree. We now know that the sap does not rise through little tubes in the wood, nor through the spaces between the woody fibres ; but that it travels directly through the substance of the wood itself. The peculiar sensitiveness of wood to moisture is well known to the carpenter and the cabinet-maker, and when the wood is in its fresh, or so-called living state, its affinity for moisture is immeasurably greater. If a piece of fresh wood be dried at one end while the other end is kept immersed in water, the water passes through it very rapidly, almost as though it were a sponge. We have to regard the leaves of a plant as united to the roots by the woody fibres in such a way that when the leaves are dried slightly, more water is immediately conducted to them directly through the woody matter, and against the action of gravity. The elevation of water in this way might seem at first sight to be contrary to the principle of the conservation of energy. That this is not the case is shown by the fact that more heat is required to evaporate water which is absorbed by woody tissue than is required to evaporate the same amount of water in the free state. The potential energy of the raised water has been increased, so far as gravity is concerned, but its *chemical* potential energy has been decreased, at the same time, by its combination with the wood. There has, therefore, been merely a *transformation* of energy, from the chemical form into the gravitative form.

Before returning to the leaves, let us say a word about the absorption of water by the roots. If the roots of a plant be carefully observed, it will be seen that in addition to the larger branches there are innumerable other minute appendages which are called root-hairs, and which pass out into the soil in every imaginable direction. The chief function of these root-hairs is to absorb the moisture with which they come in contact, *together with such mineral matter as may be dissolved in it.* The moisture thus absorbed by the hairs is passed onward to the roots themselves, and it then soaks upward through the plant, as we have seen, as the evaporation goes on in the leaves. But the root-hairs do not act simply like so many fibres of blotting-paper; they have other functions which are not yet fully understood. If a seed be planted in shallow earth over a polished plate of marble, the roots, when they have grown down far enough to lie along the surface of the stone, will etch it away so as to leave quite a sensible imprint. This shows that the root secretes some sort of corrosive substance, which is probably designed to aid it in dissolving such mineral matters as may lie in its course. As the roots of the plant extend further into the soil, the root-hairs near the stem die, and new ones are continually formed, further out, where they will come in contact with fresh portions of soil.

It is important to note that the moisture which is absorbed by the roots and passed up to the leaves does not consist of *pure water*. It is, instead, a dilute solution of mineral matter. The watery part of it evaporates in the leaves, while the dissolved matter remains behind, and accumulates in the leaves until it becomes nearly enough saturated to be available for the purposes of growth. From this mineral matter, together with the carbon that has meanwhile been separated from the carbonic acid of the air, the chlorophyll corpuscles, still drawing energy for the purpose from the sunlight, build up substances of great chemical complexity. We do not know the steps by which this is done, but the first thing that we can perceive, as a result of the action of the chlorophyll — "the first obvious product," as Sachs calls it — is *starch*. The presence of starch in leaves is easily shown. For this purpose the leaf should be picked late in the afternoon of a sunny day, and it should then be boiled in water for a period of from ten minutes to half an hour, according to the thickness and texture of the leaf, thin leaves requiring less time than fleshy ones. After the boiling (the object of which is to kill the tissue, hydrolyze the starch, and break up the cell-walls somewhat) the leaf should be soaked in 95 per cent. alcohol until the chlorophyll is extracted, and the leaf rendered colorless. A dilute solution of iodine in weak alcohol will then reveal the presence of starch by the formation of the blue iodide of starch.

Starch, as is well-known, is insoluble in water; and before it can be used in the plant it must be transformed into a soluble sugar. It is not likely that the starches and sugars are identical in all plants, but in most cases the sugar which is formed is probably closely similar to the substance known in trade as glucose. The transformation of starch into sugar is easily effected by the action of ferments, which may be present in very small quantities. (The presence of such ferments in the leaves of plants has been shown by direct chemical tests.) The sugar, when formed from the starch, dissolves at once in the moisture or sap of the plant, and is then diffused everywhere through the tissues by the process known as osmosis, which is described and discussed in all the books on physics. There is a close analogy here between plants and animals. When an animal eats starchy matter the starch is transformed into sugar by means of the saliva and pancreatic fluid. The sugar thus produced is dissolved, and passes through the intestine and into the general circulation, by the same process of osmosis that occurs in plants. Once in the blood it is carried to the liver, where it is transformed into a starch-like substance called glycogen, and the supply thus stored up is drawn upon as the system may require it. In precisely the same way the sugar in plants is transformed back into starch and deposited in the seeds, and in other special receptacles, which may be within the stem of the plant, or attached to the roots. Corn, wheat, and grain of all kinds furnish illustrations of starch deposited in the seeds, and the potato, turnip, and beet are familiar examples of the storage of starch in the roots.

We do not know precisely how the plant makes use of the sugar that its sap holds in solution,— that is, we do not know the precise process by which this sugar is transformed into plant-tissue; but the transformation occurs at certain points which are called growing points, and the action appears to be not unlike that which takes place when a crystal of some substance is forming from a solution. The analogy is not at all perfect, because in the crystal there is supposed to be no change in the chemical nature of the substance which is deposited, while in the plant the sugar is built up into the most complicated substances that we know of, including that elusive body, "protoplasm," which is so firmly united, in the minds of the laity, with the name of the late Professor Huxley.

We cannot go further into the chemistry of plant-growth, without making this article of unreasonable length. We have touched briefly on one of the interesting branches of the great science of botany, to illustrate the point that we made at the outset — namely, that the subject, as ordinarily studied, is dry and dusty, and that there are hosts of profound problems about plants, which can only be answered by observing the plant as it grows, or by examining it in the laboratory. In conclusion, we may say that compound microscopes and other expensive apparatus, although desirable, are nevertheless not *necessary* to one who would study the "higher botany." Many of the deeper secrets of the flowers — those relating to the forms of the blossoms, for example, and to the distribution of seeds — will have to be solved by patient watching in the fields; and there is plenty of room here for original work by any earnest student — work, too, which cannot be done by post-mortem examinations of the cadavers to be found in the conventional herbarium.

A SINGULAR fact is recorded in the *Moniteur Industriel*, namely, that on the shores of Brittany, between St. Malo and St. Lunaire, in the vicinity of the St. Enogat station, at a place called Port Blanc, the tides have lately displaced a considerable amount of sand, say to a depth of some nine to thirteen feet. Accompanying this remarkable phenomenon is the fact that forests known to have been buried for periods covering some eighteen or twenty centuries have now been brought to light, and a vast forest has, it appears, been discovered in process of transformation into coal; ferns and the trunks and barks of trees are to be seen in an advanced state of decomposition, being already beyond the peat formation, showing, in fact, the films and flakes which are found in coal, and, while some of the trunks are sixteen feet in length, and still very distinct, they are becoming rapidly transformed. — *New York Sun.*

WHILE the Italian torpedo boat *Aquila* was undergoing trials, near Spezzia, Italy, on July 3, her boiler exploded. Five men were killed and thirteen injured. The other six men aboard of her escaped injury.

Technical Research.

Every engineer is engaged in technical research, sometimes at his own expense, but oftener at the expense of his clients. The more important and commanding his position the greater is the proportion of his work that lies outside the boundary of assured knowledge. The ordinary everyday problems in construction are confided to the journeymen of the craft, who, out of the records of their experience, can generally find a fitting solution, or can even go one step in advance of what has been done before. But when not one, but many, stages have to be traveled into the unknown, there is needed something more than a general knowledge of the subject, and fair ability to reason by induction. Then it is that the real art of the engineer — an instinctive power in adapting the forces of nature to new ends — comes into play. If the matter be one dealing with machinery, it is generally possible to try small-scale experiments in regard to a few, if not all, of the points of issue, and thus to eliminate some of the doubtful points in the subject. But there are many matters that are submitted to engineers the difficulty of which arises mainly from their magnitude, and which have to be treated entirely from a new standpoint. Only full-sized experiments would be of use, and therefore the whole affair becomes a gigantic piece of research work, for which the promoters find the funds, and on which the engineer stands to gain or lose reputation. Generally he gains it. It is perfectly wonderful with what a large measure of success new and difficult work is accomplished, and how exceedingly few are the serious failures. The mishaps that do occur are mostly connected with details that could be studied on a small scale if the engineer had time and money to investigate them. But while promoters will risk tens of thousands of pounds on a project, it is practically impossible to get them to provide a few thousands to be spent solely in acquiring knowledge on points that are apparently of subsidiary importance. They consider that technical research is no part of their business, and they decline to spend money in increasing the general stock of knowledge, although the first fruits would be reaped by themselves.

Great advances in engineering practice wait more often upon details than upon principles. The conception of the compound marine engine is old enough, but it was not until a satisfactory surface condenser was produced that it became commercially possible. As long as the boiler was fed direct from the sea, thirty pounds per square inch was the limit of practicable pressure, and compounding offered no advantage under this condition. The surface condenser, as now made, is a simple enough affair, yet it took many years to arrive at, because neither marine engineers nor shipowners were willing to spend the necessary money over a series of comparative experiments. Occasionally a sanguine individual ventured to try one, and when he found it unsatisfactory he generally preferred to face the known loss of abandoning it rather than enter into a series of experiments to perfect it. The triple-expansion marine engine furnishes another example. Up to about 1881 there was scarcely an engine of this kind constructed, and after that date there were very few built of any other kind. The deterrent cause in this case was a misgiving as to the possibility of finding a satisfactory material for boilers carrying 160 lb. to 180 lb. pressure, and complying with the requirements of marine service. Shipowners held back from making experiments for the benefit of the trade. For years they stuck to the compound engine, well knowing that a 20 per cent. economy was available, if only certain preliminary difficulties, by no means insuperable, could be overcome. But, naturally, no one was willing to pay for experience that would be immediately public property.

It is only under the protection of a patent that a manufacturer can afford to institute researches and pay the cost of experiments. It is a matter of common knowledge that some subjects which it would be advantageous to the public to have pursued, are allowed to sleep because it is known to be impossible to secure a broad patent for any improvements that may be devised in connection with them. In years past attempts have been made to discover the best methods of bringing certain processes or materials into practical use, and although success has not been attained, yet the way has been so far pointed out that it is hopeless to try and discover an entirely new means of attaining the end. The solution is a matter of degree rather than of principle, and as such does not lend itself to be secured under the provisions of the patent law. Superheating furnishes a case in point. It is generally believed that we are on the verge of a revival of superheating, and that it will be successful. But in years past there was a very determined attempt to use superheated steam. Apparatus was fitted in a large number of instances, particularly on board ship, and after extended trial was abandoned for several reasons. First and foremost, there was the difficulty of finding a lubricant that would not decompose under the influence of very hot steam. The introduction of mineral oils and vaseline has removed that source of failure without any effort on the part of mechanics. Then there was the chance of the superheater becoming incrusted with salt carried over from the boiler with priming water. But salt in boilers is, or should be, a thing of the past, now that evaporators are so common, and thus a second source of failure has disappeared. The other difficulties were chiefly mechanical, and individually were not serious. But, taken in the aggregate, they are fairly formidable, and it is certain that they will take some time and a liberal expenditure of money to entirely overcome. As our columns have shown, attempts are now being made on a practical scale to introduce superheating. The attitude of the profession is one of expectancy; the majority are waiting to appropriate the result of other people's experiments, certain that nothing can be discovered that will furnish grounds for anything but a narrow patent.

It would be possible to adduce examples in many other departments of engineering to show that science languishes and progress is delayed because our predecessors advanced far enough to demonstrate the principles on which we should act, and yet fell short of attaining a commercial success. The last step, which they failed to take, often from not having the requisite material available, is capable of many solutions, and, therefore, seldom can be made the subject of a paying patent. A man may devise half a dozen means of attaining the end, and may fancy that he has closed every avenue to his competitors; but no sooner has he published his plans than alternative methods, of which he never dreamed, start forth like the ghosts at Macbeth's banquet. The man of business acumen waits and lets other people make his experiments for him, relying on his commercial ability to secure a fair share of the results, even if he be a little late in getting a start.

There is, however, one class of men who find it to their interest to make experiments without the hope of direct gain. We refer to professors in technical colleges. They are very favorably circumstanced for making researches, in that a large amount of apparatus is at their disposal, and that they have, to some extent at least, the command of funds for the purpose. Further, they generally have a considerable amount of leisure in the session, while the vacations are far in excess of what is necessary for physical and mental recuperation. They actually get more holiday than the school usher, who has not only to instruct his pupils, but who has also to undertake the formation of their characters and to join in their games. From morn till night, Sunday and week-day, the unfortunate assistant schoolmaster is boy-ridden. He eats with him, he walks with him, he plays with him, and often he sleeps with him. In spite of three intervals of rest per year, he grows narrow and petty, and his society is avoided by men of the world. But the professor is not subject to such contracting influences. He has his lectures to prepare and deliver, and then he is free. If he is to be something more than an animated text-book — a retailer of other men's ideas — he must experiment to furnish himself with original matter, or at any rate with novel illustrations. Further, if he have ambitions beyond the teaching of youths, he must provide for a larger audience than that contained in his class-room. We once heard a civil servant say, "The way to make a reputation in the office is to make a reputation outside it," and that is true of others than those that work for the crown. The engineering professor, until he has made himself a name by original work, is like a figure set up in a fair for every clown, who has learned to chip and file, to have his fling at. He is a mark for the cheap gibe of the man who has never attempted enough to find the depths of his own ignorance. If he would meet the world with a smiling face, untouched by such petty annoyances, he must be sustained by the esteem of the profession. The only way to earn this is by practical work, either in the way of construction or of research. The former avenue is often closed, and even if it be open, it is difficult of entrance to a man who has a permanent engagement which cannot be set aside at will. But at research the professor is on his native heath, and the profession is deep in his debt for much valuable information that has been evolved by a great expenditure of time and thought. Possibly all of it is not immediately applicable in daily life, but that which cannot be used to-day will be available at some future time, as the scope of our knowledges increases. If the total amount of engineering data that has been evolved in scientific colleges and schools could be separated from that obtained from other sources, and presented to us in bulk, we should be amazed to find how great and wide-spreading it is.

The powers of the technical laboratory are, however, distinctly limited. Full-sized experiments are beyond its scope. If no other consideration intervenes, there is always expense to be considered. In spite of the constantly rising fees charged for tuition, educational establishments share in a marked degree in that "eternal want of pence" that troubles the greater part of humanity. The available funds have to be spread over the largest possible area, like boarding-school butter. Investigations on a really large scale can, therefore, not be attempted. There is very little chance of getting these done elsewhere in a systematic manner if, as we have already pointed out, the results cannot be secured to the experimenter under the patent laws. One notable exception, however, is found in this country to this rule. We refer to the researches undertaken by the Institution of Mechanical Engineers. On these there have been spent hundreds — possibly thousands — of pounds, and the results have been freely given to the world. The researches made by the Institution on riveting, on friction, on steam-engine economy, and on alloys, are splendid monuments of the large-mindedness of the council. We know that certain continental societies have carried out similar inquiries, but not, we believe, with the same completeness. It is doubtful if any private person could obtain similar results, since, were his purse ever so deep, he would not be able to command the harmonious and zealous assistance of a number of men of equal ability to those serving on the research committees. He could not offer them such an honorable position as that of being the chosen representatives of a large and influential professional body. He would be obliged to content himself with the services of one man of the first rank, assisted by others of less eminence.

It is strange that such a splendid example should be almost solitary. There is ample scope for other societies to undertake work of this kind without incurring the reproach of being imitators, or of trenching on each others' territory. Next to the necessary work of holding meetings and publishing their transactions, there is no purpose, to which their funds could be applied, so directly valuable to their members, and so remunerative to the profession. It is not necessary that a scientific body should have great accumulated resources. It is prudent, of course, to have something in hand to tide over a few years of bad trade, but that is quite a different matter to accumulating a vast estate. Engineers are not usually men with a long tale of ancestors, whose memory bids their descendants repay the benefits they inherit by making an ample provision for posterity. On the contrary, they have usually made their own way in the world, and are but little indebted to their forefathers. It is contrary to their instincts to make elaborate provision for those who will come after. If the next generation cannot maintain an institution for themselves in average times, they are not likely to derive much benefit from one existing on endowments. If a father have but a moderate sum to bestow on his family, it is far better that he should spend it in setting them up in life with all the advantages of education, rather than he should leave them in comparative ignorance with a limited fortune which is less than a competence.

On all sides we hear the cry for technical education. But if it be good for the youth to have knowledge gathered up for him, and carefully tabulated and codified, surely it is also advantageous for the grown man to have the knotty points of science unravelled for him, so that he may lay out his clients' money with advantage. Economists tell us that cheapening of production increases demand, and this does not apply only to manufactured goods. Scores of pieces of engineering construction are left unattempted because it is known that the cost so often exceeds the estimate. The reason is that the engineer has not the necessary data to guide him, and has largely to guess at his figures. The capitalist naturally declines to pay for the necessary research, since it is not his business to instruct the profession he employs ; the private engineer has neither the time nor the money to undertake it; the professor finds the means at his command inadequate for the task. And so matters stand still, waiting till the investing public forget the smart of their last loss, and gather confidence for another plunge. In the meantime the average technical society reads papers, distributes the sessional volumes, and congratulates its members on their wealth. It is a pity it does not do something to enable them to increase their individual incomes, by enabling them to furnish positive categorical assurances to their clients as to the efficiency of their designs and the reliability of their estimates.

It is easy, we know, to raise a host of objections to research work being undertaken by societies. It may be suggested that some departments of the profession will be aided and others will be neglected; that the council will consider the needs of their own practices and neglect that of the rank and file; that reputation will be created at the general expense, and so on. It is so much easier and so much pleasanter to find objections than to undertake the work. But the fact remains that the Institution of Mechanical Engineers has now pursued its experiments for years, on a very extensive and liberal scale, and that no complaints have been made. A large amount of most valuable information has been gained, and there is the prospect that more will be added. But, we ask, why should it be left to one society to furnish funds and time and labor for the entire profession? The possibility and success of these researches have been demonstated, and it is time that other bodies undertook them as well.—*Engineering.*

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The Locomotive.

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NEW SERIES — VOL. XVI. HARTFORD, CONN., AUGUST, 1895. No. 8.

The Lever Safety-Valve.*

GENERAL REMARKS.— We have received so many requests for a rule for calculating the position of the weight on a safety-valve, and the blowing-off pressure when the position of the weight is given, that we have thought it wise to publish such a rule in THE LOCOMOTIVE. It would be easy to give a simple formula for the purpose, but we have considered that the wants of engineers would be best met by explaining the *theory* of the lever-valve, and showing, as clearly as possible, the reason for each step in the calculation.

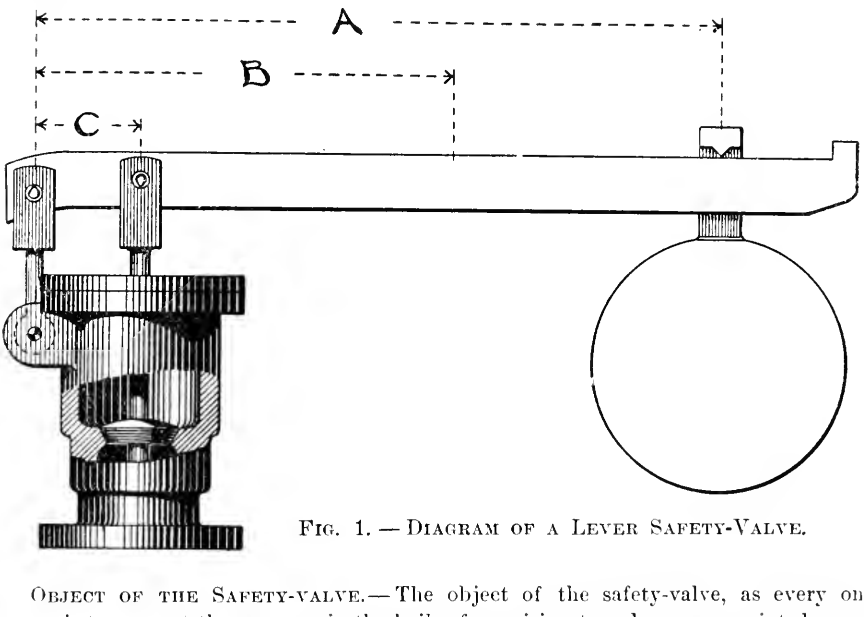

FIG. 1. — DIAGRAM OF A LEVER SAFETY-VALVE.

OBJECT OF THE SAFETY-VALVE.— The object of the safety-valve, as every one knows, is to prevent the pressure in the boiler from rising to a dangerous point, by providing an outlet through which steam can escape when the pressure reaches a certain limit, which is determined by the strength of the boiler, and by the conditions under which it is to work. The simplest device for attaining this end is the "dead-weight" valve, the principle of which is illustrated in Fig. 2. It consists simply of a plate of iron, laid upon a nozzle, and held down by a weight. The calculation of the blowing-off point of such a valve is very simple. In the valve here shown, for example, the

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steam acts against a circle two inches in diameter. The area of a two-inch circle is $2 \times 2 \times .7854 = 3.14$ sq. in., and the weight tending to hold the cover plate down being 314 lbs., it is evident that the valve will not blow off until the steam pressure reaches 100 lbs. per square inch. Dead-weight valves are used somewhat in England, but they are seldom met with in this country, the commoner form here being that suggested in Fig. 1. It may be well to say that Fig. 1 does not purport to be a good form of valve. We should certainly object to it, if it were placed upon a boiler offered to us for insurance, because no guides are provided for the lever or for the valve stem. These features were intentionally omitted in the engraving, in order that their presence might not draw the attention away from the main points under consideration — the calculation, namely, of the blowing-off pressure and of the position of the weight.

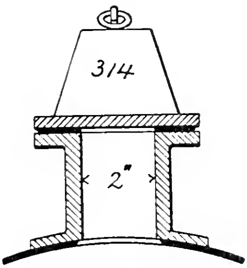

FIG. 2. — A "DEAD WEIGHT" VALVE.

THEORY OF THE LEVER. — In order to be able to perform safety-valve calculations intelligently, one must have a clear idea of the principle of the lever; and it is hoped that such an idea may be had from a study of the illustrations that are presented herewith. These represent a lath, or other

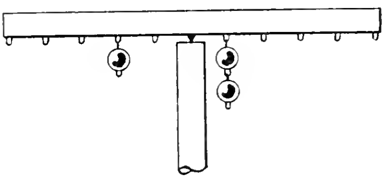

FIG. 3.

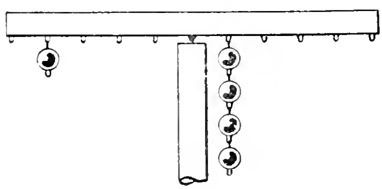

FIG. 4.

light piece of wood, which is balanced upon a knife edge, and into which, on the under side, a number of small staples are driven at equal distances. A number of balls of lead are also supposed to be provided, all exactly alike, and all being

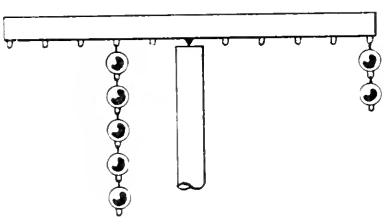

FIG. 5.

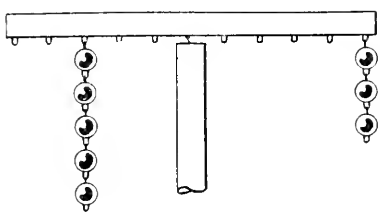

FIG. 6.

furnished with a hook at the top and a staple at the bottom. Two of these weights, when hung upon the first staple, as shown in Fig. 3, will just balance one weight hung upon the second staple, on the other side of the fulcrum. In the same way, four of them, when hung upon the first staple, as shown in Fig. 4, will just balance one hung upon the fourth staple. Five upon the second staple, as shown in Fig. 5, will just balance two upon the fifth staple; and three upon the fifth staple will just balance five upon the third staple, as shown in Fig. 6. It will be seen that in every one of these cases the lath is balanced, *provided* the weight upon one side, when multiplied by its distance from the fulcrum, is equal to the weight upon the other side, multiplied by *its* distance from the fulcrum. This is the principle of Archimedes, and it is used in all calculations relating to the lever. (The reader may find it a profitable exercise to show that the systems shown in Figs. 7 and 8 are balanced. A suggestion is afforded him in Fig. 7, while in Fig. 8 he is left entirely to his own resources. He should find

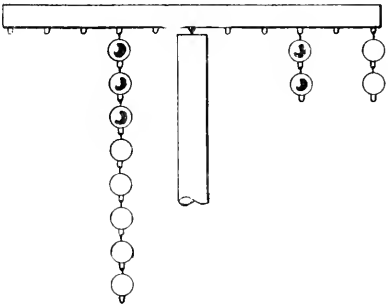

Fig. 7.

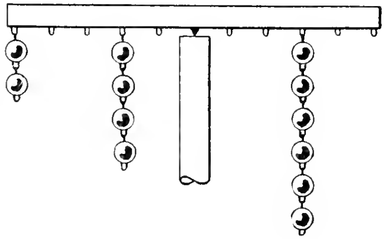

Fig. 8.

no difficulty in either case, however, if he has grasped the fundamental idea which is contained in the illustrations given above.)

Application to the Safety-valve.— We are now prepared to apply the principle of the lever to the safety-valve, although there is still one point to be cleared up before we can give a complete rule. (The point to which we refer is the influence of the weight *of the arm which carries the ball;* but for the present moment we shall consider this arm to be devoid of weight, and we shall introduce a correction for it later on) Fig. 9 is a crude representation of a safety-valve, in which the total steam pressure

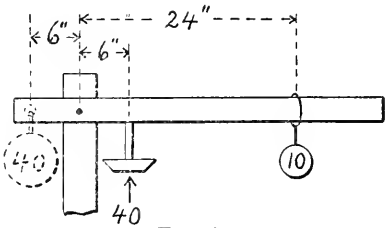

Fig. 9.

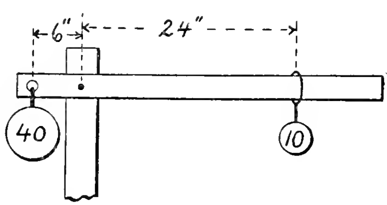

Fig. 10.

against the disk of the valve is supposed to be 40 lbs., and the ball is supposed to weigh 10 pounds. If the valve stem is 6″ from the fulcrum, the ball will have to be 24″ from the fulcrum in order for the valve to blow off at the given pressure — that is, at 40 lbs. This is easily seen, since 6×40 equals 10×24; but if the reader has any doubt about the applicability of Archimedes' rule in this case, he may note that the upward pressure due to the steam can be conceived to be replaced by a 40 lb. weight hung 6″ to the *left* of the fulcrum, as indicated by the dotted circle. The lever will then be equivalent to the one shown in Fig. 10, which is similar in all respects to those shown in Figs. 3 to 8, and to which Archimedes' rule plainly applies. If the blowing-off pressure were not given in Fig. 9, and we were required to find it from the other data there shown, we should reason as follows: When the valve is on the point of blowing off, the upward thrust of the valve-stem is just balanced by the downward tendency of the ball; and, therefore, from Archimedes' principle, 10×24 must equal 6 times the thrust of the valve-stem. But 10×24 equals 240, and hence 240 is 6 times the thrust of the valve-stem, and $240 \div 6$ ($= 40$ lbs.) must be the total pressure exerted on the disk of the valve when it is about to blow off. If the pressure *per square inch* were desired, we should have to divide 40, the total pressure on the valve disk, by the area of the disk in square inches.

THE ARM OF THE VALVE.—In order to take the *weight of the valve-arm* into account, we shall first make a short digression for illustrating the meaning of the expression "center of gravity." Consider, first, the system shown in Fig. 11, where there is one ball on the first staple and one on the fifth. The one ball on the fifth staple is equivalent to five balls on the first one; so that the two balls on the right hand side of the

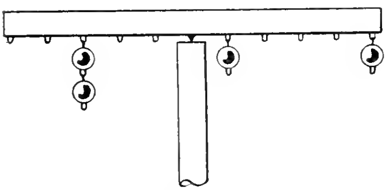

FIG. 11.

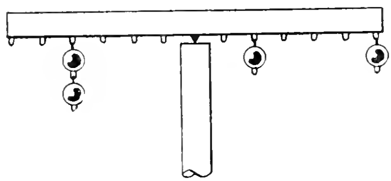

FIG. 12.

fulcrum are equivalent to *six* balls suspended from the *first* staple. They are therefore balanced by the two balls on the third staple; and, in general, if two balls be hung from *any* of the staples, they would be exactly balanced by a pair of balls whose distance from the fulcrum was the average of the distances of the first two. Fig. 12 is a further illustration of this fact. Now, referring to Fig. 13, let us conceive the valve-arm to be without weight, except two small and equal pieces of it, whose distances from the fulcrum are respectively $10''$ and $20''$. By analogy with the two preceding illustrations, we see that these two little masses would be just balanced by a similar pair of masses, placed $15''$ from the fulcrum. In Fig. 14 the same idea is extended to four masses, spaced at equal distances: they would be just balanced by four similar masses, hung at a distance from the fulcrum equal to half the length of the arm. While this kind of reasoning is applicable, strictly speaking, only to the case in which the valve-arm is of equal thickness and width throughout, and has no irregularities whatever, we may, *in practice*, apply it to *all* valve-arms which are *approximately* uniform in cross section; and by extending the conception of Figs. 13 and 14 until the little masses become so numerous as to fill the entire lever, we conclude that a valve-arm of this sort would be balanced by a similar arm suspended (as shown in Fig. 15) at a distance

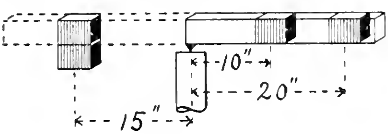

FIG. 13.

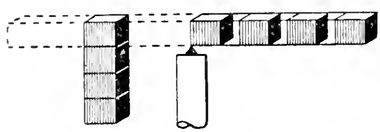

FIG. 14.

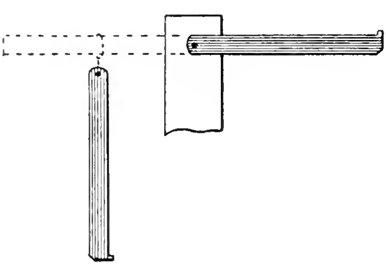

FIG. 15.

from the fulcrum equal to half the length of the arm itself. This amounts to saying that a uniform valve-arm acts the same as it would if its weight were all concentrated *at the middle point of the arm.* The point in a body which possesses this property is called the *center of gravity* of the body. As we have said, the center of gravity of a straight lever may, in practice, be considered to be half way out towards the end of the lever; but if the lever has an appreciable *taper*, the center of gravity will be nearer the fulcrum. The position of the center of gravity can be found, in such cases, by

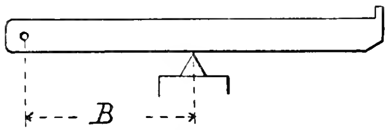

Fig. 16.

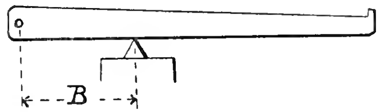

Fig. 17.

calculation; but it is simpler to take the lever out, and balance it across a three-cornered file, as shown in Figs. 16 and 17. It will balance when the center of gravity is just over the edge of the file; and the distance *B* can then be measured directly.

Calculation of the Blowing-off Pressure.—We are now prepared to give a complete example of the calculation of the blowing-point of a safety-valve. Let us take the valve shown in Fig. 18. The arm is 32 inches long and weighs three pounds; the ball weighs 20 pounds and is set 28 inches from the fulcrum; the valve-stem is 4″ from the fulcrum; the valve-disk is 2″ in diameter, and the disk and stem, together, weigh 1½ pounds. It is required to find the blowing-off pressure. In the first place, let us consider the *ball.* It is possible to load the valve-disk directly (just as in the case of Fig. 2) with a weight which shall have precisely the same effect, in preventing the escape of steam, that the actual 20-pound ball has; and our first undertaking will be to find out how big this imaginary "dead weight" would have to be. When we say that it is to be "equivalent" to the 20-pound ball on the lever, we mean that it would just balance that ball, if it were on the *left* side of the fulcrum, instead of on the right; and hence, by Archimedes' principle, 28″ × 20 lbs. must equal 4″ multiplied by the imaginary "dead weight." Now 28 × 20 = 560, and 560 ÷ 4 = 140. In other words, the 20-pound weight, at a distance of 28″ from the fulcrum, has just the same effect as a 140-pound weight would have, if placed directly upon the valve-disk. In the same way we may investigate the effect of the valve-arm. It weighs 3 pounds, and its center of gravity is 16″ from the fulcrum. A 3-pound weight, 16 inches from the fulcrum, is the same thing as a 12-pound weight, 4 inches from the fulcrum; because 3 × 16 = 48, and 12 × 4 = 48. Hence the valve-arm is equivalent to a 12-pound weight placed directly upon the valve-disk. The whole lever valve may therefore be regarded as equivalent to a "dead weight" valve loaded with 153½ pounds; for the ball is equivalent to a dead load of 140 pounds, the arm is equivalent to a dead load of 12 pounds, and the valve-disk and stem, taken together, weigh 1½ pounds; and 140 + 12 + 1½ = 153½. We have therefore found out that the valve will begin to blow when the total pressure of the steam against the valve-disk is 153.5 pounds. The part of the disk which is exposed

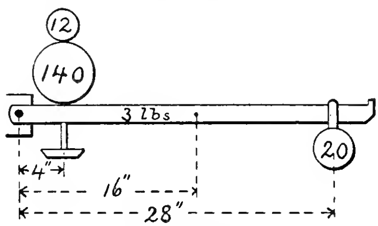

Fig. 18.—Finding the Blowing Pressure.

to the steam is 2″ in diameter, and its area is therefore $2 \times 2 \times .7854 = 3.1416$ square inches. The total steam pressure against this area being 153.5 pounds, the pressure against each square inch of it will be

$$153.5 \div 3.1416 = 48.9 \text{ pounds (nearly).}$$

A valve with the dimensions given above will therefore blow off at just a trifle less than 49 pounds per square inch; and the calculation is similar in all cases.

SETTING THE WEIGHT — The method of setting the weight, when the blowing-off pressure is given, is almost precisely the reverse of the calculation given above. As an example, consider the valve shown in Fig. 19. The dimensions are as follows: Diameter of the valve = 4″, length of the lever = 66″, weight of the ball = 50 lbs., weight of the lever = 18 lbs., weight of the valve-disk and stem = 7 lbs., distance of valve-stem from fulcrum = 3″. It is required to set the ball so that the valve shall blow at 100 lbs. per square inch. The calculation is as follows: The area of a 4-inch disk is

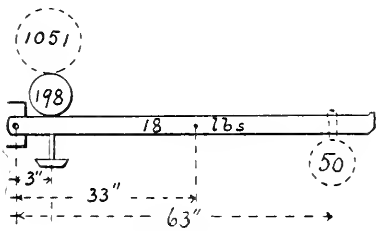

FIG. 19. — SETTING THE BALL.

$$4 \times 4 \times .7854 = 12.56 \text{ sq. in.}$$

and if the steam pressure is 100 lbs. per square inch, the total upward pressure against the valve-disk is $12.56 \times 100 = 1,256$ lbs. If the valve were of the "dead-weight" kind, a load of 1,256 lbs. on the valve-disk would therefore cause it to blow at 100 lbs. per square inch. We therefore have to set the ball at such a place that the action of the ball, the lever, and the direct weight of the valve-disk and stem, shall be equal to a direct load of 1,256 lbs. Now the lever weighs 18 lbs., and its "center of gravity" is (say) 33″ from the fulcrum. It is therefore equivalent to a 198-pound weight laid directly on the valve-disk; for by Archimedes' rule we must have

$$33'' \times 18 \text{ lbs.} = 3'' \times \text{equivalent dead load.}$$

Now $33 \times 18 = 594$, and $594 \div 3 = 198$ lbs., as stated above. In Fig. 19 this dead load (which is equivalent to the weight of the lever itself) is represented by the small weight marked "198"; and the large dotted ball above it (whose weight we are about to find) represents the dead load that is equivalent to the 50-lb. ball out on the lever. The dotted weight, together with the 198-lb weight, and the weight (7 lbs.) of the disk and stem, must be equal to 1,256 lbs., as we have seen. That is, the dotted weight must be 1,051 lbs.; because

$$1,051 + 198 + 7 = 1,256.$$

The problem has now resolved itself into placing the 50-lb. ball at such a point that it shall be equivalent to a dead load of 1,051 pounds. The valve-stem being 3″ from the fulcrum, Archimedes' rule gives us

$$1,051 \text{ lbs.} \times 3'' = 50 \text{ lbs} \times \text{distance of ball from fulcrum.}$$

Now $1,051 \times 3 = 3,153$: and $3,153 \div 50 = 63.06$ inches. That is, the ball must be placed 63 inches from the fulcrum, in order that the valve may blow at 100 lbs. per square inch.

Rules. — The processes of calculation which are explained above may now be summarized in the following two rules*:

RULE I. To find the blowing pressure when the position of the ball is given. Multiply the weight of the ball by its distance (A) from the fulcrum, and divide by the distance (C) of the valve-stem from the fulcrum. (This gives the dead-weight that is

* The letters refer to Fig. 1.

equivalent to the *ball.*) Then multiply the weight of the lever by the distance (B) of its center of gravity from the fulcrum, and divide by the distance (C) of the valve-stem from the fulcrum. (This gives the dead-weight that is equivalent to the *lever.*) Add together the two "dead weights," so calculated, and add in, also, the weight of the valve-disk and stem. (This gives the total weight that is keeping the valve-disk down.) Then divide the sum thus found by the area of the valve-disk, in square inches, and the quotient is the pressure, in pounds per square inch, at which the valve will blow.

RULE II. To set the ball, so that the valve shall blow at a given pressure. Multiply the area of the valve-disk by the blowing-off pressure, expressed in pounds per square inch. (This gives the total effort of the steam to force the valve-disk up.) Subtract, from this total pressure, the weight of the valve and stem. The remainder is the "dead weight" to which the lever and ball, taken together, must be equivalent. Then multiply the weight of the lever by the distance (B) of its "center of gravity" from the fulcrum, and divide by the distance (C) of the valve-stem from the fulcrum. The result is the "dead weight" to which the *lever* is equivalent; and if this be subtracted from the *total* dead weight, just mentioned, the remainder will be the "dead weight" to which the ball alone must be equivalent. Multiply this remainder by the distance (C) of the valve-stem from the fulcrum, and divide the product by the weight of the ball. The quotient is the distance, A, that the ball must be placed from the fulcrum, in order that the valve may blow off at the desired pressure.

Cautions. — In applying these rules, two things must be carefully observed. In the first place, the diameter of the valve-disk must be measured at $a\ b$, in Fig. 20, and *not at* $c\ d$; for the steam acts only on the circle whose diameter is $a\ b$. Again, if the

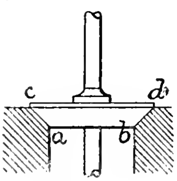

FIG. 20.

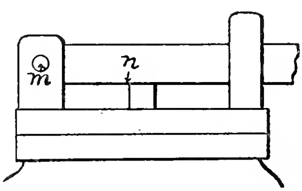

FIG. 21.

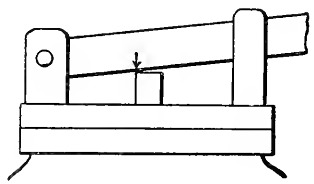

FIG. 22.

valve stem has a *square top*, as indicated in Figs. 21 and 22, $m\ n$ must be taken as the "distance of the valve-stem from the fulcrum"; because the moment the valve raises in the least degree, the pressure of the stem is all applied to the lever at n, as is plainly indicated in Fig. 22.

EXAMPLES. — (1) A valve has a disk 5″ in diameter, and the stem is $3\frac{1}{2}$ inches from the fulcrum. The lever is 60″ long, and as it tapers somewhat, its "center of gravity" was investigated by the method given in Figs. 16 and 17, and found to be 27″ from the fulcrum. The lever weighs 20 pounds, the disk and stem weigh 8 pounds, and the ball weighs 80 pounds and is 54″ from the fulcrum. Find the pressure, per square inch, at which the valve will blow off. (2) A valve is $4\frac{1}{2}$″ in diameter, and the stem is $2\frac{3}{4}$″ from the fulcrum. The lever weighs 15 pounds, is 56″ long, and tapers so little that it may be considered uniform throughout. The valve-disk and stem weigh $6\frac{1}{2}$ pounds. Find where a 75-lb. ball must be placed, in order that the valve may blow off at 80 pounds per square inch.

Answers to these examples will be given next month.

Although the foregoing article is intended simply to explain the *principle* underlying the lever safety-valve, it may be well to touch upon one point concerning the *construction* of such valves. The point we have in mind is this: When the boiler is under steam, it is an easy matter to try the valve, and find out whether it works freely or not. It ought also to be easy to do this, when the boiler is out of use; and in many cases it *is* so. Usually, when the boiler is not under steam, it is sufficient to raise the weight and the lever, and then to try the valve-stem with the thumb and finger; but some valves are so constructed that the valve-desk is *free from the stem*, and in such cases the fact that the *stem* is free proves nothing whatever, so far as the disk itself is concerned, and the disk must be separately investigated before the valve can be pronounced in good condition. If there is no escape pipe screwed into the valve, the disk can usually be reached from the exhaust side, and its condition noted; but if such a pipe is provided (as it is, in many cases) the inspector has to examine the disk as well as he can, from the *inside* of the boiler. If the valve does not happen to be secured directly to the nozzle, an examination from the interior of the boiler is not practicable, and then the waste-pipe has to be unscrewed, or the bonnet of the valve taken off, before the disk can be reached. These difficulties, when combined with the fact that there is often no external evidence to show whether the valve is secured to the stem or not, lead us to recommend strongly that valves with separate disks be avoided altogether. They have no very marked advantage over those in which disk and spindle are all in one piece, and as they are likely to deceive one into the belief that all is in good condition, when in reality *the disk may be stuck fast*, we feel justified in condemning their use altogether.

Inspectors' Report.

JUNE, 1895.

During this month our inspectors made 7,961 inspection trips, visited 14,887 boilers, inspected 6,803 both internally and externally, and subjected 667 to hydrostatic pressure. The whole number of defects reported reached 10,967, of which 1,028 were considered dangerous; 72 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	907	59
Cases of incrustation and scale,	1,881	89
Cases of internal grooving,	183	24
Cases of internal corrosion,	712	37
Cases of external corrosion,	795	40
Broken and loose braces and stays,	108	40
Settings defective,	304	17
Furnaces out of shape,	489	20
Fractured plates,	294	65
Burned plates,	251	21
Blistered plates,	254	11
Cases of defective riveting,	1,331	62
Defective heads,	132	9
Serious leakage around tube ends,	1,690	274
Serious leakage at seams,	407	21
Defective water gauges,	351	39

Nature of Defects.	Whole Number.	Dangerous.
Defective blow-offs,	178	80
Cases of deficiency of water,	20	13
Safety-valves overloaded,	64	13
Safety-valves defective in construction,	90	19
Pressure-gauges defective,	423	50
Boilers without pressure-gauges,	25	25
Unclassified defects,	78	0
Total,	10,967	1,028

Boiler Explosions.

June, 1895.

(144.) — A serious accident happened, on June 2d, in the electric light station at Milford, Mass. Some trouble was experienced on account of a leakage from the safety-valve, and the electrician, George A. Drew, together with the engineer, G. W. Conant, endeavored to repair the valve. While they were at work some part of the valve broke, and the men were hurled violently to the floor by the escaping steam. Mr. Conant received only a sprain, but Mr. Drew was seriously injured. A third employé, who was in the boiler-room at the time, assisted in getting the injured men out, and also drew the fires.

(145.) — George Smith's steam saw-mill, located in the woods about eight miles from Laurel, Del., was annihilated, on June 5th, by the explosion of the boiler. The engineer, sawyer, and two helpers were in the mill at the time, but all of them escaped injury.

(146.) — Fireman Fletcher Sells was instantly killed, on June 10th, by the explosion of a water purifier in the Crystal Ice manufacturing plant on West Broad street, Columbus, Ohio. Oliver Roehm, a brother of Victor Roehm, the manager of the plant, was also terribly scalded. Roehm and Sells were the only men in the boiler-room at the time of the explosion.

(147.) — A boiler exploded, on June 13th, on the Clark farm, near Bradford, Pa., where an oil well was being drilled. Charles Graham, Francis Hane, and John Gonter were standing on the derrick floor at the time, preparing to run the tools in the hole, but they all escaped serious injury. The boiler-house was demolished. The dome of the boiler was hurled 400 feet in one direction, and the rear portion of the shell was thrown 100 feet in another.

(148.) — A boiler exploded, on June 14th, in T. J. Langley's reed and harness factory, Fall River, Mass. Lena H. Horton, Adele Dube, Robert Murray, and Adolph Bellefeuille were killed, and Thomas Berry, Mattie Duroeles, Joseph Nuttall, Annie Hurst, Mary Partridge, William Russell, Alice Tremblay, and Ida LePage were injured. Berry was badly burned about the face and crushed about the body; his skull was also fractured, and he may die. The mill was entirely wrecked, and the property loss will amount to about $20,000.

(149.) — One of the boilers in the water-works at Union City, Tenn., exploded on June 17th with disastrous results. Engineer G. F. Carmon was instantly killed, his body being literally torn to pieces. It is said that another employé (whose name we could not learn) was buried under the ruins. The brick building in which the boilers stood was wholly demolished, and the property loss is estimated at $20,000.

(150.) — A boiler exploded, on June 17th, at the Union Cotton Press, corner of South Peters and Terpsichore streets, New Orleans, La. Clemson Penrose was killed instantly, and Preston Keaghy and A. S. Frankenbush were injured seriously and perhaps fatally. Henry Schneider, Henry Heffler, W. H. Turner, Laura Jones, M. B. Shelby, L. J. Johnson, John Schultz, William Ellis, John Linn, and George Linn were also injured to a greater or lesser extent. We have seen no estimate of the property damage, but it is said to have been large.

(151.) — On June 17th a boiler exploded in Attica, Ind., while a well was being drilled on Charles Peterson's place. William Smith had charge of the engine, and Leonard Stambaugh of the drill. Other persons were sitting about watching the work. Mr. Smith was killed instantly, and Frank Peterson was hurt so badly that he died within twenty minutes. Mr. Stambaugh was horribly scalded, and it is said that he cannot live. Henry Shumar, J. W. Hamar, and Alexander Hamar, were also badly injured, the latter being blown forty feet, over two fences.

(152.) — A boiler exploded in the stamp mill of James M. Lucas, on the Tuerto, Golden, N. M., on June 19th. Mr. Lucas evidently knows little of the tremendous destructive power of steam, for it is reported that he "thinks it was the malicious work of some enemy, and that giant powder was used to accomplish the purpose"

(153.) — A small boiler, located just outside of Brown's restaurant on Market street, Hartford, Conn., exploded on June 19th. The damage was not great, and nobody was injured.

(154.) — A boiler exploded, on June 21st, in Moses' saw-mill, at Spring Hill, near Little Rock, Ark. Joseph Collins and three other men named Brent were killed, and a number of persons were injured.

(155.) — Alonzo H. Crocker's mill, at West Carlyle, near Grand Rapids, Mich., was blown to atoms, on June 22d, by the explosion of a boiler. Martin Skinner and Arthur Barney were killed instantly, and Avery Crocker, the engineer, was fatally injured. One account says that "the bricks of the boiler setting were scattered over a radius of a quarter of a mile."

(156.) — The whaleback steamer *Christopher Columbus* met with a serious accident, on June 23d, while on her way from Milwaukee to Chicago. When directly off Waukegan a fitting on the main steam pipe failed, and the boat was immediately enveloped in a cloud of steam. Albert McConkey was fatally scalded, and cannot live. James Loring, John Hopp, and a man named Steit, were also terribly scalded, and may die. The others injured were as follows: Miss Boxheimer, severely burned about the face and hands; H. H. Darrow, face badly scalded; George W. Keil, badly burned about the face and arms; George W. Keough, terribly scalded about the face and arms; Arnold Kein, slightly scalded on the hand; Frank Rosner, face, breast, and arms badly burned; J. E. Ryan and Nicholas Seter, terribly burned; and Miss Jessie L. Stone, scalded somewhat about the face.

(157.) — On June 23d, while W. F. Kinney, of the J. I. Case Company, was working on the top of a big traction engine back of the warehouse on Eleventh and X streets, Lincoln, Nebraska, the boiler exploded. No damage was done except to the engine. This was almost destroyed. Mr. Kinney very fortunately escaped injury.

(158.) — The boiler in McSurstin's mill, on Credit river, near Shakopee, Minn., exploded on June 25th. Joseph Berres, the engineer, was killed. His body was thrown 175 feet.

(159.) — A boiler exploded, on June 26th, in Hammond & Andrews' mill, near Josselyn, Ga. Mr. Anderson, one of the members of the firm, who was superintending the mill, was killed. William Smith was also killed, and Richard Wright was hurt so badly that at last accounts it was considered impossible for him to live. Henry Covington was also painfully injured, but will recover. The building was destroyed, and some of the machinery was found 500 yards away.

(160) — A terrific boiler explosion occurred, on June 27th, at the Langhead coke plant of R. L. Martin & Co., near Fairchance, Pa. The office of the company, which was near the boiler-house, was blown to pieces, so that there were not two boards of the building left together. Superintendent Louis McDowell and Bookkeeper Charles Wilson, who were sitting at their desks, were fearfully injured. They were badly bruised and terribly scalded by the steam and hot water. The force of the explosion was such that the big safe in the office was blown several feet from its original position. The noise of the explosion was heard four miles away.

(161) — A boiler exploded, on June 26th, in Kray & Kelley's paper box factory, at East Weymouth, Mass. W. E. Kray and George Loring were badly scalded, and at last accounts it was considered doubtful if Kray would live.

(162.) — An upright boiler in use at the Crocker paper mill, at Holyoke, Mass., exploded early in the morning of June 28th. Fortunately, nobody was injured.

(163.) — On June 29th a boiler exploded in T. M Ingraham's mill, near Tyler, Texas. John Spear, fireman, was struck by a flying piece of iron. The entire side of his head was crushed in, and he died in a short time. Thomas Ingraham, Jr., was severely scalded about the back, and a young man whose name we could not learn was also severely scalded on the breast and arms. The engine-house was totally wrecked, and the property loss was large.

(164.) — The boiler of the river steamer *Cornucopia* exploded, on June 30th, near Norfolk, Va., killing Engineer John Kilburn, Fireman Baker, and a deck hand whose name we did not learn.

(165.) — A boiler tube failed, on June 30th, on the steamer *O. E. Lewis*, which runs between Boston and Winthrop, Mass. Fireman John Cunningham was fearfully burned, but his condition is not critical.

An interesting discussion has for some time been going on as to whether repeated vibrations change the molecular structure of iron and steel. Some metallurgists believe that a fracture caused by repeated strains is the result of a change in the structure, and that fibrous wrought-iron is transformed into granular under continuous shocks, while others regard such an opinion as entirely erroneous. Numerous experiments instituted by Badchinger, of Munich, in which bars were submitted to repeated shocks, lead him to the conclusion that strains in iron and steel repeated frequently, millions of times, bring about no change of structure. Reference is also made to certain experiments by which a bar of wrought-iron was made to show, in two fractures only a few inches apart, two distinct kinds of fracture, the one sharply crystalline, the other fibrous, dependent simply upon whether the breaking force was a sharp blow or a slowly applied load. Another authority points out that crystalline fracture is caused by the manner of breaking; that is, transversely broken fibres show granular crystalline faces, but, when pulled apart longitudinally, the same iron will show a fibrous structure. — *New York Sun.*

The Locomotive.

HARTFORD, AUGUST 15, 1895.

J. M. ALLEN, *Editor.* A. D. RISTEEN, *Associate Editor.*

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Subscription price 50 cents per year when mailed from this office.

Bound volumes one dollar each. (Any volume can be supplied.)

Papers that borrow cuts from us will do us a favor if they will mark them plainly in returning, so that we may give proper credit on our books.

ON page 81 of THE LOCOMOTIVE for June, 1895, in the third line from the bottom of the page, for "February" read "April."

WE have frequent inquiries for books relating to the examination of engineers and firemen. In reply we may say that Emory Edwards' "900 Examination Questions and Answers for Engineers and Firemen" (published by Henry Carey Baird & Co., 810 Walnut street, Philadelphia) is very useful and convenient. Mr. Edwards is an engineer of wide experience in both naval and stationary practice, and his book is a good one.

Award of the Hodgkins Prizes.

Some account of the Hodgkins Fund prizes, for discoveries and essays concerning atmospheric air, was given in THE LOCOMOTIVE for July, 1893. We learn, through the New York *Sun*, that the committee of award has completed its examination of the 218 papers submitted in the competition, from contestants in almost every part of the world.

"The American committee," says the *Sun*, "is composed of the following members: Dr. G. Brown Goode, appointed by the Secretary of the Smithsonian Institution; Assistant Surgeon-General John S. Billings, U. S. A., by the President of the National Academy of Sciences; Prof. M. W. Harrington, by the President of the American Association for the Advancement of Science. A foreign advisory committee, composed of the late Prof. Huxley, M. Janssen of the French Academy of Sciences, and Prof. Wilhelm Von Bezold, Director of the German Meteorological Service, was consulted in connection with the award of the prizes.

"The committee, on August 6, announced its decision as follows:

"First prize of $10,000, for a treatise embodying some new and important discoveries in regard to the nature and properties of atmospheric air, to Lord Rayleigh, of London, and Prof. William Ramsay, of University College, London, for the discovery of argon, a new element of the atmosphere. [An account of this element will be found in THE LOCOMOTIVE for March, 1895.]

"The second prize, of $2,000, was not awarded, owing to the failure of any contestant to comply strictly with the terms of the offer."

This prize was offered "for the most satisfactory essay upon — (*a*) The known properties of atmospheric air considered in their relationship to research in every department of natural science, and the importance of a study of the atmosphere considered in view of these relationships; (*b*) The proper direction of future research in connection with the imperfections of our knowledge of atmospheric air, and of the connection of that knowledge with other sciences." There is a certain haziness about these specifications, and it is not surprising that no one fulfilled them, in the judgment of the committee. Probably very few tried to do so.

"The third prize of $1,000," continues the *Sun*, "was awarded to Dr. Henry de Varigny, of Paris, for the best popular treatise upon atmospheric air, its properties and relationships. Dr. de Varigny's essay is entitled *L'Air et la Vie* (Air and Life).

"A considerable number of papers submitted in competition received honorable mention, coupled in three instances with a silver medal, and in six with a bronze medal. Honorable mention, with silver medals, is awarded to F. A. R. Russell; Esq., Vice-President of the Royal Meteorological Society of Great Britain; to C. L. Madsen, Esq., of Copenhagen, Denmark, and to Mr. A. L. Herrera and Dr. Vergara Lopez of the City of Mexico. Honorable mention, with bronze medal, is awarded to Drs. Franz and Carl Oppenheimer of Berlin; Mr. Alexander McAdie of the United States Weather Bureau; Dr. O. Jesse of Berlin; Mr. Hiram S. Maxim of Kent, England; Dr. A. Loewy of Berlin, and Messrs. D. Deberaux-Dex and Maurice Dibos of Rouen, France. Honorable mention is also awarded to Dr. Charles Smart, U. S. A.; Dr. A. Marcuse of Berlin; Dr. A. Magelssen, Christiania, Norway; Prof. C. Nees, Copenhagen; Dr. F. J. B. Cordeiro, U. S. N.; Prof. F. H. Bigelow, Washington; E. C. C. Daly, Esq., London; Dr. F. Viault, Bordeaux, France; Prof. E. Giesler, Bonn, Germany; Dr. J. B. Cohen, Leeds, England; Prof. Emile Duclaux, Paris; and Dr. Ludwig Eilosvay von Nagy Ilosva, Budapest, Hungary.

"The Hodgkins Fund, from which these prizes were drawn, was established in October, 1891, by Thomas George Hodgkins, of Setauket, N. Y. The donor specified that the income from a part of this fund was to be devoted to the increase and diffusion of more exact knowledge in regard to the nature and properties of atmospheric air in connection with the welfare of man. An announcement of the prizes which were offered was made by the Secretary of the Smithsonian Institution on March 31, 1893. The offer of a prize of this value excited general interest throughout the civilized world, and papers were received from nearly all those who were at all interested in this branch of scientific research.

"It is not likely that the income from this fund will be expended exactly in this way another year, but another method may be adopted, which will accomplish the same purpose."

"Cassier's."

The issue of *Cassier's Magazine* for July, 1895, is remarkable in more ways than one. It is devoted almost exclusively to a study of the problems that arose in attempting to utilize, on a grand scale, the water-power of Niagara Falls. It is, as the publishers have said, "A complete story of the great Niagara power enterprise, comprised in ten articles, with nearly two hundred illustrations, including portraits of the officers and directors of the Cataract Construction Company, the members of the International Niagara Falls Commission, and the engineers under whose supervision the work was carried out."

We are first presented with full-page portraits of the officers and directors of the Cataract Construction Company, eleven in number. Then follows an article on "The Use of the Niagara Water Power," by Francis Lynde Stetson, which is admirably illustrated, and full of suggestive facts. The engraving on page 184 is especially interesting; it represents the distinguished men who constituted the International Niagara Falls Commission. Lord Kelvin is in the center of the group, and about him are Prof. Mascart, Prof. Unwin, Dr. Sellers, and Col. Turrettini. The enormous size of the great lake system drained by the Niagara river is strikingly illustrated by the diagram on page 179. Few persons realize that Lakes Superior, Michigan, Huron, and Ontario are so deep that their beds are, in places, from 200 to 400 feet below the level of the sea.

Following Mr. Stetson's article is a short one by Professor Unwin on "Mechanical Energy and Industrial Progress," and then follows a similar one on "Some Details of the Niagara Tunnel," by Mr. Albert H. Porter, who was resident engineer for the Construction Company, and under whose supervision the preliminary work was done. Mr. George B. Burbank, who was resident consulting engineer, and afterwards chief engineer, then contributes a paper on "The Construction of the Niagara Tunnel, Wheel-Pit, and Canal." Mr. Clemens Herschel, the consulting hydraulic engineer, writes of "Niagara Mill Sites, Water Connections, and Turbines," and Mr. L. B. Stillwell, who supervised the installation of the electric apparatus, contributes "Electric Power Generation at Niagara." We should like to review these articles at length, but space will not allow it. One of the most striking things in Mr. Stillwell's article is his account of the huge nickel-steel field-rings for the dynamos. They are 11 feet $7\frac{1}{8}$ inches in diameter, and were forged up from the ingot, without a weld, by the Bethlehem Iron Company.

The remaining articles relating to Niagara are "The Industrial Village of Echota at Niagara," by Mr. John Bogart; "Notable European Water Power Installations," by Col. Theodore Turrettini; "Distribution of the Electrical Energy from Niagara Falls," by S. Dana Greene; and "The Niagara Region in History," by Peter A. Porter.

The publishers of *Cassier's Magazine* are to be congratulated upon the success that they have achieved with their magazine, from the very beginning. Every issue is replete with interesting matter, and profusely illustrated with good engravings. The "Niagara Falls Number," however, surpasses all that they have attempted before; and we take pleasure in expressing our unqualified admiration of it. It shall have a permanent place on our editorial shelf.

Hot Water Boilers and Systems.

The Yorkshire Boiler Insurance and Steam Users' Co., Limited, of Bradford, England, issues the following circular to its patrons, for the care of hot-water heating systems and circulating boilers:

"Constant water supply and free circulation are the essential points to be observed. If any part of the circulating system becomes blocked, expansion of the water or formation of steam by the applied heat will inevitably burst something — probably the boiler. The pipes may become blocked from three causes: (1) Freezing up, (2) furring up, (3) closed stop-valves. Therefore, before lighting the fire see that he whole apparatus (including boiler, feed tanks, and all circulating pipes) is full of water, and the feed and circulation free. In cold weather, and epecially during a frost, never let the fire go out, but bank it up, regulate the heat by dampers, and keep it slumbering at night or when hot water is not required. If there are any stop-valves on the pipes, be most particular to see that they are always open. A dead-weight safety-valve (which may be bought for about ten shillings) is considered essential. It should be fixed upon a short pipe leading direct from the boiler, and suitably guarded. It should be daily tested to see that the valve is free. Any circulating pipes approaching outside air or passing through walls should be well wrapped with felt. All circulating boilers should be opened and cleaned certainly once in each year, and oftener if the feed water is sedimentary. At the same time the internal condition of the pipes should be ascertained, which may be done either by disconnection at convenient places, or by drilling. Air cocks should be fixed at the highest point of bends and dips, and should be frequently opened to liberate entrapped air. Should snapping or noise occur in the pipes, the circulation is not free. In such a case try the safety-valve and air-cocks and see to the feed; if this course fails, the pipes must be disconnected. In case of doubt, send to the company at once."

An excellent little pamphlet, written several years ago, by William J. Gibson, of Cottage City, Mass., formerly in the postal service, has just come under our notice. It is entitled *Ten Reasons Why We Do Not Get Our Letters*, showing by illustrative anecdotes that the cause in nearly all cases is some fault or bad judgment in the writers; and gives under each reason good advice how the evils are to be remedied. The gross volume of delay and injury caused by all these is so enormous, — four to five million letters going astray every year, — that we think it a public service to reprint his recapitulation, with the sum of his explanations.

1. Mail your own letters. (Others forget and leave them in their pockets, perhaps of suits laid aside. But wives cannot always get away, and husbands will still accumulate odium from forgetting.)

2. Direct them fully and to the right place, city, and State. (Dead Letter Office gets 50,000 a year partially addressed, 6,000 more not addressed at all; men continually put on their own city for the one meant, or the wrong State.)

3. Register important letters. (Clerks may missend them; one careless or sleepy clerk sent a letter with a draft, in spite of its being correctly addressed, to a new prairie town, where it was kept six months before returning to the Dead Letter Office. If registered, it would have been hunted up at once.)

4. Write nothing on the northeast corner. (P. O. stamp may obliterate the name otherwise.)

5. Use government stamped envelopes. (Stamps are forgotten or don't stick; 300,000 such letters are mailed every year.)

6. Have a letter-box at your door. (Letters pushed under the door, or packages left on the step, are always liable to be lost.)

7. Have correspondents write "Transient" on letters sent you while traveling. (Regular residents of that or a similar name get them otherwise, and you may not receive them at all; certainly not if your stay is short.)

8. In strange offices show your written or printed name to the clerk. (If spoken through a partition it is liable to be misunderstood; and one gets his letters much more promptly, because a possible hunt in the wrong place is saved.)

9. In writing to strangers for information of no moment to them, to old, or infirm, or poorly educated people, inclose a stamped *and directed* envelope for replies.)

10. Address letters *distinctly*, in loud penmanship and loud black ink, with the letters clearly formed. (*Three millions* of those which reach the Dead Letter Office every year go there because the writing is too faint or the addresses illegible.—*Travelers Record.*

Incorporated 1866.

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The Locomotive.

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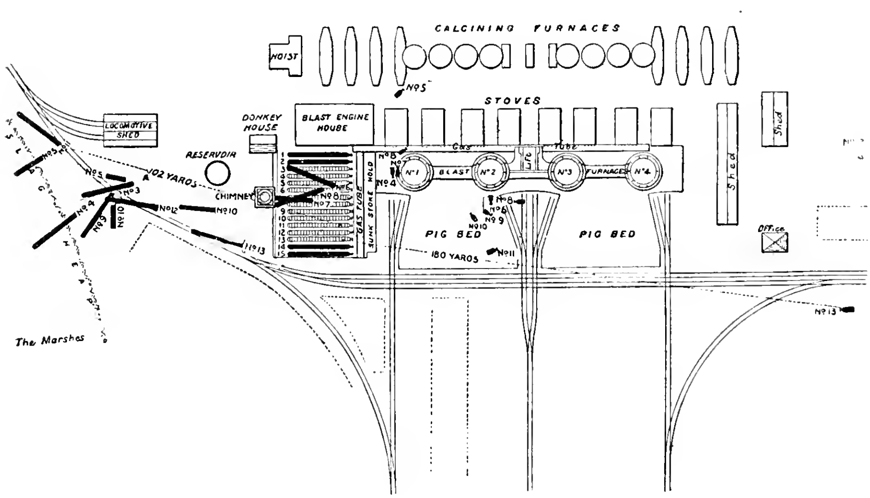
The Redcar Boiler Explosion.

The explosion of a steam boiler has become so common an occurrence, with the increasing use of steam, that in many cases the newspapers dismiss the incident with three or four lines, and often they are not considered sufficiently "newsy" to be mentioned at all. The cases in which two boilers explode simultaneously are not so common, and when *three* or more give way at one time, the occurrence attracts considerable attention. The greatest explosion on record, so far as the number of boilers involved is con-



THE REDCAR EXPLOSION.

cerned, was the one which occurred at Shamokin, Pa., on the 11th day of last October, in which twenty-seven of them exploded simultaneously. In the celebrated Friedenshütte explosion, which occurred in Upper Silesia, on July 25, 1887, only twenty-two boilers were involved. At Shamokin the number of persons killed was but six, although several others were injured. At Friedenshütte the death list included twelve persons, in addition to which thirty others were injured. So far as we are aware, the cause of the explosion was never unequivocably established in either of these cases. (For an account of the Shamokin explosion see THE LOCOMOTIVE for December, 1894; and for the Friedenshütte explosion see the issue for June, 1888.)

We have now to record another explosion of a similar character, although of lesser magnitude, which occurred at the Warrenby Iron Works, near Redcar, England, on June 14, 1895.* The general facts of the disaster are given by *Engineering* as follows: "The Warrenby Iron Works, near Redcar, were erected some 23 years ago by Messrs. Walker, Maynard & Co., and are still owned by that firm. The steam power was provided by a range of 15 boilers, of the plain cylindrical, egg-ended, externally-fired type, heated by the gases passing off from the blast furnaces. They measured 66 feet in length and 4 ft., 6 in. in diameter, the working pressure being 60 pounds per square inch. Shortly after nine o'clock on the evening of Friday, June 14th, when, fortunately, only about one-fourth of the total number of men usually employed at the works were engaged on night duty, *eleven* of the boilers exploded. The two outer ones at each end of the range did not fail, but remained intact, or nearly so, and pretty much in their original positions. Of the 11 that burst, 10 severed at the third ring seam of rivets from the front end, and the eleventh gave way at the fourth ring seam. The third ring seam, it may here be pointed out, was just over the bridge wall. When the boilers were thus divided, the two sections of each flew in opposite directions, some of them being separated by about 250 yards. The violence of the explosion will be better estimated when it is stated that one of the boilers, or the greater portion of it, was blown upwards of 100 yards forwards, and the back end of another boiler 180 yards backwards, while other fragments were carried to considerable distances and scattered indiscriminately, some of them falling one on the top of another. The brickwork of the settings was reduced to a heap of débris, but the chimney and the blast furnaces escaped injury. It was a fortunate circumstance that the explosion did not occur during the daytime, when a greater number of workmen would have been on the premises. As it was, the results were deplorable: as many as 11 [12] persons were killed, and about 20 others injured, some of them very seriously."

This account, when taken in connection with the outline plan of the works presented herewith, gives a very fair idea of the general circumstances of the explosion. So far as we are aware, no estimate of the property loss has been made, except that the owners of the plant state that the boilers alone were worth about $25,000, and, of course, the total loss would be much greater.

Passing now to the consideration of the *cause* of the explosion, we may note that two distinct and contradictory conclusions were reached by the two authorities who examined this point officially. The coroner's jury found that the explosion was due to the "overheating of one of the boilers through deficiency of water," and that "there had been no negligence, and that everything had been kept up to the correct standard." There is always a large contingent, in any community, which holds tenaciously to the belief that boilers never explode, except from low water; and juries, unless composed of experienced men, are only too ready to accept this solution in any given case, unless there happens to be incontrovertible evidence to the contrary. For this reason we do not consider the finding of the coroner's jury, in the present case, to be particularly valuable. The investigation subsequently carried out by the Board of Trade, in conformity with the Boiler Explosions Act of 1882, is much more instructive. It extended through six days, and the testimony taken is suggestive in many respects. The general conclusion reached by the Commission appears to have been, that the explosion was due to the

* For the data concerning this explosion we are indebted to our esteemed contemporary, *Engineering*.

unequal expansions, and consequent strains, that are likely to occur in boilers of this type. Mr. K. E. K. Gough represented the Board of Trade in the case, and in his opening statement he said that "the 11 boilers, the explosion of which formed the subject of the investigation, were part of a group of 15, all of the plain, cylindrical, externally-fired class, measuring 66 feet in length by 4 feet 6 inches in diameter, the shell being composed of 20 belts of two plates each. The back end of each boiler was composed of six pieces, and the front end of five pieces. A projecting neck was attached to the front end, for the connection of the water gauge. All the shell plates, with the exception of those in No. 15 boiler (which was constructed of steel), were of Robert Heath's single best Staffordshire iron." They were originally $\frac{3}{8}$ inch thick, and were united by single riveted lap joints, $\frac{15}{16}''$ in diameter, and the pitch $1\frac{3}{4}$ inches. Boiler No. 1 was made in 1880; Nos. 2 to 7, inclusive, in 1873; Nos. 8 to 14, inclusive, in 1875 or thereabouts; and No. 15 in 1895. "The mountings of each boiler," continued Mr. Gough, "consisted of two safety-valves loaded by lever and weights to a pressure of about 60 pounds per square inch; a glass water-gauge fitted to the end plate of the neck of the boiler, which projected from the brick-work; a low-water alarm, three manholes, and other usual fittings. There was, however, no separate pressure gauge to each boiler, but only one for the whole series [!], in the blast engine-house, and another in the donkey engine-house. The boilers were set in brickwork, and each was supported by five cast-iron brackets connected to the boiler by bolts, the feet of the brackets resting on iron plates on the top of the side walls of the flues. The boilers were fired by the gases from the blast furnaces, suitable openings being provided for the admission of air to promote combustion. The feed-water, which was taken from the town supply, was first heated by exhaust steam, then filtered, and afterwards delivered into the boilers at a temperature of 170° or 180°."

Referring to the events immediately preceding the explosion, Mr. Gough said: "The boilers were in charge of Ayton, the blast engineman. About 3 P.M. on Friday, June 14th, the gas was turned on to No. 4 boiler [which had just been cleaned], and steam was raised about 6 P.M. The stop-valve was opened and all the 15 boilers were then connected. The blast engineman, as No. 5 was next in turn for cleaning, shut off the gases from that boiler about 8.40 P.M., and at the same time closed the valves for admitting air to the furnaces. He went along in front of the boilers, saw that the water was well up in the gauge glasses, and told the attendant to watch the glasses, as the feed was then on. No sound was heard from any of the low-water alarms. He then went into the engine-house and saw that the pressure by the steam gauge was about 58 lbs. Casting was at this time taking place from three of the blast furnaces, and at about 9.20 P.M., when this operation appears to have come to an end, the explosion took place. Boilers No. 3 to 13 (inclusive) all exploded, and, with the exception of No. 13, each separated along the third circumferential seam from the front end. No. 13 separated at the fourth circumferential seam from the front end. No. 14 had its side crushed in, and the two ends of the several boilers were blown in opposite directions and landed in various positions about the works. The contents issued forth amongst the men employed on the blast furnaces, four being killed and 17 others injured, eight of them so seriously that they subsequently died. Inquests were held touching the death of these 12 persons, and verdicts were returned to the effect that 'the explosion was caused by overheating, but how that overheating was caused, there was no evidence to show.'"

So far as the low-water theory of the explosion is concerned, we have to take into consideration the following facts: (1) The low-water alarm did not blow on any one of the eleven boilers that burst; (2) Mr. J. J. Lightfoot, who had worked under Ayton, the blast engineman, for six or seven years, testified that "the low-water alarm whistles worked well"; (3) there was no bulging; (4) the *longitudinal* joints were not started; (5) the only evidence tending to indicate low water was that offered by Mr. William P. Ingham, a consulting engineer, who had drawn up a report for the use of the coroner. Mr. Ingham testified, before the Board of Trade Commission, that "he found evidences of overheating at the first four rings of the front end of No. 13. Externally there was blue oxide, and internally the scale was shelled off in places, and the usual blue or plum color was on the plates." In consideration of the fact that plates overheated through low water are usually *red*, Mr. Ingham's testimony can hardly be regarded as conclusive, and the Commission rightly declined to be governed by it.

Dismissing the low-water theory, let us examine the other possible causes. In the first place, we note that the testimony showed that there was no marked corrosion of the plates, and no considerable amount of scale. It might be thought, perhaps, that the *age* of the boilers was sufficient to account for the explosion; but in the absence of any noticeable signs of deterioration, we do not think that this theory is adequate. The age of a boiler bears no very definite relation to its safety, for boilers often explode when quite new, while others are in good condition after long years of service. (In illustration of this last statement we may mention a case that recently came under our notice in Hammond, Ohio, where a boiler has been in almost continuous service, *day and night*, in a paper mill, since 1856 — a period of thirty-nine years. It was thought best, recently, to take it out and replace it with a new one, of more modern construction; yet, after its removal from the setting, it had every appearance of being good for still longer service. This boiler was well made in the first place, and has been well cared for since.)

Taking the great length of these boilers into account, it must be admitted that the mode of support of the shells, and the location of the feed, are matters of the greatest importance in determining the cause of the explosion. We do not find that the position of the feed-pipe was discussed at all before the Board of Trade Commission. The mode of support was considered, however, but we have not data enough at hand to know whether it was entirely satisfactory or not. Judging from Mr. Gough's opening remarks (quoted above) we should say that there were five pairs of lugs to each boiler, arranged substantially in accordance with the practice in this country for boilers of much shorter length. If this were so, or if the support were in any way *equivalent* to this method, we should consider the design most faulty; for even if the lugs could all be brought to a good bearing at any one time, they would not remain in this condition for any length of time. The yielding of the boiler under varying conditions of temperature and pressure would certainly cause great and serious changes in the distribution of the strains in the shell. These changes would not be likely to affect the longitudinal joints, but if the boiler be considered as a sort of long beam, loaded with a considerable weight of water, and strained also by the internal pressure, it will be apparent that the *girth* joints would be most likely to show distress. If the material of the shell were good, and possessed the proper ductility, the distress at the girth joints would be most likely to show itself through persistent and incurable *leakages;* while if the material were deficient in ductility, the strains (supposing the mode of support to be the prime cause of the explosion) would be almost certain to cause a circumferential fracture along the rivet holes. The testimony taken before the Commission elicited the fact that the plates were made of "best" Staffordshire iron. This name *looks* well from a distance, but if we were in England we should learn that it is only a trade name for a rather poor quality of metal. There is "best" iron, and "best best" iron, and "best best best" iron; and in the present case the material was only just plain "best." In fact, Mr. David Watson, engineer and surveyor to the Board of Trade, said, in his testimony, that "the ductility of the plates was very low, and he doubted if it had ever been much better [*i. e.*, he did not think it likely that the ductility had deteriorated during the lifetime of the boilers]. What was known as 'best' quality," he added, "was really the lowest; and it was certainly too low to be exposed to the flames."

We have given the reasons that would have led us to expect the continued recurrence of fractures along the rivet holes in the girth joints; and the testimony brought out before the commission, on this point, is truly appalling, and confirms our opinion concerning the cause of the explosion, with extraordinary force. In fact, the boilers gave such unmistakable indications of the true state of things, that it is almost incredible that they should have been kept in service. They were, however, and the inevitable disaster came.

The evidence concerning the circumferential fractures did not extend back further than 1888; but there was no need that it should. It is abundant enough as it stands. Briefly stated, the record for the past eight years is as follows: **(1)** In 1888 a fracture was found along a girth joint in No. 6 boiler, and **(2)** another was found in the same boiler in 1889. **(3)** A similar one occurred in No. 7 in February, 1889; **(4)** in July, 1889, there was a rip in No. 8; **(5)** in October, 1889, it became necessary to put a 4-foot patch on the bottom of No. 10; **(6)** in December, 1889, there were rips in Nos. 7 and 14; **(7)** in February, 1891, new plates were required in one of the boilers, from the same cause; **(8)** on March 25, 1891, a fracture occurred along the eighth girth joint of No. 5; **(9)** in October, 1891, three plates had to be replaced in No. 3; **(10)** in 1892, a new bottom plate was required in No. 13; **(11)** in May, 1894, two fractures were discovered along the girth joints of No. 6 boiler, one of them (in the fifth ring) being 3 ft. 8 in. long, and the other (in the seventh ring) 3 ft. 10 in. long. **(12)** In May, 1894, a fracture developed in the sixth ring of No. 9; **(13)** in June, 1894, a fracture 2 ft. 3 in. long was found along a girth joint in No. 4; **(14)** in August, 1894, a similar fracture, 5 feet long, occurred in No. 2; **(15)** in March, 1895, another one was found in No. 4; and **(16)** on June 14, 1895, eleven of the boilers fractured completely around their girth joints, simultaneously, killing twelve persons, injuring about 20 others, and scattering destruction in all directions.

Such is the frightful record of this battery of boilers during the past few years. It shows plainly, that low water had nothing to do with the terrible *finale*, and it indicates, without much doubt, that the true cause was faulty support, combined, perhaps, with an improper arrangement of the feed-pipe. (We cannot speak positively concerning the feed-pipe, because we do not find that it was described by any of the witnesses, nor by Mr. Gough.) The fact that ten of the exploded boilers parted at the same place, indicates that the cause that determined the explosion acted similarly in all of them; and this consideration, alone, would be sufficient, almost, to exclude such irregular and accidental causes as low water, or overheating through accumulation of scale.

In closing this account we wish to say one word in defense of the externally fired boiler. All through the report of the investigation that we have reviewed, we find frequent expressions concerning the "liability of externally fired boilers to seam-rip." Doubtless these expressions were intended to refer to the long, plain cylindrical boilers of the Redcar type; but it is unfortunate that this limitation is left to be *inferred* by the reader. So far as the horizontal *tubular* boiler is concerned, we may say that in our wide experience we have not found this type to be liable to any such defect, when properly designed and constructed.

Inspectors' Report.

JULY, 1895.

During this month our inspectors made 7,952 inspection trips, visited 16,077 boilers, inspected 8,883 both internally and externally, and subjected 750 to hydrostatic pressure. The whole number of defects reported reached 13,983, of which 1,259 were considered dangerous; 95 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,138	58
Cases of incrustation and scale,	2,658	98
Cases of internal grooving,	219	27
Cases of internal corrosion,	1,045	64
Cases of external corrosion,	983	67
Broken and loose braces and stays,	149	40
Settings defective,	443	48
Furnaces out of shape,	525	28
Fractured plates,	353	64
Burned plates,	343	27
Blistered plates,	460	22
Cases of defective riveting,	1,544	91
Defective heads,	351	106
Serious leakage around tube ends,	1,865	234
Serious leakage at seams,	432	17
Defective water gauges,	357	69
Defective blow-offs,	199	61
Cases of deficiency of water,	11	7
Safety-valves overloaded,	81	32
Safety-valves defective in construction,	135	40
Pressure-gauges defective,	573	46
Boilers without pressure-gauges,	11	11
Unclassified defects,	108	2
Total,	13,983	1,259

Boiler Explosions.

JULY, 1895.

(166.)—The boiler at Lowry's mill, on Laurel Run, near Dunbar, Pa., exploded about June 28th. Several men were injured. [This account was received too late for insertion in the proper place.—ED.]

(167.)—The Howard roller mills, at Howard, S. D., were wrecked on July 2d by the explosion of a boiler. The building, which was four stories high, was totally demolished, and O. P. Walker, the engineer, was killed outright. T. C. Gould was fatally injured, W. H. Clark was injured so badly that he died later in the day, and J. P. Lawson died three days later. Robert Debolt also received painful injuries, and C. A. Lawson was badly burned, but will recover. The mill was recently fitted with new machinery throughout, and the loss will be at least $15,000.

(168.) — The boiler at the pumping station of the Yosemite mine, near Salt Lake City, Utah, exploded on July 2d. We have not learned of any fatalities or injuries, but the stoppage of the pump made it necessary to abandon the mine until new boilers could be procured.

(169.) — Alonzo H. Crocker's mill, at West Carlyle, twelve miles south of Grand Rapids, Mich., was blown to atoms on July 2d by the explosion of the boiler. Martin Skinner and Arthur Barney were instantly killed, and Avery Crocker was fatally injured.

(170.) — A boiler exploded at Paterson's tar works, on Front street, Toronto, Ont., on July 2d. The building took fire. No one was injured.

(171.) — On July 4th the boiler of a small pleasure boat on Wooton Lake, near Trinidad, Col., exploded. The boat was a small one, and the boiler was fired up on the Fourth for the first time this season. A trial trip had been made around the lake, and the passengers had just been unloaded at the wharf when the boiler exploded with terrific force, seriously injuring Charles Macomber and a Mexican boy and girl, whose names we could not learn. A number of others were more or less severely scalded and burned by escaping steam. Fortunately, the fragments of the boiler were blown away from the wharf; otherwise the results would have been appalling. The boat itself was entirely destroyed.

(172.) — A terrible boiler explosion occurred at McManaman's distillery, on the Short-Line railroad, about thirty-three miles from Louisville, Ky., on July 3d. The engineer, whose name could not be ascertained, was terribly scalded about the face and chest, and his right leg was shattered below the knee by a piece of flying iron. It is said that his chance of recovery is small. Mr. McManaman had examined the boiler a few minutes before the accident, and he states that he found everything apparently in good condition.

(173.) — A boiler exploded on July 4th, at Deacon, near Logansport, Ind., in Albert Irvin's saw mill. Wesley Woodruff was badly scalded, but will recover. The front end of the boiler passed through the side of the mill and damaged it to a considerable extent.

(174.) — John Niles's saw-mill, near Salt Lake City, Utah, was destroyed by fire on July 4th, while the owner and all of his men were absent. The boiler also exploded, but we cannot say whether the explosion was the cause of the fire, or the result of it.

(175.) — James Phillips was killed, and Joseph Cropper was seriously and perhaps fatally injured, on July 4th, by the explosion of a traction engine-boiler on Mrs. Jones's farm, in the Neck district, near Cambridge, Md.

(176.) — On July 6th, the boiler of a new steam yacht exploded on Lake Titus, near Malone, N. Y. The owner of the yacht, Mr. E. W. Knowlton, was badly cut about the head by flying pieces of iron, and at last accounts was in a critical condition. W. A. Short, who was also on the yacht at the time, was injured in the leg.

(177.) — A boiler at Schaffer's meat market, Lima, Ohio, exploded July 13th with great force. Mr. Schaffer's daughter was struck by a flying piece of iron and fatally injured, and Mr. J. C. Knapp was horribly scalded. One of the flues of the boiler is supposed to have been defective.

(178.) — A terrific boiler explosion occurred at Henry Wells's farm on Sunfish Creek, about twenty miles from Waverly, Ohio, on July 13th. Taylor Unger, the engineer, was blown nearly two hundred feet and was instantly killed, his skull being frightfully crushed. John Wells, a son of the owner of the place, was also killed. His neck was broken by the shock and he was terribly scalded. George Brant was frightfully scalded, and, although he was still alive at last accounts, his physician pronounced his injuries necessarily fatal. Two laborers, whose names we could not learn, were also badly scalded and burned, but it is believed that they will recover.

(179.) — The boiler of a saw-mill at Mt. Joy, near Portsmouth, Ohio, exploded on July 16th, and completely wrecked the mill. Wm. Long was badly injured.

(180.) — The boiler of a threshing machine exploded, on July 17th, near Tulare, Cal. Engineer Stephen Cornish, who was on the top of the boiler making some repairs, was killed. A man named Mitchell was also killed. Walter Carlton, who was standing directly in front of the fire-box, was fearfully injured. He was burned all over the body, and cannot live. Henry Nofsinger was injured so badly that his recovery is doubtful. John E. Roberts was scalded about the head, and is thought to be injured internally. His brother, Albert Roberts, was painfully burned about the head and neck, but it is believed that he will recover. Amos Johnson was scalded on the face, neck, and chest, and was also badly hurt by a fragment of hot iron. Henry Raymond was seriously scalded about the upper part of his body. William Braden and Frank Mitchell were also painfully scalded.

(181.) — About one o'clock on the morning of July 15th, the boiler of the Niagara Navigation Co.'s magnificent steamer, *Cibola*, exploded at Lewiston, N. Y. Within twenty minutes the steamer was a mass of flames, and shortly afterwards the American Hotel, which was near by, took fire, and the guests had hardly time to escape before the hotel was all ablaze. The steamboat hands, with the exception of third engineer Hammell, escaped by jumping into the river. Mr. Hammell's body was afterward found on the wreck, badly charred. The *Cibola* was valued at $225,000. Nothing was left of it but the iron hull. Mr. Hammell, the dead engineer, was hemmed in by flames near the coal bunkers, and was unable to escape.

(182.) — Missouri Pacific engine No. 235 exploded its boiler in the yards at Sedalia, Mo., on July 21st, as it was being attached to a train. Mr. M. H. Speady, the machinist at the shops, was thrown some distance and was badly scalded about the face, and seriously injured in the back. His condition is critical.

(183.) — On July 25th, a boiler used by a contractor on Third Street, Sheboygan, Wis., exploded, seriously injuring Leonard Verhulst and John Dorse. The boiler was entirely destroyed.

(184.) — Alexander Mousseau of Levaltrie, Ont., was killed by the explosion of a boiler in his creamery on July 26th.

(185.) — On July 26th, a boiler exploded on the Greenwalt ranch, near San Jose, Cal. A heavy iron plate struck George Greenwalt on the back of the head, fracturing his skull and killing him instantly. Horace Granger was badly scalded, and William Greenwalt was fearfully scalded from head to foot. It is probable that William Greenwalt will die, but Granger's injuries are not thought to be fatal.

(186.) — At Peckville, near Scranton, Pa., the boiler of locomotive No 181, on the Ontario & Western railroad, blew up on July 27th. Engineer Myers was instantly killed, and John Fritz was frightfully scalded. Conductor Kelley, and Brakemen Farrell and Murphy, were at the rear end of the train and escaped injury.

Spider Farming.

The following extract from the *Scientific American* may contain a useful suggestion to those housewives who don't know what to do with the eight-legged little creatures that spin webs in the corners of their rooms: —

"Although entomologists have often raised spiders for purposes of scientific observation and investigation, spider raising as a money-making industry is something rather novel. One has only to go four miles from Philadelphia, on the old Lancaster pike, and ask for the farm of Pierre Grantaire to see what can be found nowhere else in this country, and abroad only in a little French village in the Department of the Loire.

"Pierre Grantaire furnishes spiders at so much per hundred for distribution in the wine vaults of merchants and the *nouveaux riches*. His trade is chiefly with the wholesale merchant, who is able to stock a cellar with new, shining, freshly labeled bottles, and in three months see them veiled with filmy cobwebs, so that the effect of twenty years of storage is secured at a small cost. The effect upon a customer can be imagined, and is hardly to be measured in dollars and cents. It is a trifling matter to cover the bins with dust, but to cover them with cobwebs spun from cork to cork, and that drape the neck like delicate lace, the seal of years of slow mellowing, that is a different matter. The walls of Mr. Grantaire's spider house are covered with wire squares from six inches to a foot across, and behind these screens the walls are covered with rough planking. There are cracks between the boards apparently left with design, and their weather-beaten surfaces are dotted with knot holes and splintered crevices. Long tables running the length of the room are covered with small wire frames, wooden boxes, and glass jars. All of these wires in the room are covered with patterns of lace drapery, in the geometrical outlines fashioned by the spider artists. The sunlight streaming through the door shows the room hung with curtains of elfin-woven lacework.

"It is not all kinds of spiders that make webs suitable for the purposes of the wine merchant, and those selected by Mr. Grantaire are species that weave fine large ones of lines and circles. They are the only webs that look artistic in the wine cellar or on the bottles. The spiders that weave these are principally the *Epeira vulgaris* and *Nephila plumipes*.

"When Mr. Grantaire has an order from a wine merchant, he places the spiders in small paper boxes, a pair in a box, and ships them in a crate with many holes for the ingress of air. The price asked, ten dollars a hundred, well repays the wine merchant, who, at an expenditure of forty or fifty dollars, may sell his stock of wine for a thousand or more dollars above what he could have obtained for it before the spiders dressed his bottles in the robes of long ago. Mr. Grantaire has on hand, at a time, ten thousand spiders, old and young, the eggs of some of which, the choicest, he obtains from France.

"When the mother spider wishes to lay her eggs, she makes a small web in a broad crack, then she lays, say, fifty eggs, which she covers with a soft silk cocoon. In two weeks (or longer in winter) the eggs begin to hatch, an operation that takes one or two days. The egg shells crack off in flakes, and the young spiders have a struggle to emerge. Then they begin to grow, and in a week look like spiders. They often moult, and shed their skins like snakes. The brood has to be separated at a tender age, else the members of the family would devour each other until only one was left."

The Locomotive.

HARTFORD, SEPTEMBER 15, 1895.

J. M. ALLEN, *Editor.* A. D. RISTEEN, *Associate Editor.*

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WHILE the passenger steamer *Ataman* was landing at the town of Kaneff, Russia, on the river Dnieper, on August 22d, her boiler exploded, injuring thirty persons, some of them fatally. Several others jumped overboard in their efforts to escape from the clouds of steam, and were drowned.

A DISTRESSING accident occurred in the Wyoming Bottling Works, at Wilkesbarre, Pa., on July 28th. A large boiler used there for storing liquid ammonia gave way, and John Gebhardt, Harry Gabriel, and Philip Schmitt were fearfully injured. The air was filled with the fumes of the ammonia, and all the flowers, leaves, grapevines, and other vegetation in the neighborhood were blighted as if from frost. A large tree in front of the works was turned entirely purple, and numerous other trees in the vicinity were affected similarly, though to a lesser degree. We do not know the precise cause of the explosion, but it appears that Gebhardt, noticing a leak or something of the kind, undertook to set up the bolts that held one of the heads, while the boiler was under a pressure of 180 lbs. to the square inch. The head broke, and the contents were discharged.

We have repeatedly referred to the danger of screwing up nuts or bolts under pressure in this way, and the present disaster must be considered as one more object-lesson illustrating the reality of the danger. We wish it might prove a sufficient warning, but we are afraid that thoughtless men will continue in their old habits.

ON August 20th a "hang" fell from the top of a furnace in the Edgar Thompson Steel Works in Pittsburgh, Pa. John Grengo, Joseph Luckai, John Prokopovic, Stephen Havila, John Mika, Joseph Csop, Andrew Drobuah, and Michael Kafinos were killed, and eight other men received burns of such severity that some of them will probably die. It may be well to explain that a "hang" is a mass of slag and other refuse material adhering to the upper part of the blast furnace on the inside; and if it is allowed to remain, it increases in size until it either falls off of its own weight into the melted iron below, or, if its attachment is strong enough, until it entirely chokes the upper part of the furnace and prevents the escape of the gases which are liberated in the reduction of the ore. In the present case the "hang" had been neglected by the top fillers until the mouth of the furnace was nearly or quite choked up. A force of men was then sent up to remove it, and while they were at work it fell into the molten metal underneath, and the accumulated gases rushed out at the top, took fire, and exploded with a deafening roar. The sheet of flame which issued from the top of the furnace struck the men who were scattered about it, and blew them in all directions. One man was thrown over one of the elevators, and his body, striking a car below, was cut in two. Others were burned beyond recognition, and could be identified only by their clothing, or by physical peculiarities.

Riveted Joints.

We are often requested to give an opinion concerning the efficiency of a riveted joint, and our correspondents frequently neglect to give data enough for us to make an intelligent reply. In order to avoid unnecessary correspondence in such cases, we venture to suggest the dimensions that ought to be sent to us.

If the joint is single-riveted, it is sufficient to know the thickness of the plate, the diameter of the rivet (or of the hole into which the rivet is driven), and the pitch of the rivets — that is, the distance from the center of one rivet to the center of the next one. The material of which the plates are made should also be stated, as well as its tensile strength, when this is known.

If the joint is *double*-riveted it is necessary to know the diameter of the rivets (or of the holes), the pitch, or distance between the rivets from center to center (measured parallel to the edge of the sheet), the thickness of the plate, the kind of material of which the plate is made, and its tensile strength, if known. It is not usually necessary to give the distance between the two *rows* of rivets, for it is rare to find a double-riveted joint in which this distance is too small.

If the joint is *triple*-riveted, the data sent us should be similar to those specified above in the case of the double-riveted joint.

If the joint is of the *butt-strap* type, a sketch of it should be enclosed, and the pitch of the rivets (measured parallel to the edge of the plate), the diameter of the rivets (or of the holes), the thickness of the plate, and the thicknesses of the straps, should be marked on the sketch *very plainly*. The material of the plate, and its tensile strength, should also be given.

It is important, in giving the diameter of rivets, to state whether the dimension given is the *diameter of the rivet* before it is driven, or the *diameter of the hole* which the rivet is to fill; and, in general, it should be borne in mind that it is much better to send us *more* data than we would be likely to need, than it is to leave out something that it is really desirable or necessary to know.

Safety-Valve Examples.

Near the end of the article on "The Lever Safety-Valve," in our issue of last month, two numerical examples were given, in order that the engineer might test his understanding of the rules that had been stated. The solution of these examples is here appended:

Example I.— In this case the dimensions of the valve and the position of the ball are given, and the blowing pressure is required. This case is provided for by Rule I, and the numerical work is as follows: The ball weighs 80 lbs., and is 54″ from the fulcrum. It is therefore equivalent to a weight of

$$80 \times 54 = 4{,}320 \text{ lbs.},$$

hung at a distance of *one inch* from the fulcrum. The valve-stem being 3.5 inches from the fulcrum, we have

$$4{,}320 \div 3.5 = 1{,}234 \text{ lbs.},$$

which is the dead-weight that is equivalent to the ball. (That is, a weight of 1,234 lbs., applied directly to the valve-disk, would have the same effect as an 80-lb. weight hung 54″ from the fulcrum.) The second operation consists in finding the dead-load that would be equivalent to the lever itself. The center of gravity of the lever being 27″ from the fulcrum, and the weight of the lever being 20 lbs., it is easily seen that the lever is equivalent to a weight of

$$20 \times 27 = 540 \text{ lbs.},$$

hung 1″ from the fulcrum, or to a weight of

$$540 \div 3.5 = 154 \text{ lbs.},$$

placed directly upon the valve-disk. The ball being equivalent to a dead-load of 1,234 lbs., and the lever to a dead-load of 154 lbs., it is plain that the total dead-load, equivalent to the actual ball, lever, and disk, is

$$1{,}234 + 154 + 8 = 1{,}396 \text{ lbs.},$$

the "8" being the weight of the valve-disk and stem (which must be reckoned in, when a very nice calculation is desired). We conclude, therefore, that the valve will begin to blow when the total steam pressure against the disk amounts to 1,396 lbs. Now the disk being 5″ in diameter, its area is

$$5 \times 5 \times .7854 = 19.63 \text{ sq. in.}:$$

and the total pressure against this area being 1,396 lbs., it follows that the blowing pressure, expressed in pounds *per square inch* is

$$1{,}396 \text{ lbs.} \div 19.63 \text{ sq. in.} = 71.1 \text{ lbs. per sq. in.},$$

which is the answer sought.

EXAMPLE II. — In this case the blowing point is given in advance, and it is required to find the position of the ball. The diameter of the valve-disk being $4\frac{1}{2}$″, its *area* is

$$4\tfrac{1}{2} \times 4\tfrac{1}{2} \times .7854 = 15.90 \text{ sq. in.}$$

The desired blowing pressure being 80 lbs. per square inch, it follows that the *total* pressure of the steam against the valve disk, at the blowing point, must be

$$15.90 \times 80 = 1{,}272 \text{ lbs.},$$

and this must be just balanced by the weight of the ball, lever, and valve-disk. The valve-disk and stem weigh $6\frac{1}{2}$ lbs., and taking this away from the 1,272 lbs., we have

$$1{,}272 - 6\tfrac{1}{2} = 1{,}265\tfrac{1}{2} \text{ lbs.},$$

which is the "dead weight" to which the *lever and ball*, taken together, must be equivalent. Now the lever being fairly uniform, and 56″ long, we may consider its center of gravity to be at its middle point — that is, 28″ from the fulcrum. The lever weighs 15 lbs., and is therefore equivalent to a weight of

$$28 \times 15 = 420 \text{ lbs.}$$

hung 1″ from the fulcrum, or to a weight of

$$420 \div 2\tfrac{3}{4} = 152.7 \text{ lbs.},*$$

placed directly upon the valve-disk. Taking this away from the 1,265.5 found above, we have

$$1{,}265.5 - 152.7 = 1{,}112.8 \text{ lbs.},$$

which is the dead load that is equivalent to the ball alone. This dead load applied at a distance of $2\frac{3}{4}$″ from the fulcrum, is equivalent to a weight of

$$1{,}112.8 \times 2\tfrac{3}{4} = 3{,}060.2 \text{ lbs.},$$

hung 1″ from the fulcrum. The problem is therefore reduced to this simple form: To find where a 75-pound weight must be placed, in order that it may be equivalent to a

* In dividing by such a number as $2\frac{3}{4}$, it is convenient to proceed as follows:

$$420 \div 2\tfrac{3}{4} = 420 \div \tfrac{11}{4} = 420 \times \tfrac{4}{11} = \tfrac{1680}{11} = 152.7.$$

weight of 3,060.2 lbs., hung 1″ from the fulcrum. By the principle of Archimedes we have, at once,

$$3{,}060.2 \div 75 = 40.8 \text{ inches};$$

that is, the ball must be hung at a point 40.8 inches from the fulcrum, in order that the valve may blow at 80 lbs. to the square inch.

Height of Ocean Waves. — Dr. G. Schott, studying the form and height of the waves of the deep sea, found that under a moderate breeze their velocity was 24.6 feet per second, or 16.8 miles an hour, which is about the speed of a modern sailing vessel. As the wind rises the size and speed of the waves increase. In a strong breeze their length rises to 260 feet, and their speed reaches 360 or 364 feet per second. Waves, the period of which is nine seconds, the length 400 or 425 feet, and the speed 28 nautical miles per hour, are produced only in storms. During a southeast storm in the southern Atlantic, Dr. Schott measured waves 690 feet long; and this was not a maximum, for in latitude 28° south, and longitude 39° east, he observed waves of fifteen seconds period which were 1,150 feet long, with a velocity of 78.7 feet per second, or $46\frac{1}{8}$ nautical miles an hour. Dr. Schott does not think that the maximum height of the waves is very great. Some observers have estimated it at 30 or 40 feet in a wind of the force represented by 11 on the Beaufort scale (the highest number of which is 12); and Dr. Schott's maximum is just 32 feet. He believes that in great tempests waves of more than 60 feet are rare, and that even those of 50 feet are exceptional. In the ordinary trade winds the height is five or six feet. The ratio of height to length is about 1 : 33 in a moderate wind, 1 : 18 in a strong wind, and 1 : 17 in a storm; from which it follows that the inclination of the waves is respectively about 6°, 10°, and 11°. The ratio of the height of the waves to the force of the wind varies greatly. — *Popular Science Monthly.*

The Place of Iron in Nature.

Few elements are more abundant in nature than iron, while none is more widely distributed. Its compounds pervade every portion of the earth's crust. Among massive and stratified rocks alike, ferruginous deposits exists on an enormous scale, frequently assuming mountainous dimensions or covering many hundred square miles. The variety of their composition is hardly less remarkable. Thus the useful ores include ferric oxide (Fe_2O_3), known in the crystallized condition as specular iron ore and in the amorphous state as hematite; the magnetic oxide (Fe_3O_4), or magnetite; ferric hydrate (Fe_2O_3+ water), which occurs sparingly in the crystalline form as the mineral gothite ($Fe_2O_3H_2O$), but abounds in the amorphous condition of limonite ($2Fe_2O_3.3H_2O$, but probably a mixture of several hydrates); titaniferous iron, a mixture of ferric oxide with a variable proportion of titanic oxide (TiO_2); ferrous carbonate ($FeCO_3$), or spathic iron ore, with impure varieties known as clay ironstone. To these must be added iron disulphide (FeS_2), of which two crystalline modifications occur, *viz.*, iron pyrites, commonly met with in the form of brass-yellow cubes, and marcasite, much lighter in color, with a radiated structure. Among less abundant but noteworthy compounds may be mentioned magnetic pyrites (Fe_3S_4); copper pyrites (Cu_2S,Fe_2S_3), one of the most abundant ores of that metal; mispickel, or arsenical pyrites (FeSAs), the principal source of arsenic; vivianite, a ferrous phosphate of variable composition, met with in beds in which animal matter has decayed, often of a brilliant blue color.

A few illustrations of the magnitude of some ferruginous deposits may here be quoted. Pilot Knob, in Missouri, a hill seven hundred feet high, consists almost entirely of a single mass of hematite. Near Gellivara, in the north of Sweden, a mountain of magnetite exists, whose dimensions are reported as sixteen thousand feet long, eight thousand feet broad, and two thousand feet high. Beds of magnetite are met with among the Archæan rocks of Canada up to two hundred feet in thickness. In the same region are immense deposits of hematite, titaniferous ore, and iron sulphides. Zirkel describes Erzberg, a mountain in Styria, rising two thousand feet above the neighboring valley, as composed almost exclusively of spathic iron ore.

Besides those ferruginous deposits which from their form or dimensions are entitled to rank as independent rock masses, hosts of smaller aggregations are met with, such as veins, encrusting layers, nodules, and scattered crystals. Thus hematite often occurs in veins traversing crystalline rocks, while layers of ferric hydrate are deposited in their channels by waters containing iron, both above and below the surface. Many of the septarion masses so common in clayey strata consist essentially of clay ironstone. Hematite nodules, often containing fossil remains, abound among some of the carboniferous beds. Masses and single crystals of iron pyrites occur plentifully in some strata, marcasite in others, but what conditions determine the form assumed by the sulphide we do not know. The various "greensands" owe their appellation to the presence of grains of an iron silicate of very variable composition, known as glauconite; deposits of the same mineral are now forming in certain parts of the sea bed. Magnetite may here be mentioned as an essential consituent of basalt and other volcanic rocks, in which it occurs in the form of opaque octahedral crystals.

The most striking evidence of the universal presence of iron in nature is, however, found in the colors imparted by its compounds. Iron has justly been called "the great pigment of nature." Few deposits there are which are not tinged with iron in one chemical form or another. To it are due the brown, yellow, red, green, blue, and creamy tints which in endless variety characterize the vast majority of rocks. Green and blue colorations are produced generally by ferrous compounds, red by ferric anhydride, and yellow and brown tints by ferric hydrates. The presence of other substances, such as carbonaceous matter, largely affects the coloration in many instances.

Probably not more than eight or possibly ten of the elements occur in the earth's crust in larger proportion than iron. The significance of this fact will be appreciated when it is added that ninety-nine out of a hundred parts by weight of the crust are estimated to be composed of some sixteen elements at the most, leaving fifty or more which constitute the remaining one-hundredth part. Nevertheless, in comparison with oxygen, silicon, and aluminum, of which about eighty-five per cent. of the accessible rocks consist, a decidedly low place must be assigned to iron as constituting probably less than one per cent. of the whole, so rapidly does the relative abundance of the elements fall off. About half of the earth's crust is composed of oxygen.

Iron is, as would naturally be expected from the universality of its occurrence elsewhere, one of the elements, some thirty in all, which have been detected in the oceanic waters. Messrs. Thorpe and Morton report the presence of ferrous carbonate to the extent of one part in two hundred thousand in the water of the Irish Sea collected during winter. This proportion, if maintained throughout the ocean, would indicate the existence of more than four billion tons of metallic iron in solution.

In the organic world, again, iron appears to play an indispensable part. It is an essential constituent of the blood, while the production of chlorophyl in plants has been experimentally proved to be, in some way as yet imperfectly understood, dependent on the presence of iron in their nutriment. According to Ehrenberg, some species of diatoms secrete ferric oxide in considerable quantities.

But the existence of iron is not confined to our own planet. The spectroscope reveals its presence in the sun and many of the stars. It is also the chief constituent of meteorites.

Native iron is of very rare occurrence among the terrestrial rocks. Veins are all but unknown. It has most frequently been detected in the form of grains scattered through certain eruptive rocks, such as the gabbros belonging to the volcanic outbursts of Mull and Skye during the tertiary period, and in the basalt of the Giant's Causeway. Nordenskiold has discovered in the island of Disco, off the west coast of Greenland, a number of large masses of iron, one weighing nearly twelve tons; but whether they are of terrestrial origin is doubtful. Similar masses occur in the basalt of the vicinity. The great traveler himself regarded them as memorials of a meteoric fall during the outflowing of the rock in tertiary times; but Daubree has shown that the rock contains microscopic particles of iron, associated with certain other minerals in such a way as to exclude the hypothesis of the conjunction being accidental. He therefore concludes that the iron came from below with the other constituents of the mass.

This subject naturally raises the question, so often asked in view of the high density (about 5.5) of the earth as a whole compared with the average density (say 2.5) of the surface rocks, *viz.*, whether the interior contains large quantities of iron or other uncombined metals. Taking as a guide Sir A. Geikie's list of the sixteen most abundant elements, to wit, O, Si, C, S, H, Cl, P, F, Al, Ca, Mg, K, Na, Fe, Mn, Ba, it is observable that their heaviest combinations with one another barely reach the minimum specific gravity required to account for the earth's density. Whether the enormous pressure, vastly greater than any whose effects we can observe in our laboratories, to which the earth's internal layers are subjected, would serve to compress the materials to the requisite degree is exceedingly doubtful, while it is certain that the high internal temperature of the earth's interior must, to a large extent, counteract the reduction of volume through pressure. It seems most probable, therefore, that extensive deposits of heavy materials of some kind exist in the interior of the earth, and of such none is more likely to abound than iron, considering its high rank as a constituent of the crust.

Meteoric iron is known in masses varying from many tons in weight down to microscopic grains. The latter have been detected in the snows of the Alps and the Arctic region, and caught on board ship in midocean by means of sheets of glass smeared with glycerine and exposed to the wind. Grains of metallic iron abound in the red clay of the Atlantic Ocean, a fact which may be taken as a proof of its slow growth. Meteoric iron is invariably alloyed with metallic nickel. Until recently the natural occurrence of "nickel-iron" (as the alloy is termed, notwithstanding the predominance of the latter element) was unknown except as a constituent of meteorites. Masses of an alloy of the two metals (with other materials) have, however, been lately discovered in the gravel of a stream in Oregon, which differ in some remarkable respects from all meteorites hitherto known. Thus they do not exhibit the peculiar markings, termed "Widmannstatt's figures," when treated with nitric or hydrochloric acid. Josephinite is the name which has been given to the new mineral.

Iron is also found alloyed with platinum. A specimen from Siberia, analyzed by Berzelius, was found to contain 86.50 per cent. of platinum, 8.32 per cent. of iron, together with small quantities of palladium, rhodium, copper, and "gangue." Another sample from South America contained, of platinum 84.30 per cent., of iron 5.31 per cent., of rhodium 3.46 per cent., besides palladium, iridium, osmium, and copper, seven metals in all. — John T. Kemp, in *Knowledge*.

Incorporated 1866.

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Useless Tubes in Boilers.

Fourteen years ago an article under this heading was published in THE LOCOMOTIVE. It attracted some considerable attention at the time, and as there are still some boiler-makers who do not seem to understand how a tube *can* be useless, we reproduce the article in question, below, and we hope, shortly, to publish some further experiments on the same subject.

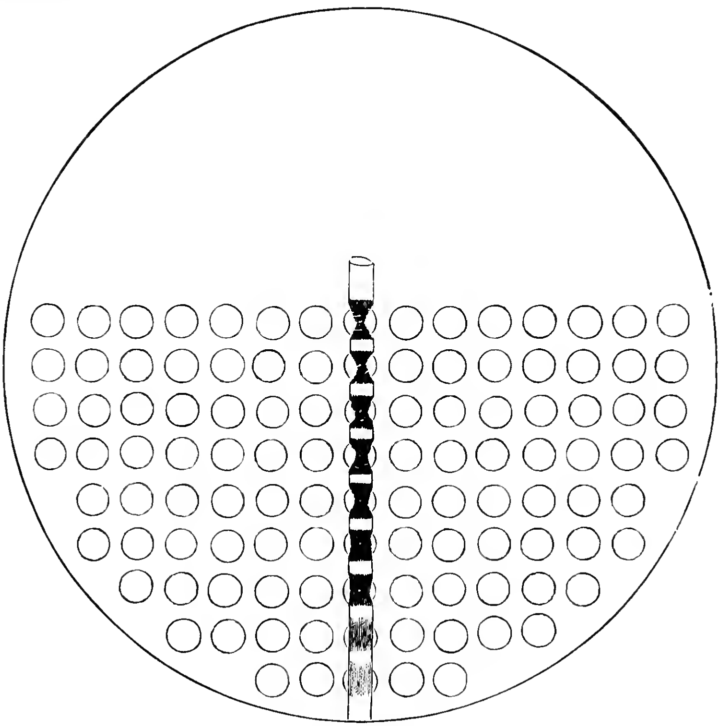

FIG. 1. — ILLUSTRATING THE EFFICIENCY OF TUBES.

In the early history of the horizontal tubular boiler the opinion prevailed that the more tubes that were crowded into a boiler, the greater the efficiency would be. It was not uncommon to find the lower half of a boiler literally packed with 2½-inch tubes. They were put down as near the bottom and the side sheets as the flanging of the tube-head would allow. They were arranged in the boiler on what is known as the "staggered" plan; that is, instead of being placed vertically one over another, they were so arranged that the tubes of one row were placed over the spaces of the row next below, and there were consequently no unobstructed spaces through which the water could circulate. But this was not the greatest difficulty. It is well known that the waters used in boilers generally carry more or less impurities in suspension — mechanical or chemical — and that these are deposited in the process of evaporation. The deposit so formed may consist of the carbonates or sulphates of lime or magnesia, or of argillaceous matter, or of mud. It settles upon the bottom and the tubes of the boilers, and if the cleaning is not frequent and careful, there will be formed, on the bottom and among the tubes, a

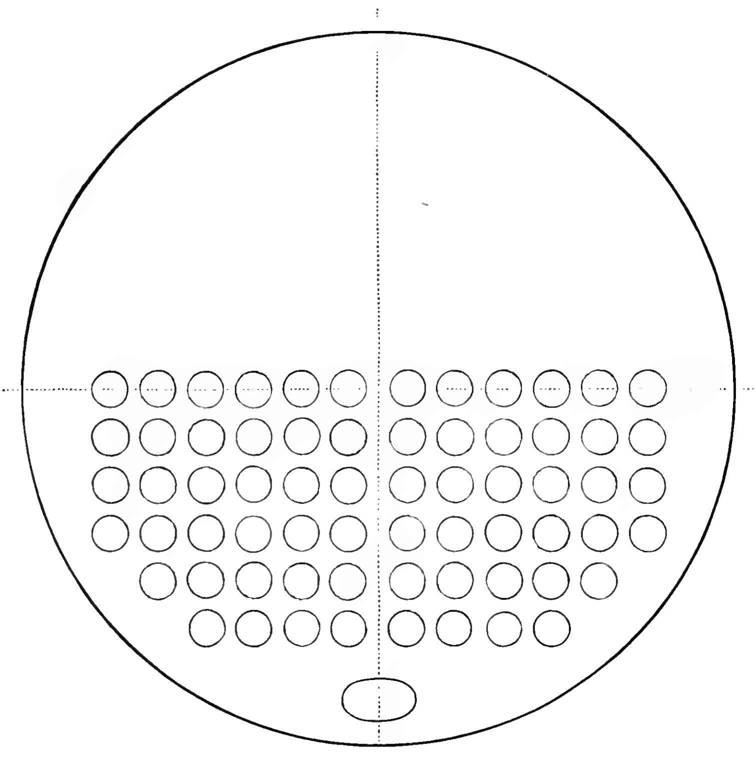

FIG. 2. — A BETTER ARRANGEMENT OF TUBES.

very hard scale, which cannot be removed without taking out the tubes. When this condition of things has come about, the efficiency of the boiler is greatly reduced. The heating surface being covered, more or less, by a substance which is a non-conductor of heat, the heat, in passing over it, is not taken up, and so passes on and is lost.

Matters were materially improved, in the course of time, by the introduction of tubes of larger diameter (3 inches), arranged in vertical and horizontal rows; but the tubes were still carried very near the bottom and sides of the shell, and the difficulty was only partially remedied. A great many boilers are made in this manner to-day, and it is a difficult matter to convince some boiler-makers that it is erroneous. Their argument is, "the more tubes, the more heating surface"; and it must be said that manufacturers, in many instances, have the same views, and in ordering boilers they demand an excessive number of tubes. One object in view in preparing this article is to show that too great a number of tubes does not make the boiler safer, or more efficient. It has been found by experiment that if the two lower rows of tubes in a boiler whose tubes extend down close to the shell are plugged up, the efficiency is not impaired,—we are speaking now of externally fired boilers. By studying the progress of the heated gases as they leave the furnace, it will be seen that they pass over the bridge wall, "lick" the bottom of the boiler its entire length, and then turn upward at the rear end and enter the tubes. The levity of these heated gases carries them mainly to the upper rows of tubes, and only a small portion of them enters the lower tubes. To demonstrate this in a way that will be understood by all (though it may not be regarded as occult enough to satisfy some individuals), a clean piece of soft white pine was placed at the front end of a boiler, nearly in contact with the ends of the center (vertical) row of tubes, as shown in Fig. 1, and was left in that position for several days. When again examined it was found that the end of the stick in contact with the upper tube was burned to a coal, so that it barely held together; at the tube next below it was little less charred, and the effects of the heat decreased more and more towards the bottom, as indicated in the illustration. Against the two lower tubes the wood was only a little discolored, showing that the upper tubes were most effective, while the very lowest were of little account.*

Another fault with the "close" arrangement of tubes is that, besides the trouble from deposit of sediment, there is no body of solid water for the heat to act upon as it leaves the furnace. In our experience we have found great difficulty with this arrangement of tubes, particularly when used with bad water. It gives a greater area of tube surface, but a considerable portion of the surface so gained is useless, and worse than useless, from the fact that the water space is unduly taken up by the superfluous tubes. Fig. 2 shows an arrangement of tubes which is far better. The lower row is well up from the bottom of the boiler, leaving a good solid body of water for the heat from the furnace to act upon. The tubes are kept well away from the shell of the boiler on the sides, no tube being nearer than three inches to the shell, and a space of double width is provided for between the center (vertical) rows of tubes. Good circulation is obtained, and the boiler is much easier cleaned and maintained at its maximum efficiency.

Inspectors' Report.

August, 1895.

During this month our inspectors made 8,345 inspection trips, visited 16,188 boilers, inspected 6,839 both internally and externally, and subjected 811 to hydrostatic pressure. The whole number of defects reported reached 13,431, of which 1,080 were considered dangerous; 101 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	986	68
Cases of incrustation and scale,	2,218	76
Cases of internal grooving,	204	25
Cases of internal corrosion,	942	59

* Our attention was first directed to this experiment by the Hon. H. B. Bigelow, Governor of Connecticut.

Nature of Defects.	Whole Number.	Dangerous.
Cases of external corrosion,	972	63
Broken and loose braces and stays,	129	34
Settings defective,	339	20
Furnaces out of shape,	455	21
Fractured plates,	370	65
Burned plates,	335	32
Blistered plates,	300	17
Cases of defective riveting,	1,443	74
Defective heads,	184	31
Serious leakage around tube ends,	1,958	186
Serious leakage at seams,	540	39
Defective water gauges,	497	91
Defective blow-offs,	209	43
Cases of deficiency of water,	27	17
Safety-valves overloaded,	60	21
Safety-valves defective in construction,	129	41
Pressure-gauges defective,	557	47
Boilers without pressure-gauges,	6	6
Unclassified defects,	571	4
Total,	13,431	1.080

Boiler Explosions.

AUGUST, 1895.

(187.)—On August 1st a section of a safety boiler failed at the Union Brewery in Peoria, Ill. The explosion occurred at just six o'clock, as the men were leaving the place. George Gipps and T. W. Slugel, the night engineer, narrowly escaped being scalded to death.

(188.)—A boiler exploded on August 2d in Akers Brothers' mill, situated about seven miles southeast of Kelseyville, Lake County, California. Eleven people were about the mill at the time of the explosion, but only four of them were injured. Joseph Thompson, the engineer, was killed, and Charles Fouts received injuries from which he has since died. John Akers, one of the owners, was blown high in the air, but was fortunate enough to alight in the top of a tree. He was severely injured, but will recover. One of the workmen, whose name we have not learned, was found in a pile of logs about seventy feet from the mill, with both legs broken. The front end of the boiler was blown four hundred feet.

(189.)—The boiler of locomotive No. 181, on the Ontario & Western Railroad, blew up with terrific force on August 3d, on a branch of the road leading to the Blue Ridge breaker at Peckville, Pa. Engineer Herman Myers was instantly killed, and Fireman John Fritz was frightfully scalded, and may die. The engineer was blown many feet into the air, and his body was found sixty yards from the scene of the explosion. Trees near the track were twisted into every conceivable shape, and pieces of the wrecked engine were blown in all directions.

(190.)—A threshing-machine boiler exploded on August 5th at Worley, fifteen miles west of Morgantown, W. Va. Curtis Ammons was instantly killed, and John

Blair, the owner of the machine, was probably fatally injured. John Pitsnaggle and two sons of John Blair were injured, but we could not learn how badly.

(191.) — On August 7th a boiler-head blew out at Tyson's Chrome Works, in Baltimore, Md. Stephen Scofield was severely scalded from head to foot, and at last accounts was in a critical condition.

(192.) — On August 7th a boiler exploded at Demorest, Ga., on the little steamer *Estes*. Some of the excursionists were slightly injured.

(193.) — By the explosion of a boiler at Richard Parham's mill, near Allensville, Ga., on August 8th, George Parham was killed, and William R. Parham, John Parham, and one other man were injured, some of them seriously.

(194.) — The boiler in W. H. Brennan's factory, at Atlantic City, N. J., blew up on August 8th, and several employés narrowly escaped scalding.

(195.) — George W. McMurray was killed on August 9th by the explosion of a boiler which was used for drilling an oil well near Oakdale, Pa. Victor Martin was slightly injured.

(196.) — The boiler of a steam-threshing machine owned by John Frazier exploded on August 9th near Sanford, Ind. Mr. Frazier, who was firing the boiler, was struck by a flying piece of iron, and badly injured. Several other men also received minor injuries.

(197.) — A boiler exploded on August 9th at the pumping-station near the Nickel Plate Railroad tank at Geneva, Ohio. Nobody was injured, but Lyman Cole had a narrow escape from death.

(198.) — A frightful boiler explosion occurred near Monticello, Fla., on August 10th, at P. B. Bird's steam mill and cotton gin. Allen Brooks, Prince Hall, and Amos Gross were killed, and James Reagan, Charles Harrison, Cinderella Johnson, and Nancy Johnson were injured. The buildings were completely wrecked, and the property loss was quite large. It is doubtful if the injured persons recover.

(199.) — On August 12th a boiler exploded in John Hines's mill on Clay Lick, near Mount Sterling, Ky. Hines was blown literally to pieces, parts of his body being found eighty yards from the mill. His son, Butler Hines, was also killed, and the fireman, Frank Smith, was fatally injured. A. J. Downs, one of the workmen, was also injured, and may not recover.

(200.) — A boiler exploded in the Empson canning factory, at Longmont, Col., on August 12th. John Baker, Albert Hanson, George Plain, Frank Printy, and Herbert Vaughn were more or less seriously scalded and bruised.

(201.) — A steam thresher exploded on the farm of Anton LaMott, at Hugo, near Anoka, Minn., on August 12th. Julius Cartier was blown to pieces, and his father, Joseph Cartier, was hit on the head by a flying piece of iron, and injured so badly that he died two days later. —— Merrier was also killed, and J. LaMott was seriously injured. Cartier owned two threshing engines, which had both been inspected and condemned the week before by Deputy Inspector Hanft. Both had serious cracks in the fire sheets. Joseph Cartier was licensed as an engineer, but his son, who was not licensed, was running the boiler at the time of the explosion. Inspector Sutton learned that young Cartier had weighted the safety-valve at three different times in order to get up greater speed, and he estimates that the pressure may have been in the neighborhood of 300 pounds when the boiler gave way.

(202.) — A small boiler in the stair-building shop of H. E. Hubbard, Meriden, Conn., exploded on August 12th. Nobody was injured, and the damage will not exceed a thousand dollars.

(203.) — On August 13th the boiler of a threshing machine belonging to David F. Clark of Clear Lake, S. D., exploded, scalding the fireman, James Altman, so badly that he died on the afternoon of the next day.

(204.) — A traction engine boiler belonging to Mr. James Elmore of Sadler, Texas, exploded on August 13th, killing the engineer, Stephen Miller, and severely scalding John Buchanan. Three other persons were scalded, but none of them seriously.

(205.) — A boiler exploded on August 14th in the Fort Orange Paper Company's mill at Castleton, near Troy, N. Y. One side of the boiler-house was blown out. James Lawton, the watchman, was killed instantly, and his body was found in the ruins. William Johnson, the fireman, was also fatally injured, and died a few hours later. The property loss was about $3,000. It is rumored that the fireman allowed the connection to the water column to become choked up, and that he did not use the gauge cocks, and therefore did not know where the water stood in his boiler. The men who were killed had both been in the employ of the paper company for fifteen years.

(206.) — A boiler on a threshing machine exploded at Oakland, I. T., on August 14th, instantly killing William Craft, Lee Norwood, and Pinkerton Norwood. William Tippet was badly scalded, and cannot recover; C. P. Hamm was bruised and scalded, and will die; James Wilken was also scalded, and is in a critical condition; Claude Howell and T. P. Carter were severely bruised; J. P. Walker was injured painfully, and Mr. Short, the engineer, was badly scalded, and will die. Half a dozen others received burns of a more or less serious character.

(207.) — On August 16th a boiler exploded in a mill at Carrabelle, Fla., tearing out the end of the engine-room, and throwing débris a great distance. Fortunately no one was hurt, although seventy-five workmen were about the building.

(208.) — On August 17th a threshing machine boiler exploded on the McNally farm, six miles southwest of Spencerville, Ohio, and the engineer was fatally scalded.

(209.) — On August 19th a boiler exploded in the basement of the Gumry Hotel, in Denver, Col., converting the rear half of the building instantly into a heap of ruins, and killing twenty-two persons. A number of others were seriously injured — we cannot say precisely how many, because the returns are somewhat unsatisfactory; our list, although incomplete, includes seven names. A daily paper gives the following graphic account of the attempts that were made to rescue those imprisoned in the ruins: "In front of the house there was the sound of glass falling, and people were rushing in night clothes in horror from the doors, and appealing piteously from the windows for help. . . . The firemen, with torch and lantern, entered all parts of the hotel. Out of the pile of brick, wood, and iron below there came feeble moans and piteous cries for help. . . . There still seemed to be no fire. The blaze had been smothered by the falling building, and the firemen devoted their efforts to the work of rescue. And then suddenly the flames broke out, and the workers were driven away, and the voices ceased to cry for help. The great mass was from that moment nothing but a grave. The most that the firemen could do, while the flames shot up fiercely and the smoke drove them back, was to fight fiercely for the life of one poor fellow whose head and shoulders protruded from the burning mass. At times the cries of a babe and the moans of men and women could be heard, but the flames and smoke increased, and finally the voices were all silenced." The explosion was one of the most fearful, so far as the loss of human life is concerned, that we can remember. In many respects it was similar to the explosion which destroyed the Park Central Hotel, in this city, on February 18, 1889, which was illustrated in our issue for March of that year. (The Park Central explosion resulted in twenty-three deaths.) The coroner's jury, after a six-days investigation of the Gumry Hotel disaster, found that it was impossible to fix the responsibility upon any one person, but that the owners, Peter C. Gumry and Owen Griemer, were blamable for allowing their engineer to work sixteen hours out of the twenty-four. They also censured the engineer, Heilmuth Loescher, charging him with negligence; and the city boiler inspector was criticised for not examining the boiler after repairs were made upon it. The total value of the property destroyed was about $75,000.

(210.) — A fearful boiler explosion occurred on August 20th at the New Bedford Machine Shop, New Bedford, Mass. The boiler-house was completely wrecked, and portions of the boiler were thrown 400 or 500 feet. Peter F. Healey was injured so badly that he died a short time afterwards in the hospital. Charles Paddleford was painfully injured. The boiler not only carried away the boiler-house, but also passed through the eighteen-inch stone wall of the main building.

(211.) — A boiler in William Gordon's planing mill at Udora, Ont., exploded on August 20th. Mr. Andrew Thompson was badly injured, and died in about two hours. A small baby (the property of Mr. Wesley Ruttle) received a scalp wound from a fragment of the boiler. The property loss was about $2,000.

(212.) — A threshing-machine boiler exploded on August 23d near Hickson, N. D. Engineer James Conley was badly burned about the head and face, and two of his ribs were broken. John Johnson, the fireman, was fearfully injured about the head. Both men will recover. Several other employés received minor injuries.

(213.) — Monroe Babcock and Annie Hoffman, a nine-year-old girl, were killed on August 26th by the explosion of a threshing-machine boiler at Oowassa, near Eldora, Ill. Three other persons were badly injured, and it is feared that some of them may not live.

(214.) — A boiler exploded on August 29th in the car factory at Warsaw, Ind., killing Quincy Nebruner, the fireman, and James Hoffman, a teamster.

(215.) — A threshing machine boiler blew up at Ardock, near Grafton, N. D., on August 31st. Engineer Patterson was instantly killed.

An inspector writes as follows: "Upon calling at ———'s mill to make an inspection, a short time ago, I found the safety-valve sent away for repairs! A blank flange had been bolted on in its place, and the engineer was going to run without any safety-valve until the old one had been repaired and returned. They were carrying from 60 to 70 lbs., and the boiler was rather old. I told the engineer not to fire up the boiler at *our* risk, as we would not carry it a single hour. He considered the matter a short time, and finally put on another valve before firing up."

The Locomotive.

HARTFORD, OCTOBER 15, 1895.

J. M. ALLEN, *Editor.* A. D. RISTEEN, *Associate Editor.*

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THERE always will be pessimists in the midst of us, ready to tell of the retrograde tendencies of the world, and to point out ways in which the civilization of previous centuries was better than that of to-day. The supposed physical degeneracy of the modern man and woman is a favorite theme with these philosophers, and we are frequently invited to look 'way back across the ages to the palmy days of Rome and Athens, and to reflect on the anatomical superiority of the barbarians who "flourished" in those times. Well, we haven't any quarrel with our pessimistic friends; they are apt to be good fellows, though we wish they would give a little more weight to the statistics that show an increase (in recent years, at any rate) in the average duration of human life. Nevertheless, it is refreshing to find a man who is planted as firmly on the other side of the fence as Prof. T. Clifford Allbut appears to be. "I do not hesitate to say," he writes, "that when I look back upon the young men and women of forty and thirty years ago, I am amazed rather at the physical splendor and dashing energy of our young friends of to-day. The world seems to have filled with Apollos and Dianas; cheap food and clothing, improved sanitation, athletics that bring temperance with them, frequent changes of air and scene, and a more scientific regulation of all habits, seem, since my adolescence, to have transformed middle-class youth; and the change is rapidly spreading downward" [*i. e.*, into the lower classes].

President E. F. C. Davis.

We regret to announce the death of Mr. E. F. C. Davis, president of the American Society of Mechanical Engineers. Mr. Davis was born at Chestertown, Md., in 1847, and was graduated from Washington College, Maryland, in 1866. Subsequently he became an apprentice with Brinton & Henderson of Philadelphia, after which he worked for Hoy, Kennedy & Co. of Newcastle, Del. Several years later he went to Pottsville, where he was employed first by the Pottsville Iron & Steel Co., and afterwards by the Colliery Iron Works. In 1878 he became superintendent of the Pottsville shops of the Philadelphia & Reading Coal and Iron Co., and nine years later he became mechanical engineer for the same company. In 1890 he was made general manager of the Richmond Locomotive & Machine Works, which position he held until last spring, when he became general manager of the C. W. Hunt Iron Works of New York city. Mr. Davis was Vice-President of the American Society of Mechanical Engineers from 1891 to 1893, and was President of the Society at the time of his death, on August 6th. He was a man of marked ability, and his personal qualities commanded the respect and esteem of all who were so fortunate as to know him.

We append a transcript from the minutes of the American Society.

"The American Society of Mechanical Engineers desires, through its Council, to spread upon the records of the Society and of its Council a minute expressive of the respect and regard which its members feel and seek to make public, upon the sudden and untimely death, from an accident, of their colleague, Mr. E. F. C. Davis, President of the Society. The formal mould of memorial resolutions in which a corporate body ordinarily records its action seems inadequate for a proper voicing of the spirit which pervades the Council in the presence of the death of one whom its members had known so well, and whom they had learned to admire and to love. His wise and mature judgment, his business and professional knowledge, his conservative yet energetic counsel, and his courteous consideration for others, had made him one from whose administration of the Society's affairs the highest hopes had been entertained. Although with such grief the stranger intermeddleth not, yet the Council would presume to express their heart-felt sympathy with those nearest and dearest to Mr. Davis, upon whom this blow has so crushingly fallen.

"*Resolved*, That copies of this minute be furnished to the engineering journals, with a request that they give it publicity in such a way that it may serve to convey to the profession something of the sorrow and regret with which the American Society of Mechanical Engineers has heard of their loss, in the death of their President."

SOLDERS FOR GLASS. — Mr. Charles Margot finds that an alloy composed of 95 parts of tin and 5 of zinc melts at 200° [C.?], and becomes firmly adherent to glass, and, moreover, is unalterable and possesses a beautiful metallic luster; and, further, that an alloy composed of 90 parts of tin and 10 of aluminum melts at 390° [C.?], becomes strongly soldered to glass, and is possessed of a very stable brilliancy. With these two alloys it is possible to solder glass as easily as it is to solder two pieces of metal. It is possible to operate in two different manners. The two pieces of glass to be soldered can either be heated in a furnace and their surface be rubbed with a rod of the solder, when the alloy as it flows can be evenly distributed with a tampon of paper or a strip of aluminum, or an ordinary soldering iron can be used for melting the solder. In either case, it only remains to unite the two pieces of glass and press them strongly against each other and allow them to cool slowly. — *Scientific American.*

Concerning Thermometers.

Of all the instruments that are used in making physical measurements, there is surely none that seems simpler, at first sight, than the thermometer. The problem of determining the temperature of a body would appear to consist simply in applying the bulb of the thermometer to the proposed body, and noting the scale-reading on the stem, after the mercury has ceased to rise or fall.

When, as in most engineering problems, the temperature of a body is not required with any very great nicety, the operation of determining it is indeed quite as simple as is indicated in the foregoing paragraph; but when it is proposed to determine a temperature *with all the accuracy possible*, the problem is quite a different one. It is seldom necessary to measure a temperature closer than the nearest half-degree, yet it sometimes happens (as, for example, in finding the mechanical equivalent of heat), that *hundredths of a degree* are too large to be neglected; and in such cases the skill of the experimenter is taxed to the utmost, to detect all the possible sources of error, and eliminate them. Some of the difficulties that are met with in refined thermometry are suggested in the following article, and others may be found in the published accounts of the more exact of the various physical researches that have been carried out during the past thirty years or so.*

In the first place, we cannot hope to have any very precise measurement of temperature, until we have a correspondingly precise definition of the quantity to be measured —that is, until we know with great accuracy just what is meant by the word "temperature." We all know, in a general way, what temperature is, and we can usually tell, without much difficulty, which of two bodies is the hotter or the colder; but this general estimation of a temperature, directly by the senses, is a very different thing from the precise measurement of it, to the hundredth of a degree. The first case may be compared to the determination of a distance by roughly *pacing* it, and the second one to *measuring* it with a millimeter scale. We cannot *measure* temperature, in the proper sense of the word, until we have first provided a rigid, unvarying scale, with which the proposed temperature can be compared with great precision.

There is no special difficulty in devising such a scale—in fact, the trouble is that there are so many of them possible, that it is not easy to make the best selection. We might make use of the properties of saturated steam, for example, and define temperature as proportional to the pressure of the steam, or to the square root of that pressure, or to the logarithm of it, or to any other convenient function of it. Or we could vary the same idea by substituting some other kind of saturated vapor for the steam. Or, again, we could make use of the fact that the electrical resistance of a metal changes with the temperature; and we could define temperature as proportional to the change in electrical resistance of a given piece of platinum wire, or any other kind of wire. Many other plans will readily occur to the reader, and it will not be necessary to give further examples. Either of the foregoing methods is well worth serious consideration; and, in fact, they are both actually used, in one form or another, in certain kinds of investigation. It is more usual, however, to make use of the familiar fact that the size of a body changes when the temperature alters. Most substances grow *longer* when they are heated; other substances, such as rubber, and iodide of silver, grow *shorter;* and it is possible to cut bars from certain kinds of crystalline bodies, in such a way that their lengths are quite *independent* of the temperature. We might select some convenient metal, such as iron, or silver, or platinum, and define temperature as proportional to the change in length of a bar of this metal. We might find it hard to put this method into practice, but nevertheless it is logical, and it is certainly theoretically sufficient. In fact, it is in constant use in our own office, for indicating the general temperature of one of the rooms; though we should not care to use it, if any great accuracy were required. In all ordinary cases, it is preferable to make use of the expansibility of some sort of fluid, contained in a transparent envelope. Various kinds of fluid are used for this purpose. The careful scientist uses air, or nitrogen, or hydrogen, for reasons that we cannot here discuss; but it is much more common to use a liquid of some kind, sealed up in a glass tube. A great number of liquids have been tried in this way, and mercury has been found to give the most general satisfaction, although alcohol and glycerine are

* See for example, Rowland, in the *Proceedings of the American Academy of Arts and Sciences* for 1879, and Griffiths, in the *Philosophical Transactions of the Royal Society of London*, volume 184.

also used to some extent; and temperature is usually defined as "proportional to the apparent expansion of a mass of mercury, enclosed in an envelope of glass." *

Suppose, then, that this be accepted as a convenient definition. The next thing to do is to choose a convenient zero-point, from which to reckon the temperatures, and a convenient size of *degrees*. These may be selected in various ways. Thus Fahrenheit, in order to avoid having to deal with temperatures *below* zero (or *negative* temperatures) took, as his zero-point, the coldest temperature known to him. This was obtained by placing the bulb of the instrument in a mixture of snow and salt. The lowest point reached by the mercury was then marked "zero." The size of the degrees could then be chosen arbitrarily, and the stem spaced off into equal lengths; or some other fixed point could be selected, and marked "100°," or "500°," or "1,000°," or any other convenient number, and the stem divided into a corresponding number of equal parts. This second method was the one adopted by Fahrenheit. Making use of the fact that the temperature of the human body is nearly constant, he placed the bulb of an alcohol thermometer in his mouth, and marked the point to which the fluid rose "24°". Later on he decided to call this higher temperature "96", ($96=4\times24$), in order to make the degrees come of more convenient length; and he then divided the stem, between these points, into 96 equal parts.

Such was the original Fahrenheit system. It was good enough for general household use, but entirely too crude for scientific purposes. Neither of the fixed points could be determined with any approach to precision, and hence no two thermometers agreed with each other, when graduated in this way. When it came to be known that the freezing point of water, and the boiling point (under standard conditions of pressure), are exceedingly constant, the plan of graduation was changed. The temperatures of freezing and boiling were not the same on all thermometers, on account of the imperfections in graduation which we have noted above; but they seemed to be about 32° and 212°, respectively, and these values were finally adopted as definitive. A Fahrenheit thermometer is therefore graduated, nowadays, by immersing it first in *freezing* water, and then in the steam rising from *boiling* water; the stem is marked "32°" and "212°" at these respective points, and the intermediate graduation marks, 180 in number (since $212° - 32° = 180°$), are so placed that the volume of the mercury-thread, between any two successive divisions, shall be the same in all parts of the stem. The process is the same with the *Centigrade* thermometer, except that in this case the fixed points are marked "0°" and "100°", and the space between them is divided into 100 parts, instead of 180.

We shall not dwell upon the difficulties that are met with in the actual experimental determination of the fixed points of a thermometer, as these are pretty well covered in most of the standard books on physics. It will be sufficient to say that the boiling-point is the more difficult of the two to determine, because careful attention must be paid to the height of the barometer, as the boiling-point is known to vary with the pressure. It is also found that the temperature of boiling water is not always precisely the same even under a constant pressure. The slight differences that exist appear to depend upon the state of purity of the water, upon the nature of the vessel in which it is contained, and upon the way in which the heat is applied. The *steam* that rises from the water, however, appears to have always the same temperature, provided the pressure be

* The scientist has what he calls an "absolute scale," which does not depend upon the special properties of any particular substance. This scale, which is based upon certain general equations in thermodynamics, is coming more and more into favor; but what we say in the text about the "usual" definition of temperature, is nevertheless quite true.

kept constant; and hence it is customary to immerse the bulb of the thermometer merely in the *steam*, and not in the *water*.

We said that the degree marks on a thermometer must be placed so that the *volume* included between any two consecutive marks shall be the same in all parts of the stem. If the capillary bore of the stem were of *uniform diameter* throughout, this would be the same thing as dividing the stem into degrees of equal *length*; but unfortunately it is found to be impossible to produce a thermometer whose stem shall have a truly cylindrical bore. Usually they are more or less conical, being greater in diameter at one end than at the other; but they are *always* somewhat irregular, and a thermometer is of no use whatever, in accurate scientific work, until it has been "calibrated"; that is, until the irregularity of the bore has been investigated at every point of the stem. It is usual, therefore, to graduate the stem of a delicate thermometer into degrees of *uniform length*, and after the variations of the bore have been investigated, a table of corrections is prepared, which takes all these irregularities into account, and enables one to apply, to any given reading, a correction which will reduce that reading to what it would have been, if the bore of the instrument had been perfectly true. The accurate calibration of a thermometer is quite a delicate operation, and calls for no little skill and patience.

Even after the fixed points have been determined, and the instrument has been calibrated with precision, there are numerous sources of error remaining, some of which are exceedingly perplexing. In the first place, there is what we may call the "personal error" of the instrument. To understand what this is, we must remember that our temperatures are not measured by the simple expansion of *mercury* alone. When the temperature rises the mercury indeed expands, *but so also does the glass vessel that contains it*. The bulb of the thermometer grows larger, too; and it is easily seen that if the mercury did not expand at all, the expansion of the bulb would cause the thread in the stem to travel *downwards*, instead of upwards; and we should have a thermometer in which the higher graduations would be nearest the bulb. In the real instrument both the mercury and the glass expand, and what we actually observe is the *difference* between the two expansions. It is probable that all samples of pure mercury would expand equally, under equal changes of temperature; but it is quite certain that different specimens of glass do not do so, even when they are taken from the same melting. The difference is no doubt due partly to slight differences in composition, and

COMPARISON OF THERMOMETERS.

A	*B*	*C*	*D*	*A*	*B*	*C*	*D*
°	°	°	°	°	°	°	°
212.00	212.00	212.00	212.00	356 00	358.41	358.77	357.93
230.00	230.13	230.16	230.11	374.00	376.52	377.08	376.00
248.00	248.32	248.40	248.25	392.00	394.52	395.33	393 98
266.00	266.58	266.68	266.45	410.00	412.70	413.69	412.00
284.00	284.92	285.06	284.74	428.00	430 88	432.00	430.07
302.00	303.26	303.44	302.99	446.00	449.10	450.43	448.16
320 00	321.66	321.88	321.30	464.00	467.24	468.95	466 45
338.00	340.05	340 32	339.62	482.00	485.15	487.22	484.41

partly to the various unavoidable stresses that exist in the finished thermometer, and which cannot be entirely removed by annealing. Whatever the *causes* of the irregular expansion of glass may be, the *result* is that even when a pair of thermometers agree perfectly at certain temperatures, they are sure to disagree at other temperatures. In order to show the reality of these differences, and to give some idea of their magnitude also, we present a short table, showing the results of a comparison of four mercury in-glass thermometers which were examined by Regnault. These thermometers (distinguished in the table by the letters *A*, *B*, *C*, and *D*) all agreed perfectly at the freezing point and the boiling point, and the readings have all been corrected for imperfections in the bore, so that the differences between them are due simply to the unavoidable "errors of observation," and to what we called, a short time ago, the "personal errors" of the different instruments. The original thermometers were graduated according to the Centigrade scale, but we have reduced all the readings to the Fahrenheit system, as this is likely to be more familiar to our readers. Thermometer *A* is here taken as the standard, but there is no reason for preferring it to *B*, or *C*, or *D*. That is, when *A* read 482.00° under certain conditions, and *C* read 487.22° under the *same* conditions, there was no reason for preferring either of these readings to the other; and yet they differ by over five degrees!

There are several ways to get rid of the "personal error" of a thermometer. One is to investigate the expansion of the glass envelope by a separate series of experiments, planned for this especial purpose. Such experiments are very troublesome and expensive, however, and it is better to merely compare each thermometer with a standard one, which has been elaborately investigated, once for all, and which is carefully preserved for this purpose. Comparisons of this kind are made, for a reasonable charge, at several places. The Johns Hopkins University may be mentioned, in this country, and the Kew observatory in England.

In addition to the various errors due to the structural imperfections of thermometers, there are others which depend upon the way in which they are used. For example, if the bulb of a thermometer is immersed in a hot liquid, and the stem is left out where the temperature is a couple of hundred degrees lower, the mercury in the stem will be cooler than that in the bulb, and the resulting reading will be too low. The error due to this cause will be quite small, but nevertheless it is not absolutely negligible when refined measurements are required. Again, it is no easy thing to make the bulb of a thermometer come to the *exact* temperature of a body in which it is submerged. At first the bulb approaches the desired temperature very rapidly, but soon the thread moves slower and slower, and when the difference has sunk to only a tenth of a degree or so, there is scarcely any discernible motion of the thread. It follows that there is always danger of taking the reading *too soon*. Theoretically, it would take an infinite time for the thermometer to acquire the precise temperature of the liquid in which it is immersed; but in practice, an hour or two may be sufficient to bring the two near enough together to make a reading practicable. This error may be eliminated by taking the mean of two measurements, one made by immersing the thermometer when *warmer* than the liquid to be investigated, and the other by repeating the experiment with the thermometer *cooler* than the liquid.

The effect of variations in the atmospheric pressure are also felt by delicate thermometers. The bulbs of such thermometers are thin, and they yield sensibly under an increase in pressure; so that a given reading will be too high when the barometer stands higher than it did on the day the thermometer was standardized, and too low if the barometer stands lower than it did at that time. According to some authorities this "barometric error" is proportional to the difference between the atmospheric pressure at the time the thermometer is read, and that which prevailed at the time it was standardized; but Professor S. U. Pickering, who is a very careful observer, found that the error does not follow this simple law with accuracy, but that every thermometer has its own peculiar irregularities, which must be separately investigated.

There is also what is known as a "capillary error," in delicate thermometers. The phenomenon which is known to physicists under the name of "surface tension," and which causes small masses of liquid to behave as though their surfaces were little elastic bags or membranes, produces a pressure within the bulb of the thermometer, which is greater, the greater the convexity of the top of the thread in the thermometer stem. If the convexity of this surface were always the same, the capillary error could be neglected; but as a matter of fact the top of the thread is flatter when the thermometer is falling, and rounder when it is rising; it is also flatter where the bore of the stem happens to be a little larger than it ought to be, and rounder where the bore is a little too small. These irregular capillary effects are of considerable magnitude when the bore of the thermometer is made very fine (with the object of attaining greater sensitiveness); and they are often sufficient to cause the mercury to move past certain parts of the graduation by jerks and jumps, rather than with the regular, uniform expansion that is essential to accuracy. Such thermometers are extremely vexatious, and their readings are always regarded with suspicion.

One of the most troublesome things about a delicate thermometer is the fact that when it is used to measure a proposed temperature its reading is not entirely determinate, unless special precautions are taken; that is, the temperature that it indicates will depend, not simply upon the *actual* temperature that is to be measured, *but also upon the recent history of the thermometer itself*. This is due to the fact that when glass is subjected to an alteration in density, or to a new distribution of strains (as it is when its temperature is changed), it does not immediately go back to its original condition. Some observations made by Rowland in connection with this point may be of interest. Taking a thermometer which had lain in its case for four months or so, at a temperature of about 70° to 75° Fah., he found that when immersed in freezing water it read precisely 32.00° (after the various known corrections had been applied). He then heated it to 86° Fah. for a short time, and found that after this treatment it indicated the temperature of freezing water to be 31.97°. It was next heated to 104.9°, after which the reading, in freezing water, was 31.94°. Similar experiments were tried at other temperatures, up to 212°. After being heated to 194°, for example, the reading in freezing water was 31.58°. After a short boiling (at 212°) the reading was 31.44°; and after a more prolonged boiling it was 31.38°. The experiments were then ended, and the thermometer was examined, from time to time, to see how long it would be before its reading was again correct. The reading, shortly after the boiling, was 31.38°, as we have already said. Nine days later it was 31.80°; and after a month it was 31.96°. (Much larger errors are introduced when the thermometer has been used for *high* temperatures; in some cases thermometers have been known to read as high as 70° or so, when placed in freezing water after having been used for a considerable time at temperatures near the boiling point of mercury.) Rowland concluded, from his experiments, that after a delicate thermometer had been employed for measuring a temperature of not more than 100° Fah. or so, it would be in condition for use again in about a week.

There is one more source of error to which we desire to refer, and that is, the gradual rise of the freezing point, which goes on progressively as the thermometer grows older. Joule observed one of his thermometers for many years, and found the results given in the following table. The second and fourth columns give the readings that he obtained from the thermometer upon immersing it in freezing water on the dates given in the first and third columns. This progressive change in the freezing-point (as read by the thermometer) appears to be due to the shrinkage of the bulb of

Date.	Reading.	Date.	Reading.
April, 1844,	32°.00	March, 1867,	32°.91
February, 1846,	32 .42	February, 1870,	32 .93
January, 1848,	32 .51	February, 1873,	32 .94
April, 1848,	32 .53	January, 1877,	32 .98
February, 1853,	32 .68	November, 1879,	32 .99
April, 1856,	32 .73	December, 1892,	33 .02
December, 1860,	32 .85		

the thermometer. It is somewhat rapid when the instrument is quite new, and hence it is customary to let delicate thermometers lie in their cases for six months or so, after they are made, before attempting to graduate them.

Concerning Long Cylindrical Boilers.

To the Editor of THE LOCOMOTIVE, *Sir:*

I have read the account of the Redcar boiler explosion, in your issue for September, and I believe that this one and that at Shamokin resulted from the same cause. I often wondered why so many of the boilers exploded simultaneously, and I now firmly believe that the peculiar construction of the boilers was the cause of the trouble. Long cylindrical boilers are hard to hang up evenly, and hence the girth seams are likely to be strained to a great extent. At the blast furnaces of the Milwaukee Iron Company (now the Illinois Steel Company) they used to have ten plain cylindrical boilers, 60 ft. long and 42 in. in diameter, each of which was hung from five cast-iron arches straddling the boiler and resting upon the side walls. When the boilers were cold and the hangers were adjusted to carry the load evenly, the boilers were certainly well hung, but as soon as the firing began, the ends of every one of them lifted up from two to three inches, leaving the entire boiler and its heavy contents (including the brick covering) hanging on the middle arch. The boilers were torn off their seats at the ends, lifting small pieces of wall with them; and the girth seams near the middle were severely strained. But as the boilers were mostly in use, it was considered best to screw up the end hangers to help to carry the weight. Now, any variation of steam pressure, due to greater or lesser firing, or any other cause, would shape the curve of the boiler differently, and when the boiler was cooled down for cleaning, the middle hangers would get loose so that the boiler then rested upon its ends, straining the end girths the most. Many of those kind of boilers are so arranged that they are resting more on the ends when hot, and *only* on the ends when cold. As all boilers in a nest are treated about alike with uneven firing, and with cooling down, and as the iron and steel in all is about alike, and also the workmanship, it stands to reason that they all are weakened about in the same degree. You will remember that the Shamokin boilers also broke in two, and that their ends flew in opposite directions. I believe no boiler ought to have more than two hangers or lugs on each side. Mr. Geo. Hackney, master mechanic of the Milwaukee Iron Company, about twenty-two years ago saw the danger and had all the boilers cut in two and connected by copper goose necks, each half being hung to two arches, and this certainly was a good step.

R. BIRKHOLZ, M.E.,
Pabst Brewing Co.

HARTFORD STEAM BOILER INSPECTION AND INSURANCE CO.
HARTFORD, CONN.

Incorporated 1866.

Charter Perpetual.

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LOSS OF LIFE AND PERSONAL INJURIES,

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The Locomotive.

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On the Support of Long Cylindrical Boilers.

In the September issue of The Locomotive we gave some account of the great boiler explosion which occurred at Redcar, England, on June 14, 1895, and in the course of the article we attributed the explosion chiefly to the strains produced in the shells of the boilers *through faulty methods of support*. The support of long cylindrical boilers is a problem of the first importance, and as we have said but little on this subject for some years past, it may be well to touch upon it again.

In the first place, it is necessary to understand the trying conditions under which these boilers are run in the rolling mills and iron works in which they most frequently occur. They are run day and night, and there are great and violent changes in the work required of them, with correspondingly sudden variations of pressure. The engines may be running light, for example, and using little or no steam, when suddenly

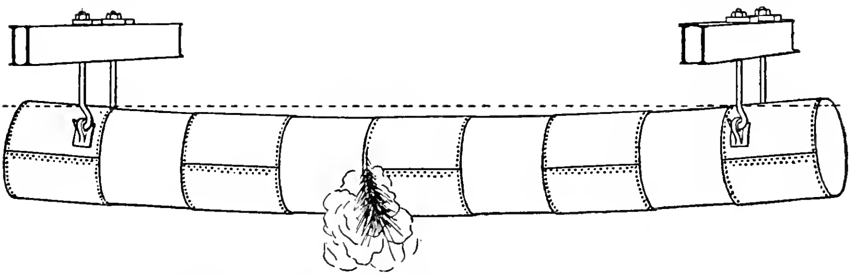


Fig. 1.— Illustrating the Sag of Long Boilers, when Improperly Supported.

a heavy bloom is seized by the rolls and the machinery comes almost to a standstill — the engine-valves being then wide open, and the draft of steam tremendous. The pressure in the boiler may fall materially while this heavy work is going on, but it will be only a few moments before the rolls are running light again, with the steam pressure up almost to the blowing-off point.

The extraordinary *length* of these rolling-mill boilers would be quite sufficient to make the problem of support a serious one, even if the work required of them were fairly uniform. They are frequently fifty feet long, and those which exploded at Redcar were no less than *sixty-six* feet long. Such boilers, even when exposed merely to the conditions of ordinary service, would be expected to change their shape sensibly under such variations of pressure and temperature as might occur; and in rolling-mill practice, where these variations are far greater, the changes of form, and the corresponding variations in the distribution of stress in the shell of the boiler, are far more serious. The long rolling-mill boilers are heated by the waste gases from blast-furnaces or cupolas, and the conditions under which they are run are very variable. At times the combustion chamber under the boilers will be fairly cool, — hardly hotter than the boilers themselves, — while at other times great sheets of flame sweep along the shell for its entire length.

Rolling-mill boilers have frequently been supported rigidly at three points — one at each end and one in the middle, — as shown at *A*, *B*, and *C*, in Fig. 2. This might seem to be a proper disposition of the supports, but experience shows it to be faulty and dangerous. The hot gases, striking against the lower shell plates, raise the temperature of the bottom of the boiler so that it becomes sensibly hotter than the top. The bottom of the boiler therefore expands and becomes longer than the top, and the boiler becomes curved in the manner illustrated, on an exaggerated scale, in Fig. 1. The entire load is

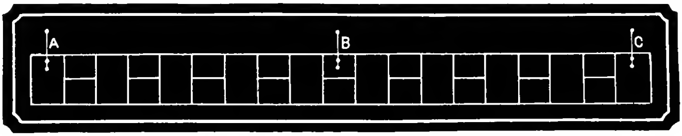
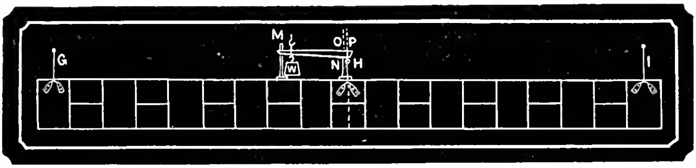
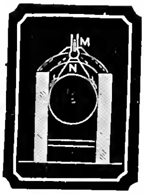


FIG. 2.—A LONG BOILER WITH THREE SUPPORTS.

then thrown on the middle support, and this, unable to carry such a heavy burden, sometimes breaks away, and the boiler falls until the end supports are again taut. The shock so produced, together with the strains already existing in the shell, on account of the pressure, often proves too great to be resisted, and the boiler parts at a girth joint, and great destruction follows. (Fig. 1 represents a boiler which is in the act of parting around one of its girth joints, in consequence of the great strain thrown upon the joint by the weight of the boiler and its contents, together with the steam pressure.)

In designing a mode of support that shall be safe and effective, the point to be borne in mind is the necessity of providing for the possible motion of the boiler, under the varying conditions of service. The supports must be strong and substantial, and





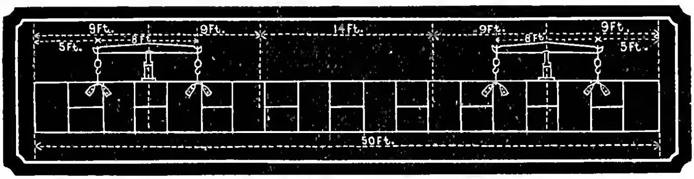
FIGS. 3 and 4.—METHOD OF SUPPORT BY MEANS OF A COUNTERPOISE.

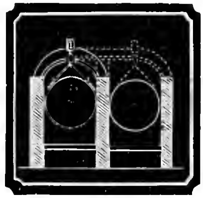
yet they must not be too rigid and unyielding. It is also necessary to see that the boiler is not bound up tightly in the brick-work; for if it is, fractures are very likely to occur.

The necessary pliability of the supports may be attained in various ways, and some of the methods that have been proposed are quite elaborate. We shall suggest only two of the simpler modes that have been tried and found to be satisfactory. A plan that has worked well in practice is shown in Figs. 3 and 4. Here there are three supports as before, but the middle one is not rigid, its hangers being attached to a lever which is provided with a weight, *W*, proportioned so as to counterbalance the weight of the boiler. To adjust this apparatus properly, the weight of the boiler and its contents must be known. As an example, let us suppose the boiler to be 50 feet long, and 48 inches in diameter. Allowing for laps, rivets, heads, and the contained water, the whole would weigh about 30,000 pounds. The center support would carry half the weight of the boiler, or 15,000 pounds.* If the lever be so proportioned that the fulcrum is 3 inches from the end *H* (where the hanger is attached), and 60 inches from the weight *W*, then, by the principle of the lever, we have

$$3'' \times 15{,}000 \text{ lbs.} = 60'' \times \text{(the weight } W).$$

Now $3 \times 15{,}000 = 45{,}000$, and $45{,}000 \div 60 = 750$ lbs., which is the weight that must be hung at *W* to balance the load that comes on the hanger *H*. (Of course in practice there are two hangers at *H*, one on each side of the boiler. In the calculation here given the two are supposed to be secured to the same lever, as indicated in Fig. 4.) It is well to make the weight, *W*, in ***sections***, so that it can be handled conveniently. The lever should run in guides that are placed ***outside*** of the weight *W*, as shown in Fig. 3; and there should be a seat for the end of the lever to rest on when the boiler is empty or not under steam.





FIGS. 5 and 6. — METHOD OF SUPPORT BY MEANS OF EQUALIZING LEVERS.

The other mode of support, referred to above, is shown in Figs. 5 and 6. In this method the weight of the boiler is supported by four pairs of hangers, which are secured to equalizing beams as suggested in Fig. 5. To illustrate the method with some degree of definiteness, we have assumed the boiler to be 50 feet long. The first support is then 5 feet from the end of the boiler, and the beam; from the outer hanger to the inner one, is 8 feet long. (It might be 10 feet long with advantage.)

There are many other ways of supporting long boilers, and in deciding on the adoption of any one of them the important point to bear in mind is whether or not the proposed system has sufficient pliability to allow the boiler to change its size or shape slightly, without interfering with the equal distribution of the load on all of the supports.

Inspectors' Report.

SEPTEMBER, 1895.

During this month our inspectors made 7,937 inspection trips, visited 16,072 boilers, inspected 6,391 both internally and externally, and subjected 845 to hydrostatic pressure. The whole number of defects reported reached 11,712, of which 970 were considered dangerous; 13 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment, - - - - -	1,171 -	- 63
Cases of incrustation and scale, - - - - -	2,094 -	- 59
Cases of internal grooving, - - - - - -	61 -	- 5
Cases of internal corrosion, - - - - - -	642 -	- 8

* To make this clear, consider the boiler to be cut in two at the middle, the inner ends of the two halves being both attached to the middle hanger, as at present. Then this hanger would hold half the weight of each half of the boiler; that is, it would hold *one-half of the weight of the whole boiler*.

Nature of Defects.	Whole Number.	Dangerous.
Cases of external corrosion,	865	32
Broken and loose braces and stays,	144	65
Settings defective,	264	16
Furnaces out of shape.	426	32
Fractured plates,	188	47
Burned plates,	162	10
Blistered plates,	192	1
Cases of defective riveting,	1,665	106
Defective heads,	47	15
Serious leakage around tube ends,	2,002	288
Serious leakage at seams,	396	24
Defective water-gauges,	416	98
Defective blow-offs,	170	30
Cases of deficiency of water,	18	2
Safety-valves overloaded,	55	19
Safety-valves defective in construction,	61	20
Pressure-gauges defective,	540	26
Boilers without pressure-gauges,	3	3
Unclassified defects,	130	1
Total,	11,712	970

Boiler Explosions.

SEPTEMBER, 1895.

(216.) — A boiler exploded on August 24th, at the Somaceo Mills, at Palermo, Cal. The mills were destroyed, and five persons were killed and twenty injured.

(217.) — On August 26th a boiler exploded at Minster, Ohio. Frank Busse, Carl Garrouss, and Henry Garrouss were fatally injured. Busse's skull was fractured, and the other men were injured internally.

(218.) — A boiler in George T. Houston & Co.'s large saw-mill, at Bixbee, near Armory, Miss., exploded on August 28th. Alonzo Bean was killed instantly, and Rufus Paine received injuries from which he died a few hours later.

(219.) — The boiler of the Wharf Company's pile driver at Galveston, Texas, exploded on August 28th. Thomas Cullom, the fireman, was seriously scalded and burned.

(220.) — On August 29th, the boiler of Berry Bros. steam cotton gin, eight miles east of Corsicana, Tex., exploded, demolishing the building, killing two men, and injuring several others. The gin was working smoothly on its fifth bale, and Mr. Lee Berry, the engineer, stated that the gauge showed 100 lbs., which was the pressure regularly carried by the boilers. The building was wrecked, and John Berry was killed. Lee Berry was covered with brick and other debris, and fatally injured. A Mr. Hardwick, for whom the cotton was being ginned, was blown thirty feet and slightly injured.

(221.) — A boiler exploded on August 29th, in John Flaugh's saw-mill, about twelve miles east of Huntington, Ind. Jacob Flaugh (a son of the proprietor), and Frank

Fahl were killed, and John Flaugh, Jr., was buried under a pile of debris, and somewhat injured. The mill was totally wrecked, and the noise of the explosion was heard for miles around. [The foregoing accounts were received too late for insertion in the August list, where they properly belong.— Ed.]

(222.) — On September 2d, a boiler used in drilling an oil well at Hydetown, near Titusville, Pa., exploded. The boiler was blown to fragments, but fortunately nobody was injured, although there were nine persons in the immediate vicinity. Samuel R. Wilson, the tool dresser, had just been at the boiler, and had returned to the derrick when the explosion took place. He states that there was plenty of water in the boiler, and that the steam gauge, which was thirty pounds "shy," registered sixty pounds, making the actual steam pressure ninety pounds. Portions of the boiler were found 1,800 or 2,000 feet away.

(223.) — A hot-water boiler exploded, on September 5th, in the kitchen of the Pennsylvania Training School, at Elwyn, Pa. Mary Leypoldt had her left arm and shoulder badly scalded. The boiler was wrecked.

(224.) — A boiler exploded on September 5th, in the Oscoda Lumber Company's mill at Oscoda, near Bay City, Mich. The roof of the boiler-house was blown off, and the fireman, Edward Ely, was severely scalded. He will recover.

(225.) — On September 5th, a threshing machine boiler exploded on William Cuthbertson's farm, at Ripon, near Wheatland, N. D. Fireman Louis Berry was killed. Engineer John Buddie was fearfully injured, and died some days later. Peter Broderick was also badly scalded, and may die. The boiler and engine were literally blown to pieces.

(226.) — A boiler exploded, on September 6th, in Cladfelter's mill, at Hatton, near Marshall, Ill. The mill was torn to pieces, but the only person injured was Albert Gaby, who was somewhat scalded.

(227.) — A threshing machine boiler exploded, on September 7th, at Penn, near Devil's Lake, N. D. George Bail's leg was crushed, and he may die; Philip Lonsell had a rib broken; Andrew Nelson was scalded; and Trefle Bail's arm was broken in two places.

(228.) — A boiler exploded in the Lovejoy machine shops, at Richmond, Mich., on September 9th. Fortunately no one was in the vicinity at the time.

(229.) — One of the four boilers in the Marine City Stave Co.'s salt works, at Marine City, Mich., exploded on September 10th. The boiler-house was completely demolished, no part of it being left standing. Roswell Heath, who was firing the exploded boiler, was fearfully scalded about the back, neck, shoulders, and arms, and badly bruised about the face. Charles Essenberg was also severely bruised about the face, and terribly scalded about the body and hands. It is almost certain that Essenberg cannot recover, and Heath's recovery is also doubtful. The exploded boiler was repaired, last spring, at an expense of about $1,200, and was also tested, hydrostatically, to 100 lbs. At the time of the explosion it was carrying only 60 lbs. The property loss is variously estimated at from $10,000 to $20,000.

(230.) — A boiler exploded on a ferryboat at Decatur, Neb., on September 11th. Nobody was injured.

(231.) — One of a battery of twenty-four boilers, at the Logan Colliery of L. A. Riley & Co., at Centralia, near Shamokin, Pa., exploded on September 11th. The parts of the exploded boiler were hurled about 200 yards, and seven other boilers were displaced. A piece of iron crashed through an adjoining engine house and badly injured Harry Hunter and John Coolick. The property loss is about $5,000.

(232.) — A boiler exploded, on September 12th, in James Reed's quarry, at Bay View, near Gloucester, Mass. The explosion occurred at night, and nobody was injured.

(233.) — The boiler of F. M. Cates' cotton gin, near Waynesboro, Ga., exploded on September 12th. Five men were badly scalded and bruised, and two of them will die. The exploding boiler cut down a gum tree eight inches in diameter, which stood sixty yards from the gin, and then continued in its course for thirty yards more, before striking the ground. Seventy feet of shed were blown entirely away, and half of the boiler setting was blown down.

(234.) — F. E. Crosby was fatally wounded, on September 13th, by a boiler explosion in Mayfield, Ky. James Kimball was also badly scalded.

(235.) — On September 13th a boiler exploded in L. C. Fritch's stave mill, at South Huntingdon, Pa. Blair White, one of the engineers, received an ugly bruise, but the other employés providentially escaped injury. Considerable damage was done.

(236.) — An oil-well boiler exploded on September 13th, on the Zoda farm, at Jerry City, near Bowling Green, Ohio. James Fisher, the pumper on the lease, was killed.

(237.) — On September 18th a boiler exploded in Frank Weekly's mill, at Proctorville, near Central City, West Virginia. Mr. Weekly was blown to pieces. George Matthews was also instantly killed, his body being found fifty yards away. William Turner, the engineer, was badly cut about the head, and cannot live. Several other hands were injured in a lesser degree. We have not seen any estimate of the property loss.

(238.) — A boiler exploded on the night of September 20th, on the C. & P. dock, at Cleveland, Ohio. Nobody was injured, and the damage was not great.

(239.) — On September 20th, a threshing-machine boiler exploded on Clement Joyce's farm, near Skaneateles, N. Y. Charles King and Albert Ogden were painfully scalded, but it is believed that they will recover. The property loss is estimated at $4,000.

(240.) — A boiler in use at the Montgomery County Infirmary, six miles west of Dayton, Ohio, exploded on September 21st. Paul Butonhorne and Pearl Rhodes were killed, and James Hoolan, William Johnson, Mary Miller, and Frederick Ulmer were severely injured. It is feared that Hoolan may not recover, as he received a deep cut in the abdomen. The building containing the insane ward was badly wrecked.

(241.) — On September 23d, a new hot-water heating boiler exploded in the dry goods store of H. F. Winders & Son, at Findlay, Ohio. Flying pieces of iron buried themselves in the walls and ceiling, the front and rear of the storeroom were blown out, and hot water was thrown everywhere. Isaiah Earlywine and D. C. Ford were slightly injured.

(242.) — Two plain cylinder boilers exploded, on September 24th, at the Enterprise Colliery, Shamokin, Pa. John Rodonk was seriously scalded. The boiler-house was wrecked and several other boilers were displaced. The property loss was about $2,500.

(243.) — On September 26th, the back head blew out of a threshing-machine boiler in Luxemburg, near St. Cloud, Minn. Martin Ahels, the engineer, was instantly killed. His body was hurled ninety feet, passing through a fence on the way.

(244.) — A boiler exploded, on September 28th, on the Hamlin Ranch, near Delano, Cal. Walter Garwood was instantly killed. William Miller had both legs broken, and was injured internally. Louis Sagacy was scalded slightly, and William Rowlee and several others were also slightly injured.

(245.) — Samuel Sinsibacker was terribly injured, on September 29th, by the explosion of a boiler at Ulrichsville, near Cleveland, Ohio.

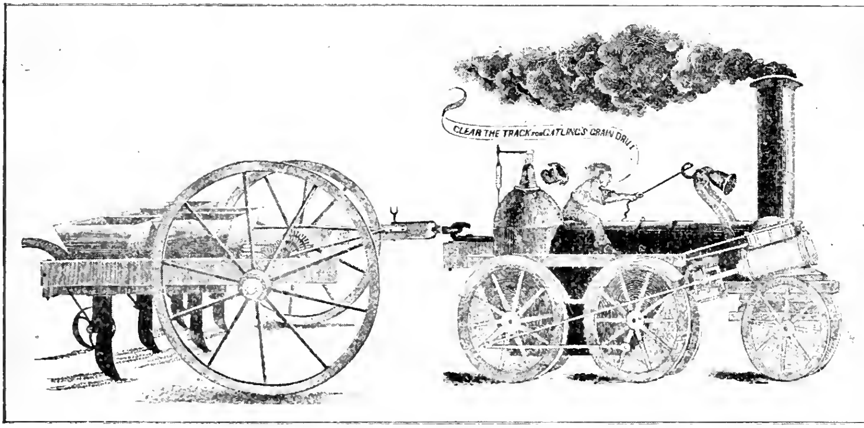
(246.)— On September 30th a boiler exploded in the bone factory at Pelham, near Lowell, Mass. The building was completely demolished, but fortunately nobody was injured.

The Story of Two Inventions.

In the year 1838, Richard Jordan Gatling, now the famous inventor, was then a young man in his twentieth year, working on his father's farm in North Carolina. He had made up his mind to go into business as a country store-keeper at the cross-roads near his home, and as his father favored the project, he went to Norfolk to buy his goods. While at the hotel in that city he heard a discussion about a trial that was to come off the next morning, at the Navy Yard, of boats with submerged wheels, and learned that the Navy wanted such a thing, and had offered a prize for the best device. A man named Harris had made a boat with lateral submerged wheels, and was to exhibit it that day. Young Gatling went down and saw the boat, and heard the projector's description of his invention, but was not favorably impressed with it. Harris died, and a man named Hunter took it up, and persuaded the Government to build a boat on his plan; but it never succeeded.

Gatling went home and pondered over the boat he had seen, and its disadvantages, and finally got up a model boat on a principle of his own, which was the "propeller," as it is now styled. The model was about 18 inches long, and its power was derived from a whalebone spring, which, by unwinding a cord from a shaft, ran the little pioneer "propeller" up and down the basin which he had constructed from the fish-pond on his father's premises. The boat worked successfully, and was the wonder of his family and the neighbors. The young inventor was so firm in the idea of the value and feasibility of his invention for propelling vessels that he asked for permission to go to Washington at once and get it patented; but his father was skeptical, and it was over seven months before Gatling got started for the Capital. It was then winter, and on his arrival at Annapolis the ice was so thick that an ice-breaker had to be used to reach Baltimore. Arriving at Washington, he left his model at a hotel and went at once to the Patent Office. Being a country lad, and rather shy, he thought he would first look around the office (it was a small concern then) and see if he could discover anything there like his own invention. Not seeing anything of the sort, he went back to the hotel, and wrapping up the model in a paper, took it under his arm and returned to the Patent Office. He explained to the man in charge of the models what he wished, and asked if there was anything in the office like his model. He was informed that only three or four days previous "a man by the name of Ericsson" had deposited a similar model, and, taking Gatling into a small room which the young man had overlooked in his preliminary survey, the attendant showed him Ericsson's model, which was almost identical with his own. The young inventor was nearly heartbroken, and returned home discouraged. At that time the idea of claiming priority did not occur to him. He supposed that the first man in the office with his model was the "best fellow." It is quite needless to speculate here as to who was the *first* to invent this great improvement, for at that time Gatling had not heard of Ericsson, nor was Ericsson probably aware of the existence of Gatling. Had Gatling known then as much of patent law as he learned afterward, the question of priority would have no doubt been settled.

Time, however, heals all wounds; the propeller was laid aside, and the inventive miud of Gatling busied itself with other matters. In 1842 the young man invented a



FROM AN OLD ADVERTISING CIRCULAR, ISSUED BY DR. GATLING IN 1845.

machine that was the pioneer in sowing grain by machinery, his machine being first used for sowing rice; but as the amount of rice raised was small in comparison to other grains, the sale of the machine was limited. In 1844, while clerk in a dry-goods house in Market street, St. Louis, Gatling read in an English paper that some one in England had invented a machine for sowing wheat in drills, which had largely increased the crop. He immediately took up his rice-sowing machine, and giving up his position as clerk, turned his energies to the development and adaptation of his machine for the sowing of wheat. He had the first lot of improved machines made in St. Louis. They sold fairly well, but the farmers objected to the regular cash price, and doubted its working well. In order to prove his faith in his own machines, and to sell them, he bargained to sell the machine for the difference between the crop raised on 20 acres sown by his machine and 20 acres sown broadcast. The difference being about 5 bushels to the acre in favor of the drill, he sold many machines at a larger price than he originally asked for them. The next season the success of the first was his advertisement, and the wheat-drill was an established agricultural implement.

F. W. P.

THE danger of having a poor fireman, or of giving him too many things to do, in addition to his regular task of caring for the boiler, is daily illustrated by incidents in our business. At a recent external inspection of an upright boiler, for example, our inspector found a hot fire burning, with the fire door shut, and 100 lbs. showing on the steam gauge, although the boiler is not supposed to carry over 60 lbs. The safety-valve was stuck. The try-cocks were out of order and broken, and there was no water showing in the glass gauge. The lower try-cock; when opened, showed very blue steam. After deadening the fire with fresh coal, and allowing the boiler to cool down somewhat, the injector was started, and it was fully half an hour before the water showed at the lowest try-cock. Of course it would be absurd to continue insurance upon a boiler so neglected. The policy was therefore canceled.

An interesting article by Dr. H. C. Hovey, on "The Isles of Shoals," is published in a recent issue of the *Scientific American Supplement.* We cannot print it in full, but the following abstract, which appeared in the *Scientific American*, may be of interest :

The Isles of Shoals are nine miles out to sea from Portsmouth, N. H. They consist of nine small islands, five of which belong to Maine and four to New Hampshire. Although discovered in 1614 by Captain John Smith, and visited since by thousands of tourists, their geology has been neglected. After briefly giving a few historical facts, Dr. Hovey tells what he found during his explorations among the rumpled and twisted rocks of this group. There are proofs that Star, Haley, Cedar, and Malaga islands are undergoing a process of elevation, having risen six feet within fifty years. Pot-holes that once were at tide level and used by the fishermen as basins for cleaning fish, are now a hundred feet back from the sea, and six feet above the ordinary tides. The channel between these islands was formerly six feet deeper than it now is. The petrography of the islands has only been partly worked out; but the signs of igneous action are impressive. Dikes of diorite and gneiss and seams of quartz and feldspar run in every direction. The trap rock yields more readily to the action of the sea than do the granite rocks, and on being worn away, leaves channels through which the waves rush with violence. In some cases the work is not yet complete, and the huge basaltic blocks lie like gigantic stairs, thus justifying the etymology of the word *trap*, which comes from "trappa," meaning steps.

A remarkable column on Appledore Island is described: it is eleven feet in diameter, and must once have been as much as twenty-five feet high, but now has been singularly sliced off by the waves. In shape it is sharply hexagonal. The rock is light colored granite, crushed and baked, and protrudes from a mass of black gneiss, beyond which are walls of white granite. It is an altogether unique occurrence.

The violence of the waves that beat about these islands would seem incredible were not so many proofs at hand. Some of them are given by Dr. Hovey. The Leightons, who own most of the islands, built a stone wall six feet high and six feet thick, to protect their Appledore hotel; but a single winter storm broke it down and scattered the stones in every direction. Last winter a storm carried great boulders completely across the islands. A boulder weighing many tons was tossed by the waves and lodged on the cliff of White Island, fifty feet above the sea level. Lightning has also done its share in the work of demolition. Glacial action has been powerful, too. These causes combined — glacial, aqueous, igneous, and electrical — have rent these islands apart, severed them from the mainland, and ground up their rocks into the masses of sand that are now piled up as dunes about the mouth of the Merrimac.

The Locomotive.

HARTFORD, NOVEMBER 15, 1895.

J. M. ALLEN, *Editor.* A. D. RISTEEN, *Associate Editor.*

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AMONG the boiler explosions given in our list this month, we find another good example of popular ignorance of the extreme violence of these occurrences. "Some miscreant blew up the boiler in James Reed's quarry last night," the account says, "by putting a keg of powder into it, and then touching it off." We don't doubt that this appeared, to those who heard the explosion, to be the only possible explanation of the affair.

OUR esteemed contemporary, the *Popular Science Monthly*, appears this month in a somewhat new dress. The most striking change is in the title, which has now become *Appleton's Popular Science Monthly.* The body of the magazine is substantially the same as before: but in the latter part we note some minor typographical changes, and a somewhat different plan of arranging the book notices. The contents of the November issue are fully up to the high standard that the *Monthly* has set for itself in the past.

PROF. John G. Flather, of Purdue University, has written a little volume on *Rope-Driving*, in which he discusses the transmission of power by means of ropes. The subject is well covered, and the book is freely illustrated, containing ninety-two photo-engravings, some of which are half-tones. We heartily commend the volume to those seeking information on the subject of which it treats. (New York, John Wiley & Sons. Price $2.00.)

MESSRS. John Wiley & Sons also issue *The Encyclopedia of Founding*, by Mr. Simpson Bolland, whose books, *The Iron Founder* and *Iron Founder Supplement*, we have noticed in former issues. The present work is arranged, as its title indicates, after the manner of an encyclopedia, the various entries being given in alphabetical order. There are a great number of cross references which add to the value of the book materially. The information given is extremely varied, and includes pretty much everything that a founder would want to know, from the crudest general principles of the art up to such refinements as the casting of handwriting and embroidery impressions. We think it would have been clearer in some places if illustrations had been used; but on the whole the book is quite satisfactory, and forms a worthy successor to Mr. Bolland's other writings. (Price $2.00.)

We publish, in this issue, an article entitled "The Story of Two Inventions," by Col. F. W. Prince, who has known Dr. Richard J. Gatling intimately for many years, and is now associated with him in business. The story of the propeller is especially interesting, though not more so, perhaps, than that of the grain drill. Some of our older readers may remember the quaint advertising circular that was posted about in country stores and other such places, half a century ago, and from which our illustration is taken. The hard-handed sons of the soil used to gather about that circular, and remark, with some freedom of speech, upon the discomfort that the engine-driver would surely experience, if he didn't change his base. But this good-natured criticism only drew attention more widely to the circular, so that it proved a very good advertisement, and a great many machines were sold.

We have received a copy of Mr. Thomas Pray, Jr.'s, *Steam Tables and Engine Constants*, which is published by the D. Van Nostrand Company, 23 Murray street, New York. It contains a considerable number of tables relating to steam and steam engines, and should prove very useful. Mr. Pray says that "every table in this work was computed, not copied"; and he adds that the data upon which they are based were taken directly from Regnault, Rankine, and Dixon. Originality is uncommon in tables of this kind, and should lend especial interest and value to the present volume. We note with pleasure the following lines in the preface: "The author has a full translation of the important papers of Regnault now nearly ready to publish, and it will follow this volume with only a short interval." The engineering world will be deeply indebted to Mr. Pray for the translation that he promises.

Louis Pasteur.

Louis Pasteur, the great French chemist and bacteriologist, died at his home at St. Cloud, France, on September 28th. Dr. H. W. Conn, in his memorial article in *Science*, says of him: "Never has the world been called upon to lament the death of one whose life was so full of gifts to humanity as that of Louis Pasteur. Others have lived with equal genius, others there have been whose influence upon thought has been equal or greater. Others have achieved an equal reputation from achievements of various kinds; but no other man in the history of the world has given to mankind so many valuable gifts as those which have come from the labors of Pasteur." He was born at Dole, France, on December 27, 1822. He entered the École Normale in 1843, and took his doctor's degree four years later. His life was extremely active, and he held a considerable number of professorships. "On the occasion of M. Pasteur's seventieth birthday," says the *Scientific American Supplement*, "a most striking illustration was afforded of the esteem in which he was held in France. The ceremony took place in the great amphitheatre of the Sorbonne, which was crowded by a brilliant assembly of the foremost men of the day in science and literature. M. Pasteur entered the amphitheatre leaning upon the arm of his son, and upon that of the President of the Republic. All present rose to their feet and greeted the hero of the day with cheers. It is seldom that such an ovation has been given to a man of science, and M. Pasteur was much affected by the touching ceremonies of the occasion. The magnificent laboratories of the Pasteur Institute in Paris were built by popular subscriptions, and really afford the best form of monument which could be erected; and it doubly honors the great scientist in its being raised during the lifetime of the man in whose honor and for the furtherance of whose work it was designed." He is best known for his work in connection with fermentation, and for his discovery of the cause of, and cure for, the silk-worm disease (*pébrine*), which had threatened the silk industry of France with destruction. He is also famed for his researches on *anthrax*, the dreaded disease that had invaded the stock yards of France, and which destroyed, at one time, over a quarter of a million sheep annually. It would be impossible to recite all his achievements. His method of treating hydrophobia by inoculation has the melancholy interest of being the last great discovery that we owe to Pasteur alone. Considering his labors as a whole, it is difficult to conceive of the vast increase in material wealth that has resulted from them; and we must add Pasteur's name to the immortal trio of whom Huxley said*: "I weigh my words when I say that if the nation could purchase a potential Watt, or Davy, or Faraday [or Pasteur], at the cost of a hundred thousand pounds down, he would be dirt cheap at the money. It is a mere commonplace and everyday piece of knowledge, that what these three [four] men did has produced untold millions of wealth, in the narrowest economical sense of the word."

The Vitality of Seeds.

There are many persons who still believe that corn and other grain found in ancient Egyptian mummy cases has been made to grow when planted under proper conditions. We believe that there is no sufficient evidence that this is so; but we know that seeds can often grow after being exposed for a long period to conditions that would seem to be absolutely fatal to life.

An interesting case of this kind came to our attention a short time ago. Mr. J. B. Pierce, Secretary of this company, bought the place where he now lives in the year 1872. At that time there was a flower garden back of the house, but not caring to be troubled with it, he spaded it up and sowed it down to grass seed, and for twenty-one years he pushed a lawn-mower industriously over the spot, and all memory of the flowers faded away. In 1893, however, —twenty-one years after the garden was "turned down,"—Mr. Pierce planted a small apricot tree within the area in question, and the little circle which he left free from grass around the base of the tree soon showed signs of life, and produced a vigorous crop of *petunias*, the plants being about three feet high at maturity. One year later the entire tract was spaded up and set out with chrysanthemums and sweet peas. This treatment seemed especially advantageous to the long-dormant petunias, for they came up in great profusion, and fully two bushels of them were pulled up and thrown away as weeds. This year the petunias, apparently discouraged, did not show up; but in place of them there came a sensitive plant, which is still prospering in a flower-pot in the house!

THE EDITOR'S CORRECTION.—Mr. and Mrs. M. Lowentritt have gone to Pittsburg to visit their son Joe. (Friday's *Blizzard*.)

With the exception that Mr. and Mrs. Lowentritt did not go to Pittsburg, and that they have no son Joe, the above item is correct. The chap who wrote the item tried to say that Mr. and Mrs. Ludwig Mayer had gone to Pittsburg. The similarity in the names is readily apparent.—*Oil City Blizzard.*

* Quoted by Mr. George Bruce Halsted, in *Science*.

Scientific Knowledge in China.

China has been so prominently before the public for the past few years that an article that appeared in a recent issue of the *Revue Scientifique*, on the knowledge of science possessed by the Chinese, seems very timely. It cannot be denied that the Chinese of the present day have very elementary ideas on any branch of science; but it has not always been so. In early times, as far back, even, as 2000 B.C., we find that science in China had reached a fairly advanced stage. Undoubtedly the Chinese possessed a great knowledge of astronomy: inscriptions have been found which prove this. In the "Chou-king," a book of records, we read that Emperor Yao, who reigned about 2357 B.C., did much to advance the study of this science. He ordered his astronomers to observe the movements of the sun, moon, and stars, and showed them how to find out the commencement of the four seasons by means of certain stars. We read, also, that he told them that a year consists of a little less than 366 days, and, as he divided the year into lunar months, he taught them the year in which the additional lunar month ought to be included. It is also known that the Chinese had the annual calendar, that they observed the planets Mercury, Venus, Mars, Jupiter, and Saturn, that they were able to calculate eclipses, and that they knew the difference between the equator and the ecliptic. It is quite probable, however, that the ecliptic was not known until the Musselmans occupied the Mathematical Tribunal, which they held for three centuries.

We see, therefore, that their knowledge of astronomy was quite extensive. The *meridian* was apparently unknown. M. Chavannes, who is at present professor of Chinese at the College of France, says that it is not mentioned in any astronomical book. As a substitute a certain star was observed at the same hour, according to the times of the year, note being taken of its positions with regard to the horizon.

Astronomy has always been closely connected with astrology. By means of astronomy the time was ascertained for the numerous public ceremonies recorded in the imperial calendar. It likewise regulated the affairs of the government. But the calendar has long since ceased to be used for this latter purpose, and the majority of the Chinese population merely look upon it as a means of continuing the mysterious ceremonies and oracles connected with the different positions of the planets. It is ordered in the "Collection of the Laws" that at each eclipse ceremonies should be gone through to deliver the eclipsed sun or moon. At this time, therefore, an alarm is sounded on the drums, the mandarins arrive armed, utter many objurgations, and thus deliver the endangered bodies.

In the seventeenth century certain Jesuit missionaries arrived in China. On seeing the low state into which the Mathematical Tribunal had fallen, they offered to help it. They found an observatory containing many instruments, which shows plainly that this branch of science had at one time reached an advanced stage. Its subsequent decay is not to be wondered at, when we remember that twenty-two dynasties were brought on the throne by actual revolutions. Nor was the decay confined to astronomy. According to the ancient books and traditions we find that various branches of science had reached a considerable degree of development.

The Emperor Kang-hi, who reigned in the seventeenth century, had a great love of study himself, and endeavored to advance the general education in China. The Jesuit missionaries instructed him in geometry and physics, and he translated some text-books into Chinese. The Chinese have usually been credited with the invention of gunpowder; but a certain document has been found by Archimandrite Palladius, a Russian sinologue, stating that in the ninth century a Persian regiment, under the Chinese sovereign, made known a material similar to wild-fire, which was afterwards used for fireworks.

Apparently chemistry has never been studied, unless by a certain sect, the Tao-tse, who spent all their time endeavoring to discover the philosopher's stone and the elixir of life. The Chinese have little knowledge of geology. The mines have been worked without any machinery, and are not very deep; fire-damp, therefore, has rarely been found troublesome. Coal was mined at as early a time as 200 B.C., in the dynasty of Han; and although the mode of extraction was primitive, enough was obtained to satisfy all wants. About 1861 the government handed the exploration of the mines over to American prospectors. The work, lasting from 1862 to 1864, was directed by Prof. Pumpelli, who, at its termination, sent the emperor a report and a map of the coal-fields. The Smithsonian Institution of Washington has had these documents published, and they have also appeared in the diplomatic correspondence of the United States for 1864. Later on Baron de Richtofen did similar work, and found that the coal-fields in China are even more extensive than those in North America.

Research work has not been carried far in natural science. In zoölogy their classifications are quite wrong. The drawings in zoölogical and botanical books often can be scarcely recognized. Their most ancient work on botany dates from 2700 B. C., and is a treatise written by the Emperor Shen-nung; it is merely enumerative. Another work, the "Rh-ya," dates from 1200 B. C., and shows signs of progress. The "Pen-tsao," an encyclopedia, is of little value, according to M. Bretschneider. This Russian investigator speaks of the Chinese as follows: — "It is an undeniable fact that the Chinese do not know how to observe, and have no regard for truth; their style is negligent, full of ambiguities and contradictions, and teeming with marvelous and childish digressions." In a more recent communication, however, M. Bretschneider retracts his words, and says that it is more that the Chinese *will not* observe than that they *cannot*, for Lichi-Tchen, author of several interesting pamphlets, brings forward many facts concerning cultivated plants.

The medical science of the Chinese is very elementary. Occasionally, here and there, a successful doctor is to be found. Their lack of knowledge in this direction is not to be wondered at, since Buddhism forbids dissection of bodies. In the temple of Confucius a bronze figure is to be found, on which all the different parts are marked where the surgical needle may be applied. This needle is practically the only instrument used in the profession.

The height of civilization in China was reached at the end of the reign of Kang-hi. The gradual decline is supposed to have commenced with the Tartar domination.— *Nature* (adapted).

Where Our Woods Come From.

Mr. A. B. Green contributes an interesting article, under this heading, to the *Pratt Institute Monthly*. A selection from it is given below :

The extent and density of the forest growth of the United States, at the beginning of our existence as a nation, surpassed that of any land of equal extent on the globe; in the number of species, both deciduous and evergreen, it exceeded by five times the forests of Europe. Such a growth, at the time of the landing of the first settlers, spread almost unbroken from the Atlantic to the Mississippi ; while an equally dense forest,— chiefly of conifers, many of an enormous size, — occupied the Pacific slopes.

For a study of the forest growth of the United States, we may separate it into three portions. First, a belt of fir, pine, and spruce, extending along the northern border of the United States from ocean to ocean, and reaching southward to the neighborhood of the 40th parallel. Fir is the name often given to a large variety of coniferous trees, of a pyramidal form and regular proportions, although it is properly applied to only one family. The true fir is found on the Pacific coast, particularly in the extensive forests of Washington and Oregon, where it often attains immense size, and at the present time supplies most of the ships' masts used in this country. The second portion is a belt of the hard, or yellow pine extending from the Atlantic Ocean to the Rocky Mountains, and northward to the 40th parallel. The third portion contains a growth of hard woods extending generally all over the country, from north to south, and reaching its greatest development in the region between the 35th and 40th degrees of latitude.

Nearly all the States produce some lumber ; but in many, the product is not sufficient to supply even the local needs, while in others thousands of feet are daily wasted because of its abundance. The chief sources of supply of the woods most commonly used are as follows : White pine, so largely used in house-building and furniture throughout the Northern States, comes from the forests of Michigan, Wisconsin, and Minnesota. Maine formerly furnished considerable pine, but the supply in that State has diminished until all that it produces goes to supply the home market ; New York and Pennsylvania also produce white pine, but only in limited quantities. To-day Michigan stands first as the greatest pine producing State ; the value of its lumber product, with that of Wisconsin and Minnesota, is equal to one-third of the total value of all timber produced in the United States. Spruce is obtained in large quantities from Maine, Washington, and Oregon, and is imported into the United States very largely from Canada. Hemlock is found in Pennsylvania ; it is poorer and cheaper than spruce, but is used as its substitute in the frames of houses.

Hard, or yellow pine, used in the construction of heavy buildings, is supplied by a belt which, beginning in Virginia, passes southward through North and South Carolina, Georgia, and Florida, and extends westward into Texas. This tree reaches its greatest development in Georgia, and it is here that it is most extensively cut. Hard woods, ash, maple, oak, and cherry, are scattered through almost every State east of the Mississippi; but there are districts where the growth is especially dense. The first region is that included in the western parts of West Virginia, North and South Carolina, Eastern Kentucky, and Tennessee; while a second area extends into Mississippi and produces some fine hickory and oak lumber. Black walnut is obtained from the slopes of the Alleghany Mountains in West Virginia, Kentucky, and Tennessee. It is also abundant in Northern Mississippi and Texas.

Whitewood, obtained from the tulip-tree, comes chiefly from the slopes of the Alleghany Mountains in Tennessee and North Carolina ; it is also supplied from the southern portions of Indiana and Illinois, in the vicinity of the Ohio and Wabash Rivers. Whitewood is extensively used in the South as a substitute for white pine, and is one of the largest trees in the East. The red-gum is found abundantly along the bottom-lands of the Mississippi River in Mississippi, Tennessee, and Arkansas. Cypress is found in Georgia and in all of the Gulf States. Cypress is the substitute for white pine in the Southern coast States, and is largely manufactured into doors, sash, blinds, and shingles. Our red cedar comes mainly from Florida. Formerly Alabama was the great cedar State, but her supply is now almost exhausted.

The California redwood grows along the northern half of the coast of California, where it is often found over fifteen feet in diameter and from one hundred to two hundred feet in height. In this region is found the heaviest continuous belt of forest growth in the United States ; it extends from northern California through the western parts of Oregon and Washington, and eastward into Idaho. These forests are almost wholly of redwood, fir, spruce, and white cedar, with very little hardwood.

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The Locomotive.

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The Horse-Power of Boilers.

The expression "horse-power of a boiler," although frequently used in engineering practice, is highly unsatisfactory on account of its indeterminateness. No one can calculate what actual horse-power can be realized from a boiler, without knowing what sort of an engine is to be used: for a boiler which gives fifty horse-power with a small, non-condensing, slide-valve engine, may give four or five times as much power when used in connection with an engine of more improved design. Nevertheless, the expression "horse-power" has became a trade term, and custom has given to it a nominal meaning which was first definitely fixed by the Centennial Commission. After a careful discus-

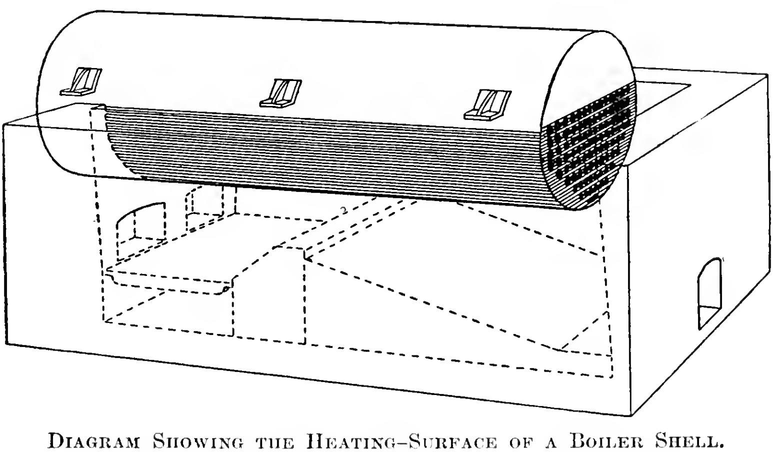

Diagram Showing the Heating-Surface of a Boiler Shell.

sion, the Commission concluded that with the engines then commonly in use, it was possible, in average good practice, to realize an actual horse-power from 30 pounds of steam per hour, the pressure being 70 pounds, and the temperature of the feed water 100° Fahr. This definition of the phrase "horse-power," as applied to boilers, has met with almost universal acceptance among boiler-makers and designers, so that when an order is given for a boiler of a stated number of "nominal horse-power" it is understood (in the absence of any agreement to the contrary) that a "horse-power" means the evaporation of 30 pounds of water per hour, under the conditions stated above.

In computing the horse-power of a boiler by the Centennial rule, or by any other rule, the first problem is to find the heating surface of the proposed boiler, which consists of all those parts of the shell, heads, and tubes, which are exposed to the direct action of the fire or of the hot gases that come from it. We shall proceed to consider these parts in detail.

The part of the *shell* which is exposed to the fire, is indicated by the heavy shading in the illustration. It extends from the back head to the rear surface of the front wall of the setting; and it is limited at the top by the side walls, where they extend inward and touch the boiler. To obtain this area with precision, we should know the exact length of the shaded area, and also the height of the side walls of the furnace; but in practice it is usually assumed that the shaded area is equal to one-half of the area of the entire shell (omitting the dry-sheet, of course, in case there is one). This simplifies the calculation very much, and yet the results correspond quite closely to the actual facts. The *front head* of the boiler is of little or no value as a heating surface, because, if the boiler is well designed, the temperature in the uptake does not greatly exceed the temperature of the boiler itself, and hence there cannot be any considerable absorption of heat through the front head. This head should therefore be entirely omitted in the calculation. The *back head* is more directly exposed to the heat of the furnace, and allowance is sometimes made for such heating surface as it contains. In our own practice we do not make allowance for the back head, however, because the only part of its surface which is available, in any case, consists in the small segments which lie between the tubes, together with a narrow strip around the flange and just under the back arch. While there might be some heating value to these parts when the boiler is new, we do not consider that they are worth taking into account after it has been used for a time, because scale is likely to form upon them; and even though the scale were not heavy enough to produce over heating, and consequent injury to the boiler, it might still be quite sufficient to destroy the efficiency of the head, when considered as a heating surface. The *tubes* are of great importance in computing the heating surface, because their combined area is very large, as can be seen in the numerical example that we give below. In computing the heating surface of a tube, we have first to consider whether we should take the internal or external surface, as the effective one. This question admits of discussion, and could only be settled definitely by actual measurement of the external and internal temperatures of the tube, when the boiler is in operation. If it were found, by experiments of this sort, that the tube, as a whole, is nearly as hot as the gases within it, then the *external* surface should be taken; while if the tube were proved to be hardly hotter than the water in the boiler, there can be no doubt that the *internal* surface should be taken as the effective one. We do not know that any such measurements have been made; and, in the absence of them, some engineers base the calculated heating surface upon the internal diameter, while others use the external diameter, and still others the average of the two. Our own practice has been to take the *external* diameter; and we believe that this course is justified by experience.

This point being settled, the next step is to find the area of the tube, by multiplying its outside circumference by its length — the circumference being found by multiplying the outside diameter by 3.1416. (The diameter of the tube is usually given in *inches;* so that if the surface is required in *square feet*, it is necessary to divide the given diameter (or circumference) of the tube by 12, so that it may be expressed as a fraction of a foot.) The area of one tube being thus found, we multiply it by the *number* of tubes, and thus find the united surface of all of them. This, when added to the heating surface afforded by the shell, gives the entire surface upon which the rated horse-power of the boiler is to be based.

A numerical example will make the rule plainer. Thus let it be required to find the heating surface of a 72-inch boiler, 18 feet long from head to head, with 92 tubes, each $3\frac{1}{2}$ inches in diameter. The diameter of the boiler being 72 inches, its circumference is

$$72 \times 3.1416 = 226.1952 \text{ inches.}$$

To express the circumference in *feet*, we divide this result by 12; thus

$$226.1952 \div 12 = 18.8496 \text{ feet.}$$

The length of the boiler, between heads, being 18 feet, the total area of the shell is

$$18 \times 18.8496 = 339.2928 \text{ sq. ft.:}$$

and

$$339.2928 \div 2 = 169.6464 \text{ sq. ft.,}$$

which is to be taken as the effective heating surface afforded by the *shell*. Passing now to the tubes, we find that the circumference of a $3\frac{1}{2}$-inch tube is

$$3.5 \times 3.1416 = 10.9956 \text{ inches,}$$

which is equal to 0.9163 of a foot (since $10.9956 \div 12 = 0.9163$). The *surface* of the tube is then found by multiplying the circumference by the length; thus

$$0.9163 \times 18 = 16.4934 \text{ sq. ft.,}$$

which is the area of a single tube. The combined area of the 92 tubes that the boiler contains is therefore

$$92 \times 16.4934 = 1{,}517.3928 \text{ sq. ft.,}$$

which is the heating surface afforded by the *tubes*. Upon adding this to the heating surface afforded by the shell, we have

Heating surface of shell	= 169.6464 sq. ft.
" " " tubes	= 1,517.3928 "
Total effective heating surface of boiler	= 1,687.0392 sq. ft.,

or, in round numbers, 1,687 square feet. (It will be seen that the tubes are of far more importance than the shell, as has been already said, above.)

The foregoing method of calculating the heating surface of a boiler may be somewhat simplified, by arranging the computation in the manner indicated by the following

RULE FOR FINDING THE EFFECTIVE HEATING SURFACE OF A HORIZONTAL TUBULAR BOILER: Multiply the diameter of a tube (in *inches*) by the number of tubes, and to the product add the *radius* of the boiler (also expressed in inches). Multiply the sum by the length of the boiler, from head to head (expressed in *feet*), and then multiply again by the decimal 0.2618. The result is the effective heating surface of the boiler, in square feet.

This rule is the exact equivalent of the process explained above, and differs from it only in the fact that the *order* of the various operations has been changed, so as to make the numerical work somewhat easier. That it is really the same thing, and yet at the same time simpler in its application, is shown by the following solution of the problem given above:

(Diameter of tube) × (No. of tubes) = 3.5 × 92	= 322.
Radius of boiler (in inches)	= 36.
Sum	= 358.

Then, the length of the boiler being 18 feet, we have

$$358 \times 18 = 6{,}444;$$

and, finally, $6{,}444 \times 0.2618 = 1{,}687.0392$ sq. ft.,

which is identical with the result already obtained.

The heating surface of the boiler being known, the next step is to find what evaporative duty may be expected of the boiler, in ordinary good practice. To solve this part of the problem we have to know from experiment what amount of water can be economically evaporated by each square foot of heating surface per hour. The Centennial Commission considered that two pounds was a fair estimate. In our own practice we find that when the boiler is well designed, and the draft is good, an evaporation of $2\frac{1}{2}$ pounds of water per hour may be had from each square foot of heating surface. In exceptional cases the evaporation may run as high as 3 pounds; but under ordinary circumstances it is found that $2\frac{1}{2}$ pounds is all that can be reasonably expected. Accepting the estimate of the Centennial Commission of 2 pounds per square foot per hour, it follows that fifteen square feet of heating surface will be required for each "nominal horse-power" of the boiler; for at 2 pounds per square foot, the evaporation on 15 square feet will be 30 pounds per hour, which is the amount of steam required, in the Commission's definition of the "horse-power." The nominal horse-power of a boiler would therefore be found by dividing the heating surface (in square feet) by 15. If the data afforded by our own experience be accepted, it follows that the boiler will have one nominal horse power for every 12 square feet of heating surface; for if each square foot evaporates $2\frac{1}{2}$ pounds per hour, the total evaporation on *twelve* square feet will be $12 \times 2\frac{1}{2} = 30$ pounds per hour. Hence, in our own practice we calculate the nominal horse-power of a boiler by dividing the total effective heating surface (in square feet) by 12.

If it is desired to calculate the *actual* horse-power that a given boiler may be expected to furnish, we must first know something about the engine that is to be used. For the boiler merely *produces* the steam, and it is the *engine* which transforms the heat-energy of the steam into mechanical energy; so that if the engine is efficient, a large yield of mechanical energy may be expected; while if it is wasteful, the yield of mechanical energy will be much smaller, even when the boiler is worked just as hard as before. The duty of a given engine can usually be pretty closely estimated by a person who is familiar with the performance of other engines of the same type; and, in fact, large engines are often built by contract to run with a given steam-consumption per horse-power per hour. If the duty (or steam consumption) of the engine is known, the *actual* horse-power that may reasonably be expected from the boiler can be calculated by the following:

RULE FOR FINDING THE ACTUAL HORSE POWER: First find the heating surface (in square feet) as before. Multiply this by $2\frac{1}{2}$, which will give the number of pounds of steam that the boiler can produce per hour. The evaporation thus found is then to be divided by the weight of steam required by the engine that is to be used, per horse-power per hour, and the quotient is the actual horse-power that may reasonably be expected when the proposed boiler and engine are run together, under favorable conditions.

In conclusion we shall give a numerical example illustrating the application of this rule, taking, for this purpose, the boiler whose heating surface has already been computed. The heating surface being 1,687 square feet, the evaporative duty of the boiler, per hour, will be

$$1{,}687 \times 2\tfrac{1}{2} = 4{,}217.5 \text{ pounds.}$$

We will assume, first, that the engine is of the ordinary single-cylinder non-condensing form, and that it uses 30 pounds of water per horse power per hour (which is the duty assumed by the Centennial Commission). The actual horse-power developed under such circumstances is then

$$4{,}217.5 \div 30 = 140 \text{ H. P.}$$

On the other hand, if the engine were of the triple-expansion, condensing form, with a steam-consumption of (say) 12.5 pounds per horse-power, the rule would give

$$4{,}217.5 \div 12.5 = 337.4 \text{ H. P.},$$

which is the actual yield of mechanical energy that could reasonably be expected with this engine and boiler.

Inspectors' Report.

October, 1895.

During this month our inspectors made 10,091 inspection trips, visited 19,658 boilers, inspected 6,538 both internally and externally, and subjected 927 to hydrostatic pressure. The whole number of defects reported reached 12,941, of which 1,635 were considered dangerous; 61 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,118	48
Cases of incrustation and scale,	1,996	66
Cases of internal grooving,	99	9
Cases of internal corrosion,	661	31
Cases of external corrosion,	847	41
Broken and loose braces and stays,	156	64
Settings defective,	396	46
Furnaces out of shape,	479	17
Fractured plates,	245	41
Burned plates,	215	27
Blistered plates,	238	7
Cases of defective riveting,	2,111	542
Defective heads,	111	19
Serious leakage around tube ends,	2,219	366
Serious leakage at seams,	474	37
Defective water gauges,	471	83
Defective blow-offs,	204	68
Cases of deficiency of water,	25	9
Safety-valves overloaded,	114	24
Safety-valves defective in construction,	97	41
Pressure-gauges defective,	483	44
Boilers without pressure-gauges,	5	5
Unclassified defects,	177	0
Total,	12,941	1,635

Mr. J. R. Roosevelt, secretary to the United States Embassy, has presented to Lord Rayleigh and Professor Ramsay the check of the embassy for $10,000, being the Hodgkins prize awarded by the Smithsonian Institution, of Washington, for their discovery of a new element in the atmosphere. The recipients of the prize have also written a etter of thanks to the Smithsonian Institution.— *Scientific American.*

Boiler Explosions.

OCTOBER, 1895.

(247.) — A boiler exploded on October 1st, in Banister's bone mill, at Pelham, N. H. The mill was blown to atoms, and the building and machinery were completely wrecked. Fortunately nobody was injured.

(248.) — On October 1st a boiler exploded in Dale, Mitchell & Co.'s big mill at Alexanderville, Ga. Henry Carpenter, Jerry Meyer, and another man whose name we could not learn, were killed, and five other men were injured, among the injured being Henry Mitchell, the superintendent of the mill, and his son.

(249.) — Joel Beckwith & Co.'s stave factory, at Greencastle, Pa., was completely wrecked, on October 2d, by the explosion of one of the boilers. It does not appear that any one was seriously injured, and we have seen no estimate of the damage.

(250.) — A boiler exploded on October 4th, at the Franklin mine, near Seattle, Wash. R. M. Gibson and Philip Early were burned and otherwise injured, so that they died next day.

(251.) — A threshing-machine boiler, belonging to John Shy, exploded on October 5th, in Townsend township, Ohio. Six men were sitting in front of the boiler at the time, but they all escaped injury, the boiler passing directly over them, and striking the ground 100 feet or more away. The threshing outfit was blown to pieces and the fragments were scattered in all directions.

(252.) — A boiler exploded on October 6th, in Alexander J. Howell & Sons' soda factory, Westchester, N. Y. The fire department turned out, and found the boiler house reduced to a mere heap of bricks and iron. Frank Thorn, the night engineer, was killed, his body being found in the ruins under a pile of bricks. The property loss was about $5,000.

(253.) — On October 7th a boiler exploded in George W. Brown's saw-mill at Orr Station, on the Sherman, Shreveport & Southern railroad, near Greenville, Texas. The explosion occurred at noon, while the men were away at dinner; so that nobody was hurt. The mill and its contents were badly wrecked.

(254.) — The boiler in the washroom of the Lehigh Valley car shops, at Ithaca, N. Y., exploded on October 7th. William Tree, a cleaner in the wash gang, was badly scalded about the body and face. It is doubtful if he can recover. D. S. Williams was also quite badly injured. The building was completely wrecked.

(255.) — One boiler in a battery of ten exploded on October 7th, at the Sterling colliery, Shamokin, Pa. Daniel McIntyre, an engineer, received injuries which are feared to be fatal. The boiler-house was demolished, and the property loss is estimated at about $2,000.

(256.) — A locomotive boiler exploded on the Philadelphia & Reading railroad, near Wernersville, Berks county, Pa., on October 7th, wrecking the engine. Engineer Charles Frill and Fireman John D. Fegley were badly injured. Fegley was hurled into a neighboring field.

(257.) — A boiler exploded on October 8th, at the Wharton Iron Mine, Hibernia, N. J. The boiler-house was torn to pieces, and the whole village was shaken up. Engineer Milton Smith was hurled twenty feet into the air, and was badly hurt and scalded;

Philip Vosburgh was also scalded, and John Clark, William Kelley, John Malone, and Michael Ryan were painfully bruised. The property loss is estimated at from $10,000 to $15,000.

(258.) — On October 9th a threshing-machine boiler exploded near Wakeman, Ohio. C. B. Canfield was seriously injured about the back.

(259.) — The explosion of a threshing-machine boiler on October 10th, near Mount Lake, Minn., resulted in the deaths of Joseph Schumacher, Jasper Malette, and two other men, whose names we could not learn.

(260.) — One of a battery of fifteen boilers exploded on October 11th, at the Delaware mine of the D. & H. Coal Company, at Mill Creek, near Wilkesbarre, Pa. The explosion was felt all over the town, and windows and dishes were broken in many of the residences. Nobody was hurt. The exploded boiler was used to hoist coal, and to operate the breaker engines and pumps, and was not connected with the fan. Hence the explosion did not interfere with the ventilation. The men in the mine were taken out by way of another opening.

(261.) — A small boiler used for furnishing heat for a big incubator belonging to Frank Kuestner, of West Bethlehem, Pa., exploded on October 14th, blowing up the incubator, and, as one account puts it, "making a fearful mess." Five thousand eggs were smashed, and two hundred small chickens were killed. The cellar in which the boiler stood was also badly damaged.

(262.) — On October 15th, a boiler exploded in Henry Wadsworth's saw-mill, at Palestine, near Greenville, Ohio. James Howard and Washington Stover were instantly killed.

(263.) — A boiler exploded on October 17th in Julius Peters' saw-mill, eight miles southeast of Carrollton, Mo. Albert Peters, the eleven-year-old son of the proprietor, was blown about fifty feet, and sustained injuries from which he will die. Julius Peters was badly cut and bruised about the face, and will lose the sight of one of his eyes. Eben Webb and Joseph Barker were also injured, but to a lesser extent. The mill was entirely destroyed.

(264.) — A boiler exploded on October 17th, in the rear of the "Exchange," one of the leading hotels in Montgomery, Ala., while most of the guests were at supper. The electric light plant, the laundry, and the entire rear portion of the hotel were destroyed, and every house in town was shaken up. The hotel was instantly enveloped in darkness, and a panic followed, the women and children screaming and falling down the stairways. When matters had straightened themselves out it was found that nobody was killed. Four laundresses were injured, but none of them fatally so. Mr. O. L. Folds, the engineer, was struck on the head by a piece of scantling, but was not seriously hurt. The explosion was compared, by a local journalist, to "a reduced, but none the less frightful, reproduction of the last days of Pompeii." The loss is estimated at from $10,000 to $12,000.

(265.) — On October 17th, a fire occurred at the Juniata Sand Company's works, at Huntingdon, Pa., and during the course of it two of the boilers exploded. The plant was completely destroyed, and the machinery ruined. The damage is estimated at from $10,000 to $12,000; but we have seen no estimate of the proportion of this which was due to the explosion alone.

(266.) — A boiler exploded, on October 17th, at Haley's mill, near Spottsylvania Courthouse, Va. One man received severe injuries, from the effects of which he will die. Another man was also injured to a lesser extent, and will recover. The mill was destroyed.

(267.) — A boiler exploded at N. K. Dillard's mill, near Paris, Texas, on October 18th, instantly killing George Johnson (the engineer), and fatally injuring J. W. Jackman and three others. Eight men also received severe injuries, from which, however, they are expected to recover. The mill was entirely demolished, and the remains of the boiler were found hundreds of yards away.

(268.) — George Jackson was seriously scalded and cut, on October 18th, by the explosion of a boiler at George Boehner's slaughter-house, at Springfield, Ill. We did not learn the extent of the property damage.

(269.) — An oil-well boiler on the J. I. Collin's lease, at Wingston, near Bowling Green, O., exploded with terrible effect on October 20th. Henry Baker, the pumper, was found dead, several rods away. The boiler-house was completely shattered and strewn nearly all over a ten-acre lot.

(270.) — On October 21st, while a gang of men was at work repairing a high-pressure steam pipe connecting two batteries of boilers (twenty-two in all) at the American Wire Nail Works, Anderson, Ind., the pipe burst. Abraham Delcamp and Michael McNair were fearfully bruised and burned, and cannot live. Robert Bissell, Thomas Finden, George Hallis, John Jones, Edward Kieser, Henry Myers, James Rodgers, A. J. Sheets, and Henry Wycroff, were also severely injured, but at last accounts it was not thought that any of them would die. Part of the building in which the explosion occurred was blown down.

(271.) — On October 21st, a boiler flue collapsed in the basement of the Conservatory of Music, at Denver, Col. We did not learn of any personal injuries. [See also explosion No. 274, below.]

(272.) — A boiler exploded, on October 22d, in Holmes & Coleman's fence-picket mill, at Lomax, Ill. The mill had been shut down for an hour, and most of the men had gone away. John Holmes, one of the proprietors, was instantly killed, his body being blown fifty feet, and mutilated almost past recognition. Joseph White was also crushed and scalded, so that he was dead when found. L. B. Coleman and A. S. McGee were fearfully injured, but will recover. The mill was two stories high, and covered a considerable area. It was demolished so completely that hardly anything was left standing.

(273.) — The boiler of an engine used in sinking a well at the new county infirmary, two miles south of Warsaw, Ind., exploded on October 22d, killing the engineer and badly scalding one of the patients. The cell-house was also damaged to some extent. The explosion occurred while most of the workmen were at breakfast.

(274.) — While testing a boiler used for heating purposes in the basement of the Conservatory of Music, in Denver, Col., on October 22d, three men narrowly escaped death. They had been replacing a flue that had failed the day before, and when the work was completed it was decided to test the job under a steam pressure of 25 pounds. The new flue stood the test, but an old one, next to it, collapsed, and the basement was instantly filled with scalding steam. Andrew Blair and Roy C. Howell were severely burned. Blair was firing at the time, and his injuries are so serious that it is feared that he may not recover.

(275.) — The boiler of a traction engine exploded, on October 23d, at Helmer, near Butler, Ind. George Cowen and Henry Ballerck were injured so badly that they cannot live.

(276.) — A boiler exploded on October 24th, in Arbuckle & Coberly's mill, at London, Ohio. W. S. Coberly was terribly scalded about the head, face, and arms, and Perry Justice was bruised and scalded so badly that his recovery is doubtful. A young man named Roberts was also badly burned.

(277.) — On October 25th, a tube failed in a boiler at the Akron rolling mill, Akron, Ohio. Gustav Emmel, who was firing the boiler, was terribly scalded and burned. It is thought that he may die, though there are hopes of his recovery.

(278.) — Two boilers exploded on October 26th, in the Pacific Coast Mill, at Fairhaven, Wash. Fireman Thomas Armstrong and watchman J. Whitmore were killed instantly, and T. A. Bennett, G. W. Newkirk, G. T. Lewis, and G. W. Lindley, were injured more or less seriously. Newkirk's injuries are so severe that his physician says he cannot recover. The mill was destroyed. The estimates of the property loss are very various. The Seattle *Times* places it at $15,000.

(279.) — On October 26th, a boiler exploded on the tug *T. T. Morford*, at Chicago, Ill. The *Morford* was wrecked, and sank immediately. The pilot-house of the *O. B. Green*, another tug which was alongside of the *Morford*, was also blown off. Captain John Ferguson, master of the *Green*, and John Erickson, fireman on the *Morford*, were killed outright, and Charles Dick, engineer on the *Morford*, was fearfully injured, so that he died within a few hours at the hospital. Captain John Cullinan (of the *Morford*) and Lineman Daniel McRae were burned and otherwise injured, but will recover. At last accounts Erickson's body had not been found, although the river had been dragged for it.

(280.) — The boiler of a portable wood-sawing machine exploded on October 27th, at Wausau, near Milwaukee, Wis. Nobody was near it at the time.

(281.) — A boiler used to operate Frank Hafer's stone-crusher, exploded on October 28th, at the Shippensburg Normal School, near Chambersburg, Pa. We could not learn the particulars, except that nobody was hurt.

(282.) — A small boiler in the rear of Abraham Salisbury's elevator at Milwaukee, Wis., exploded on October 28th. The roof of the building in which the boiler stood was blown off, but the damage was small, and nobody was injured.

(283.) — A boiler exploded on October 29th, in the Lagonda Hotel, at Springfield, Ohio. Live coals were scattered everywhere, and a fire followed. The total damage, due to the explosion and the consequent fire, was about $50,000.

(284.) — A portable boiler exploded on October 30th, about two miles north of Port Washington, Ohio. Raymond Best was injured so badly that he died within a short time. His brother also received lesser injuries.

(285.) — A flue collapsed on October 30th, in the boiler of the old "Diamond Jo" Mississippi river packet *Libbie Conger*, as she was passing the mouth of Duck Creek, near Davenport, Iowa. Christopher Batalia was blown overboard and was drowned.

(286.) — A boiler exploded in Stedman's mills, near London, Ky., on October 30th, killing Matthew S. Herndon and a boy named Fields, and fatally injuring two other men.

(287.) — A boiler in the Edison Electric Light station, at Cincinnati, Ohio, exploded on October 31st, doing considerable damage. Several workmen narrowly escaped being scalded to death by the escaping steam.

The Variation of Latitude.

The astronomical world has been extremely interested, for the past few years, in the question of the fixity of the earth's axis of rotation. Of course it has long been known that this axis gradually changes its direction in space, owing to the attraction of the sun and moon upon what is called the "equatorial bulge" of the earth,— the "bulge" in question consisting of that part of the earth which lies outside of an imaginary sphere whose center is at the earth's center, and whose radius is such that the imaginary sphere coincides with the earth's actual surface at the north and south poles, but lies *inside* of that surface everywhere else. This motion of the axis is discussed in all the books on astronomy, and has been known for many years; but it is characterized by the important fact that as the *axis* slowly swings around, *the earth swings with it*, in such a way that if a stake were driven into the ground at the true north pole at any given instant, the point so fixed would always *continue* to be the true north pole. It has now been discovered that there is another and very different kind of motion, not previously known (although *suspected*, a long time ago); and the honor of discovering it belongs to an American astronomer, Dr. S. C. Chandler, of Harvard University. He has found that the axis about which the earth rotates preserves its direction in space (subject to the very slow motions of precession and nutation, referred to above), but that the earth itself shifts about uneasily, but in a regular way, so that the imaginary stake that we have conceived to be driven at the north pole at some given instant would not remain coincident with the axis of rotation. Relatively to the earth, the axis of rotation would describe a sort of curve about the stake. The motion is indeed slight, for the stake, if once coincident with the true pole, could never depart more than fifty-three feet from it, and could not go so far away as that, unless it were driven at a specially selected instant; yet, slight as this motion is, it is quite large enough to be noticeable in the refined astronomical work of to-day. The chief effect produced by the newly-discovered motion is to cause a variation in the latitude of all places on the earth's surface; for, owing to the shifting of the earth, any given spot is sometimes nearer the pole than its average distance, and sometimes further away. This leads to a wonderful and wide-spread complication, when we contemplate the accurate astronomical and geodetical measurements that have been made in the past. All of these measures, that involve a knowledge of latitude, will have to be corrected. The task thus brought to view is almost hopeless, and yet in some cases in which the corrections have been applied, it has been found that work which had yielded results apparently poor, or absurd, was really excellent, and very accurate. As a single instance of this, we may mention the work done by Professor Asaph Hall in determining the parallax of the star Vega. The result that he obtained, after an enormous amount of labor with the big telescope at Washington, was that the parallax of the star is *negative*; — a result which is quite preposterous, because, if it had any meaning at all, it could only mean that Vega is *more than an infinite distance* away, which is highly absurd. When the corrections that Dr. Chandler's researches indicated to be necessary had been applied to the observations, it was found that there was no longer any absurdity in the result, but that the observations were highly accurate, and that they gave a real and reasonable value of the parallax of the star. We append an article from the *Scientific American*, in which this subject is further discussed, in a popular way:

"It will now and then happen to the seeker after knowledge that he will have to unlearn as well as to learn; but it will be a rare experience for him to have to call in question such a supposedly fundamental truth as that of the invariability of terrestrial latitude. If there is one fragment more than another of our childhood's 'geography lesson' that abides ever with us, it is this: that 'the earth turns upon its axis.' And now we are told that it does not, and that, as a consequence, it is literally true that the parallels of latitude are perpetually shifting — not much, it is true; but sufficiently to make it comically possible, as was once suggested, that certain dwellers in the proximity of the Canadian border line never know for more than six months together in which country they live. The axis of the earth, or, to speak more accurately, the axis of the earth's figure, is an imaginary line, passing through the center of the earth, and terminating at its two flattest points, known as the North and South Poles. Up to the year 1888, it was supposed that the earth rotated about this axis. If this had been true, the latitude of any given spot, as determined by observation, should have been invariable. As a matter of fact, it had been noticed, even as far back as the last century, that there was a slight, but perceptible, variation. The latitude of a given spot, as shown by two observations taken at different times, was found to vary. Between the years 1884 and 1888, Dr. S. C. Chandler gathered together all the observations that had from time to time been made, and, after a careful analysis, was able to prove that these variations are accounted for by the fact that the earth does not rotate about its axis of figure, as above described, but about another axis, which he called the axis of rotation. This axis of rotation bisects the axis of figure at its center, and always preserves the same direction in *space* (except for the extremely slow motions of nutation and precession, as explained above); but, relatively to the earth, the axis of rotation slowly describes a sort of curve about the poles of the axis of figure. From this consideration it is evident that the equator of the earth's figure, and the small circles parallel to it, do not preserve the same planes relatively to space, but that they have an oscillatory motion. Hence the variation in latitude. [Here follows, in the original, a comparison of the earth's motion with that of a top; the comparison is omitted because it is not accurate.] The motion of the axis of rotation about the axis of figure is not very simple, being made up of two superposed motions. The pole of the axis of rotation moves in a small circle which is itself moving around the pole of the axis of figure. The period in which the small circle is described is between 423 and 434 days; and the center of this circle makes a circuit about the pole of figure in from 361 to 369½ days. The radius of the circle is fourteen feet, and its center travels in an ellipse, the major axis of which is twenty-five feet, and the minor axis about eight feet. A remarkable verification of Dr. Chandler's discovery was afforded by a series of tidal observations extending over thirty-five years, some of which were taken on the Pacific Coast and some on the Atlantic. These show a mean time of oscillation of the sea's level of about 431 days, which agrees remarkably well with the period of revolution as mentioned above. Newcomb had pointed out that if the theory of the revolution of the axis of rotation were true, low tide at any spot should occur when the pole of rotation lay nearest that spot — a suggestion with which the above-mentioned tidal observations fully agree."

The Locomotive.

HARTFORD, DECEMBER 15, 1895.

J. M. ALLEN, *Editor.* A. D. RISTEEN, *Associate Editor.*

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OUR esteemed contemporary, the Denver *News*, indulges in a little rather grisly humor in connection with explosion No. 274, in the list published this month. It begins its account with a heading, in scare type, which reads : NINE LIVES WIPED OUT! But it presently appears that a black cat was the only creature killed outright, and that the scare-line was merely a playful allusion to the extraordinary vitality that fable says all pussies have.

THE end of the year being now at hand, with Christmas and its festivities in view, we desire to make our customary announcement that the index and title-page to THE LOCOMOTIVE for the current year will be ready shortly. They will be sent on request to any of our readers who have preserved their copies, and wish to bind them. The bound volumes for 1895 will also be ready in January, and may be had at the usual price of $1.00 each, postpaid.

NUMBER 270, in our list of explosions for October, printed in this issue, affords one more fearful object lesson, illustrating the danger of attempting to repair pipes, valves, or boilers, while they are under steam. This time two men were killed, and nine others received terrible injuries. We wish these frightful examples could educate all engineers, boiler-makers, and pipe-fitters, so that they might all see the foolhardiness of the thing ; but we are afraid that the old dogs will refuse to learn new tricks, no matter how gruesome the instruction ; and we suppose that similar accidents will continue to occur, with about the usual frequency.

The Secrets of Ashes.

The plant world presents many curious phenomena, which excite the student's curiosity and stimulate his imagination. Some of these phenomena are obscure, and have to be diligently sought for; while others stare us in the face, and are, in fact, so *familiar* that they do not receive the attention they deserve, until some unusually observant person calls attention to them. Some of the more unobtrusive of these mysteries are brought before us by a study of so homely a material as the *ashes* that remain after plants have been burned.

It is well known that the great majority of the more familiar plants obtain their nutriment partly from the air, and partly from the soil. Some, it is true — as in the case of the curious epiphytes, or air plants, that grow in hot countries — obtain all their substance from the air; while others, such as sea-weeds (which have no true roots), absorb everything they need from the water in which they are submerged. Confining our attention to the more familiar land plants, however, we may say that there are, in general, two sources from which the supplies required for their growth are obtained. Carbon, for example, is believed to be drawn exclusively from the air; the leaves of the plant absorbing the carbonic acid that is always present in a certain small proportion, splitting it up into its constituent parts — oxygen and carbon — retaining the solid carbon, and pouring the gaseous oxygen back into the air. It is quite probable that the traces of ammonia that are present may also be absorbed by the leaves, the nitrogen of the ammonia being also used for the purposes of growth. The minor solid components of plants — the lime, magnesia, potash, silica, phosphorus, iron, etc., — are absorbed from the soil by the roots, and carried up to the leaves through the stem.

If a plant be dried and then burned, all the gaseous and volatile constituents pass away in smoke, and that which is left behind — the ash, namely, — represents, for the most part, the solid matter which has been absorbed by the roots. A study of the composition of the solid matter thus absorbed reveals many interesting and wonderful things, a few of which we are about to suggest. (For the data presented below we are indebted to Professor Kerner's wonderful work on the *Natural History of Plants*, which is now available to American and English readers through Professor Oliver's most excellent translation.)

The first thing that strikes us, upon examining a plant ash, is that the solid matters that are taken up by the roots are not absorbed in anything like the proportions in which they occur in the soil. In fact, it seems almost as though the rootlets were intelligent chemists, recognizing each substance that they touch, and knowing what quantity of it is required by the plant above. This is well illustrated by the analysis of the ashes of different plants growing side by side, in the same soil. Thus Kerner gives four such analyses, made on specimens of (1) the water-soldier (*Stratitoes aloides*), (2) the white water-lily (*Nymphæa alba*), (3) a stone-wort (*Chara fœtida*), and (4) a reed (*Phragmites communis*). The results, so far as potash, soda, lime, and silica are concerned, are as follows:

Results of Analyses of Plant-Ashes.

Substance Found.	Plant Examined.			
	Water-soldier.	Water-lily.	Stone-wort.	Reed.
Potash,	30.8	14.4	0.2	8.6
Soda,	2.7	29.7	0.1	0.4
Lime,	10.7	18.9	54.8	5.9
Silicic Acid,	1.8	0.5	0.3	71.5

When it is remembered that these four plants all grew close together, and that the soil from which their supplies were drawn was identical, so far as could be discovered, the results here given are truly wonderful. The stone-wort, it will be seen, contained a very large quantity of lime, and barely a trace of potash, soda, or silica; while nearly *three-quarters* of the ash of the reed consisted of silica, and there was less than one-ninth as much lime as was found in the stone-wort.

If we pass from the consideration of different plants growing in the same soil, to that of the same plant growing in different soils, the results are equally wonderful. Thus Kerner gives analyses of the ash obtained from the foliage and branches of the yew-tree (*Taxus baccata*), the specimens analyzed being taken from soils rich in serpentine, limestone, and gneiss, respectively. The results are presented in the accompanying table. It will be seen that there are some slight difference in composition, but when the wide difference in the soils is taken into account, it is remarkable that the proportions are so nearly alike.

ANALYSES OF THE ASH OF THE YEW-TREE.

Substance Found.	Nature of Soil.		
	Serpentine.	Limestone.	Gneiss.
Silicic Acid,	3.8	3.6	3.7
Sulphuric Acid,	1.9	1.6	1.9
Phosphoric Acid,	8.3	5.5	4.2
Iron Oxide,	2.1	1.7	0.6
Lime and Magnesia,	38.8	41.2	36.3
Potash,	29.6	21.8	27.6
Carbonic Acid,	14.1	23.1	24.4

One feature that was prominent in the analyses of the yew-tree ash has been purposely obscured in the table by counting the lime and magnesia *together*. It appears that when a plant needs a certain substance for its growth, it will sometimes make use of some other substance, *whose chemical properties are closely similar*, provided the more desirable one cannot be had in sufficient quantities. Thus the ash of the yew-trees growing over limestone contained 36.1 per cent. of lime, and 5.1 per cent. of magnesia; and that of the trees growing over gneiss contained 30.6 per cent. of lime and 5.7 per cent. of magnesia. The serpentine soil, however, was much poorer in lime than either of the others — serpentine being composed almost entirely of silica and magnesium — and the trees growing upon this soil, being unable to obtain the necessary quantity of *lime*, accepted, in the place of the lime, an equal weight of *magnesia*, a substance strongly resembling lime in its chemical properties; the observed quantity of lime in these trees being only 16.1 per cent., while magnesia was present to the extent of 22.7 per cent. This peculiarity reminds one of the experiments that were tried, some few years ago, to find out whether hens could construct egg-shells of anything except lime. The hens upon which the experiment was tried were fed upon materials from which lime was carefully excluded, until they began to lay eggs entirely devoid of shells. They were then allowed reasonable rations of various salts of barium — a body closely resembling calcium, which is the basis of lime. The results were negative. No shells appeared, whatever the compound of barium that was supplied. It was found, however, that *any* compound of lime would do, it being apparently a matter of indifference to the hen whether she was fed on the sulphate, carbonate, phosphate, or any other salt of calcium, that she could eat without discomfort. Any compound of lime would yield shells, but no compound of barium would do it. We wish somebody would try that same experiment, substituting *magnesia* for lime, so that we might know whether the yew-tree has a more catholic taste than the hen, or not.

Another thing that plant-ashes reveal is that plants often possess a most amazing power of collecting large quantities of a particular substance that they may happen to need, even when this substance is present in the soil or the water in which they are growing, in such extremely minute quantities that it can barely be detected there by the most delicate chemical tests that we possess. For example, certain kinds of saxifrages, when growing upon a substratum of quartz and slate, frequently collect so much carbonate of lime that this substance forms a marked incrustation on the edges of the leaves, even though no trace of lime can be found in the soil in which they are growing, nor in the rocks beneath it, except in the little scales of mica that occur here and there, but which are not easily decomposable. Another case of this sort, more remarkable still, is afforded by the white water-lily mentioned in the first table. It will be noticed that this plant contains a large proportion of soda — this body forming, in fact, almost one-third of the total weight of the ash. The soda thus found is present in the plant as sodium chloride; — that is, in the form of common salt. It might be inferred that the water in which it grew was brackish; but this was not the case. A careful analysis of the water revealed the presence of only about one-third of one per cent. of salt, and the earth in which the roots of the plant were fixed contained *only one one-hundredth of one per cent.* of that substance! Another instance of the same general character is afforded by the sea-weeds of the North Sea, which are so rich in iodine that they formed the chief source of this substance for many years, in fact, until the extensive South American deposits of sodium iodide were discovered, a few years ago. One would naturally infer that the sea-water in that part of the world would contain considerable quantities of iodine, or, at least, of soluble iodides; and yet the fact is, that nobody has yet succeeded, by the most delicate tests, in discovering any trace of it. Such a fact as this indeed suggests the possibility that iodine is not an element, but that it is constructed, by the sea-weeds that contain it, out of the chlorine that the sea contains in abundance. (Iodine and chlorine are certainly very similar in their chemical relations, but the hypothesis here put forward is, of course, the merest conjecture.)

One more fact relating to the marvelous power of selection that plants sometimes exhibit must close our list. This time we are concerned with the tiny little things called diatoms, which construct for themselves the beautiful shells of silica that affords microscopists so much delight. One would certainly think that these quartz-like shells could not be constructed unless silica were present in large amounts; but here is what Kerner says of a case which came under his observation: "Above the Arzler Alp, in the Solstein chain near Innsbruck, there is a spring of cold water which falls in little cascades between blocks of rock. The water of this spring is hard, and it deposits lime at a little distance from the source. Exactly at the spot where it wells out of a fissure in the rock its bed is entirely filled by a dark-brown flocculent mass which consists of millions of cells of the beautiful *odontidium hiemale*, a species of diatom with siliceous coating. These cells are ranged together in long rows, and are present in numbers and luxuriance such as are scarcely ever to be observed in other situations. Yet the spring water flowing round contains so little silicic acid that no trace of this substance can be discovered in the residue from the evaporation of 10 liters [over two gallons and a half]."

No adequate explanation of the marvelous selective power of plants has been given. In fact, it is doubtful if we yet know enough of the actual facts to frame a rational theory to account for them; but we have learned enough, at all events, to cause us to respect them, profoundly, in their capacity as *analytical chemists.*

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