(3) 544

HISTORY OF WEAVING.

LONDON:
GILBERT AND RIVINGTON, PRINTERS,
ST. JOHN'S SQUARE.

THE

HISTORY AND PRINCIPLES

OF

WEAVING

BY HAND AND BY POWER.

Reprinted, with considerable Additions, from "Engineering," with a Chapter on Lace-Making Machinery, reprinted from the "Journal of the Society of Arts."

BY ALFRED BARLOW.

"—— That honest, best, and most beneficiall Trade in the kingdome."—SPEED.

WITH SEVERAL HUNDRED ILLUSTRATIONS.

SECOND EDITION.

London:
SAMPSON LOW, MARSTON, SEARLE, & RIVINGTON,
CROWN BUILDINGS, 188, FLEET STREET.
1879.

PREFACE.

THE Art of Weaving forms the most extensive and important part of the Textile Manufactures, whether considered on account of its commercial value or for its usefulness, variety, or beauty of its products. It also calls forth a greater number of mechanical appliances and ingenious contrivances than any other Art, and is on that account alone always a source of interest to the Engineer and the Mechanician, as well as to the Manufacturer and the Weaver.

Formerly the Art depended almost entirely upon the handicraft skill of the weaver, and his contrivances were limited in their combinations to produce designs of any considerable extent. They were, also, cumbersome and complicated, and entailed an amount of labour and patience that would much astonish the weaver of the present day. But, by the introduction of the Jacquard Machine and the Power Loom during the present century, the whole system of weaving, with some few exceptions, has been changed, and practically become a New Art.

During the same period the Lace Frame has been invented, and by the application of the Jacquard apparatus to it for the production of figured lace, it has created an entirely new and important branch of manufacture. The numerous inventions that have led to this result seem to have culminated in this admirable machine, which for ingenuity is unsurpassed in the whole range of mechanism.

Yet the Loom with its products, "wherein the wealth of our Nation is folded up," and upon which we are so dependent for personal comfort, health, and cleanliness, is far behind other important Arts and Manufactures in respect to treatises upon its varied processes. The few works that have appeared are intended for technical readers, and are either confined to certain branches of the Art or limited in extent, and do not treat upon the subject generally.

To supply this deficiency is the object of the present work, which is based upon and includes a series of Articles written for the Proprietors of "Engineering."

The part which is devoted to the Lace Manufacture includes, by permission, a description, written for the "Journal of the Society of Arts," of the Levers Lace Frame which was exhibited in the International Exhibition, Kensington, 1874, by the Nottingham Chamber of Commerce.

As many of the machines and processes are now for the first time illustrated and described in this work, a few defects may possibly occur, inseparable perhaps from so varied and complicated a subject, and which can scarcely be avoided. But if there be any, it is believed they will not materially affect the chief object intended—namely, to give in as clear a manner as possible the "HISTORY AND PRINCIPLES OF WEAVING."

A. B.

London, 1878.

CONTENTS.

CHAPTER XXXV.

CHAPTER XXXVI.

APPENDIX.

ADDITIONS AND CORRECTIONS.

Page 84, *line* 39. *For* "is eleven inches in length and" *read* "eleven inches in length and is."

Page 109, *line* 24. *For* "headle" *read* "treadle."

Page 170. *Add the following paragraph after line* 39:—

The "shaft monture" is to dispense with the front harness altogether by forming loops in the leashes below the comber board, and inserting in them thin iron shafts, by means of which the ground could be worked without the aid of separate headles.

Page 172. *Add to line* 25:—Preferably the 1st and 3rd and 2nd and 4th may be connected so that the hooks can draw or weave tabby independently of the shafts.

Page 281, *line* 34. *For* "*a* and *b*" *read* "*d* and *e*."

Page 321, *line* 7. *For* "card" *read* "cord."

Page 336, *line* 8. *For* "on" *read* "or."

THE

HISTORY AND PRINCIPLES

OF

WEAVING.

CHAPTER I.

CHRONOLOGICAL ACCOUNT OF WEAVING, ETC.

A chronological account, comprising a description of ancient processes and materials used in weaving—Its early history—Introduction into England—The Weavers' Company—The immigration of foreign weavers—With notices of the principal inventions and other matters connected with weaving, from the earliest period to the year of the Great Exhibition, 1851, compiled from various sources.

WEAVING is an art by which threads of any substances are crossed and interlaced so as to be arranged into a perfectly expanded form, and thus be adapted for covering other bodies.[1]

It would, perhaps, be impossible to assign the origin of any of the useful arts upon which the necessities and comforts of mankind depend to any particular nation or race. Any attempt to do so would at best prove unsatisfactory and fruitless.

The means adopted by uncivilized nations or tribes of the present age for the production of clothing is probably the same as that which was practised in prehistoric times, and it would be more reasonable to assume that such was the case than to surmise, in place of proof, the history of an art that may be almost coeval with the existence of man himself.

The earliest records of the art of weaving are to be found in the Old Testament, where frequent allusion is made to the loom and its products, "of curtains of fine twined linen, and blue and purple

[1] Johnson.

and scarlet, with cherubims of cunning work." In the Book of Genesis it is related that Pharaoh arrayed Joseph in "vestures of fine linen;" and as this refers to a period nearly 4000 years ago, it is believed to be the earliest historical allusion to the art.

That it was held in great esteem in ancient times cannot be doubted, and Job did not disdain to draw a comparison of his troubled life from the loom when he lamented that his "days are swifter than the weaver's shuttle, and are spent without hope."

The oldest remains of woven materials that have hitherto been discovered were found some years ago in the ancient Swiss lake dwellings, which are supposed to have belonged to the stone age. Abundant evidence of fishing-gear, consisting of cord, hooks, &c., were found, also the remains of a kind of cloth, which appeared to be of flax, not woven but plaited, have been detected. Some specimens of these are in the Museum at Kensington.

Within the last few centuries nearly the whole surface of that portion of the earth which was unknown to the ancients has been explored, and many races of men have been found that were not known even in somewhat recent times. Nearly all of them, when first visited, were found to have more or less skill in weaving and spinning, mat-making, plaiting, netting, and the making of paper cloth. Since they have become acquainted with civilized nations they have been able to obtain better and more suitable articles than they could possibly make for themselves, and, in consequence, they neglect their own mode of manufacture. But there are numerous specimens of their workmanship in various ethnographical museums, as well as the descriptions given by travellers of the methods adopted for the production of such articles that they were accustomed to make for their own use. As there was a great resemblance in the method of working amongst the various tribes, a few instances will be sufficient to show the state of the art, which was probably the same as it was amongst all races of men in the most remote ages.

On the discovery of Otaheite, about a century ago, the natives were found to be extensively employed in making matting, not only for the purpose of sitting upon by day and sleeping upon at night, but the finer sort they used as garments in rainy weather. Grass rushes, and the bark of trees, and the plant called wharran were the materials used for the purpose; some of their mats were better and finer than any produced in Europe. They had no hemp, but the want of it was supplied by the bark of a tree, of which they made ropes and lines, and thus provided themselves with fishing-nets.

But the principal and most curious manufacture carried on by them and other similar races was a kind of paper cloth. For this purpose the bark of trees was used to make the pulp. Three descriptions of trees furnished the necessary bark, viz., the Chinese paper mulberry-tree, the bread-fruit-tree, and a tree resembling the wild fig-tree of the West Indies.

The best cloth was made from the mulberry-tree, being finer, softer, and whiter, and better adapted for taking colours. The bread-fruit-tree produces a much coarser texture, and the last-mentioned tree is very coarse, and in colour similar to brown paper; but this last description is the only one of the three that will withstand water. The shrub was cultivated round the houses of the natives, and when it was two years old it was cut down, when a new one sprang from its roots, the tree being one of the most prolific in nature. The bark was always taken from young trees, which were carefully drawn into long stems without any branches except at the top. When the bark was stripped off it was laid for some time in a stream to moisten, and women-servants separated the inner part from the outside, for which purpose they went naked into the water. The fine inner coat, thus prepared, was spread out on plantain leaves. A square piece of hard wood, fluted on its four sides by furrows of different sizes, was then used in beating the bark on a smooth board; and, by sprinkling some water upon it during the operation, it at last formed a very equal and fine cloth of the nature of paper, but much more pliable and less apt to be torn, and which could be made of considerable length and breadth—sometimes two or three yards wide and fifty yards long.[2] In the process they used a kind of glutinous water to make the bark cohere together. The whole operation was performed by women, who afterwards dyed the cloth of different colours and patterns.

In Loango the weavers make their cloth of a grass about two feet high, which grows untilled in the desert plains, and needs no preparation to be put to work. The length of the grass is the length of the web, and they make the cloth rather narrower than long. This cloth is woven like ours; but they make it on their knees *without shuttle or loom*, having the patience to pass the woof through the web with their fingers in the same way that our basket-makers

[2] Hawkesworth.

weave their hurdles. Although they work with such quickness that one can scarcely follow their fingers with our eyes, they get but slowly forward, and the best workmen do not make more than the length of an ell of cloth in the space of eight days.[3]

In Mandingo the women prepare the cotton for spinning by laying it in small quantities at a time upon a smooth stone or piece of wood, and roll the seeds out with a thick iron spindle, and they spin it with a distaff. The thread is not fine, but is well twisted, and makes a very durable cloth. The weaving is performed by the men. The loom is made exactly upon the same principle as that of Europe, but so small and narrow that the web is seldom more than four inches broad. The shuttle is of the common construction, but, as the thread is coarse, the chamber is somewhat larger than the European.[4]

In the ethnological department of the British Museum may be seen numerous specimens of paper cloth, skin dresses, mats, nets, plaited work of various kinds, cords, and ropes made by uncivilized nations. On the other hand, there are various specimens of cloth made by the ancient Peruvians and Egyptians. These articles, as might be expected from more cultivated races, exhibit a far more advanced state of the art. The cloth is not only composed of better spun threads, but the weaving is of a higher quality, showing at once that the ancient Peruvians and Egyptians were far more advanced in these arts than any of the uncivilized nations of the present age.

The Peruvians were greatly skilled in weaving, and they made shawls, robes, carpets, coverlets, hangings for the imperial palaces and the temples. Their cloth was finished on both sides alike, and the finest was made of the wood of the huanacos and vicūnas.

When Pizarro exhibited the llama to Charles V., as the only animal of burden known on the new continent, and the fine fabrics of woollen cloth which were made from its shaggy sides, the latter gave it a much higher value in the eyes of the monarch than what it possessed as an animal for domestic labour.[5]

The Peruvians, at the appointed season, sheared their flocks, and the wool was deposited in the public magazines. It was then dealt out to each family in such quantities as sufficed for its wants, and

3 Proyart's "History of Loango."
4 Mungo Park's "Account of the Mandingos."
5 Prescott's "History of Peru."

the spinning and weaving was performed by the female part of the households, who were well instructed in the business.

In very recent times, if not actually at the present, it was not uncommon for women in the north of England and in the Highlands to weave at home many coarse articles of domestic use, and the cloth so woven was more durable, it is said, than that which is made by the regular manufacture.

A writer who accompanied the troops in the late Ashantee war states that "the Fantee weaver uses a loom of a very primitive construction, but is marvellously quick at his work, throwing the shuttle from side to side with his hands, and working the treadles with his toes. The thread used is extremely fine, and of the brightest colours, but the pattern is not of a very elaborate nature. The material is very dear, being a dollar a yard, at least double the price of English fabric, but is very strong and lasts much longer. Few natives, however, can afford the price, so that our merchants have it all their own way."

The animal substances used by the ancients for the purpose of weaving[6] were as follows:—sheep's wool, goat's hair, beaver's wool, camel's hair, fibres of the pinna, silk. The vegetable substances were—flax, hemp, mallows, broom, and cotton. Mineral substances —gold, silver, and asbestos. The last-named material being used for lamp-wicks, and for the process of cremation. In recent times, various other materials have been used, such as jute, alpaca wool, and glass. Amongst the ancient Egyptians the clothing of the poorer classes was composed of woollen cloth, and cotton and wool were used by the rich. The priests wore linen in accordance with their idea of its purity, for they were not allowed to enter the temples with any articles of dress composed of wool, and on no account were they allowed to wear it for under-clothing, that material being considered unclean, owing to its property of breeding or being liable to become infested with worms and insects. Allusion to this fact is made by Isaiah: "They shall wax old as a garment; the moth shall eat them up." "For the moth shall eat them up like a garment, and the worm shall eat them like wool."[7] In Anglo-Saxon times advantage was taken of this defect, for a cloth woven of goat's hair was used by the clergy for bedding, and occasionally for shirts by devotees, which were noted to be difficult to keep free from vermin.

Although woollen and cotton cloth have always been most com-

[6] Yates's "Textrinum Antiquorum." [7] Isaiah l. 9; li. 8.

monly used for clothing and other purposes, it is fortunate that the Egyptians did not enshroud their dead with either of these materials, and particularly so with wool. Thus linen was chosen for shrouds, and was always used for that purpose solely on account of its cleanliness and lasting qualities.[8] The dead were encased in its folds, so that the bodies should be preserved uninjured, for a space of 3000 years, when it was believed that the former spirit would return after its transition state and habitation of the bodies of various animals, to resume its former existence.

It was from this circumstance that what actual knowledge is now possessed of Egyptian weaving is owing, and the preservation of numerous specimens found in the mummy pits of Egypt. Some of the fragments of linen cloths so found were sent to England by Mr. Salt, and were deposited in the British Museum. They were very fine, and the finest appeared to be woven with threads of about 100 hanks to the pound, with 140 threads to the inch in the warp and 64 in the woof. The Egyptian priests were partial to cotton dresses, and they were supplied to them by the Government, which is distinctly mentioned on the Rosetta stone.

Notwithstanding the allusion to silk in the English version of the Old Testament, it was declared by Braunius, and his statement is not disputed, that there is no mention of it in the whole of the Sacred Book, and that it was unknown to the Hebrews in ancient times. The first ancient author who gives any evidence respecting it is Aristotle, and the great estimation in which it was held in Mahomet's time cannot be more evident than the fact of its being the only material used for human clothing which Mahomet introduced amongst the luxuries of Paradise.

Amongst the ancient Greeks and Romans weaving was not only carried on as a domestic employment, but also on a large scale similar to other extensive branches of trade. Descriptions of banners, and the robes of emperors and priests, are frequently to be found in ancient authors, but unfortunately there is a total absence of any description of the process adopted by the weaver for their production. An idea of them may be obtained from ancient sculptures and the figures portrayed on vases, but no remains of the clothing itself are to be found. In more recent times, from the tenth to the thirteenth centuries, numerous specimens of Syrian, Greek, Saracenic, Spanish, Sicilian, Oriental, and Italian weaving

[8] Sir G. Wilkinson's "Ancient Egyptians."

remain, examples of which are shown in the Kensington Museum. They display a high degree of skill on the part of the weaver, and the draw-loom was probably used in their production.

Therefore, as far as can be at present ascertained, the history of weaving from ancient to medieval times depends solely upon the few samples of cloth that have been preserved, and the representations of ancient looms that will be hereafter shown. It is evident, however, that the art progressed gradually and slowly. From the embroidered work of the ancients it proceeded step by step, until not only plain and figured velvets were produced, but "velvet upon velvet," viz. a velvet figure raised upon a velvet ground, and tissue work of great richness were achieved. Still nothing is known regarding the origin of these improvements, nor is the time of their introduction into England, at various periods, in any way clear. Some branches of the art seem to have been introduced, and after being carried on to a great extent, to have been disused, forgotten, and again introduced. This was the case with tapestry work. But when the importance of the art became evident to Englishmen, it gradually took firm hold, and progressed with varied degrees of success until within the present century, when so vast and important have the textile manufactures become, that the wealth and prosperity of the country are almost entirely dependent upon them.

There were three great events which led to this result by introducing numerous artisans skilled in their business, by whose means the manufacturing arts were established. The first event was the encouragement given by Edward III. to the Flemings to come and establish themselves under his protection. He had observed the great wealth that had accrued to neighbouring potentates by their fostering the textile manufactures, and he determined to take advantage of it himself for the benefit of his country. He therefore took every means to bring skilled workmen from abroad, and establish them here.

The second and third events arose from quite another cause, namely, the immigration of Flemish and French workmen to escape the persecution they were subjected to in their own countries.

In addition to these it may be remarked that the Crusaders, during the Twelfth Century, are reputed to have brought back with them a knowledge of many of the Eastern arts, and it is by no means improbable that damask weaving (named from Damascus) may have been one of them.

The woollen manufactures of Flanders are said to have commenced about the middle of the Tenth Century, during the years 958 and 960, and it is to that country that England is so much indebted for the early introduction of their improved method of manufactures.

It has been frequently asserted that the ancient Britons had no knowledge of the art, and that it was first introduced into Britain by the Romans in the reign of Claudius, when they established factories at Winchester and other places for the making of cloth for the use of their army, and sailcloth for their navy, then located here. They also made embroidery for the imperial use, and other textile manufactures. But there can be little doubt that the Britons did know how to weave, for pieces of coarse cloth resembling baize have been found in ancient British Barrows, and but recently a shroud was found in a Celtic Barrow in Yorkshire, which was plaited, and formed a loose, coarse fabric, and Boadicea is said to have worn under her cloak a motley tunic, checkered over with many colours, which was probably of native workmanship.

The example set by the Romans would soon be followed by the Britons, and probably they would be taught and employed in the factories to assist the Roman operatives. Nothing, however, is definitely known respecting the art during the Roman occupation, but it appears to have been carried on and to have grown to considerable importance at the Anglo-Saxon period. Embroidery was also practised, and the Anglo-Saxon women were famous for their skill in using threads of coloured silk as well as of gold and silver. Their work was called "English work," as in previous times a similar fabric was called "Phrygian." The ladies at that time were brought up to spin; thus Edward the Elder sent his "son to scole and his daughter to work wole," viz. to learn the use of the distaff and the needle.

The Anglo-Norman ladies also excelled in the art, and tapestry came to be used as an ornament to the walls of the barons, which was probably made by the ladies of the household. William of Malmesbury says, "The shuttle is not filled with purple only, but with various colours, moved here and there among the thick spreading threads, and by the embroidery art they adorn all the woven work with various groups of figures." An ornamental cloth called "baudekin" was made, and was long in great repute.

A few specimens still exist of weaving and embroidery that were worked in Anglo-Saxon and Anglo-Norman times, and perhaps the most interesting one is the well-known Bayeux Tapestry, representing the Conquest of England, which is said to have been the work of Matilda, the wife of the Conqueror, and her assistants. Not only an excellent copy in photography of this interesting work may be seen in the Museum at Kensington, but a small piece of the cloth itself, which was brought home by Mrs. Stothard when her husband was employed in making drawings of the work. It is now believed that it was not the work of Matilda, but that it was done by English hands, perhaps in London, by order of one of the three knights who came from Bayeux.[9]

Long before the Conquest the weavers had formed themselves into a Fraternity or Company, as was also done by artisans following other trades, but they had no power of incorporation. On this account they were opprobriously denominated "Adulterine Gilds," and were amerced to the king for their illegal and presumptuous proceedings.[1]

Gild, Guild, or Geld, primarily means a payment. It signified a tax, tribute, or mulct.[2] As explained by Johnson, it is a Fraternity originally contributing funds to a common stock or corporation. They were, as above stated, in existence so early as in Anglo-Saxon times, although little is known of them during that age. The commissioners appointed in Charles the Second's reign to report on the City Companies asserted that the Weavers' Company was the oldest, and that opinion is still maintained. During the Anglo-Norman period, there is an account, says Herbert, of only one Guild, namely that of "Tellaij," or woollen cloth weavers, although there must have been others at that time in existence.

Henry I., to whom they paid an annual rent of sixteen pounds for their immunities, granted them a charter, which does not appear to be now in existence, but it was renewed or confirmed by Henry II. This charter seems to establish the fact of some of the Guilds having enjoyed immunities immediately after the conquest, which could only have been acquired from long previous usage. The charter, still in the Company's possession, granted by Henry II., is as follows:—

"Henry, King of England, Duke of Normandy and of Guian, Earl of Anjou,

[9] Rev. D. Rock. [1] Maitland's "History of London."
[2] Herbert's "History of the Twelve Great City Companies."

to the Bishops, Justices, Sheriffs, Barons, Ministers, and all his true Lieges of London, sendeth greeting, Know ye that we have granted to the Weavers in London their Guild to be had in London, with all the Freedoms and Customs that they had in the time of King Henry, my Grandfather. So that none but they intromit within the City of their Craft, but he be of their Guild; neither in Southwark, or other places pertaining to London, otherwise than it was done in the Time of King Henry, my Grandfather. Wherefore I will and straightly command that over all lawfully they may treat, and have all aforesaid; as well in Peace, free, worshipful, and wholly, as they had it freer, better, worshipfullier, and whollier than in the Time of King Henry, my Grandfather. So that they yield yearly to me two Marks in Gold at the Feast of St. Michael, and I forbid that any man to them do any unright or Disease, upon Pain of ten Pounds.

Witness Thomas of Canterbury, Warwick fil Gar. Chamberlaine, at Winchester."

The king established the cloth fair in the churchyard of the Priory of St. Bartholomew, Smithfield, and the place still retains its name.

Henry also, in the thirty-first year of his reign, confirmed their charter to the Weavers in London that made Woollen Cloth; and, amongst other articles, decreed that if any man made cloth of Spanish wool mixed with English wool, the Portgrave, or Chief Magistrate of London, "ought to burn it"!

The Guilds at this time had power to hold meetings, elect annual officers, keep accounts, make bye-laws, and govern the several trades with almost absolute sway.[3] They alone had power to sell without control in London all things belonging to their "mystery," and the Weavers' Guild allowed none of their craft to work between Christmas and the Purification, or at night by candlelight, and at other times proscribed.

King John, in the third year of his reign, granted the city a charter, which, at the request of the mayor and citizens, confirmed "that the Guild of Weavers shall not from henceforth be in the City of London, neither shall it be at all maintained. But because we have been accustomed yearly to receive eighteen marks in money, every year of the said guild, our said citizens shall pay unto us and our heirs twenty marks in money for a gift at the Feast of St. Michael at our exchequer."

By this charter the Guild of Weavers were expelled the city, but for what offence is not mentioned, although the crime must have been very considerable to occasion the expulsion of the whole body. Still in those days, and under such a reign, persecution and extortion, in the absence of evidence, may have had something to do with the matter.

[3] Herbert.

The company originally consisted of the cloth and tapestry weavers, who by Act of Parliament of Henry IV., were put under the government and correction of the Lord Mayor and Aldermen of the City. They consist of two wardens and sixteen assistants, with a livery of no definite number. The number, according to a recent list of those members who were eligible to vote, was about eighty.

The original purpose of the Weavers' Guild was simply that of a trade union, and was intended for the protection and encouragement of the business. There were weavers' guilds in other cities besides London, such as Winchester and Salisbury, and they paid fines to the king for their privileges of making cloth. To London was accorded the sole right of exporting woollen cloths, but clandestine attempts at exportation were frequently made. The privileges

of the companies included many meddlesome and ridiculous enactments, interfering with the personal liberty of the weaver, so that the free course of trade was prevented. As above stated, the domestic life of the weavers, the width and quality of the cloth to be produced, and the price at which it was to be sold, were all regulated by law. These companies at the present time no longer retain or carry out the purposes for which they were intended, and little else than the bare name of the trade is now connected with them, and their endowments, meant originally for the fostering of the business, are said to be applied to other purposes.

The arms of the weavers of London are—Azure, on a chevron arg. between three leopard's-heads or, and having in the mouth a shuttle of the last, as many roses gules.[4]

During the Conqueror's time some of the English wool was

[4] Sir Richard Hoare's "Modern Wiltshire"—Old and New Sarum. Vol. vi.

exported, and returned in cloth of a better quality than that made at home. The Flemings were noted for their skill in cloth-making which was so great, that "it seemed in them to be almost a gift or instinct in nature." An inundation of the sea having driven a number of these artisans out of their own country, they sought refuge in England under the protection of William, from the circumstance of the Queen being their countrywoman. This invaluable colony were the founders of the woollen trade in England. The Conqueror settled them at Carlisle, but the ill-will and jealousy of their semi-barbarous neighbours constantly involved them in broils, and they were removed in the year 1111 by Henry I. to Ros, now a part of Pembroke, where their posterity can be distinguished to this day.[5]

As very little is known respecting the condition of clothiers, it may be interesting to note the position held by the mercer, a kindred trade, at this period. In Edward the First's reign, according to the tax-gatherers of that day, the person who united the trade of mercer and spicery-seller seemed to correspond very much with the country dealer, and it is probable from the value of his stock, which did not exceed 3*l.*, that his wares were not more numerous than a modern pedlar.[6] The stock of one consisted of the following articles, viz.:—

	£	*s.*	*d.*
A piece of Woollen Cloth valued at	0	7	0
Silk and fine linen	1	0	0
Flannel and Silk purses	1	4	0
Gloves, Girdles, Leather purses, and Needlework . .	0	6	8
Other small things	0	3	0
	£3	0	8

This stock, together with the household furniture and utensils, is valued at 5*l.* 9*s.* 3*d.* Another mercer's goods were valued at 6*s.* 8*d.* The dealer was called mercator, which may be translated mercer, as it seems to correspond both in name and trade with the Scotch merchant. The difference in the value of money, however, at that and the present time is very considerable—perhaps fifteen times as much as it now represents.

1100. If tradition may be trusted, it appears that in the reign of Henry I. the cloth manufacture must have been exceedingly prosperous, and foremost amongst the manufacturers was the redoubtable Thomas Cole, the rich clothier of Reading, "whose wains filled with cloth crowded the highway between that town

[5] Fuller, 1662. [6] Sir F. M. Eden's "State of the Poor," 1797.

and London." Henry gratified Cole and his fraternity with the set measure of a yard, by making his own arm the standard thereof.

1199. Cloth was worked at Nottingham at this date, and all persons within ten miles of the town were forbidden to work dyed cloth except in the borough. White and red cloth made in Ireland was much used in England.

1236. At this time the Scots made their own flax into linen, and their wool into coarse cloth, and the Flemings had a factory at Berwick-on-Tweed.

1261. The barons enacted that no wool was henceforth to be exported.

1305. According to Anderson's History of Commerce, there were at this time 4000 woollen drapers and 150,000 journeyman weavers in Louvaine!

1307. The linen manufacture became well established in Norfolk, and Aylesham became noted for its flaxen fabrics. "The fine Cloth of Aylesham," "The Aylesham Linens," and the "Aylesham Webs," are frequently mentioned in old records. English weavers, it is said, knew how to work artificially designed and well figured webs.

1329. The woollen trade settled at Worsted in Norfolk. The manufacturers were enjoined by Parliament to work their cloth better than they had done.

It was in this reign, Edward the Third's, that the woollen manufacture was firmly established. Before this time the statutes take no cognizance of clothing, as being of inconsiderable importance, and needing no rules to regulate it. Wool was exported, and 100,000 sacks per annum paid an export duty of fifty shillings per sack; but the king discovering the great advantages that would accrue to the nation by fostering the clothing manufacture, strictly prohibited the exportation of it, and enacted that no foreign-made cloth should be brought into England, and that none but English cloth should be worn, except by the king and queen and other privileged persons. He therefore proclaimed "that all clothworkers of strange lands of whatsoever country they be, which will come into England, Ireland, Wales, and Scotland, within the king's power shall come safely and surely, and shall be in the king's protection to dwell in the same lands, dwelling where they will, and exercise their trades and have sundry privileges; by which invitation many were drawn, so was it the principal cause of advancing that honest, best and most beneficial trade in the kingdom, to the great enrichment, strength, and honour thereof."[7]

Edward became surety for the immigrants till they could gain by their occupation. Rymer has preserved a document, in which the king takes John Kempe, together with his apprentices bred to the business, servants, goods and chattels, upwards of sixty persons, under his protection. These appear to have been fine woollen weavers. Another colony of Walloons came over shortly afterwards, who were followed in succeeding years by many others of their countrymen.

While the king was thus laudably employed so far in peopling towns and villages with these ingenious and industrious workmen, the magistrates of Bristol were busy in thwarting them. In 1342 they persecuted with exactions Thomas Blanket and some other citizens, who, taking advantage of the influx of the immigrant Flemings, had set up looms in their own houses and hired weavers and other workmen to commence making woollen cloth. Blanket appealed to the king. In the king's letter to the corporation he says, "considering that the manufactures may turn out to the great advantage of us and all the people of our kingdom, you (the mayor) are to permit the machines to be erected in their houses at their choice, without making on that account any reproach, hindrance, or undue exaction." This mandate put a stop to the rapacity of the corporation. From this Thomas Blanket the name of the well-known fabric is supposed to have been taken.

1353. The first staple of wool held in England at Westminster. So great were the advantages conferred upon the country by Edward that they were long remembered; and Fuller, writing three centuries later, speaks of them as fresh as though it had been in his own time, and quaintly remarks, that—

> The king observing the great gain to the Netherlands by the export of this wool, in memory whereof the Duke of Burgundy instituted the order of the Golden Fleece—where indeed the fleece was ours, the gold theirs, so vast was their emolument by the trade of clothing. The king therefore resolved if possible to reduce the trade to this country, for

---

[7] Speed.

Englishmen at this time knew no more what to do with the wool than the sheep that wear it, as to any artificial or curious drapery, their best clothes being no better than Friezes—such their coarseness from want of skill in the making. Unsuspected emissaries were employed by our king in those countries, who wrought themselves into familiarity with those Dutchmen as were absolute masters of their trade, but not masters of themselves, as journeymen and apprentices; these bemoaned the slavishness of these poor servants, whom their masters used rather like heathens than Christians—yea rather like horses than men; early up and late in bed, and all day hard work, and harder fare, as a few herrings and mouldy cheese, and all to enrich the churles their masters without profit to themselves. But, oh, how happy should they be if they would but come into England, bringing their mystery with them, which would provide their welcome in all places! Here they should feed on fat beef and mutton till nothing but their fulness should stint their stomachs. Yea they should feed on the labours of their own hands, enjoying a proportionable profit of their gains to themselves: their beds should be good, and their bedfellows better, seeing the richest yeomen in England would not disdain to marry their daughters unto them, and such the English beauties that the most envious foreigner could not but commend them. Many Dutch servants left their masters and brought over their trade and tools, such which could not yet be made in England; and happy the yeoman's house into which one of these Dutchmen did enter, bringing industry and wealth along with them. Such who came in strangers within, soon after went out bridegrooms and returned sons-in-law. Yea those yeomen in whose houses they harboured soon proceeded gentlemen, gaining great estates to themselves, arms and worship to their families. The king sprinkled them throughout the country, though, generally, when left to themselves, they preferred a maritime habitation."

As soon as the great value of the woollen manufacture became known and understood, England became very jealous of anything that might be detrimental to its progress. Laws were repeatedly passed to prevent the exportation of wool, and it is said that the woolsacks still used in the House of Lords were originally placed there as seats to remind the Peers of the importance of the wool trade, the great staple at that time of England. The earliest mention[7] of them is said to be in Act 31 Henry VIII., cap. 10, "For placing the Lords," the eighth section of which directs that the Lord Chancellor, Lord Treasurer, or any other officer, who shall be under the degree of a Baron of Parliament, shall sit and be placed at the uppermost part of the sack, in the midst of the said Parliament Chamber, either there to sit upon one form or upon the uppermost sack. D'Ewes in his journal, speaking of the Parliament of Elizabeth, 1558 and 1559, says that the Lord Keeper, Sir Nicolas Bacon,

[8] From "Notes and Queries."

when her Majesty was absent, sat on the first Woolsack which is placed athwart the House, the seal and mace by him. The other woolsacks were then, as now, allotted to the judges. In the standing order of the House of Lords, 1621, it is declared, "That the Lord Chancellor sitteth on the Woolsack as Speaker to the House." But it is believed they were first placed there in the reign of Edward III.

The various branches of manufacture settled, according to "Fuller's Church History," at the following places, namely:—

Westmoreland—Kendal cloth.
Lancashire—Manchester cotton.
Yorkshire—Halifax cloth.
Devonshire—Kersey.
Gloucestershire—cloth.
Worcestershire—cloth.
Wales—Welsh friezes.
Norfolk—Norwich fustians.
Suffolk—Sudbury bayes.
Essex—Colchester sayes and serges.
Kent—Kentish broadcloths.
Somersetshire—Taunton serges.
Hampshire—cloth.
Berkshire—cloth.
Sussex—cloth.

Some of the manufacturers had great renown in their day, and their memories still live. In the North of England there were Cuthbert of Kendal, Hodgeskins of Halifax, and Martin Byram of Manchester. In the West there were Thomas Cole of Reading, Jack of Newbury, Fitzallen of Worcester, Sutton of Salisbury, Gray of Gloucester, Tom Dove of Exeter, and Simon, or Subroath, of Southampton. A famous Dutch cloth-maker in Gloucester had a new name, "Web," given to him by King Edward III.

The Poet Chaucer lived in this reign. In his "Canterbury Tales" he thus describes the dress of the knight: "Of Fustian he weared a Gipon." The Serjeant-at-Law wore a coat of mixed stuff; the Canon was dressed in a cloak, and the Friar, "Of double worstede was his semicope."

When speaking of the county of Suffolk, Weever, the Antiquary, alludes to the prosperity that had existed through the introduction of the cloth manufacture at this period, as follows:—

"Otherwise I should not find so many marbles richly inlaid with brass to the memory of clothiers in foregoing ages, and not one in these later seasons. All the monuments in the Church of Newland which bear any face of comeliness and antiquity are erected to the memory of clothiers, and such as belong to that mystery."

The encouragement given by Edward III. for the introduction of cloth manufacture, therefore, may be considered as the first important step that was made towards the firm establishment of the manufacturing arts into England.

1354. The following statement of the foreign trade of the country at this period is of interest, and contrasts favourably with the trade nearly three centuries later (see 1622) in James the First's reign. It appears, however, that the king had again allowed wool to be exported, probably because more was produced in the country than could be used in the home manufacture.

State or balance of the English trade in the twenty-eighth year of Edward III. :—

EXPORTS.	£	*s.*	*d.*
One and thirty thousand, six hundred, and fifty-one sacks and a half of wool, at 6*l.* value each, amount to . .	189,909	0	0
Three thousand, thirty-six hundred, and sixty-five felts, at 40*s.* value each hundred at six score, amount to .	6,073	1	8
Whereof the custom amounts to	81,624	1	1
Fourteen last, seventeen dicker, and five hides of leather, after 6*l.* value the last	89	5	0
Whereof the custom amounts to	6	17	6
Four thousand, seven hundred, and seventy-four cloths and a half, after 40*s.* value the cloth, is	9,549	0	0
Eight thousand and sixty-one and a half of worsted, after 16*s.* 8*d.* value the piece, is	6,717	18	4
Whereof the custom amounts to .	215	13	7
Sum of the out-carried commodities in value and custom	£294,184	17	2
IMPORTS.			
One thousand, eight hundred, and thirty-two cloths, after 6*l.* value the cloth	10,992	0	0
Whereof the custom amounts to	91	12	0
Three hundred and ninety-seven quintals and three quarters of wax, after the value of 40*s.* the hundred of quintal	795	10	0
Whereof the custom is	19	17	0
One thousand, eight hundred, and twenty-nine tuns and a half of wine, after 40*s.* value per tun	3,659	0	0
Whereof the custom is	182	0	0
Linen cloth, mercery, and grocery wares, and all other manner of merchandise	22,943	6	10
Whereof the custom is	285	18	3
	£38,969	4	1
Sum of the inplusage of the out-carried above the in-bought commodities amounteth to	£255,215	13	1

1360. In Ireland a woollen stuff called Sayes was extensively made and exported. It was greatly admired abroad, and imitated by foreign manufacturers.

1369. Perhaps the most important of the immigrants at this period was John Kempe, and the host of ingenious Flemings who followed him. They established the manufacture of fine woollen cloth on a foundation that has not once been shaken for five hundred years. But neither their skill, industry, nor the knowledge they had spread of a valuable manufacture, nor their misfortunes, could save them from the persecution of the native cloth-makers and weavers, who were become skilful and were growing rich, from following their examples and instructions. They were at all times the objects of vulgar hatred and malice, and their lives were in danger.

In the summer of this year, more particularly, they became the victims of popular fury, and gross outrages were committed upon them, until Edward issued a proclamation declaring them to be under his especial protection. A short time after his death, the ill-will of the native workmen again broke out into open violence against the "cursede forrainers."

1379. Richard II. acted as a mediator, and an agreement in 1379 was effected between the native and foreign interests, which was confirmed by the royal authority.

The foreign workmen were now so numerous in London, that places were assigned to them in which they could deliberate on the affairs of their communities. The churchyard of St. Lawrence Poulteney was appropriated to the Flemings, and that of St. Mary Somerset to the Hollanders.

Richard II. was fond of fine clothes, he had one coat of gold and precious stones which cost 31,000 marks. In his reign a decree was enacted, that "no merchant shall stretch before his shop a red or black cloth, or anything by which the choice of the buyer is frequently deceived."

1421. Mohair cloth, called Baracani, manufactured in Perugia, was in great demand in the southern countries.

1436. Coventry celebrated for woollen cloth caps and bonnets.

1455. The art of spinning and throwing silk had been introduced by a company of silk women, of what country is not known. In a petition to Parliament they stated that the Lombards and other Italians imported such quantities of threads and rib-bands, and other silk things, that they were impoverished. To protect them an Act was passed prohibiting the importation of the articles which they fabricated.

1473. Cloths of silver and gold were manufactured in London.

After this period not only were woollen fabrics manufactured in sufficient quantities to supply the demand at home, but also to provide a large amount for exportation.

1480. The silk manufacture introduced into France by workmen from Italy.

1486. Henry VII., observing that the woollen manufacture had become languid and was declining owing to the unsettled state of the country under his immediate predecessors, drew over a great number of the best cloth-workers from the Netherlands, which gave a new vigour to cloth-making operations.

1494. Improvements made in Fustian cutting.

1500. Coventry celebrated for blue thread called "Coventry true blue."

1510. In the reign of Henry VIII. the manufacture of broad cloth made with broad looms is said to have been introduced. They required two men to work one, and John Winscombe, better known as "Jack of Newbury," is asserted to have been the first to adopt them. This famous clothier, as manufacturers were then called, was another example of enterprise and energy, which was appreciated so highly, perhaps from its rarity, in former times. This worthy man was then, and long afterwards, considered as the greatest clothier England ever beheld. He had a hundred looms "in his house," each managed by a man and a boy. He feasted the king and queen on one occasion, and in the expedition to Scotland against James IV., who was defeated at Flodden Field, he marched with a hundred of his own men. He died in the year 1520, and his house was afterwards converted into sixteen separate houses or tenements.

Tapestry weaving, which appears to have become neglected and forgotten, was reintroduced into England about this time by William Sheldon, the founder of Weston House, Warwickshire. Under his direction were woven a curious series of maps, which formerly ornamented the hall of Weston House. A portion of them represented the counties of Hereford, Salop, Stafford, Worcester, &c. They ultimately came into the possession of Richard Gough, the Antiquary, and are now in the Bodleian Library.

Shakespeare makes frequent mention of weavers and matters pertaining to them. The passage in Henry VIII. Act i. where Wolsey is charged with taxation refers to this period. To keep up his semi-regal state he is said to be the "putter on of these exactions," and Queen Katherine tells the king that his subjects are almost in loud rebellion against the taxation they were subjected to. Thus the Duke of Norfolk states :—

> "Not almost appears,
> It doth appear; for upon these taxations
> The clothiers all, not able to maintain
> The many to their longing, have put off
> The spinsters, carders, fullers, weavers, who,
> Unfit for other life, compell'd by hunger
> And lack of other means, in desperate manner
> Daring the event to the teeth, are all in uproar,
> And Danger serves among them."

1519. When circumnavigating the globe in this year, Magellan found the Brazillians using "this vegetable down" (cotton) in making their beds.

Cotton fabrics were sent by Cortes from Mexico to Spain.

Cotton was cultivated and manufactured at this time on the coast of Guinea.

1528. The Company of Clothworkers incorporated.

1530. The art of knitting known in England.

The spinning-wheel known or invented about this time.

1536. De Vica found the cotton plant in Texas.

1542. First Act of Parliament relating to the linen trade in Ireland.

1552. An Act passed directing that all cottons called Manchester, Lancashire, and Cheshire cottons full wrought to the sale shall be in length 22 yards, and breadth three quarters of a yard in the water, and shall weigh thirty pounds in the piece at least. Also that cloth called Manchester Rugs and Friezes, shall contain thirty-six yards, and be three quarters of a yard wide when in the water, and weigh forty-eight pounds at least.

1554. Fustians of Naples made at Norwich.

1558. An Act of this time relates that—

"Certain evil-disposed persons, who buy and engross great store of linen cloth, do cast the pieces of cloth over a beam or piece of timber made for their purpose, and do by sundry devices rack, stretch, and draw the same both of length and breadth, and that done do then with battledores, pieces of timber and wood, and other things sore beat the same, ever casting thereupon certain deceitful liquors mingled with chalk and other things, whereby the said cloth is not only made to seem much thicker and finer to the eye than it is indeed, but also the thread thereof being so loosed and made weak, that after three or four washings it will hardly hold together, to the great loss and hindrance of the natives."

These practices were forbidden.

1560. Cotton was imported from Antwerp into England.

"Mrs. Montague, Her Highness's silk-woman, presented the queen with a pair of black silk knit stockings, which after a few days wearing pleased Her Highness so much that she sent to Mrs. Montague for more. The queen, who was not ignorant of the attraction of a smart-looking foot and ankle, liked them so that she would not henceforth wear any more cloth hose."

1561. Barbara, the wife of Christopher Uttmann, at the castle of St. Annaberg, on the borders of Saxony, invented the art of making pillow lace.

1567. The second great event which did so much to establish the manufacturing arts in England, occurred at this period owing to the persecutions of the Duke of Alva.

The Netherlands at this time were an assemblage of separate states, and were all subject to Philip II. of Spain. The Lutheran and Calvinistic opinions had made great progress in those quarters at that time, and Philip, being an intolerant bigot by nature, was determined to repress them, and for that purpose sent the Duke of Alva to Flanders at the head of Spanish and Italian troops, to enforce implicit submission. An inquisition was established, new bishops appointed, and in a short time 18,000 persons perished by the hands of the executioner. The Duke of Alva's government lasted five years. The minds of the people, who had previously received Philip as their protector, now became alienated, and the Prince of Orange, who was himself under sentence of the Inquisition, raised an army, and was proclaimed Stadtholder of Holland and Zealand in 1570. He succeeded in abolishing the Romish religion and throwing off the Spanish yoke, but Philip offered 25,000 crowns for his head, and this illustrious man fell a victim to an assassin in 1584,[9] which circumstance was known as "the crime of the times."

[9] Tytler.

In consideration of the services of the Duke of Alva, the Pope called him "his beloved son," and presented him with a sword wrought with gold and precious stones.

During this period of persecution, thousands of the Hollanders came to England, which was the only sanctuary they had left. Queen Elizabeth was offered the sovereignty of their province, but she contented herself with relieving her distressed neighbours, and took them under her protection (1585), and concluded to send 5000 foot and 1000 horse into the Netherlands to fight for them.

The King of Spain from this and other circumstances became incensed thereat (1588), and sent his Invincible Armada against England, and raised a rebellion in Ireland against the queen.[1]

The refugees who came to England brought with them their several arts, many of which had not been practised or known in England before that time, and it is probable that the draw loom for Damask weaving was then introduced.

The citizens of Norwich appear to have been the first to have taken advantage of the Duke of Alva's persecutions, for the city at that time being in a very depressed state, owing to the decay of the worsted manufacture, many were forced to leave their houses, and go into the country to get their bread. The Mayor and corporation, being anxious to restore the prosperity of the community, waited upon the Duke of Norfolk, who was then at his palace in that city, and it was decided to invite some strangers of the Low Countries, who, by leave of the queen, had come to Sandwich and London for refuge from the Duke of Alva.[2] Upon application to the queen by the Duke of Norfolk, she gave letters patent to thirty master workmen each with ten servants to settle in the city, who set up the making of baizes, serges, arras-mochades, curelles and such-like goods mingled with silk and linen yarn, which gave employment to a great many hands. Houses which had fallen into decay were now repaired and inhabited, and both city and county grew rich—the latter by the great demand for farm produce, and the former by the profits from this new introduction of manufactures.

In like manner other places benefited, as the following interesting account of the time will show.

[1] "The Wicked Plots, &c., of the Spaniards" (Harleian Miscellany).
[2] Blomefield's "History of Norfolk."

When the Dutch came and introduced Bay and Saye making the bailiffs of Colchester, Robert Northern and Richard Northey wrote to the Lords of the Privy Council, informing them of the arrival of certain Dutchmen from Sandwich, viz., "Whereas of late a number of Dutchmen have come to this town of Colchester, about eleven households to the number of fifty persons, small and great, where they made their abode longer than other strangers have been accustomed. We therefore called the best of them to know the cause of their coming, who answered they were part of the dispersed flock of late driven out of Flanders for that their consciences were offended with the Masse, and for fear of the tyranny of the Duke of Alva—they came into this realm for protection, and that there were more of them at Sandwich who wished to be permitted to come also—with such sciences as are not usual with us, but weave sackcloth, make needles, parchment, weavours and such-like, so that they shall not be any hindrance to any man or occupation here. We dare not presume to give them licens of ourselves, but great profit might arise to the common estate of this town, greatly decayed &c., and therefore we have given them friendly entertainment until we might signifie the same to your Honours. And we cannot but greatly commend them—to be very honest, Godly, civil, and well-ordered people not given to outrage or excess, &c."

To this a reply was given (24th March, 1570), which states, —"As ye do acknowledge your towne to be benefited by their being there, we are right glad that we first commended them unto you, and cannot but allow their conformity, your gentle handling of them, and the concord betwixt you, the which we trust God will encrease with benefits towards you, &c." Signed by N. Bacon, C.S., T. Sussex, R. Leicester, and dated from Greenwich.

King James I. in his time gave them particular care and protection, and granted them letters patent in 1612, for their better security, for it appears that the English weavers had persecuted them, "notwithstanding they had set to work many of the poor people, to the benefit of the towne, and henceforth they were of great advantage to the town." [3]

1567. A patent was granted to Charles Hastings, Esq., that in consideration that he brought in the skill of making frisadoes as

[3] Morant's "History of Essex."

they were made at Harlem and Amsterdam, being not used in England, that therefore he should have the sole trade thereof for divers years, &c. Some clothiers of Coxfall having made frisadoes, were proceeded against by Hastings, but they "demurred," says Noy, "that it was *against* law to have such penalties of the goods, and 100 pounds to be forfeited by *force* of a letters patent." Hastings went no further, but found that the clothiers did make baizes very like to Hastings' frisadoes, and had done so before Hastings' patent.

1569. Gaspar Campion published "A Discourse of the Trade of Chio," in which he says there is cotton, wool, &c., also coarse wool to make beds.

1570. A conspiracy was formed by John Throgmorton and others, to drive the Flemish out of Norwich, but it was disclosed in time, and many were arrested and condemned. It was their intention to proceed, after collecting forces at Harlestone fair and at Bungay and Beccles, "to Norwiche in such a sodeyne as at the Mayre's feaste to have taken the whole cupboorde of plate to have maynteyned the enterpryse," and then by sound of trumpet and beat of drum, to have expelled the strangers from the city and the realm.

"The strangers applied to the Queen, who issued a letter to the Corporation, minding them of the poor men who had to fly from their own nation through religious persecution, but it was not without a second interposition that matters were quietened."

1573. John Tice attained to the perfection of making all sorts of tufted taffaties, cloth of tissues, wrought velvets, branched satins, and other kinds of curious silk stuffs.

1575. Bombazines first made at Norwich in this year.

1578. At the pageant exhibited to Queen Elizabeth, at Norwich, the following varieties of looms were "pourtrayed:" "Looms for worsteds, for russets, for darnix, for mockads, for lace, for caffa, and for fringe; and upon the stage at one end stood eight small women children spinning worsted yarn, and at the other end many knitting worsted hose."

1579. Morgan Hubblethorne, a dyer, was sent to Persia to learn the art of making and dyeing carpets.

Naipery or table linen, in general use, but was imported.

Cloth called mildernix, or powledavis, of which the sail-cloth for the navy was made before this time, was "altogether brought out of France and other parts beyond sea, and the skill and art of weaving the cloths was never known or used in England, until about this year, when perfect art was attained thereto."

1582. A second return made of the "strangers" that had recently settled in Norwich, shows that there were 1128 men; 1358 women; 815 children, strangers born, and 1378 English born —in all 4679.

Abul Fazel celebrates the town of Sinnergan, in India, for the manufacture of cotton cloth named cassas.

1583. Mr. Ralph Fitch, an English traveller, visited Sinnergan, a town near Senapore, "where there is the finest cloth made of cotton that is in all India."

1589. About this time William Lee, curate of Calverton, invented the stocking frame.

Cotton cloth imported into London from the Bight of Benin. The Dutch engine or ribbon loom, is said to have been invented about this time, in Germany.

1590. Camden, speaking of Manchester, says, "This town excels the towns immediately around it for handsomeness, &c., but did much more excel them in the last age, as well by the glory of its woollen cloths, which they call Manchester cottons."

1605. James I. joined himself unto the Clothworkers' Company, as men dealing in the principal and noblest staple ware of all these islands. "Beeing in the open hall, he asked who was the master of the Company, and the Lord Mayor answered, 'Sir William Stone;' unto whom the king said, 'Wilt thou make me free of the Clothworkers?' 'Yea,' quoth the master, 'and think myself a happy man that I live to see the day.' Then the king said, 'Stone, give me thy hand, and now I am a Clothworker.'"

1610. William Lee died neglected and broken-hearted in France.

1620. The stocking-frame firmly established, and made in great numbers.

1621. This year is generally regarded as the birth-year of cotton culture in the United States. It had previously been found growing in a wild state in various parts of the South. A volume called "Purchas's Pilgrims," says, "Cotton seeds were first planted as an experiment in 1621, and their plentiful coming up was at that early day a subject of interest in America and England."

A tract called "A Declaration of the State of Virginia," published in London in 1620, mentions cotton wool as one of the commodities of that "collony." In 1621 cotton wool was 8*d.* per pound in Virginia.

		£	*s.*	*d.*
1622.	Total amount of exports from England .	2,320,436	12	10
	" " imports including customs, 191,059*l.* 11*s.* 7*d.*	2,619,315	0	0
	Balance lost to England by foreign commerce	£298,878	0	0

1629. The silk-throwsters of London incorporated. A few years previously, Mr. Burlamach, a London merchant, introduced silk-throwing on a considerable scale.

1631. The Company of Silkmen incorporated.

1631. Calicoes first brought into England, from Calicut, India.

1638. A company of Yorkshiremen, about twenty families, settled at Rowley, Massachusetts, and established the manufacture of cloth. Here they built the first fulling-mill, which is said to have been erected by John Pearson, in 1643, and it was in operation so late as 1809. It then contained a cedar tenter-post brought by them from England, which remained perfectly sound. The second fulling-mill was built at Watertown, in 1662.

1641. In a curious pamphlet published at this date the following remarks relating to manufactures are made, which show the state of the trade at that time:—

"The Dutch likewise buyes his Woolls in Spaine, carries it home to his owne house, there spins it, weaves it, and workes it to perfection, then brings it back into Spaine in Sarges, Sayes, and such-like Stuffes; and so there againe sels the same to good profit and vents it.

"The towne of Manchester, in Lancashire, must be also herein remembered, and worthily, and for their industry commended, who buy the yarne of the Irish in great quantity, and weaving it returne the same againe in Linnen, into Ireland to sell; neither doth the industry end here, for they buy Cotton Wooll in London, that comes first from Cyprus and Smyrna, and at home worke the same, and perfit into Fustians, Vermilions, Dymities, and other such Stuffes, and then returne it to London, where the same is vented and sold, and not seldome sent into forraine parts, who have meanes at far easier termes to provide themselves of the said first materials."[4]

[4] "The Treasure of Traffike," by Lewes Roberts, 1641.

Mr. Baines, in his "History of the Cotton Manufacture," says that no mention of the cotton manufacture has been found earlier than the above. In this year it had become well established in Manchester. What before this time went under the name of Manchester cotton fabrics were really composed of wool.

1650. After the annihilation of the royal authority, or between that and the Protectorate, the City of London became the grand focus of the Parliamentary Government. Guildhall was a second House of Commons—Goldsmiths' Hall their bank, Haberdashers' Hall their court for adjustment of claims, Clothworkers' Hall for sequestration. Weaver's Hall might be denominated their Exchequer. From this place Parliament was accustomed to issue bills about and before 1652 in the nature of our Exchequer, and which were commonly known under the name of "Weavers' Hall Bills."

1657. The Stocking Weavers' Company incorporated.

1660. The manufactures carried on in Manchester about this time are thus quaintly described:[5]—

> "As for Manchester the Cottons thereof carry away the credit of our nation, and soe they did an hundred and fifty years agoe. For when learned Leland on the cost of King Henry the Eighth, with his guide travailed Lancashire, he called Manchester the fairest and quickest town in this country; and sure I am it hath lost neither spruceness nor spirits since that time.
>
> "Other commodities made in Manchester are so small in themselves and various in their kinds, they will fill the shop of an Haberdasher of small wares. Being therefore too many for me to reckon up or remember, it will be the safest way to wrap them altogether in some Manchester-Tickin and so to fasten them with the *Pinns* (to prevent their falling out and scattering) or tye them with the *Tape*, and also (because sure *bind* sure *find*) to bind them about with *Points* and Laces, all made in the same place."

1664. "Sir Martin Noel told us," says Pepys in his Diary, "the dispute between him as framer of the additional duty, and the East India Company whether calico be linen or no, which he says it is, having been ever entered so. They say it is made of cotton wool and grows upon trees."

On the 26th of July in this year Pepys also relates that "Great discourse of the fray yesterday in Moorfields, how the butchers at first did beat the weavers (between whom there hath

[5] Fuller's "Worthies."

been ever an old competition for mastery), but at last the weavers rallied and beat them. At first the butchers knocked down all for weavers that had green or blue aprons, till they were fain to pull them off and put them in their breeches. At last the butchers were fain to pull off their sleeves that they might not be known, and were soundly beaten out of the field, and some deeply wounded and bruised, till at last the weavers went out tryumphing, calling one hundred pounds for a Butcher."

1665. An Act passed, 12th Charles II., making it a felony to export wool. Thomas Telham, of Warwickshire, and 2000 others, left the kingdom to escape such restrictions, and were followed by many others from Hampshire.

1667. The Gobelins Manufactory established at Paris for the making of Tapestry, and other furniture, for the use of the Crown. The factory was built by two brothers, Giles and John Gobelin, in the reign of Francis I., and was called the "Gobelins folly" till 1667, when the name was changed to Hôtel Royal des Gobelins, and it has ever since been the first manufactory of the kind in the world.

1668. A number of Walloons, under encouragement of the king, came and established themselves.

1671. A patent was obtained by Edmund Blood for carding and weaving waste silk, which was probably the first attempt to spin waste silk similar to cotton-spinning.

1676. Calico-printing commenced in London in a very imperfect manner.

The Dutch engine loom introduced into London from Holland.

1677. Samuel Pepys was elected Master of the Clothworkers' Company this year, and presented a richly-chased "Loving Cup," still used on all festive occasions.

1678. The East India Company had imported Indian muslins, chintzes, and calicoes in such quantities into Great Britain, and they were so cheap and popular that those interested in the ancient woollen manufacture loudly complained against further importation. A pamphlet entitled "The Ancient Trades Decayed and Repaired Again," was published in London, in which the author laments the interference of cotton with woollen fabrics.

M. De Gennes presented his model of a "machine for making woollen cloths without the aid of a workman," to the French Royal Academy.

An Act passed by the Lord Mayor and Common Council of London for regulating the cloth-markets of the city and preventing foreigners from buying and selling.

1685. The third and by far the most important event tending to the thorough establishment of the industrial arts in England arose from another act of persecution on the part of the Catholics, but this time it was against the Protestants of France. During the reign of Henry IV. (the great), King of France, an Act was granted in 1598 for the toleration of the Protestants, the massacre of St. Bartholomew having occurred in a preceding reign. This Act was revoked in the year 1685 by Lewis XIV., and is now well known as the "Revocation of the Edict of Nantes." The Protestant worship was suppressed, their churches demolished, and their ministers banished. The Protestant laity were forbidden under the most rigorous penalties to quit the kingdom. But by this measure France lost above 500,000 of her most industrious and useful subjects, who eagerly transferred their property, talents, and industry to Prussia, Holland, and other Protestant States. It is said that 70,000 of them came and established themselves in various parts of the United Kingdom, and introduced many arts previously unknown in this country or not practised at that time.

1686. Abraham Opdengrafe claimed from the Governor of the State of Pennsylvania the premium offered to him who should make the first and finest piece of linen cloth.

Velvet-weaving introduced in Spitalfields.

The value of silk imported into England at this time was 700,000*l*. per annum.

1687. Joseph Mason obtained a patent for an engine, by the help of which the weaver may do without the assistance of a draught boy, "which engine hath beene tryed and found out to be of greate use to the said weaveing trade."

1688. The price for weaving linen in America at this time was 10*d*. and 12*d*. per yard, the width being half-yard.

1690. A print ground established by a Frenchman on the banks of the Thames at Richmond.

1691. John Barkstead obtained a patent for "making of callicoes, muslines, and other fine cloathes of the sort out of cotton wooll of the growth of our Plantations in the West Indies."

An Act passed prohibiting the importation of European manufactured silks.

1696. A pamphlet entitled "The Naked Truth in an Essay upon Trade," bewailing the introduction of cotton fabrics, was published, in which it states they were "becoming the general wear in England."

1697. Cotton imported into Great Britain, 1,976,359 lbs.

1698. Francis Pousset obtained a patent for the true art of making "black silke crape and white silke crape."

1700. In consequence of the great dissatisfaction and opposition to the introduction of cotton fabrics into Great Britain during the 17th century an Act was passed prohibiting the introduction of printed calicoes for domestic use as apparel or furniture under a penalty of 200*l*. on the wearer or seller. But it did not prevent the use of them, quantities of which were smuggled into the country, and De Foe relates that weavers did not hesitate to tear such dresses off those who wore them.

Population of Lancashire, 166,200.

About 1,000,000 lbs. of cotton used in Great Britain, employing 25,000 persons.

1701. Cotton imported, 1,985,856 lbs. Cotton goods exported, 23,253*l*.

An Act passed prohibiting the importation of manufactured silks from India and China.

1702. A weaver in Dunfermline made a seamless shirt—a feat frequently done since that time.

Mr. Crotchett of Derby established a silk-mill, but it proved unsuccessful.

1708. De Foe, in the "Weekly Review," January 31, deplores the growing popularity of cotton goods, and attributes to it the loss of above half of the woollen manufactures, and the people employed therein.

Spinning schools established in Ireland.

1710. Cotton imported, 715,008 lbs. Cotton goods exported, 5690*l*. Joseph Beaumont, a London merchant, went to Ireland by order of the House of Commons, and the Trustees for the Improvement of the Linen Manufacture, to report on the same.

1712. The excise duty of 3*d.* per square yard on printed calicoes was raised to 6*d.*

During the time of the South Sea Bubbles, numerous petitions praying for Letters Patent for carrying on all manner of trade were applied for by the dishonest schemers of that period. Amongst them may be mentioned schemes

For sowing hemp and flax;

For making sail cloth;

For making sail cloth and fine holland;

For making linen and sail cloth, with powers to carry on the cotton and silk manufactures.

The following were carried on without application for patents or charters:—

For the clothing trade—Colchester bays; Puckle's machine for making muslin; Irish sail cloth; improving the silk manufacture; for making stockings; woollen manufacture in the North of England, &c., &c.

An order was granted by the Lords Justices for prosecuting certain of these companies, some of them being of a scandalous nature, which at once put a stop to them.

At this time a Bill was sent by the House of Commons to the Lords, for the preservation of the woollen and silk manufactures; but the Lords having heard counsel, put off the bill for six weeks for further consideration. The weavers taking this to be a rejection of the bill, some thousands of them, with their wives and children, went in a tumultuous manner from Spitalfields to Westminster, and demanded justice of their Lordships as they passed to the House. Detachments of the Horse Guards being sent for, the weavers returned home without committing damage of any consequence. But the "hot fit returning," they threatened to demolish the house of a French weaver, and to rifle that of the East India Company; but the Horse and Foot Guards, as well as the Trained Bands being sent for, their designs were happily prevented.

1718. The successful establishment of the silk-throwing business at Derby, by Mr. Thomas Lombe, and commencement of the modern factory system.

1720. Cotton imported, 1,972,805 lbs. Cotton goods exported, 16,200*l.* Ribbon-weaving introduced into Coventry about this time.

An Act passed prohibiting the use or wear, in Great Britain, of any apparel whatsoever of any printed or dyed calico, under a penalty of 5*l*. And a penalty of 20*l*. if such goods were used as household stuff or furniture. In the following year another Act was passed, prohibiting the use of printed calico, whether printed in England or elsewhere.

These restrictions were brought about by the complaints of the Norwich manufacturers, who stated that the weaving of printed calicoes and linen were destructive of the woollen and silk manufactures. The Manchester manufacturers resorted to making other fabrics in order to avoid the Acts, and made new cloths resembling the ancient fustians, which along with muslins and neckcloths of cotton were exempt. They were made of cotton and linen mixed, and became much in vogue.

According to the statement of a Norwich weaver as set forth in his "case" against the Manchester calicoes, it appears that 12lbs. of wool manufactured into woollen stuffs was a week's work for one of their looms, and the cost of workmanship was as follows:—

	£	*s.*	*d.*
Wool sorting	0	0	3
" picking	0	0	8
" combing	0	2	0
" spinning	1	4	0
" throwing . . .	0	4	0
" dying	0	4	0
" winding	0	1	0
" warping	0	0	6
" weaving	0	12	0
" calendering . . .	0	0	6
" pressing	0	1	6
	£2	10	5

From the same source it appears that every hundred weavers required the services of other trades as follows:—

Weavers	100
Wool sorters	4
" pickers	10
" combers	20
Spinners	900

Throwers	4
Turners of the throwing mill .	4
Thread makers . . .	4
Doublers	50
Bobbin winders . . .	12
Back-throw winders . .	12
Quill boys	50
Warpers	5
Dyers	6
Pressers	6
Total .	1187

1725. M. Bonchon invented the application of perforated paper for working the draw-loom, being the origin of the Jacquard Machine.

1727. James Le Blon obtained a patent for the art of weaving tapestry in the loom, "a secret never known or practised before."

1728. M. Falcon substituted a chain of cards to turn on a prism or cylinder, in lieu of the paper band of M. Bonchon.

1730. John Wyatt, then living at a village near Lichfield, first conceived the plan of spinning by means of rollers, and prepared to carry the same into effect.

1732. Richard Arkwright, born at Preston, December 23rd.

1733. John Wyatt constructed a "model about two feet square, by means of which, in a small building at Sutton Coldfield, without a single witness to the performance, was spun the first thread of cotton ever produced without the intervention of the human fingers. The wool had been carded the common way, and was passed between two cylinders, from whence the bobbin drew it by means of the turit."

John Kay obtained a patent for his invention of the "fly shuttle."

1734. Cotton was planted in Georgia from seed sent to the trustees, by Philip Miller of Chelsea.

1736. The prohibition to use cotton in the manufacture of mixed goods repealed.

1738. A patent was granted to Lewis Paul, a partner of John Wyatt, for spinning by rollers. Wyatt is supposed to have been the inventor, and Paul to have supplied the capital required.

1739. On the 6th November a great number of weavers assembled before the house of an eminent master weaver in Spital Square, and endeavoured to destroy it, upon a report being sent to bring the rest of the master weavers into a combination for the journeymen weavers to wind their silk gratis. The Guards were sent and the Riot Act read; but as they did not disperse within the limited time, great numbers were taken prisoners, some of whom escaped, but ten were secured and committed to Newgate, but soon bailed out. Several soldiers were dangerously wounded by bricks and tiles thrown on them from the tops of the houses. Riots also occurred in the years 1765, 1767 and 1769.

1741. Cotton imported into Great Britain, 1,645,031 lbs. Value of cotton goods exported, 20,709*l.*

Mr. Baines, in his "History of the Cotton Manufacture," says, "I have before me hanks of cotton yarn spun about 1741 and wrapped in a piece of paper, on which is written the following in the handwriting of Mr. Wyatt:—'The enclosed yarn spun by the spinning engine (without hands) about the year 1741. The movement was at that time turned by two, or more, asses walking round an axis in a large warehouse near the mill in the Upper Priory, Birmingham. It owed the condition it was then in to the superintendency of John Wyatt. The above was wrote June 3rd, 1756.'"

1742. M. Dubreuil, a French planter in Louisiana, invented a machine for separating the seed from the cotton fibre. The seed had hitherto been picked out of the fibres by hand.

1745. John Kay and Joseph Stell obtain a patent for applying tappets to the Dutch engine loom for weaving narrow goods to be worked by means of "hands, water, or any other force."

M. Vancanson applied the griffe to M. Falcon's invention, and placed the apparatus on the top of the loom in the position now occupied by the Jacquard machine.

1748. Lewis Paul of Birmingham, gentleman, procured a patent for two carding machines, one a flat, and the other a cylindrical arrangement.

1750. The population of Lancashire, 297,400.

1751. Cotton imported into Great Britain, 2,976,610 lbs. Value of all kinds of cotton goods exported, 45,986*l.*

1753. The Society of Arts founded. (Charter 1847.)

1758. Jedediah Strutt, of Derby, patented the Derby-rib machine, being the first important modification of the stocking frame.

1760. Robert Kay, of Bury, son of John Kay, invented the "drop-box" about this time.

Joseph Stell obtained a patent for the application of "sundry toppets" for weaving figures in the narrow or Dutch loom, and for applying two boys or Jacks instead of the old drawing engine.

Richard Arkwright established himself as a barber at Bolton. It is related that his wife burned the models he was making, which act he looked upon as "a sin and a crime." He never forgave her, and when in his greatest prosperity he only allowed her a pittance of four shillings per week—being all she could legally claim from him at that time.

Lewis Paul's carding machine introduced at Wigan by a gentleman named Morris.

A considerable share of the calico printing business was removed from London to Lancashire.

1762. George Glasgow patented a method of weaving two, three, or four pieces of single cloth combined together by a "stitching shaft" in imitation of stitched women's stays.

1764. James Hargreaves, a weaver of Sland Hill, near Blackburn, invented a spinning jenny to spin without the use of rollers.

Richard Arkwright went to Nottingham with an improvement upon the jenny of Hargreaves.

Calico printing introduced by Messrs. Clayton at Bramber Bridge, near Preston, afterwards carried on by Robert Peel.

Eight bags of cotton imported into Liverpool from the United States.

Morris and Betts patented the eyelet-hole machine, surreptitiously obtained from its inventor, Butterworth.

1765. A weaving factory filled with swivel looms established at Manchester by Mr. Gartside.

1767. Arkwright employed a clockmaker named Kay, of Warrington, to make a model of a spinning frame with rollers, that had been previously invented by Thomas Highs (or Hayes), for whom Kay had made the original model.

James Hargreaves completed his spinning jenny.

1768. Coarse cloth and "linsey-woolsey" made in nearly every family in the States, the carding and spinning being done by members of the family, and the weaving by itinerant weavers, who travelled through the country, nearly every family being provided with a loom.

1769. Arkwright patented his machine for spinning by rollers (see 1773).

James Watt took out a patent for his steam engine.

Robert Frost made the first figured lace web.

J. Crane, and J. P. Porter applied the draw-boy and slides to the stocking frame for brocading and flowering gloves, aprons, &c.

1770. James Hargreaves obtained a patent for his spinning jenny.

Mr. Crawford, a London merchant, patented the silk doubling frame, containing probably the first self-acting stopping motion when a thread breaks.

1771. Arkwright's first mill was built at Crumford. Marsh and Horton patent their invention for making knitted or knotted hosiery.

The stocking frame introduced into Scotland.

Mr. Almond was awarded 50 guineas for his improved loom. (see Fig. 262).

1772. Thomas Highs received a present of 200 guineas from the manufacturers of Manchester for the invention of a double jenny which was publicly exhibited in the Exchange.

Richard Williams patented a new method of manufacturing goods with "cotton whoofs or woollen linen or cotton warps and dressing such goods with a long shag on their surface." They were finished by having a long shag drawn upon them by means of teasles or wire cards.

1733. Previous to this time cotton was only used as weft.

The invention of the "stripper" to the carding engine claimed by both Arkwright and Hargreaves.

The first attempt to work a power loom at Glasgow was made this year, and a Newfoundland dog working in a race wheel or drum supplied the necessary power.

The "Spitalfields Act" passed, fixing the price at which weavers should be paid. The business in consequence went to Macclesfield, Manchester, Norwich, Paisley, &c.

1774. A law passed sanctioning the manufacture of cotton goods, hitherto prohibited under heavy penalties, subject to a duty of 3*d*. per square yard, on being printed and stamped. It was death to counterfeit the stamp or to sell goods knowing them to have the counterfeit stamp thereon.

The population of Manchester was 41,032.

Robert and Thomas Barber obtained a patent for a power loom in which the cone pick is used.

Cloth made entirely of cotton sanctioned.

Thomas Wood invented the so-called endless carding by nailing the cards on the cylinder spirally instead of longitudinally.

1775. Arkwright took out a patent for a series of machines.

Crane of Edmonton invented the Warp lace machine.

The first spinning jenny seen in America was exhibited in Philadelphia in this year, made by Christopher Tully.

A company for promoting American manufactures was formed this year at Philadelphia.

1776. Deacon Barber erected a fulling mill at Pitsfield, Mass.

A cotton-mill erected in Philadelphia.

1778. James Hargreaves, inventor of the spinning jenny, died April 22, at Nottingham, in great distress.

Average amount of cotton imported into England, 6,766,613 lbs.

1779. Oliver Evans, of Philadelphia, invented a machine for making card-teeth, which it did efficiently at the rate of 1500 per minute.

Samuel Crompton, of Bolton, aged twenty-one, invented the "mule" jenny. It is a combination of Wyatt's and Hargreaves' spinning machines—hence the name.

William Cheape obtained a patent for a new way of arranging the simple, so that the weaver can draw it without the use of a draw-boy, or draw-boy machine. The simple being carried down in front of the batten.

1780. Attempts made in Lancashire and in Glasgow to manufacture muslin with weft spun by the jenny, but failed, owing to the coarseness of the yarn.

Benjamin Blackmore obtained a patent for weaving bolting cloths without seams.

Corduroy made at Worster, Massachusetts.

An Act passed to prevent the exportation of machinery in any form used in the textile manufactures, under a penalty of 200*l.*, and imprisonment for twelve months.

Sir Richard Arkwright had twenty factories, either his own property, or paying for permission to use his machinery.

Mr. J. Wilson was made a burgess of Dunfermline, on account of the benefit he had conferred on the town by his invention of a draw-boy machine.

1781. Sir Richard Arkwright brought an action against Colonel Mordaunt for an invasion of his patent. He also brought other similar actions against other persons.

Muslins were first made in England this year.

1782. Sir Richard Arkwright had nearly 5000 persons employed at his mills in Nottingham. He presented to Parliament his "case," or claim for important inventions, &c., in which he acknowledged Paul's patent.

The whole produce of the cotton manufacture of Great Britain did not exceed 2,000,000*l*. There were 143 cotton factories, giving employment to 60,000 persons.

1783. Above a thousand looms were set up in Glasgow this year, for the manufacture of muslins.

Cylinder printing invented and patented by Thomas Bell, of Glasgow.

1784. Fourteen bales of cotton were shipped to Liverpool, of which eight were seized as being improperly entered, on the ground that so much cotton could not have been produced in the United States.

1785. Trial concerning the validity of Arkwright's patents. The counsel opposed to Arkwright states that 30,000 people were employed in the establishments set up in defiance of the patents, and that nearly 300,000*l*. had been expended on the factories. Arkwright's patents were set aside, and the inventions thrown open to the public.

Dr. Cartwright obtained a patent for a vertical loom.

The first steam-engine applied for driving cotton machines was erected by Messrs. Boulton and Watt, at the works of Messrs. Robinsons, of Popplewick, Notts.

1786. Dr. Cartwright obtained a second patent for a "Weaving Machine," or loom, in which warp and weft stop motions are attempted.

In Lancaster, then the largest inland town in the U.S., there were at this date twenty-five weavers of woollen, linen, and cotton cloth; also three stocking weavers and four dyers.

A complete set of brass models of Arkwright's machines were made this year for transmission to the United States, but were seized on the evening before being shipped.

At this period one-third of the cotton consumed in England was brought from the British West Iudies, one-third from the foreign West Indies, one quarter from Brazil, and the remainder from the Levant.

1787. Dr. Cartwright obtained a third patent for improvements in his power-loom, which comprised spring-picking motion. Stop-motion when shuttle fails to enter the box, plyers, temples, &c.

Cotton used for candle-wicks this year amounted to 1,500,000 lbs., or nearly as much as the whole importation of cotton in 1701.

An Act passed to encourage the art of designing original patterns for calico printing.

Number of cotton-mills in Great Britain, 143, as follows:—Lancashire, 41; Derbyshire, 22; Nottinghamshire, 17; Yorkshire, 11; Cheshire, 8; Staffordshire, 7; Westmoreland, 5; Berkshire, 2. Rest of England, 6.—Flintshire, 3; Pembrokeshire, 1; Lanarkshire, 4; Renfrewshire, 4; Perthshire, 3; Edinburghshire, 2; Rest of Scotland, 6.—Isle of Man, 1. There were 550 mules, and 20,700 jennies, containing, with the water frames, a total of 1,951,000 spindles, representing capital invested of 1,000,000*l.* They gave employment to 26,000 men, 31,000 women, and 53,000 children, or taken together with those employed in the subsequent processes of manufacture, a total of 350,000.

Cotton machinery first introduced into France.

1788. Joseph Alexander and James McKevin, weavers from Scotland, who understood the use of the fly shuttle, went to Providence, Rhode Island, to weave corduroy. A loom was put up in the market-house with the first fly shuttle probably ever used in America.

Thomas Clarke obtained a patent for the application of false beams, which gave way when the shuttle was trapped. Also for attaching the pickers to a rod passing under the shuttle race from one picker to the other.

The first loom in Philadelphia was built and worked this year.

Dr. Cartwright obtained a fourth patent for the use of eccentrical wheels (cams) to drive the batten with variable motion.

The first steam-engine used for cotton-spinning in Manchester was erected by Boulton and Watt for Mr. Drinkwater's Mill.

1788. Numerous grants were given about this time by the legislature of various states in America for the introduction of cotton machinery, and several experienced workmen from England were encouraged.

A large manufactory established in Boston, U.S., where sail cloth was made.

Patrick Walsh, in a letter to Dr. Meare, thus describes the origin of the celebrated Sea Island Cotton:—" I had settled in Kingston, Jamaica, some years ago, when, finding my friend Frank Leavet with his family and all his negroes in a distressed situation, he applied to me for advice as to what steps he should take, having no employment for his slaves. I advised him to go to Georgia and settle on some of the Islands, and plant provisions until something better turned up. I sent him a large quantity of various seeds of Jamaica, and Mr. Moss and Colonel Brown requested me to get some of the Pernambuco cotton seed, of which I sent him three large sacks, of which he made no use but by accident. In a letter to me during the year 1789 he said, 'Being in want of the sacks for gathering in my provisions, I shook their contents on the dunghill, and it happening to be a very wet season in the spring, multitudes of plants covered the place. These I drew out and transplanted into two acres of ground, and was highly gratified to find an abundant crop. This encouraged me to plant more. I used all my strength in cleaning and planting, and have succeeded beyond my most sanguine expectations."

1789. Dr. Cartwright obtained a patent for combing and spinning machinery.

1790. Mr. W. Kelley, of Lanark Mills, was the first to turn the "mule" by water power, and Mr. Wright, a merchant of Manchester, made a double mule.

The price for jeans in America was at this date 7*d.* per yard, exclusive of warping and winding. The weaver could weave seven yards per day.

The first steam-engine used by Arkwright was erected in his mill at Nottingham by Boulton and Watt.

Messrs. Grimshaw, of Gorton, erected a weaving factory at Knot Mills, Manchester, for the use of Dr. Cartwright's looms under a licence. The mill was burned down by a mob before it was completed.

The first sheetings, shirtings, checks, and ginghams made in America were made this year.

1791. A Mr. Felix Crawford made "flying shuttles" at No. 364, South Second Street, Philadelphia.

Richard Gorton patented a loom worked by a crank, and a "piece of square iron" is provided which strikes against a stop when the shuttle is not in the box.

Stephen Dolignon obtained a patent for a loom to weave by a machine rocking to and fro by gravity.

S. T. Wood patented a method of passing the shuttle through the shed by means of levers in a similar manner to De Gennes's loom.

1792. Dr. Cartwright obtained a fifth patent for a change shuttle box and an engine for raising a pile, and circular knives for cutting the same.

Sir Richard Arkwright died at his house at Cromford, aged sixty. He was knighted in 1786.

1793. Eli Whitney in this year invented the famous cotton or saw gin. He was a native of Massachusetts, and was employed as teacher in the family of General Green. On one occasion Mrs. Green remarked to Whitney, who was an ingenious man, that if any one could invent a machine that would clean or separate the seed from the cotton lint, no doubt he could. She urged him to make the attempt, and he proved successful.

Andrew Kinlock, with the assistance of a joiner and clock-maker, set up a power loom in Glasgow to be worked by hand power. After expending about 100*l.* upon it, he managed to weave ninety yards of cloth. His loss was made good by four members of the Glasgow chamber of commerce. Shortly afterwards he erected forty looms on the same principle, which looms, with the exception of a few slight improvements, were working in 1845 at Pollockshaws and Paisley, at which time Andrew was still living and was then eighty-five years of age. In the year 1800 he went to Staley Bridge to set up looms. In 1812, when the hand-loom weavers burned a mill down with 170 looms, Andrew had a narrow escape of his life.

In Spitalfields there were 4000 looms idle.

Messrs. Strutt of Derby erected the first fire-proof mill in England.

1794. A power-loom invented by Mr. Bell, of Glasgow, but was abandoned.

Whitney's cotton-gin patented March 14th.

1795. The second cotton-mill in the United States erected in Rhode Island.

Thomas Hofland patented a loom for giving a double blow with the batten.

1796. Mr. Robert Miller, of Glasgow, took out a patent for a power-loom, long known as the "wiper" loom from the circumstance that the picking and treadle motions were worked by cams which were called "wipers." There was a stop rod, said to be the first ever used, attached to the loom, to stop the loom when the shuttle failed to enter the box, and on this account its inventor termed it the "protector." (See 1791.)

1797. The scutching machine invented by Mr. Snodgrass, of Glasgow.

1798. Mr. Tennant, of Glasgow, patented the application of chloride of lime for bleaching purposes.

First cotton-mill and machinery in Switzerland erected.

No duty upon raw cotton imported up to this year. The following tariff was passed, which lasted to the end of the year 1800:—

	£	s.	d.	
On cotton, imported by the East India Company	4	0	0	per cwt.
„ British Colonies and Plantations	0	8	9	per 100lbs.
„ Turkey and the United States	0	6	6	„
„ Other parts	0	12	6	„

1799. Cotton machinery first introduced into Saxony.

1800. Michael Greenwood, a weaver of Leeds, fixed a number of wires, called a false reed, at the back of the reed of the woollen loom, which had the effect of breaking the stickiness of the warp and preventing, in a great degree, the shuttle being thrown out of its course.

1801. Mr. Monteith, of Pollockshaws, erected 200 power looms of Robert Miller's patent.

Dr. Cartwright's patent-right prolonged.

Jacquard exhibited his loom at the French Exhibition.

Population of Lancashire 762,565.

1802. William Redcliffe invented the "Dandy Loom"—a compact hand-loom with take-up motion attached.

Robert Brown, of New Radford, obtained a patent for a fishing-net making machine.

Copper wire inserted into wood-blocks for printing calicoes.

M. I. Brunel (afterwards Sir M. I. Brunel) patented a method of weaving artificial selvages to cloth, that would not unravel when being washed.

Sir Robert Peel, of Bury, was the first to print calicoes on the *resist* work system. It consisted in printing various mordants on those parts of the cloth intended to be coloured, and a paste or *resist* on such parts as were intended to remain white. The plan was discovered by a commercial traveller named Grouse, who sold the process for 5*l*.

Bandana handkerchiefs and cloths were first made this year at Glasgow.

New tariff on cotton imposed.

1803. Thomas Highs, the inventor, died, aged eighty-four.

William Radcliffe obtained a patent for his dressing machine in the name of his assistant, Thomas Johnson.

John Todd patented a loom with worm and wheel take-up motion and stop-rod.

J. Hall obtained a patent for a take-up motion for hand looms, in which the take-up roller was partly covered with "card."

William Horrocks patented a loom which afterwards came into very general use.

D. Bonner obtained a patent in Scotland for the comb draw-loom. It had one comb and lever only, and lifted wires; but shortly afterwards John Philip made one with four combs and levers, with knotted cords in lieu of wires. This had an advantage so great that it is said 600*l*. was paid to Bonner not to interfere with Philip's improvement.

1804. William Radcliffe (Thomas Johnson) obtained a second patent for further improvements in his dressing machine.

1805. A large weaving factory erected by James Finlay and Co. at Catrine, in Ayrshire.

Peter Marsland patented a plan for sizing cotton yarn in an air-tight receiver, from which the air was withdrawn by a pump.

Thomas Johnson and James Kay obtained a patent for revolving temples, formed like bevelled wheels, with pins in the edges to hold the cloth as it passes through them; also the application of projections on the picking cams.

1806. Mr. Peter Marsland, of Stockport, patented a crank motion to the batten by which the motion was caused to be slow during the passing of the shuttle.

S. Williamson patented a loom to weave two pieces of cloth side by side, with a shuttle box in centre of the batten.

1807. Mr. John Duncan, author of an "Essay on the Art of Weaving," invented and patented a tambouring machine of very ingenious construction, and containing a number of needles.

William Atkins patented a plan for weaving the selvages of shawls with separate shuttles, having boxes on each side for the purpose in addition to the boxes for the ground-work.

Estimated number of spindles in operation in the United States at this date was 4000.

1808. Snodgrass's scutching machine introduced into England, for beating and opening up cotton ready for carding.

John Heathcote took out his first patent for a bobbin-net machine.

1809. Dr. Edmund Cartwright obtained a grant of 10,000*l.*

Mr. John Heathcote obtained his second patent for a bobbin-net machine.

1810. The art of dyeing "Turkey red" discovered and practised by M. Krechlin, of Mulhausen.

William Cotton patented a let-off motion by which the warp was held between two rollers pressed together, one of which is actuated by a worm and wheel.

The throstle frame introduced into the United States.

1811. Number of spindles in operation in the United States estimated at 80,000.

1812. Samuel Crompton, the inventor of the "mule jenny," was granted 5000*l.* by Parliament. The invention not having been patented, Crompton had been unable to reap any advantage from it.

John Webb patented a loom for weaving rugs, in which the reed was open at the lower edge, and by means of "conductors" the threads from a separate beam might be moved horizontally so as to form a figure, after the manner of lappet weaving.

The number of spindles in operation in Great Britain estimated at between 4,000,0000 and 5,000,000 on the principle of Crompton's mule jenny.

Thomas Lee obtained a patent for weaving Kidderminster or Scotch carpet, with three or more warps of distinct colours. (Three-ply carpets.)

John Levers, of Nottingham, invented the lace machine known by his name.

1813. The first factory in America (if not in the world), where a power loom was used and spinning and weaving were carried on under the same roof, was erected at Waltham, Massachusetts, by Messrs. Lowell, Jackson, and Moody. This factory is still in operation.

Peter Ewart obtained a patent for a loom to be worked by air or steam by means of bellows, or a cylinder attached to the loom.

Mr. Benjamin Law commenced the shoddy, or rag wool manufacture, at Batly.

At this date there were but 100 dressing machines and 2400 power looms in operation in Great Britain. Hitherto they had shown no advantage over the hand-loom, and it was the opinion of a writer (Lees) of that time that, "whenever the great current of English twist flows unrestrictedly into the Indian market all the exertions to improve the steam loom will become futile, and all the capital and machinery employed in working it a ruinous speculation. The Indian will obtain our twist, weave it into cloth, return it to England, and with all our boasted machinery—all our steam looms and their subordinate preparatory machines, undersell us in our own market."

1815. P. and J. Taylor patented a method of giving two beats with the batten with only one revolution of the cranks.

1816. Mr. Brunel (afterwards Sir M. I. Brunel) invented and patented the first circular knitting machine.

Two thirds of the Spitalfields weavers out of employment.

1817. The number of power-looms in Lancashire was estimated this year at 2000, only one half of which were said to be in operation.

Benjamin Taylor patented a draw loom worked by a barrel studded with pegs, and causing one shed to rise while another was falling, and thereby counterpoise each other.

J. A. Wilkinson applied power to reed-making machinery.

1819. Kirk Boot, Esq., a Boston merchant, explored the wilds, as a hunter, where the city of Lowell now stands, "the Manchester of America," and discovering its resources, in company with others purchased the land and water privileges under the name of "The Proprietors of the Locks and Canals on Merrimac River."

W. Sawbridge applied a draw-boy machine on the top of a ribbon loom, and worked by two treadles.

1820. In England there were 12,150 power looms in operation, and in Scotland 2000.

Francis Lambert obtained a patent for a new method of producing the figure in weaving gold and silver lace, &c., which is simply an application of the Jacquard machine, being the first appearance of it in the patent list.

Robert Bowman patented a tappet motion by which the headles were made to rise and fall.

John Paterson, formerly a cooper of Musselburg, invented a machine for making fishing-nets, which he patented in Scotland in this year, and established a factory. Messrs. Stuart have since acquired Mr. Paterson's works and patent rights—have also improved the machines, and still carry on the business to a large extent.

1821. Stephen Wilson obtained a patent for a reading-in machine and punching apparatus for preparing cards for the Jacquard loom.

1822. The first cotton-mill erected at Lowell, Massachusetts.

William Goodman patented a narrow loom with two tiers of shuttles.

Mr. Richard Roberts obtained a patent for a tappet wheel by which the headles could be raised and lowered. Also for a let-off motion and a method of using several tiers of shuttles in the narrow loom.

Aza Arnold, a native of Rhode Island, said to have applied and put into operation this year the train of three bevel wheels (Houldsworth's equational box) to regulate the bobbin of the roving frame.

Mr. Thomas Nash, of Dundee, received a small consignment of Jute from London, and tried to get some of the manufacturers to spin it, but none would make the attempt, and after lying aside for four or five years, it was sold for making door-mats. Another consignment was placed in the hands of Messrs Balfour and Meldrum, who succeeded in spinning it, and thereby laid the foundation of the Jute trade in Dundee. In 1838 the import of Jute was 1136 tons, and in 1865 it amounted to 71,702 tons.

1823. Robert Guest estimated that there were 10,000 power looms this year in operation in England.

Five Jacquard machines at work in Coventry. The first was introduced some short time previously by Mrs. Dresser. In 1832 there were 600, and in 1838 there were no less than 2228.

Aza Arnold obtained a patent in America for his bevel wheel combination or equational motion. It was patented in England by Mr. Houldsworth in 1826. This valuable contrivance is said to have been originally invented by one Johnson, of Manchester, in his search after perpetual motion. He believed that if he could obtain a multiplying power by means of wheels of the same diameter, that force also would be multiplied. The contrivance may be said to be a modification of the sun and planet motion, and is of singular merit. It is used for the purpose of giving the same number of twists per inch in the length of thread wound upon a bobbin, for as the bobbin increases in diameter at each additional layer of thread wound upon it, an alteration in the speed of the spindle must be made to correspond with it—hence Mr. Houldsworth gave the name of "equational" to the motion. (See 1826.)

1824. George Dauforth, of Massachusetts, invented the tube frame, or "Taunton speeder."

Stephen Wilson obtained a patent for weaving two pieces of velvet face to face and cutting them asunder afterwards.

P. Gasset patented a shuttle with one or more bobbins placed upon spindles fixed vertically.

Stephen Wilson patented a method of printing the warp before weaving so that figures are thrown up on the surface of the cloth.

John Potter used two cylinders with pegs fitted in a "swinging frame."

The "Spitalfields Act" repealed. (See 1773.) At this time there were 17,000 looms in Spitalfields.

In Manchester 10,000 hands employed in the silk manufacture.

1825. Mr. Richard Roberts, of Manchester, obtained a patent for his self-acting "mule."

5325 silk looms at work in Macclesfield.

Mr. Henry Houldsworth, of Manchester, took out a patent for a combination of wheels to regulate the bobbin and spindle.

The Jacquard machine introduced into Scotland.

Mr. Dyer, of Manchester, introduced the Dauforth tube frame.

Eli Whitney, inventor of the cotton-gin died, aged sixty.

30,000 power looms said to be in operation in England, and 250,000 hand looms in Great Britain.

1826. Mr. Henry Houldsworth, jun., of Manchester, obtained a patent for a "differential or equation box"—a similar combination to Arnold's previously patented in America. (See 1823.)

The Prohibition Act of Manufactured Silk Goods repealed, and an *ad valorem* duty of 30 per cent. substituted.

A power-loom weaver, about fifteen years of age, is said to be able at this time, by attending two looms, to weave twelve pieces 9·8 shirtings per week, and some could weave fifteen pieces.

At this date there were 9700 looms in Coventry, of which number 7500 were owned by the operative weavers.

1827. Samuel Crompton, inventor of the mule, died, January 26th, at Bolton.

1828. The cap-spinner was invented and patented by Charles Dauforth, of Paterson, N.J.

The use of leather belts in place of wheel-gearing to main shafting was introduced by Mr. P. Moody, at Lowell.

1829. Gilbert Brewster, of Poughkeepsie, N.Y., patented the "Eclipse Speeder."

Josué Heilmann, of Mulhouse, patented his embroidering machine, which contained from 80 to 140 needles, governed by a pantograph, to which was attached a pointer to trace over the surface of any given design. The needles, by means of the pantograph, reduced the size of the figure. They had an eye in the middle of their length, and were passed to and fro through the cloth by means of pincers. The work produced was similar in effect to hand-embroidery of small figures—at the present time more effectually done by means of swivels and circles.

16,000 looms in Spitalfields, 7000 of which were unemployed, and in Macclesfield only 3000 were employed. This was attributed to the admission of foreign silks, which had been prohibited from 1765 to 1826.

1830. J. H. Sadler obtained a patent for a loom to be worked by means of a pendulum set in motion by the hand.

The power loom applied to weaving cloth in Scotland.

1831. The "Ring" spinning frame was invented this year by John Sharp, of Providence, R.I.

In the United States in this year there were—

Mills	801
Looms	33,433
Males employed	18,590
Females „	38,727
Children „	4,091

Messrs. Watson, of Hawick, sent to a merchant, Mr. J. Locke, in London, a quantity of *tweels* (twilled cloth), which word was misread as "tweeds." On sending for more goods Mr. Locke ordered them as "tweeds," which name is still adopted.

1832. In Glasgow there were at this date sixty-three weaving factories and 14,127 looms, and in Lancashire there were 80,000 power looms.

Mr. R. Whytock, of Edinburgh, patented the system of printing figures upon the warp for weaving Brussels carpets, called tapestry carpets, which effected a great saving in materials. The process has been very extensively used at Halifax.

The stop motion in the drawing-frame invented by Samuel Batchelder, and used at Saco, Maine, and patented in England by H. Houldsworth.

1833.

The number of power looms in Great Britain	In England	85,000
	In Scotland	15,000
		100,000

The number of hand looms employed in the cotton manufacture being estimated at 250,000.

Josué Heilmann invented a measuring and folding machine for piece goods.

A power-loom weaver, with the assistance of a girl about twelve years of age, could attend four looms, and weave eighteen pieces of 9-8 shirting per week. A hand-loom weaver could weave only two such pieces.

J. F. Gerard obtained a patent for a method of using perforated paper instead of cards to the Jacquard machine.

1834. Messrs. Hornby and Kenworthy patent a method of applying a friction pulley and face plate, for altering the speed of the take-up motion—the rate of speed being regulated by the friction pulley being brought nearer to, or farther from, the centre of the plate. Also for a "vibrating or fly reed," together with a system of levers to throw the loom out of action when the weft thread breaks.

L. and J. Smith obtain a patent for a method of picking from the crank shaft by means of inclined planes fixed on the periphery of a fly-wheel on each end of the crank shaft, and each of these inclined planes are made to operate upon its respective picking stick at every second revolution of the shaft. This was the forerunner of the scroll-picking motion.

John Ramsbottom and Richard Holt patented a loom, to which they applied a weft-stop motion, consisting of several slight wires attached to a lever, which, in the absence of the weft thread, caused a spring to act upon the driving strap, and move it from the fast to the loose pulley. This invention was the forerunner of the present system.

Jacquard died August 7th.

A Committee was appointed this year by order of the House of Commons to inquire into the case of the hand-loom weavers who had become greatly impoverished by the introduction of the power loom, the evidence showing their sad condition.

1835. Messrs. Cropper and Milnes obtained a patent for applying lace machine bobbins and carriages for producing figures on the surface of cloth, as in swivel weaving.

John Osbaldeston patented a method of making healds of fine brass wire so twisted together that an eyelet-hole was left in the middle.

Mr. John Heathcoat, the inventor of the bobbin-net frame, obtained a patent for weaving narrow articles, such as tapes, standing edgewise, their faces being parallel to each other.

Mr. Samuel Draper, of Nottingham, tried to adapt the Jacquard machine to the lace frame (see Chapter 32).

1836. James Morison applied the Jacquard machine to drop boxes. Alpaca wool introduced.

1837. Cotton warps introduced into the Bradford stuff manufacture, a step that has proved of the greatest advantage to that trade.

1838. Mr. Woodcroft obtained a patent for a shedding motion, with rising and falling shed; also for a tappet motion in which movable segments are used to raise or lower the headles.

1839. John Rostron obtained a patent for a continuous chain of tappets, formed by a succession of side links connected by transverse bolts or spindles, upon which are placed small bowls or rollers, as tappets, of various widths, &c.

F. Vouillon patented his method of drawing glass, of various colours, into fine fibres, and weaving the same in damask work.

Peter Lomax employed the Jacquard machine to raise the knobs on counterpanes by means of hooks for raising the same.

James Smith patented a revolving temple with points.

C. Gilroy patented a fork and grid weft stop motion.

1840. George Clarke patented a flexible rack or endless band, on which tappets could be fixed for actuating the headles.

Charles Parker obtained a patent for changing the shuttle when the weft thread is broken or the bobbin empty. This was to be effected by using a drawer with two compartments, each of the width of a shuttle, and by means of a lever and spring barrel, the other compartment is moved into the place of the one with expended weft.

Miles Berry patented a carpet loom with shuttle boxes fixed to the side of the loom instead of to the batten.

1841. Messrs. Kenworthy and Bullough obtained a patent for a roller-temple, which is still in use, and is a most effectual contrivance. Also for a weft stop-motion, as at present used. This patent, in addition to the above important improvements, included a stop motion to the cloth beam when the weft thread broke, or became exhausted.

Mr. Horton Deverill applied Jacquard apparatus to the lace frame, it is said for the first time successfully. He adopted two griffe bars. Several patents had been taken out previously (see 1835).

1842. John Railton obtained a patent for a temple consisting of two or more small metal rollers or bars upon which a right and a left handed thread is formed, and then fluted, so that they form a series of points or pins. As the cloth passes over it is distended by the right and left handed screws acting in opposite directions.

R. W. Sievier patented a method of weaving terry velvet or looped surfaces by varying the length of the stroke of the batten, and loosening the pile beam to beat the loop forward after it had been held by binding shoots, and thereby dispensing with wires.

James Bullough patented a loose reed motion to prevent the shuttle when trapped from injuring the warp. Also a Jacquard with a separate motion to work the cylinder from the crank shaft.

Thomas Thompson patented a method of inserting and withdrawing wires or tags as used in weaving terry velvet.

1843. Luke Smith patented a circular change box, having three boxes for shuttles, and actuated by studs fixed on a revolving belt. This patent includes the scroll picking motion, to pick from the crank shaft. Also to throw two shuttles through two sheds, one above the other at the same time. The top shuttle to rest on the lower one.

1844. John Smith patented the use of a sliding lever, with an eye in lieu of a shuttle—the weft thread being inserted double.

William Kenworthy obtained a patent for actuating the stop-rod independently of the shuttle, thereby relieving the shuttle from the burden.

Joseph Meeus proposed to force the shuttle through the shed by pressing the warp-threads on the tail of the shuttle, also by the use of a magnet acting on an iron shuttle.

1845. Squire Diggle obtained a patent for a tappet chain composed of plates acting as cams of various sizes to elevate the shuttle boxes. This system has been very extensively adopted for various other purposes.

John Sellers applied a brake in conjunction with the stop-rod motion of the loom, being a most important improvement to the power loom.

Duty of 30 per cent. on silk-manufactured goods reduced to 15 per cent., making it unprofitable to smuggle.

In 1860 the duty on all kinds of foreign silks was repealed by Mr. Gladstone.

1846. William Unsworth patented a shuttleless loom for narrow goods; the weft being carried through the shed by bent arms and held on vertical pins when passed through.

Messrs. Reid and Johnson form two separate sheds, and use two shuttles in a vertical loom.

Josué Heilmann, born at Mulhouse, France, in 1796, invented the combing machine for combing cotton of long fibres, particularly valuable for fine spinning. He was also the inventor of the embroidering machine, &c. (see 1829 and 1833).

1847. K. Vogel patented a method of making healds by braiding together the strands throughout the length of the leash, with the exception of the loop or eye.

John Carr obtained a patent for stopping the motion of the batten only, and not the loom, when the shuttle did not enter the box.

1848. William Curtain patented a method of cutting the pile of carpets or velvets by means of a sharp curved blade fixed at the end of the wires, which, upon being drawn out of the loops, completely severs the top of the pile (see Chapter 18).

1849. William Thomas obtained a patent for weaving the webbing for Venetian blinds by causing the connecting parts to be woven together, instead of being sewn as heretofore.

John Bottomley applied small shuttles or swivels to the power loom.

F. W. Norton patented the application of stationary wires, placed longitudinally for the production of looped fabrics, the warp threads being passed over the wires in a similar manner to cross weaving.

Edwin Heywood obtained a patent for weaving with swivels and forming two sheds, so that the swivels and ground shuttle could be thrown simultaneously.

The double-action Jacquard machine patented by Alfred Barlow.

1850. Cloth plaiding and blankets are still made in the households of the remoter districts of the Highlands.

1851. This year will be ever memorable as the Great Exhibition year. During the past half-century, France had held no less than eleven exhibitions of a similar nature, which had proved of great advantage towards the advancement of the arts and manufactures of that country. To follow the example thus given, the Society of Arts attempted, in 1845, to carry out a scheme of a similar kind in this country, but it was not until the year 1849, when Prince Albert was President of the Society, that they succeeded in making the necessary arrangements for the purpose. The scheme being new to the nation, it naturally offered many obstacles to carry it into effect, but they were overcome, and the result was not only eminently successful and self-supporting, but it realized a surplus fund of such great extent as to provide means for future exhibitions and museums of a similar nature. Upwards of six millions of persons visited the Exhibition. There were 17,000 Exhibitors, to whom were awarded 170 Council medals; 2918 Prize medals, and honourable mention to 5084.

The textile manufactures and machinery were profusely represented, and many of the machines and looms were kept in operation.

Since this period, numerous inventions in various branches of weaving have been made. They, however, consist chiefly of modifications and improvements upon inventions that had already been in use. A few exceptions may be made, such as the electric loom, the pneumatic loom, and the method of drawing the shuttle through the shed by means of a carriage placed beneath the warp. But these contrivances, although they display a considerable amount of originality and ingenuity, do not appear to have been sufficiently practicable as to become of general use.

CHAPTER II.

ANCIENT LOOMS.

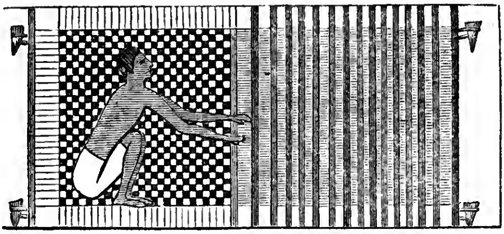
Ancient Egyptian looms—Greek and Icelandic looms—Ancient French loom—Indian looms—Chinese and Japanese looms.

It may be said of many processes practised in the useful arts which have long been in use, that they rarely suggest to the observer that they may be supplanted by new and quite different methods, and for the old system to become totally forgotten. In this way many of the ancient arts have been lost, simply through historians making no record of them. Certainly as regards weaving, there are frequent allusions in ancient writings to various fabrics and to the loom; but probably in no instance is there to be found a written description, however meagre, of the loom or process of weaving. It is not until very recent times, almost within the memory of men, especially as regards this country, that any written account of the art of weaving has been given. The cause, however, is not far to be sought. The weaver has never troubled himself about that which is so common to him, and no doubt thought the way he worked and the kind of instruments he used would last for all time. The looker-on perhaps believed the same, and as very few would observe the process sufficiently well to understand it, there might be none who would ever think of describing it. Consequently, nothing whatever is known of the ancient practice of weaving, except from a few paintings in which looms are represented. The most ancient of these are the wall-paintings at Thebes, in which the arts of spinning and weaving are shown, and on these almost all our knowledge of the ancient looms depend.

There are three representations of the Egyptian looms at Thebes, with weavers working at them, of which the following sketches are copies.

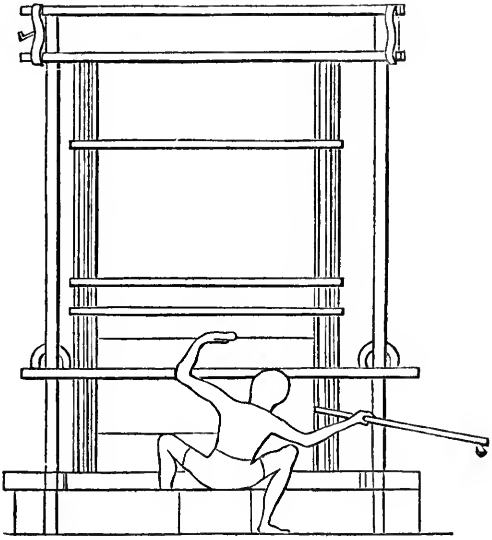
Fig. 1 represents a weaver at work upon a piece of cloth woven in a horizontal position, in fact on the ground. It is probable that it was a mat, carpet, or rug that he was making, for it is of large size, and appears to be of a definite length.

FIG. 1.



In fig. 2 the loom is a vertical one, and the weaver seems to be in the act of throwing the weft through the warp by means of a rod, at the end of which there is a hook. Now Sir Gardiner Wilkinson, from whose work[1] these sketches are taken, says that he

FIG. 2.



thinks the hooks were for the purpose of drawing the weft thread through the warp, in a similar manner, it may be supposed, to willow or horse-hair weaving, where short lengths of weft can only be used. If such was the case, the cloth would have at least one loose

[1] "Manners and Customs of the Ancient Egyptians."

selvage, and probably two. But the cloth wound round mummies appears to have both selvages perfect, therefore the rod, if employed in weaving them, must have been passed completely through the opening or shed. This, however, scarcely was the case, for the process would not correspond with the well-known rapidity of the shuttle, which was, as already mentioned, in use at that time.

In fig. 3 a smaller loom is shown, and two weavers appear to be at work making cloth. There is still the rod and hook as in fig. 2, consequently the same difficulty as to the process.

Herodotus visited Egypt about 450 years before the present era, but the only allusion to the loom which he makes is where he says, "In this country the women leave to the men the management of the loom in the retirement of the house, whilst they themselves are

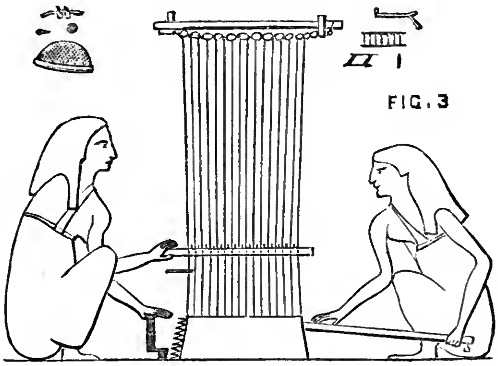


FIG. 3

engaged abroad in the business of commerce. Other nations in weaving shoot the woof above, the Egyptians beneath."

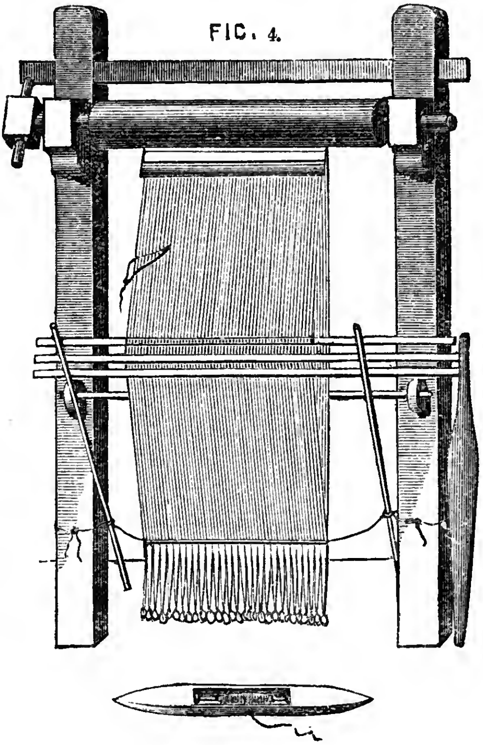
The drawings show both men and women were engaged in weaving, and such was probably the case.

It may be supposed that amongst the great number of hieroglyphics on the various ancient Egyptian remains in the British Museum, there would be some representing looms, or portions of a loom, but there appears to be only one such instance, and that one is cut on the side of a sarcophagus, and is in the form of the block letter ⊔. It is said to relate to a certain gift of cloth (of which article it is the symbol) made to the priests of one of the temples.

The looms used by the ancient Greeks and Romans are said to have been vertical ones, similar to the Egyptian looms, but nothing certain is really known respecting them.

In Dr. Smith's dictionary of "Greek and Roman Antiquities," under the article Tela (Greek loom), Mr. Yates, in describing the ancient Greek loom, compares it with the common loom used in Iceland, if not at the present, at all events in very recent times. Fig. 4 is a representation of this loom. The warp is suspended

FIG. 4.



from the top beam of the loom, and the lower ends are tied up in separate portions, which are weighted to keep the threads in tension. The cloth was woven *upwards*. Before the reed was invented the weft thread is said to have been combed evenly into its place by means of a comb adapted for the purpose, and the blow was given to drive them together by the use of a flat sword-shaped piece of wood, which was introduced into the shed for that purpose. This latter instrument was called the "spatha," and is shown in the figure at the side of the loom. Such an instrument is still used in some kinds of mat making, but not for weaving cloth as here described.

It may be remarked that the use of the comb ought not, in all cases, to imply that a reed was not used. It is far from being uncommon for weavers of the present day to use a comb, especially when they have a sticky warp to weave, or a warp that, owing to the felting property of the material, requires to be separated frequently.

The reed itself is but a species of comb, and takes its name from the material of which it was formerly made, viz., slips of reed. It is not, therefore, unreasonable to infer that the reed was used in ancient times, as well as the comb, in the weaving of the finer descriptions of cloth; and in the weaving of rugs or matting, the comb, spatha, and the hook before mentioned would thus be satisfactorily explained (see Chapter 18).

In the *upward* way of weaving, it is easy to see how to slide the shuttle from side to side, for it could run upon the comb or reed—as in some modern vertical looms—but it is not so easy to conceive how to slide the shuttle when the cloth was woven downward, unless it was thrown from hand to hand, or made to slide upon a long comb temporarily introduced.

On referring to the drawing of the loom in Olaf Olafsen's work[2] on Iceland, to which Mr. Yates alludes, the warp does not appear to terminate at the suspended weights; but it returns to the top piece of the loom, which acts as a warp beam, although the warp seems to hang upon it like a skein, to be slackened out as required.

A stretcher, or temple, is also shown, and the rods crossing the middle of the loom have short leashes attached, and in fact are headles. There are three headles shown and two lease rods.

As the cloth was woven the weights were drawn upwards, and, as above stated, the warp would be slackened out, and the weights would be refixed as the work progressed. In this instance, the drawing not being faithfully copied from Olafsen's work, has occasioned a wrong idea of the action of the loom, and a similar fault may possibly exist in the copies of the Egyptian paintings.

The same description of loom seems to have been used in Lapland as well as in Iceland, and Leems[3] says in his account of that country that they weave sheeting, which is so worked that after it has been in use a little time "in covering them," when it becomes worn, it is converted to the use of "covering for the winter's hut." A great number of these are woven from thick white thread, with dark fringes of black or ash colour. The process is thus described by him:—

[2] Published at Amsterdam, 1780.
[3] Pinkerton, vol. i. p. 447 (1808).

"The loom in which are woven these sheets is made from out of two thick beams raised on end, on the extremity of which is loosely fixed a weaver's beam, extending from the one column to the other; to this they fasten the upper end of the thread, which comes down from the weaving-beam straight to the ground; and as the thread is neither thrown with a shuttle nor pressed together, but worked with the hand, whilst it is knocked together with a little beetle on coming back, the other part of the thread is brought together by the flat part of the hand, so that a space should be open for putting in the hand through the little fork which is sustained from the ends of the two little arms that project out from the columns. Hence it falls obliquely before it gets directly down. To the lower extremity of the woof are fastened stones, lest, if loosened, it may entangle the body of the thread; but being kept stiff and extended by its weight, it should preserve the whole together. The woof is thus conveyed, and in the above manner, first to the upper part of the beam, and is woven with the hand, whence it is clear that in making sheeting or covering one must begin from the upper end. As weavers cover round in a weaving-machine the beam at the end gradually with linen by turning it round, so also the beam of the aforesaid weaving-machine is gradually covered over while turning with the stuff that is made. They weave gloves from the wool of sheep mixed with that of hares. This is the manufacture of women alone."

Weaving amongst the Greeks and Romans was a distinct trade, and carried on in towns, yet every considerable domestic establishment, especially in the country, contained a loom, together with the whole apparatus necessary for the working of wool. When the farm or palace was sufficiently large, a portion of it, called the "textrinum," was devoted to the purpose, and the work there was carried on by female slaves, under the superintendence of the mistress of the house and her daughters.

Fig. 5 represents a loom which is asserted by Montfaucon to be copied from an ancient manuscript supposed to be of the fourth century, and entitled the "Virgil of the Vatican." It formerly belonged to the monastery of St. Denys, in France.

In the fourth century the task of weaving began to be transferred in Europe from women to the other sex, a change which St. Chrysostom deplores as a sign of the prevailing sloth and effeminacy of his day.

The Indian loom is probably a very ancient contrivance, and, as

FIG. 5.

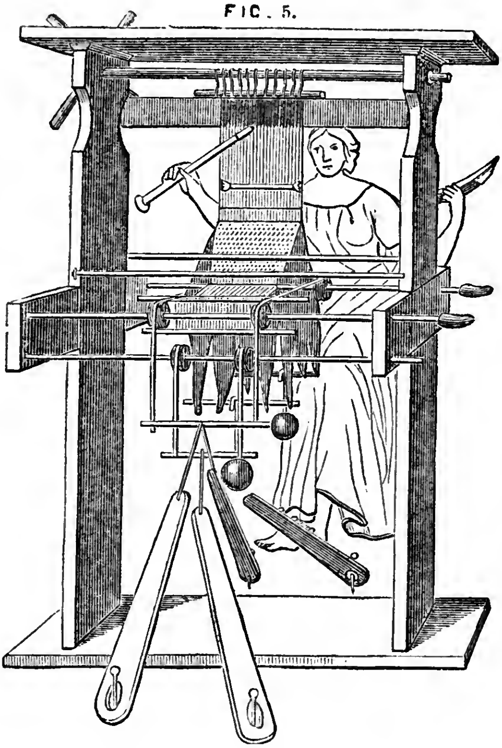
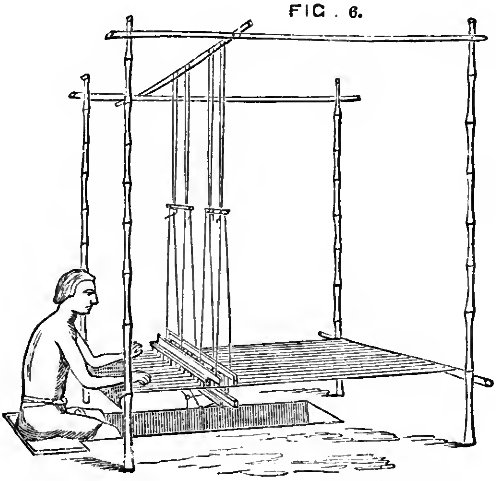


FIG. 6.



the common European hand loom is made upon exactly the same principle, it is quite possible that it may have been originally introduced from India or Persia. By its means, notwithstanding its rude construction, the most delicate muslins, cloths, shawls, and other famous Indian fabrics are produced. Consequently a full description of it can scarcely be omitted here. Fig. 6 represents a common Indian loom as used in the celebrated manufactures of Dacca.

Dr. J. Forbes Watson, M.A., in his work on "The Textile Manufactures and the Customs of the People of India," enters fully into their mode of spinning and weaving and gives descriptions of their ornamental fabrics. In describing the looms which produce the famous muslins of Dacca, he extracts from the work of Mr. Taylor, which was published for private circulation only. This gentleman formerly resided at Dacca, and was intimately acquainted with the mode of spinning and weaving there. From both these sources we learn that at Dacca the loom is *always* placed under a *shed* or *under cover*, or in the weaver's house, and not in the open air, as usually represented. The warp is fixed to the cloth-beam by a small slip of bamboo passed through the loops and fixed into the groove. The beam is wound up by a winch, and held by a stick passing through a mortice hole, and fixed to the ground.

The batten consists of two flat pieces of wood, into which grooves are cut for the reed or sley, which is fixed in by iron or wooden pins, and is suspended from the capes of the loom. The range of motion of the batten is adjusted by passing slings through several pieces of sawn shell. By lengthening or shortening the slings the extent of motion is adjusted, for upon this the regularity of the blow depends.

The balances of the headles, having the slings fixed at their extremities, are suspended from the transverse rod above. The treadles are made from pieces of bamboo, and are contained in a pit dug in the ground about 3 ft. long, 2 ft. wide, and 18 in. deep.

The shuttle is made of *light* wood, of the betel-nut tree (*Areca catechu*), and has spear-shaped iron points. It is from 10 in. to 14 in. long, and $\frac{3}{4}$ in. wide, and weighs about 2 oz. It has a long open space for the wire, upon which the reed on which the weft is wound revolves. The weft passes through an eye at the side of the shuttle.

The temple (the instrument for stretching the cloth from selvage to selvage during the operation of weaving) is formed of two pieces of wood, connected together with cord, and having at their ends two brass hooks or pins, which are inserted in the edges of the cloth on the under surface.

The weaver sits with his right leg bent under him upon a piece of board or mat, placed close to the edge of the pit, and depresses the treadles alternately with the great toe of the left foot. The stretch of the warp seldom exceeds one yard in length, and the depth of the shed is about seven-eighths of an inch.

To lessen friction, the shuttle, reed, and lay (shuttle-race) are all oiled, and a brush smeared with mustard-oil is occasionally drawn along the warp. The brush is made of a tuft of fibres of the nut-plant (*Arundo karka*). When ten or twelve inches of cloth are woven, it is sprinkled with lime-water, to prevent its being injured by insects. The most favourable condition of the atmosphere for weaving is about 82 deg., combined with moisture, and to effect this in very dry weather, shallow vessels containing water are placed under the loom. A piece of Dacca muslin measures twenty yards in length by one yard in width. In the preparation of the warp it takes two men from ten to thirty days.

The weaving of such cloth takes two persons (one to weave and the other to prepare the weft and attend) from ten to fifteen days for the ordinary assortments. Twenty days for fine, and thirty days for superfine. The "fine" superfine takes from forty to forty-five days, and the *dooreas* or *charkana* assortments, sixty days.

A specimen of cloth called *mulmul khas* (muslin made for the king), and measuring ten yards by one yard, contained 1800 or 1900 threads in the warp. It weighed 3 oz. 2 dwt. 14 grains troy. It is so fine as to pass through the smallest ring. Price 100 rupees, or 10*l*. Another specimen, as worn by native dancers and singers, measuring twenty yards by one yard, had 1000 threads in the warp, and weighed 8½ oz.

The Indian method of weaving figured muslin may be taken as the general mode adopted for weaving the various beautiful fabrics for which they are so celebrated. The process is as follows:—

"Two weavers sit at the loom. They place the pattern, drawn upon paper, below the warp, and range along the track of the woof a number of cut threads equal to the flowers, or parts of the design intended to be made, and then with two small fine pointed bamboo sticks, they draw each of these threads between as many threads of the warp as may be equal to the width of the figure which is to be formed. When all the threads have been brought between the warp, they are drawn close by a stroke of the lay. The shuttle is then passed by one of the weavers through the shed, and the weft having been driven home, it is returned by the other weaver. The weavers resume their work with the bamboo sticks, and repeat the operation with the lay and shuttle in the manner above described, observing each time to pass the flower threads between a greater or less number of the threads of the warp, in proportion to the size of the design to be formed."

It is thus seen that the ornamental fabrics of India are purely a handicraft work, and performed in the rude description of loom already described.

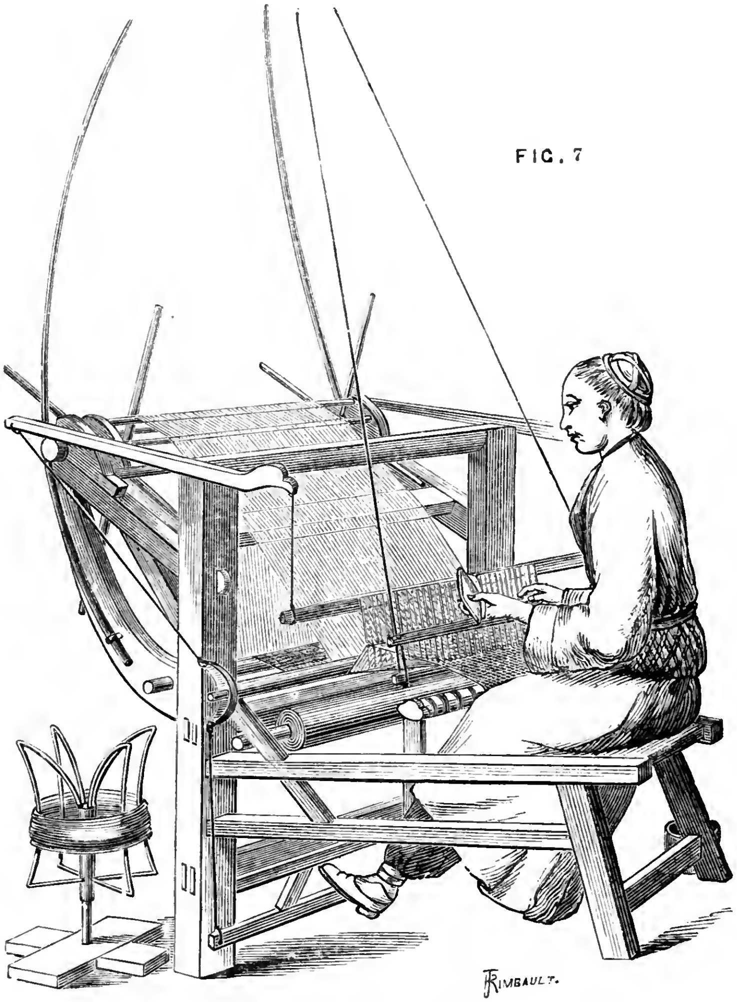
The following account of Indian weaving, from "Mill's History of British India," forms quite a contrast to the method described by Mr. Taylor:—"The loom consists merely of two bamboo rollers, one for the warp and the other for the web, and a pair of gear. The shuttle performs the double office of shuttle and batten, and for this purpose is made like a large netting-needle, and of a length somewhat exceeding the breadth of the piece. This apparatus the weaver carries to a tree, under which he digs a hole large enough to contain his legs and the lower part of the gear. He then stretches his warp, by fastening his bamboo rollers at a due distance from each other on the turf by wood pins. The balances of the gear he fastens to some convenient branch of the tree over his head; two loops underneath the gear, in which he inserts his great toes, serve instead of treadles; and his long shuttle which also performs the office of batten, draws the weft through the warp, and afterwards strikes it up close to the web."

No doubt the above relates to a different class of weaving to that referred to by Mr. Taylor, and it seems to throw some light on the Egyptian looms before mentioned.

In a "Handbook of the Manufactures of the Punjab," by Mr. B. H. Baden Powell, published at Lahore in 1872, the following particulars are given relative to Indian shawls:—

"A first-rate woven shawl (Kashmir), weighing 7 lbs., will fetch in Kashmir as much as 300*l.*, which price is made up of 30*l.*, the cost of material; 150*l.*, the wages and labour; 70*l.*, duty; 50*l.*, miscellaneous expenses. The weft is made of yarn, which is single, but a little thicker than the double yarn or twist of the warp. Silk is generally used for the warp on the borders of the shawl. When the border is narrow, it is woven with the body of the shawl; but when wide, it is woven separately, and sewn on with such nicety as scarcely to be detected. The face of the cloth is woven next the ground, the work being carried on at the back or reverse side. From four to fifteen hundred needles (shuttles) are used, according to the heaviness of the embroidery. When one line of woof is completed, the comb is brought down with a vigour and repetition

FIG. 7



CHINESE SILK LOOM.

apparently very disproportionate to the delicacy of the materials. "They are sometimes woven all in one piece, but oftener in distinct portions which are afterwards most skilfully joined together by hand."

The Chinese loom shown at fig. 7, presents such a contrast to the other primitive looms represented, that it cannot fail to be appreciated for its originality of form and the suggestiveness of its various parts. Compared with the modern hand loom it is singularly compact and adapted for household use. In ancient times weaving was practised in all the great houses, where a room was set apart for the purpose, and this form of loom would be very suitable for similar domestic use. But apart from that consideration, the power-loom maker may possibly find in its general outline an arrangement worthy of attention.

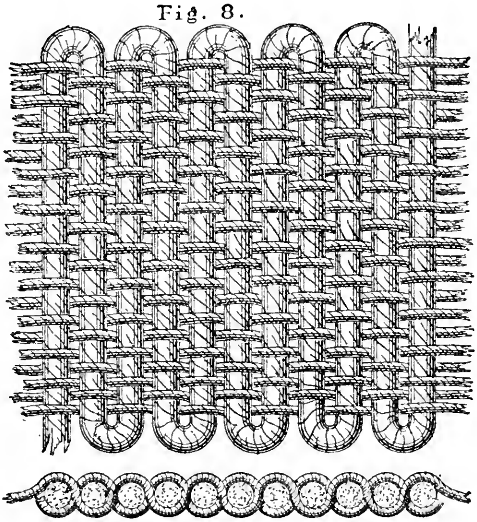
The Japanese loom for making mats, may perhaps, afford some explanation with regard to ancient vertical looms. It is composed of two upright posts, upon which a cross piece, with holes morticed through, is made to slide. On the top of the post another cross piece is fixed firmly. The warp merely consists of a number of separate threads, which pass over the top piece and under the sliding piece, and the ends are tied together. Thus the warp is really a number of loops only, and as the weft, made of rushes, &c., is inserted, the sliding piece rises, according as the warp is shortened by the intersections. The most singular part of the Japanese mode of weaving is, that they do not always use a bobbin in the shuttle, but wind the weft upon their fingers, so as to form a small skein, the weft being wound crossed in shape of the figure ∞, by which means the thread unwinds without getting entangled. It is said they prefer this method to any other.

CHAPTER III.

WARPING AND BEAMING.

The art of the weaver is shown to the greatest advantage in the manufacture of silk fabrics, for in the great variety, fineness and intricacy of the work, silk weaving not only includes the principles, but surpasses the weaving of all other substances whatsoever. Therefore, it will be first described, when every other description of weaving will be seen to be simple modifications of it, and will be readily

Fig. 8.

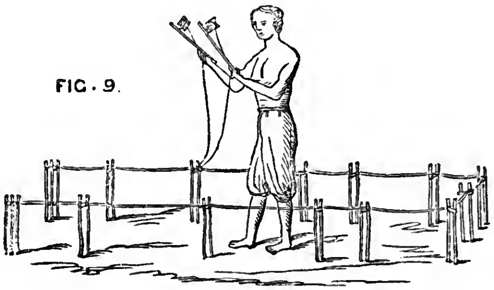


understood. If a piece of plain cloth or calico be examined, it will be found to consist of a number of threads placed paralled to each other, which are interlaced alternately by a single thread passing from side to side of the cloth. This separate thread is the weft thread, and has been inserted between the other threads, called the warp, by means of a shuttle. The alternate intersection of the warp and weft threads, therefore, constitutes plain weaving, as represented at fig. 8, which shows the combination of the threads in plain cloth, as seen when magnified. The warp threads are usually much finer than the weft thread, and the fibres are generally spun together in a similar manner to a two or three strand cord. On the contrary, the weft thread is but slightly spun, and usually consists of one strand only. By this means the weft is made soft and yielding, and is better adapted to fill the interstices of the cloth, whilst the warp thread is made firmer, and not only adds more strength to the cloth, but it is much better suited to undergo the process of weaving.

In the throwing or spinning of silk this difference of twisting is expressed by calling the weft thread "tram," which is from "trama," the Latin name for weft; and the warp, owing to its excessive twist, is called "organzine," an Italian technical term, which means extra-spun or machined.

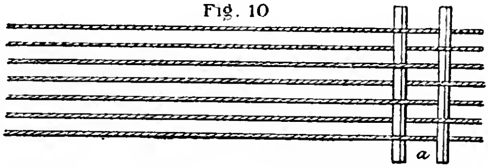
The first process in weaving is to arrange the warp threads for the loom. These differ in length and number according to the length, fineness, and width of the cloth. Before the invention of the warping frame, the process of warping was simply to place a few pegs at the required distance apart, and walk from one to the other, at the same time unwinding the threads from several bobbins or reels, until a sufficient number were collected together of the desired length. This method is still adopted in India, where sticks are fixed in the ground for that purpose, and the weaver taking two reels, one in each hand, passes alternately from one stick to the other, as represented in Fig. 9.

FIG. 9.



Warping, therefore, consists in arranging the threads according to number and colour, or in any special manner that may be necessary, and to keep them in their relative places after they have been so laid. This is effected by crossing the threads at one end of the warp alternately, and by means of a cord keeping them in that position. This will be seen by referring to *a* and *b*, Figs. 10 and 11, which show the crossing of the threads over and under the pegs

Fig. 10



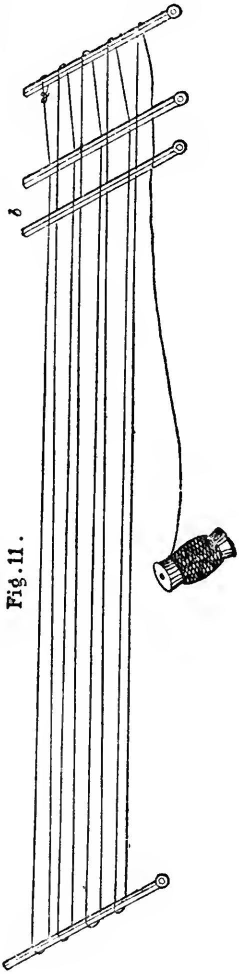


Fig. 11.

by each thread alternately. Before taking them off the pegs, if a cord be placed so as to occupy the places of the pegs, their relative order would always be kept, and the whole warp may then be rolled into a ball or looped like a chain, as may be desired, without fear of disarrangement. This intersection or crossing of the threads is called the "lease" by weavers.

It will be apparent that in long lengths of warp, and composed, as in many instances they are, of thousands of threads, some other method must be adopted for warping. This is performed by means of the warping mill or frame. The requirement being simply what is shown in Figs. 10 and 11, the action of the warping-frame will be readily understood. Fig. 12 represents the machine which is simply a large reel, and is turned by a winch and rope, as shown. A number of bobbins are placed in a frame, shown at *a*, and the threads from them are wound upon the reel.

In passing from the frame *a* to the reel the threads are concentrated at *b*, where they pass between rollers placed vertically, and sunk a short distance into the block upon which they stand (Fig. 13), so as to prevent the threads from passing beneath. In this method the cross is formed by passing the hand between the threads alternately under and over. Fig. 14 shows another plan, where at *b* the threads are passed through a corresponding number of eyes, which are fitted into the block called the "heck." The heck is made to slide up and down the frame-post by means of the cord to which it is attached. Therefore, as the reel or frame is moved backwards or forwards, the heck rises or falls, and distributes the threads in regular order upon the frame. If there are 100 bobbins or any other convenient number in the frame to wind from, a warp of any

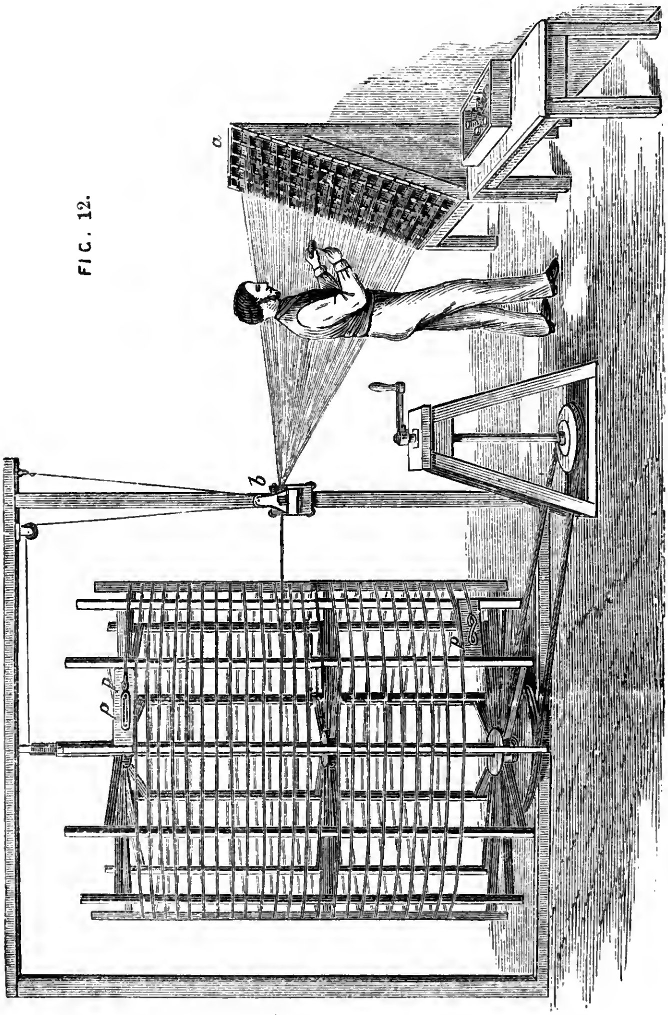


FIG. 12.

number of threads may be laid, as required, by turning the reel forwards and backwards the requisite number of times, which process lays the threads from one peg to the other, as performed by hand. The crossing of the threads, or making a lease, is effected by means of the eyes in the heck, which are shown, enlarged, at *b*,

FIG. 14.

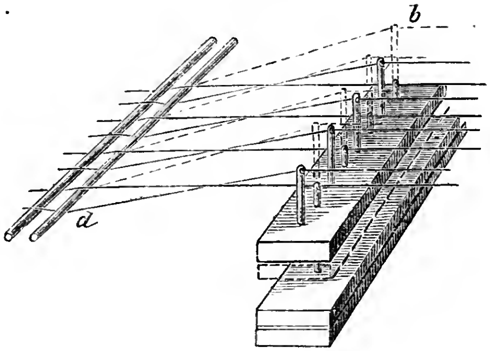


Fig. 13.

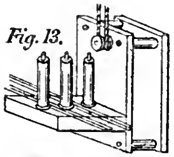


Fig. 14. They are shown fixed in two separate rails, each rail having every alternate eye fixed into it.

Now, by raising and lowering one set of the eyes above and afterwards below the other, an opening is made between the threads corresponding to the position shown in Figs. 10 and 11, and they are by this means placed in a similar order upon the pegs P P of the warping-frame.

Fig. 15.

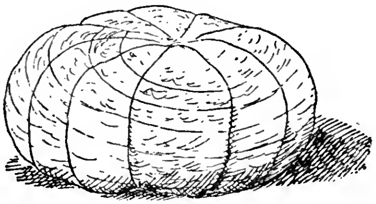
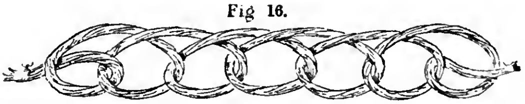


Fig 16.



The length of the warp is regulated by altering the position of the lower peg, from which the return movement is made.

The winding and unwinding of the cord round the spindle raises and lowers the heck-block, and thus acts as a guider in distributing the threads upon the large reel, and keeps each additional layer in its proper place. The warp is then taken off the reel and wound up into a ball-form, or looped in the form of a chain, as shown in Figs. 15 and 16, as may be most convenient, until required for weaving.

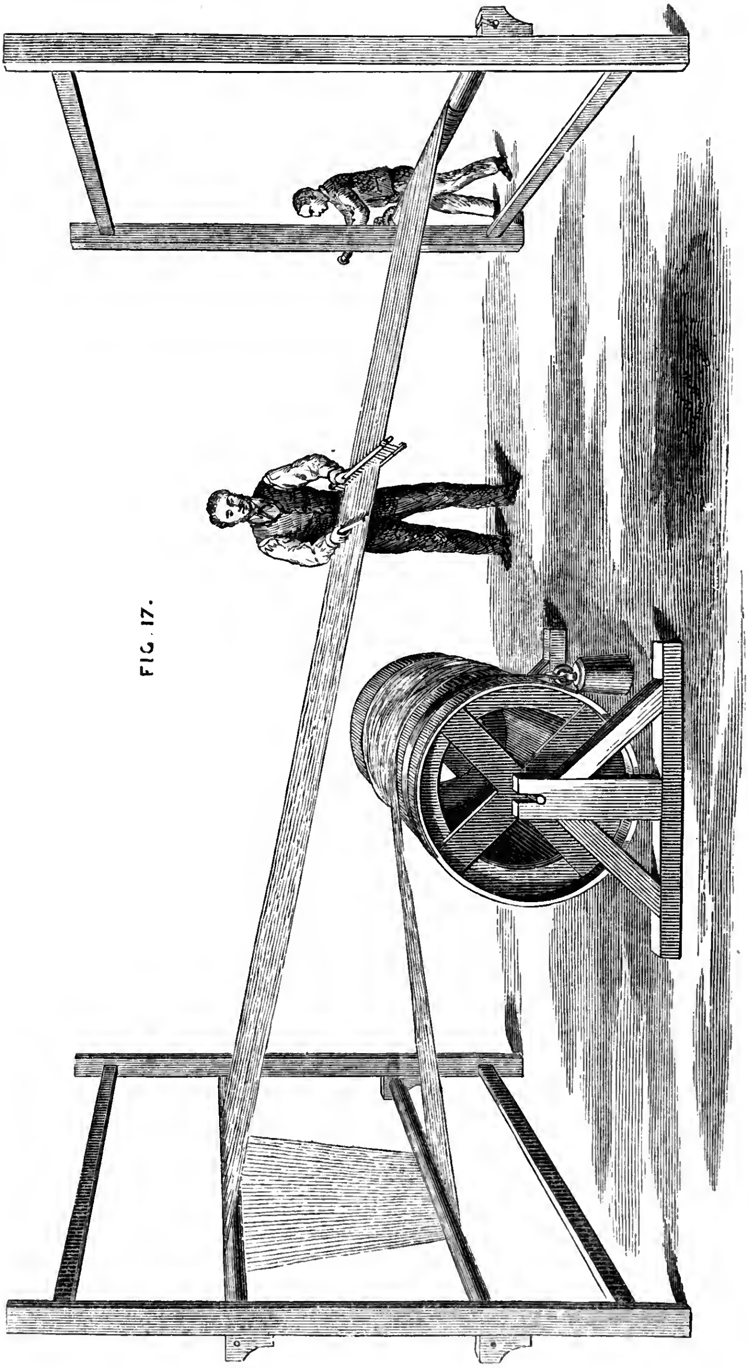


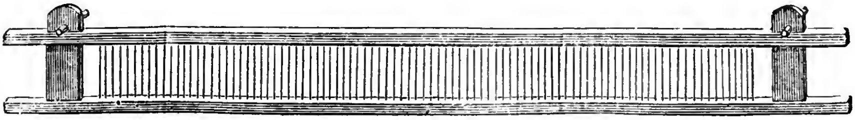
FIG. 17.

It has next to undergo the process of winding upon the warp-beam, which must be done in a perfectly even and regular order, to make it ready for the loom.

This process is called beaming, or "turning on," and in some cases it is called dressing, which in this instance means putting the warp in order, and not the process of dressing or sizing, as will be hereafter referred to.

Fig. 17 represents a common method of beaming, which consists in first winding the warp upon a large drum or cylinder, which is provided with a friction-brake, in order to give proper tension to the threads. The warp is then passed under and over two rollers, as shown, and carried thence to the warp-beam, upon which it is evenly wound. To effect this the threads are passed through a coarse comb, as shown in Fig. 18. The comb is provided with a loose cap, so that the threads can be readily distributed in proper order. As

FIG. 18.



the warp is being wound upon the beam by an assistant, or in some instances by power, the operator holds the comb, and at the same time uses a brush, or a smaller comb, to lay the threads evenly. He also repairs all broken or defective threads, and thus prepares the warp ready for the weaver.

For warping cotton warps a very different machine is used, the threads being passed direct from the bobbins and wound upon a beam. The machine is generally provided with a contrivance by means of which, should any thread break or the bobbin become exhausted, it immediately stops, and cannot proceed until the thread is repaired or replaced. This is accomplished in the following manner:—The threads, being arranged horizontally, pass on their way from the bobbins to the beam over the top of the warping-frame, and each thread passes through an eye made at the end of a short wire staple.

The staple is supported by the thread, which has the effect of keeping the thread slightly in tension. Now, in case the thread should break, the staple falls, and the lower end then comes into contact with a vibrating bar, which passes beneath all the staples so long as they are held up by the threads; but immediately a staple falls, it stops the vibrating bar, and, by means of a trigger-motion, the strap is thrown from the fast to the loose pulley. Mather and Rossetter's patent is a good example of this class of machine. In Mr. Singleton's machine the wire staples are loose, and as they fall, they pass between two revolving rollers which touch each other; thus, if a thread breaks, the staple falls between the rollers, and, of course, pushes them apart a sufficient distance to put in operation a trigger-motion, as before mentioned.

As the warping-machine could scarcely contain the number of bobbins to wind from that are required for a warp, a number of beams which have been filled, as above described, are placed together and re-wound upon another beam as required; thus, ten beams, with 200 threads each, would suffice to fill warp-beams with 2000 threads each, and of course would fill ten of the same size. This process may be either done during the operation of dressing or sizing, as in the case of common cotton warps, or separately.

In the process of beaming the reed to guide the threads on the beam is frequently made to expand or contract in width so as to be adjusted to the width of the beam. This is done by fixing the reed on a frame made like the letter W, which being closed up or drawn out, either contracts the number or expands them according to the space required to be covered on the warp beam. Thus any given number of warp threads may be distributed over any desired space simply by extending or contracting the guide frame.

CHAPTER IV.

THE COMMON HAND LOOM—HEADLES—REED.

Fig. 19 represents a common hand loom, such as is adapted for plain weaving. It consists of four wooden posts framed together at the top by two long and two cross pieces. The long pieces C C are called the capes of the loom.

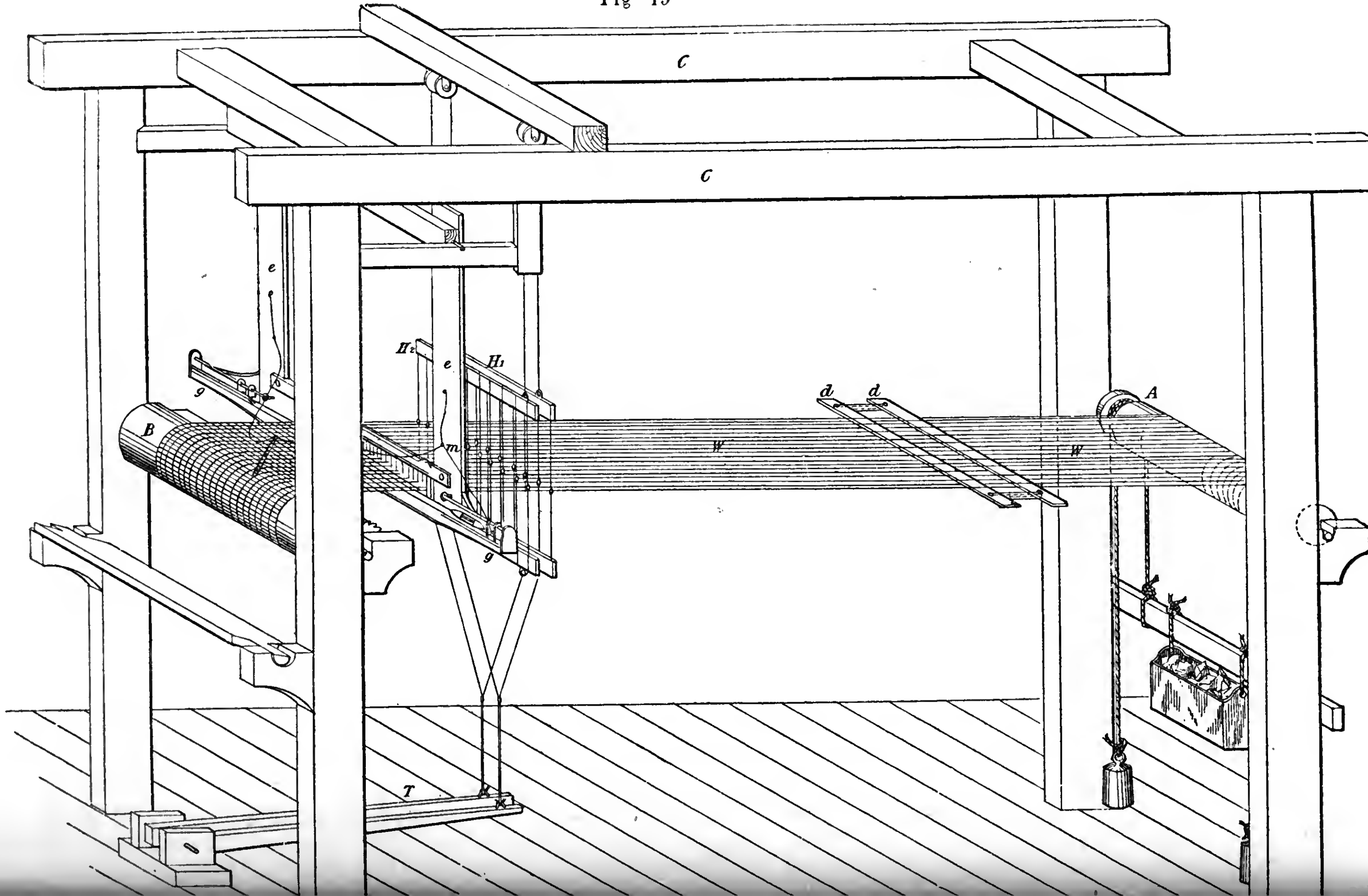
Between the two pairs of posts, forming the ends of the loom, are placed two cylindrical beams; the beam A being the warp beam, upon which the warp W is wound, and B the cloth beam, upon which the cloth is wound as it is woven.

The warp threads are placed parallel to each other, as before described, and are carried from the warp beam A and attached to the cloth beam B. This is done by threading the knotted ends of the threads upon a small rod or lath, and wedging it into the slot or groove, formed in the beam for that purpose as shown at X in section (Fig. 20).

In order to keep the threads in their relative position and parallel to each other, two rods are inserted between the warp threads *d d* in such a manner that each thread passes *over* one of the rods and *under* the other alternately, as shown. Thus a cross or lease is formed by the threads between the two rods, which not only keeps the threads in proper order, but enables the weaver to detect with ease the proper position of any broken thread he may have to repair. This arrangement of the threads is formed during the process of warping, as before described.

After the warp has passed the lease it is then passed through the headles, as shown at H^1 and H^2, Figs. 19 and 20. The headles are composed of a number of threads stretched between two laths, and they have loops made in the middle of them, or an eye called a mail is threaded upon them instead, for the purpose of passing the warp threads through. There are two headles shown, one of which re-

Fig 19



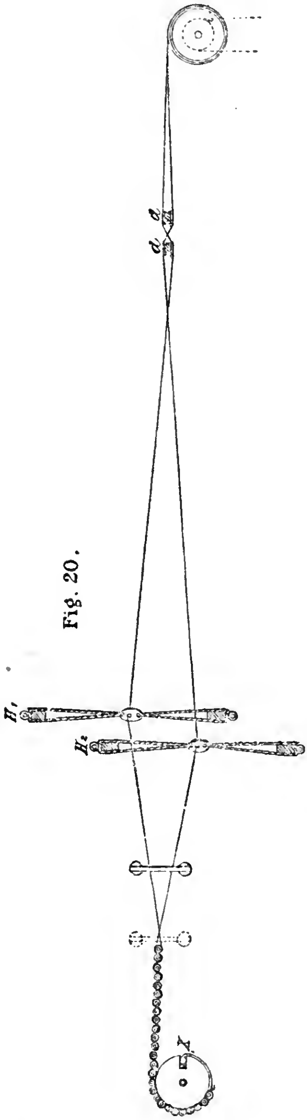


Fig. 20.

ceives every alternate thread of the warp, and the other receives the remainder. Consequently if either of them be raised, it will also raise the warp threads which have been threaded through the loops or mails of it.

The arrangement of the warp threads, and the various parts of the loom which operate upon them, may be best understood by referring to Fig. 21, which is a diagram showing each warp thread separately. Fig. 20 is a section of Fig. 21, and Fig. 19 represents the same parts as they are connected to the frame of the loom.

In Fig. 21 the headles are shown connected and balanced by cords passing over the pulleys *P P*, and the lower part attached to the treadles *T*. The right treadle is shown depressed, consequently, it raises the other treadle and the headle also. Thus half of the warp can be alternately raised for the passage of the shuttle.

The warp is kept in tension by means of weights connected to a rope passing once or twice round the beam.

The cloth beam is provided with a ratchet wheel and pawl *m*, also with a handle *z*, for winding up the cloth as woven.

Headles are made of various descriptions, but the most common forms are those shown in Fig. 22. They are sometimes made of *a pair* of clasped leashes, the warp thread passing below one clasp and above the other (see Fig. 361). The eye may either be looped or knitted in the thread, or twisted wire may be used instead of linen thread, as shown in Fig. 346. The mails used in silk weaving

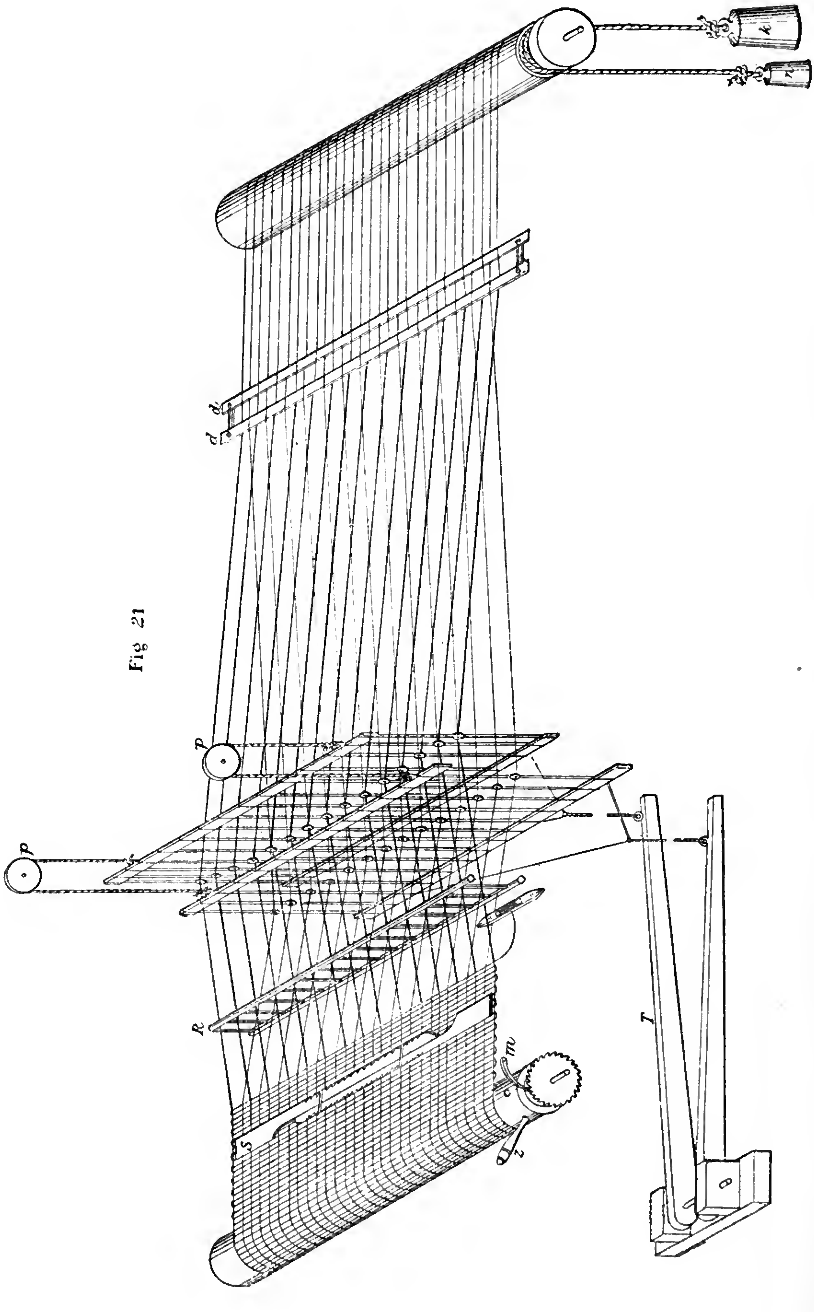
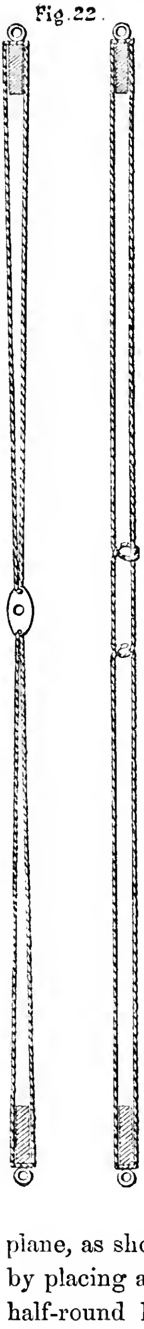


Fig 21

Fig. 22.



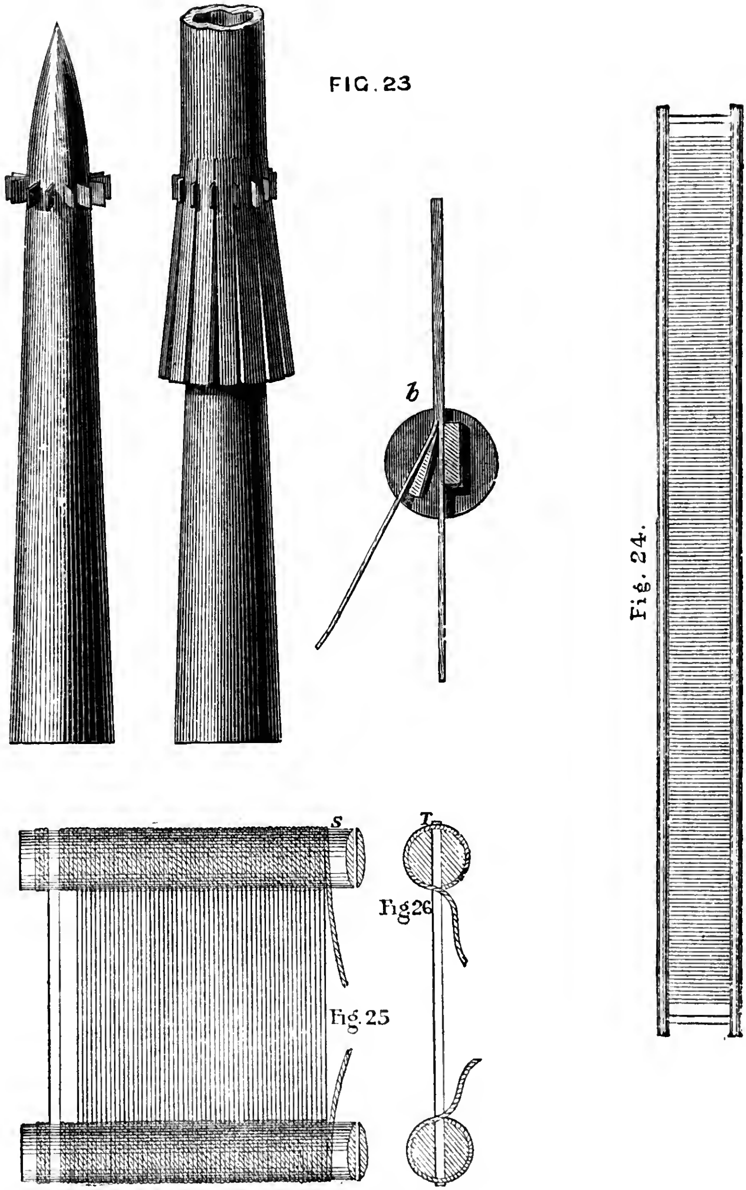
are made of glass, but for other materials steel or brass mails are used.

In the figure only one each of the leashes is shown, but as there must be one to each warp thread, the required number must be provided for. Thus if there are five hundred threads per inch in the width of the cloth, there must be 250 leashes per inch in each of the headles. But as the leashes are composed of thread much thicker than the warp threads, they necessarily take up more room, and could not in weaving fine warps be placed upon one pair of headles. In such cases more headles are used, each having its share of the leashes, and half of them are raised at once so as to raise one half of the warp threads. Or in some cases, two sets of leashes are used on one headle; that is, one row is placed on one side of the laths, and the other on the other side, by which means double the number of leashes can be carried by one pair of laths without overcrowding, and thereby making half the number of headles sufficient for the purpose.

After passing the headles, the warp threads are threaded through the comb or reed, (*R*, Fig. 21), which is fixed in a pendulous frame or batten. The reed not only keeps the warp threads in their proper position, but by its means the weft threads are beaten together after they had been inserted by the shuttle. From one to as many as twelve threads are usually passed through each slit of the reed.

The reed or comb was formerly made of strips of reed, hence the name; but now they are made of flattened brass or steel wire.

Fig. 23 represents the old method of cleaving the reed into strips by pressing short lengths upon a taper spindle, into which radiating blades were fixed. The strips were then passed through a gauge plane, as shown at *b*. The reed or comb (Figs. 24, 25, 26) is formed by placing a number of the strips, whether of reed or metal, between half-round laths, and they are bound together by a waxed thread passing between and round each strip and at both ends, as shown



enlarged at *S* and *T*. The number of the strips differ in degrees of fineness according to the fabric to be woven, varying from a few dents per inch to 120 or upwards.

The substitution of metal strips for reed was a very important improvement, and was first effected by John Kay, the inventor of the fly shuttle.

Reeds have been made with various-shaped surfaces, so as to beat up the weft threads in curved or zigzag lines, with a view to making a kind of figured cloth. In other instances the lower edge of the dents have been left open, so that the warp threads could be moved from place to place, in order to effect cross weaving. Various other modifications have also been made in them for different purposes, but it does not appear that any of them have proved of much advantage.

Reed making was formerly a handicraft process, but machinery has long been used for the purpose. The wire is inserted and cut off at the desired length, and the waxed twine wound round the wood strips, and then pressed together to any desired guage.

A stronger wire is put at each end to strengthen and protect the fine ones as shown in Fig. 24, and the waxed threads are covered with paper to prevent injury to the warp.

CHAPTER V.

THE FLY SHUTTLE—HAND SHUTTLE—DROP BOXES, ETC.—JOHN KAY.

The reed is fixed into the lower part of a frame, called the "batten," *e e* (Fig. 27, &c.), which is suspended from two gudgeons, and is capable of being moved a short distance to and fro, in a line parallel to the warp threads. At each side of the batten, and about level with the bottom of the openings in the reed, are placed two shuttle boxes *g g*. These boxes have a spindle fitted lengthways over the centre of them, upon which the picker, a kind of hammer, is made to slide. The two pickers are connected together by a slack cord *m*, to the centre of which the "picking stick" is attached. Two short cords are connected to the picker cord to keep it suspended and free to work.

The boxes are suited to the size of the shuttle, which is driven with considerable velocity from one box to the other by means of the picking stick and pickers. It is known as the fly shuttle, and was patented by John Kay in 1733. Fig. 27, shows the batten detached from the loom, in which *p p* are the pickers which slide upon the

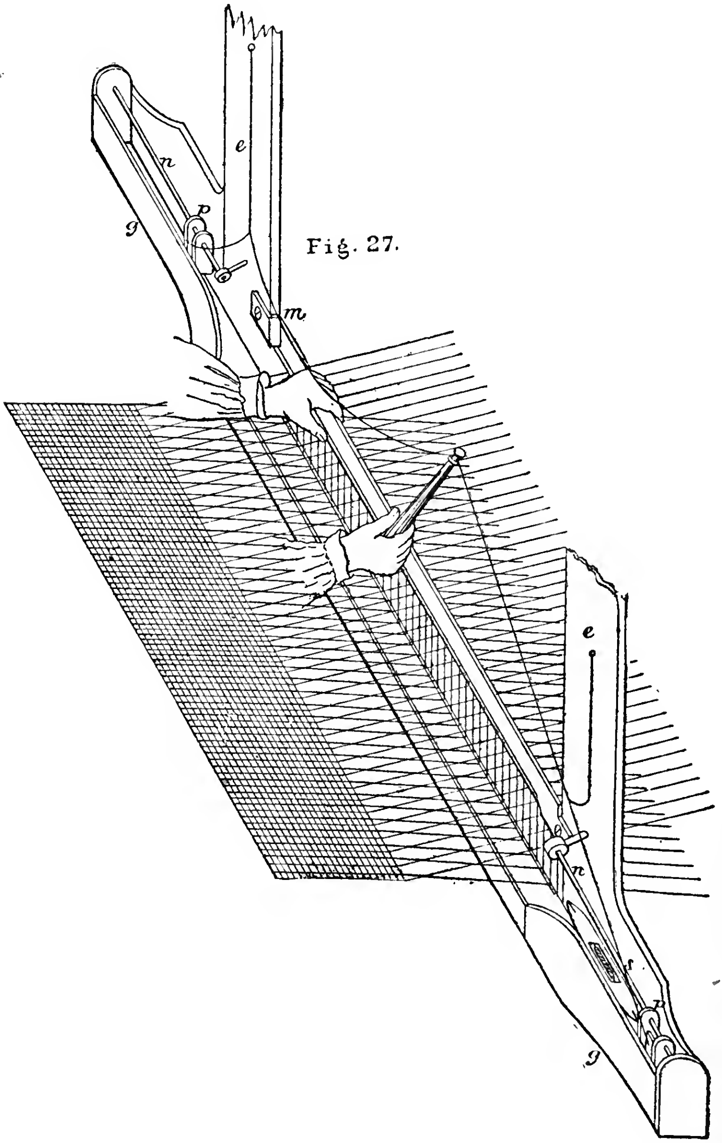
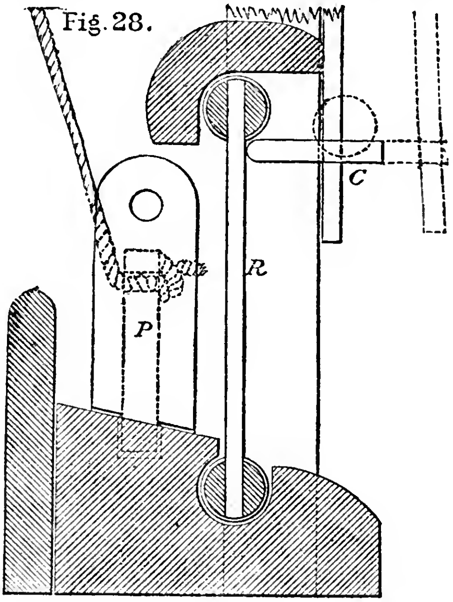


Fig. 27.

spindles *n n*; and at *s* is the shuttle in the shuttle box. The pickers are variously made, but principally of buffalo hide, dressed so as to resemble horn. Fig 28, shows a section of the batten at the centre.

The picker *P* is made with a small tongue at the bottom to slide into a groove, and cause less friction than if the pickers were made to fill the box from side to side. In the same section the reed *R* is shown pressed by flat springs, which is a contrivance added to some looms to regulate the force of the blow of the batten. There are two of these springs, one at each end of the reed, and they are attached to the presser at *C*. A screw is placed to regulate the strain according to the strength required. When the blow is given to beat the weft threads together, the reed, being pressed by the springs, gives way if too heavy a blow be struck, and thereby insures

Fig. 28.



a greater amount of uniformity, and prevents thick and thin places in the cloth, which in the absence of a "take up motion" would be likely to occur. See also Figs. 33 and 43.

The loom being ready for the actual operation of weaving, the weaver takes his seat, and places the shuttle into one of the boxes, after pushing the picker back to the far end of the box. A short length of the weft thread is allowed to hang out of the eye of the shuttle, so that it may be caught on the edge of the warp as the shuttle enters the shed for the first time. He then takes hold of the batten with the left hand, in the position shown in Fig. 27, and holds the picking stick in his right hand.

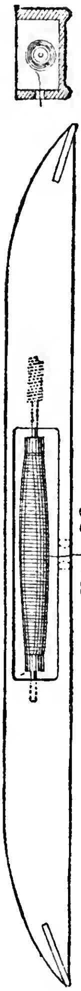


Fig. 30.

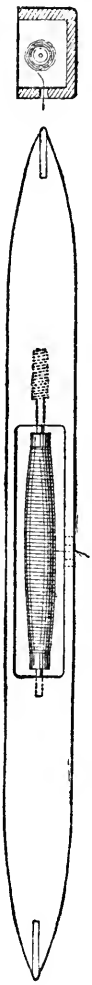


Fig. 29.

In the sketch the shuttle is shown to be in the right-hand box; in this case the weaver places his right foot upon the right treadle and depresses it, which at the same time causes the left treadle to rise, and an opening or shed is formed in the warp, as shown in the figure. He first pushes the batten backwards a few inches, which causes the opening in the warp to appear in front of the reed, as well as at the back, and thus gives room for the shuttle. He next with a smart jerk of the right hand, throws the shuttle through the warp and into the opposite shuttle box, where it comes into contact with the picker, and drives it to the far end of the box. Then he draws the batten towards him, which brings with it in front of the reed, the weft thread. He next treads upon the left treadle, and at the same time pushes the batten backwards, which opens the shed ready for throwing the shuttle back to the right-hand box. When the shuttle is thrown he again draws the batten towards him, which pushes the weft thread against the last thread, or shute. Thus the operation is continued, the three motions, viz., opening the shed by means of the treadles, throwing the shuttle, and beating together the weft threads by the reed which binds them together compactly and evenly, as necessary to the production of cloth, are accomplished.

Although the fly shuttle has been in use since 1733, still the old mode of throwing the shuttle by hand is at the present time in frequent use, but principally among silk weavers. The fly-shuttle is made straight in form, as shown at Fig. 29. It is usually made of boxwood, and is tipped at each end with smooth steel points. There is an oblong hole morticed out of the shuttle for the reception of the weft bobbin. The ordinary fly shuttle used in silk weaving measures eleven inches in length and is about one inch square in section. It weighs about three ounces. In silk weaving the bobbin is called a quill, but is generally made of a small reed about the length of a quill barrel. The reed still retains the name of quill, although quills are not used now, owing to their extra cost. The quill is fixed upon a small wire spindle, which is shown at *a*, Fig. 31. There are two

Fig. 31.

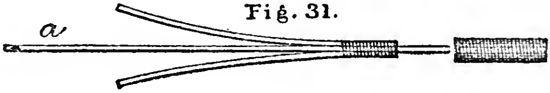
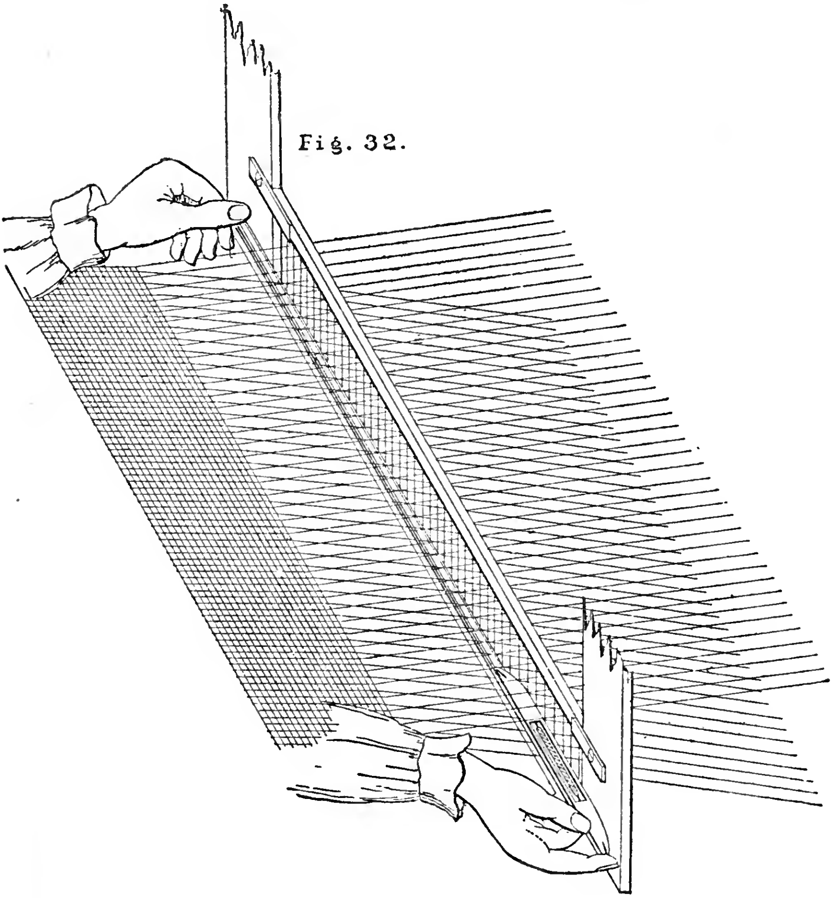


Fig. 32.



flat wire springs attached to it, which are not only for the purpose of holding the quill in position when placed on the spindle, but to cause a slight friction and consequently an elastic tension on the thread. The spindle and springs are often made from one piece

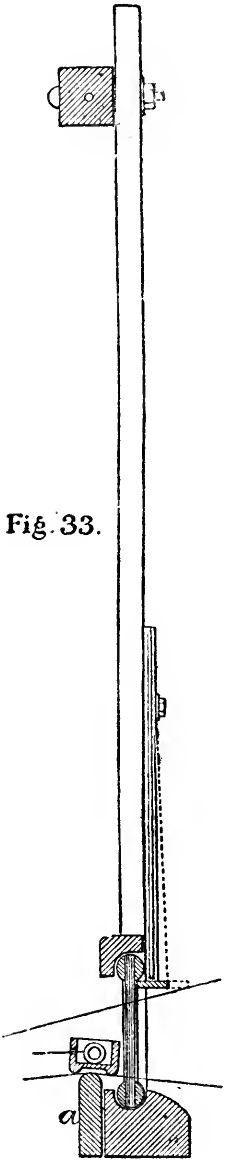
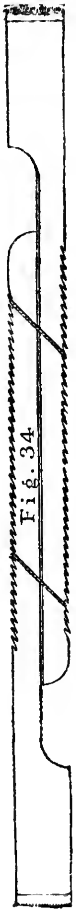


Fig. 33.



of wire by turning one or both ends, similar to a single or double hook flattened. It must be weak enough to allow the quill to move longitudinally as well as upon its axis, for the spindle is fixed stationary and without movement. When the spindle is placed in the shuttle one end is pressed against the concealed spring, which causes it to be pushed inwards, and thereby allows of the other end to be inserted into the hole at the opposite end of the mortice. The concealed spring, shown also in Fig. 31, then presses against the end of the spindle and keeps it in its place. The weft thread is made to pass out at the side of the shuttle through an eye made of glass or earthenware, which is fixed there for the purpose.

The shuttle, when thrown by hand, is somewhat curved, as shown at Fig. 30, which form is more suitable to follow the motion of the hand. Fig. 32 shows the method of throwing it. It will be seen that the thumb is placed on the shuttle race whilst the hand is held open below it to catch the shuttle. The batten is drawn towards the weaver by the thumb, although it naturally falls towards him by its own gravity, being usually worked a little out of a vertical line for that purpose. Sometimes springs are placed to draw the batten forward, in which case the weaver, with the back of the hand merely, pushes the batten backwards, whilst the spring gives the blow.

Fig. 33 shows a section of the shuttle and the shuttle race, or bed upon which it slides. It will be seen the warp threads are pressed down upon the race *a*, and the shuttle (Fig. 30), having a wide shallow groove, slides upon the ridge of the warp threads, as shown in section.

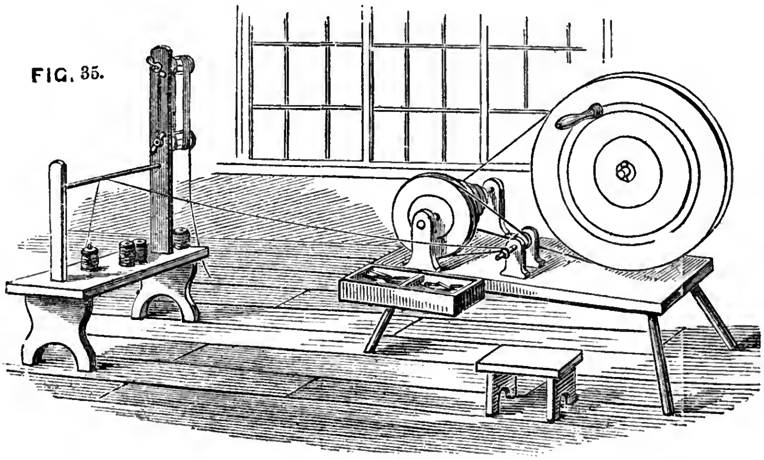
It has been shown that the ends of the warp threads are secured to the cloth beam by being inserted into a groove. The beam is held in position by means of a ratchet wheel and pawl, and as the cloth is woven it is wound up by means of a short lever. In order to keep the warp threads at a proper degree of tension, the warp beam is provided with two weights, or two pairs of weights—one pair at each end of the beam—one being much heavier than the other, and attached to the same cord; the heaviest weight being hung so as to draw the warp in a contrary direction to the cloth beam, and thereby produce a tension upon the threads. The rope to which the weights are attached is wound round the warp beam several times to give it sufficient friction. Now when the treadles are depressed, and the shed is opened for the passage of the shuttle, the heavier weight is slightly raised, and falls again when the shed is closed. As the cloth is woven the weight is gradually drawn upwards, and the small counterpoise falls. When this latter touches the ground it follows that the rope becomes slackened, and thereby takes the friction off the rope and allows the warp beam to move, although the tension caused by the heavier weight is always acting upon the warp. See *k* and *n*, Fig. 21.

This motion is made in many different forms, sometimes by means of levers, acting like a steel-yard, in which case the weights can be adjusted to any degree of tension. The tension, as the warp becomes unwound, becomes greater, through the diameter of the beam being lessened, whilst the weight remains working at the same leverage. Thus it requires occasional adjustment in weaving very long warps, where the diameter of the warp beam may become lessened perhaps one half in size. This circumstance has given rise to "let-off motions" being made to equalize the strains, but they will be referred to in power-loom weaving, where their action must be automatic. See Chapter xxiii.

The take-up motion is also effected in a similar way. In hand-loom weaving the weaver draws the cloth beam round occasionally, after weaving a few inches. In power-loom weaving this action becomes an important matter, and a great variety of motions have been invented to effect it by self-acting means.

In the process of weaving it is found that some cloth as it is woven has a tendency to draw in or become narrower. This effect requires to be counteracted, otherwise the cloth would be difficult to weave, and very irregular work would be the result. The contrivance used for the purpose is called a "temple," and they have been made in a variety of forms, but for hand-loom use a very simple one suffices. Fig. 34 represents a common form of temple. It consists of two flat pieces of wood, adjusted and laced together according to the width of the cloth, by a cord as shown. At both ends of the temple a number of pin points are fixed.

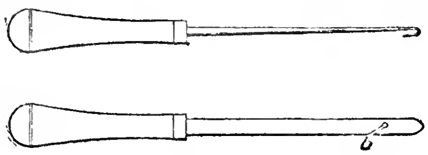
FIG. 35.



These points are placed in the two selvages of the cloth, and it is thereby held stretched out and prevented from contracting, as it would otherwise do. As the cloth is woven the temple is moved. Fig. 21 shows the temple as it lies upon the cloth at S. In power-loom weaving the temples are made to revolve, so as to require no refixing as the cloth is woven. See Chapter xxx.

The machines used by the hand-loom weaver, in addition to the loom, are the hand wheel and a pair of small reels, as shown at Fig. 35. If he has to unwind the weft from skeins, he generally winds it upon bobbins first, and from the bobbins he winds it upon the quills. These operations simply consist in placing the bobbin or quill upon the spindle of the hand wheel, and winding upon it the weft thread either in double or single threads, as may be required.

Four small implements in constant requisition by the weaver are shown below. The second of these is employed to draw the warp threads through the reed, being a hook made of a strip of flat metal, with a notch in it, as shown at *b*. But he can in hand looms very often draw it through the reed without the aid of the hook,



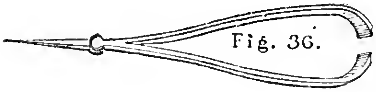


Fig. 36.

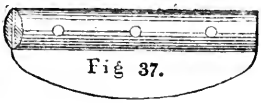


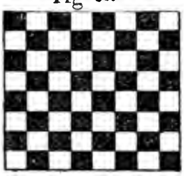
Fig 37.

which is done by turning the broken thread round the adjoining thread, which occupies the same opening in the reed, when by pushing back the reed, the thread passes between the dents, and he then pins it to the surface of the cloth, when it becomes woven in on the next throw of the shuttle. The instrument, Fig. 36, is a small pair of spring nippers, with a point at one end, to cut off any short ends or knots, &c.

For drawing the threads through the mails a small hook, as shown above, is used, and a rubber (Fig. 37) made of flat or saw-blade steel is employed for smoothing the cloth.

Each throw of the shuttle is called a "pick," consequently the loom is counted in speed by the number of "picks" per minute.

Fig 38.



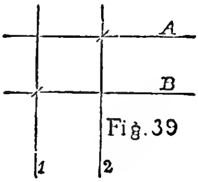


Fig. 39

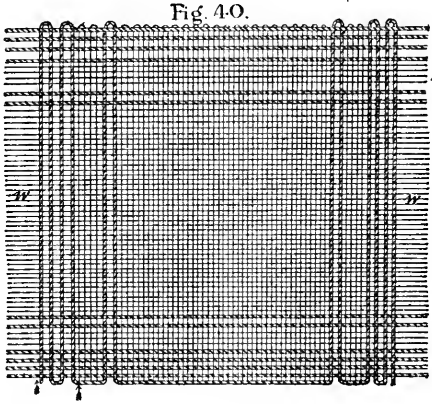
The number of weft threads, also, is named in the same way and is counted as so many picks to the inch. Sometimes the words shoot and shute are used instead of pick and weft.

In Fig. 8 a piece of plain woven cloth is represented as before stated. Fig 38 represents the same thing as it would be drawn by the weaver, and it is generally called "tabby" or plain weaving.

In arranging the loom the weaver employs another method of drawing the pattern, and in this case he would represent it as shown at Fig. 39, in which *A* and *B* represent the two headles, and 1 and 2 the treadles. The mark placed at the intersection of the lines show which of the treadles and headles are connected together. This method becomes a matter of great importance when a number of headles are used, as will be shown hereafter.

In plain weaving it has been shown that the threads of the warp and weft intersect each other alternately, but in figured weaving the intersections are varied according to the pattern, for it is by this means that the figure is produced. Still, in plain weaving, the first

Fig. 40.

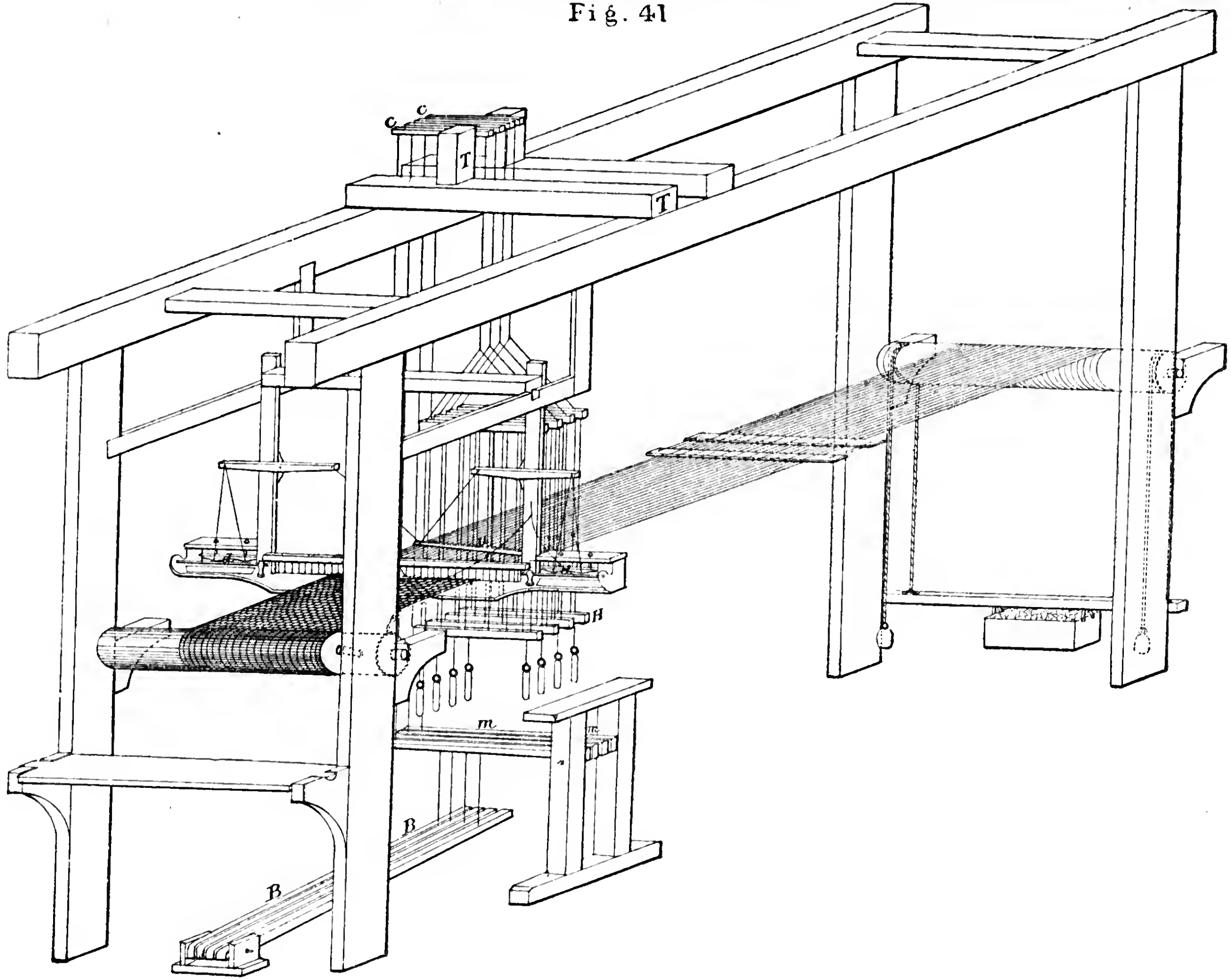


step towards figured or pattern weaving is made by varying the thickness of the threads both in the warp and the weft, as may be observed in the borders of some cambric handkerchiefs. Different coloured warp and weft threads may also be used, so as to form stripes, checks, or plaids, or materials of different kinds, such as silk and wool, may also be used with more or less effect.

But whatever the difference of the threads may be, the actual mode of weaving them is simply plain, or tabby weaving. If various kinds of threads are required for the warp, they are arranged in the process of warping, and they are afterwards entered or placed in the loom accordingly. But the various kinds of weft threads are inserted by shuttles, each description of thread having a separate one.

Fig. 40 represents a piece of cloth, or handkerchief, which has two thicknesses of warp and weft. The warp *W* has been arranged, as before described, on the warping mill; but the weft threads have

Fig. 41



been inserted by two separate shuttles, and the thick and thin weft threads may be traced as they have been carried from side to side of the cloth.

In this instance the shuttles have been changed on one side of the cloth only, consequently, at least two threads, or picks, are used before the shuttle is changed, or they may be continued as many picks as may be desired, so long as the shuttle is returned to the side from which it commenced. In other words, single picks or threads require the shuttle to be changed at either side of the cloth, so that a single or any number of threads may be inserted as desired.

When the shuttles are thrown by hand the weaver can easily throw in one or more picks or threads at pleasure, for when two or three shuttles only are used they are laid on the cloth before him, and he selects them as required. But if he uses a larger number of shuttles—say five or upwards—he generally makes use of a small box, which is fixed near the edge of the cloth, and into which he drops the shuttles endways. By this means they are convenient to select, and the use of a number of shuttles is a simple matter.

When the fly shuttle was first introduced it was intended for the use of one shuttle only, but it was afterwards found that if two or more shuttles could be used on the same principle it would be of great advantage. This was effected about the year 1760, by Robert Kay, who invented the "drop box" for that purpose. It is gratifying to know that he was a son of John Kay, the inventor of the fly shuttle.

The drop box is usually made for two shuttles only; although by an ingenious contrivance three shuttles can be used, or several more, by an extension of the same principle. It will be necessary only to describe a three-shuttle drop box, for it comprises the principles of the others.

Fig. 41 represents a hand loom fitted with a drop box, or rather a pair of such boxes, for there is one at each side of the loom, as shown; and Figs. 42 to 48 represent in detail the method of working two or more shuttles by them.

Fig. 42 shows a front view of a batten fitted with boxes *a a*, and Fig. 43 represents the back of same. Fig. 44 is an elevation of one box on a large scale, Fig. 45 a plan, and Fig. 46 is section of it, at the line *B B*. The same letters refer to the same parts in all the figures.

The drop box consists simply of a small board, upon which are

Fig 42

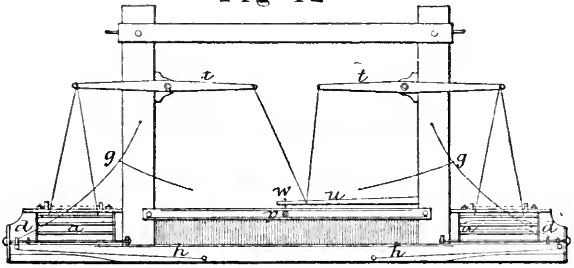


Fig. 43.

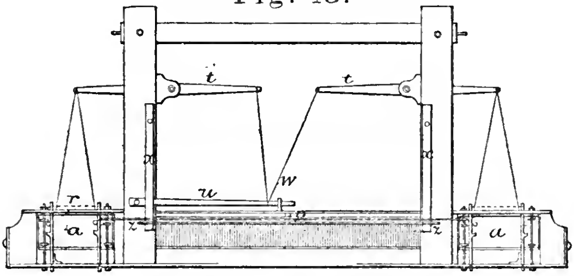


Fig. 44.

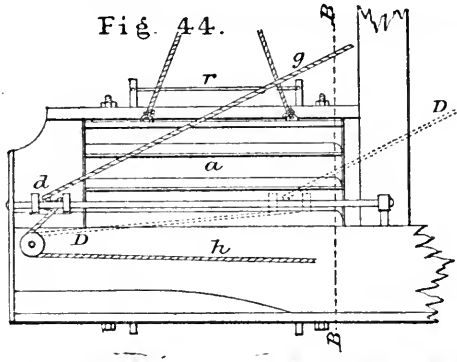
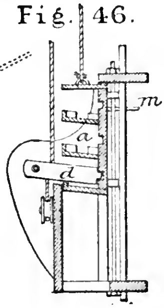


Fig. 46.



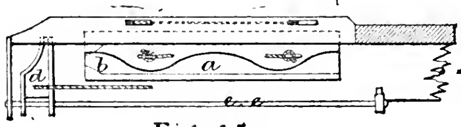


Fig. 45.

Fig. 48.

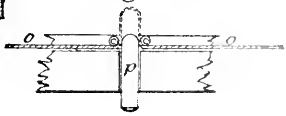
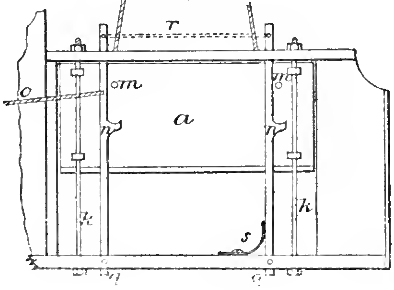


Fig. 47



fixed three or more shelves, according to the number of shuttles, and as these shelves are lowered to the level of the shuttle race, or board upon which the shuttle slides, so is the shuttle upon that shelf brought in line with the picker, and may be driven to the corresponding box on the opposite side of the batten.

In the various figures, *a a a* represent the drop box, the shelves upon which are more clearly shown in section Fig. 46, and in plan Fig. 45. The shelves are inclined in the same way as the shuttle race, but when the batten is pushed backwards for the throwing of the shuttle they become less inclined, although sufficiently so as to keep the shuttle in its proper course. The far end of each box is contracted, as shown at *b*, Fig. 45, which is to prevent the shuttle from going beyond its bounds. Shuttles are shown upon the shelves at Fig. 42, where the bottom shuttle is in line with the picker *d*. There are two pickers, as in the ordinary fly loom, but they slide horizontally, as shown at *d d*, Figs. 45 and 46, upon the spindles *e e*, and not vertically as in the single fly shuttle. This arrangement is to allow the picker to slide over any of the shelves that may be brought opposite to it. The pickers are driven by means of a stick and cords *g g*, as before described in the fly shuttle, but in this case there is an additional cord *h h*, which is elastic, and is for the purpose of withdrawing the picker out of the drop box after the shuttle has been driven, otherwise it would prevent the box from being raised or lowered when required. The picker is provided with a "nib" to slide into a groove, to lessen the friction, as in the ordinary fly, and as shown in Fig. 46. In Fig. 44 the dotted lines *D D* show the position of the picker after it has thrown the shuttle out of the box, before the elastic cord *h* withdraws it clear of the drop box. The drop box is made to slide on two small bolts shown at *k k*, Fig. 47, which represents the back of the box. In the same figure two pins *m m* are shown, also at *m*, Fig. 46, fixed in the back of the box. These pins, when the box is lowered, rest upon the hooks *n n*, Fig. 47, and prevent the box from being lowered to its full extent. But by drawing the hooks aside, the box can then descend to the full extent. The hooks are drawn aside by means of the cords *o o*, which are connected to a peg *p*, Fig. 42, placed in the middle of the batten, and shown in sectional plan, Fig. 48. When the peg is pushed inwards, as shown by the dotted lines, it draws the cords *o o* round the small pulleys as shown, and, consequently, pulls back the hooks. It will be noticed that each hook works on its fulcrum as shown at *q q*, and they are connected together by a cord at *r*. The hooks after they have been drawn backwards, recover their position by means of a small spring at *s*, Fig. 47.

The boxes are suspended from the levers *t t*, the opposite ends of which are connected with the lever *u*, Figs. 42 and 43. The boxes being heavier than the lever *u*, their tendency is to drop and lift the lever. The weaver counteracts this by holding the lever down when working the batten with his left hand, or he sometimes fixes a small catch at *w*, which can be easily thrown in and out of contact with the lever without moving the hand off the batten.

In working the loom the boxes are raised, as shown in Figs. 42 to 47, and the lever *u* is pressed or held down. Consequently the bottom shuttle box is placed opposite the picker on both sides of the loom. If the weaver releases the catch *w*, or takes his hand off the lever *u*, the boxes fall and rest upon the hooks *n n*, Figs. 46 and 47, by means of the pins *m m*, and the middle shuttle boxes are then lowered to the level of the race board. It is in this manner that a two-shuttle drop box is used, namely, by simply pressing upon the lever *u*. But if the weaver requires the uppermost box to be lowered to the level of the shuttle race, he presses with his thumb the peg shown at *p*, Figs. 42 and 48, which causes the catches *n n* to be drawn backwards clear of the pins *m m*, and allows the box to fall to its lowest level, or the level of the third box. This method may be extended so as to employ several more boxes, if required, by adding more notches or hooks on the levers as at *n n*.

It will be evident that the plan of working the boxes may be modified in various ways, but the one shown is taken from a well constructed silk loom.

It is by this simple and effectual means that two or more shuttles can be used without difficulty. Each shuttle can be thrown either once, or any number of times, and they may be thrown in any order that may be desired.

In applying the use of several shuttles to the power loom, the difficulty to be overcome is far greater than would at first sight appear. So long as the speed of the loom is but slow, the task can be accomplished in many ways, and with success. But to drive such looms at the speed exacted from the modern power loom would destroy them in a very short time. As the speed of the loom has been increased, the more simply its parts are contrived, and the more capable it becomes of working at that speed; but to apply several shuttles to a power loom, so that each shuttle can be used any desired number of picks, and be immediately changed for another shuttle, necessarily gives rise to a considerable amount of complicated motions. To simplify these as much as possible, the box containing the shuttles is applied only to one side of the loom, consequently if any of the shuttles are thrown through the shed, it is received into a stationary box at the opposite side, and it must be returned before another shuttle can be thrown. To throw the shuttles one pick only cannot be accomplished in such looms. To show the value of a loom capable of throwing "single picks" of weft, let it be supposed that the manufacturer desires to face his cloth with an occasional pick of silk weft. Now it is possible that a single pick, under certain circumstances, may be made quite as effectual in appearance as two picks would be. In this case he would be throwing a valuable material away, comparatively speaking, unless his looms were adapted to work single picks of weft.

In Fig. 43 are shown two flat springs *x x*, which are connected together by the flat bar *z z*, shown on edge. The bar and springs are for the purpose of pressing against the reed in such a manner that when the blow is given to drive the weft threads together they may be struck with nearly equal force each time, so as to prevent any inequality in the work, as previously described, but shown in end view only in Fig. 28.

John Kay was born in 1704, at Walmersley, near Bury, Lancashire. He was educated abroad, but on his return he went to a woollen manufactory, belonging to his father, at Colchester, where he made various improvements in carding machinery as well as in looms. It was here that he effected the great improvement of substituting thin blades of metal instead of strips of cane, for the construction of the reed or sley, and they were called Kay's reeds. His first patent, 1730, was for carding, twisting, and dressing mohair and worsted thread. In 1733, he patented the fly shuttle. Great opposition was made to this invention by the weavers of Colchester and Spitalfields, and he had to leave Colchester and went to Leeds, where he commenced business as an engineer in 1738. The Yorkshire weavers were the first to adopt the fly shuttle, but they would not pay for its use, and in fact they formed an association called the Shuttle Club, to pay each other's costs when prosecuted. Kay was equally determined to enforce his rights, and nearly ruined himself in Chancery suits, although they were decided in his favour. In his attempt to introduce the carding and spinning machinery he had invented, he was seriously opposed by the operatives, and was obliged to consign the spinning machines to the workhouses of Leeds and Burstall, to be used by the inmates. In 1745, in conjunction with Joseph Stell (of Keighley), he patented a small ware loom, to be worked by mechanical, instead of manual power, but either from his circumstances, or the opposition he met with, or both combined, he was compelled to leave Leeds and remove to Bury, where he resumed his improvements in spinning machinery, which soon gave rise to disturbances amongst the spinners. In 1753, a mob broke into his house and destroyed everything they found, and it is probable he would have been killed had not two friends carried him away in a wool sheet to a place of safety. In 1764, his son Robert appealed to the Society of Arts, respecting his father's invention of the fly shuttle, probably in the hope of receiving a reward, and Kay himself wrote in the same year relative to the matter. The subject was referred to a committee of mechanics, who appointed Mr. Thomas Moore, of Chiswell Street, to make trial of the invention, but he reported that he knew no person who understood it, and the Society asked for further information. Thus the matter dropped. Kay then sought refuge in France, and his machines were smuggled out of England, by Mr. Holker. He was encouraged to return to England by the British ambassador at Paris, in the hope of gaining some reward from the Government, but he was not listened to, and the hopelessly crushed engineer returned to France, where he died in obscurity and poverty, to the disgrace of his countrymen.[1]

Previous to Kay's invention of the fly shuttle, it required two men to work the broad loom, one at each side of the loom, and the shuttle was thrown from one to the other alternately.

[1] "Woodcroft's Biographies."

CHAPTER VI.

TWILLS—SATINS—DOUBLE CLOTH.

From plain weaving, the next step in advancement is the production of twills (French *touaille*). These are either regular, broken, or zigzag. A twill is known by its diagonal ribs on the surface of the cloth. The broken twill is a satin, and the object is to hide the ribbed appearance, so as to produce an even and smooth surface so well shown on satins. This fabric is said to be of Chinese origin, and the word itself to be Chinese. Double cloth weaving is another branch of weaving. By these means not only can a great variety of plain cloth be produced, but they enable the weaver to economize

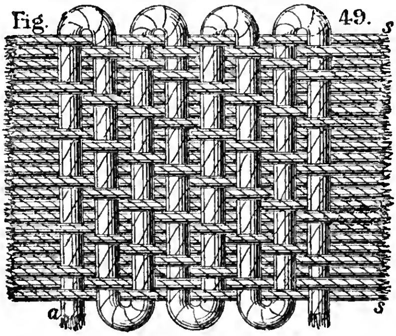


Fig. 49.

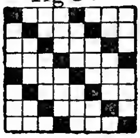


Fig 50

materials as well as to produce thicker cloth, and with different colours on each surface.

Fig. 49 represents a piece of twill or tweeled cloth, and it may be seen that the threads do not interlace each other alternately; but that they intersect at certain regular intervals. In this case the weft thread *a*, passes under every fourth thread of the warp in such a manner, that after it has passed from side to side of the cloth four times it has intersected all the threads of the warp. These intersections being made in regular and consecutive order give rise to the diagonal appearance which is known as a "twill." In like manner

Fig 51 represents a zigzag which will be seen to be simply a twill worked backwards and forwards. Fig. 50 represents the mode of showing the twill Fig. 49, on design paper, and Fig. 52 shows in the same way the zigzag, Fig. 51. To give better effect to the twill the warp threads are sometimes spun in contrary directions. Thus a right hand twill is said to appear much bolder if the thread be twisted

Fig. 51.

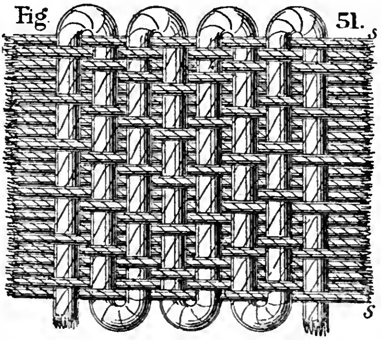


Fig. 52.

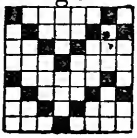


Fig. 53.

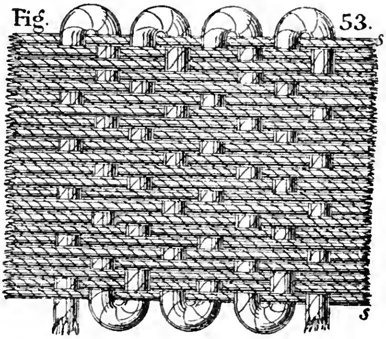
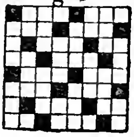


Fig. 54.



to the right hand, and for a left hand twill to have the warp twisted to the left. In Fig. 53 a satinet is represented which is also shown at Fig. 54. It will, in this instance, be observed that the white spaces on the design paper, instead of the black, correspond with the intersections in Fig. 53. This arises from the circumstance that the cloth as shown at Fig. 53 is represented on the contrary side to the design at Fig. 54, in order to show the smooth appearance peculiar to satinet—but far more so in satins—which form so great a contrast to twills and zigzags. Satinet and satins are really broken twills, that is, the intersections, instead of being made in regular order, are broken up so as to avoid as much as possible all harsh lines. In the example shown, it will be observed that three-fourths of the threads constantly appear on the surface of the cloth, but in ordinary satin seven-eighths of the threads appear or float on the surface. Therefore more headles are necessary for weaving satins than satinets, as will be hereafter noticed, and it is this circumstance that explains the distinction in the names. Figs. 55 and 56 form another variety of cloth, in which the threads are used double, and Figs. 57 and 58 a modification of Fig. 51, which is effected by reversing the position of the warp threads in the loom, as will be described.

In plain weaving it was shown that half of the warp threads were

Fig. 55.

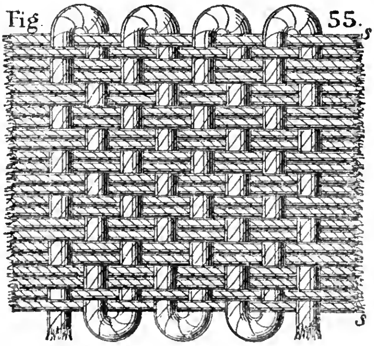


Fig. 57.

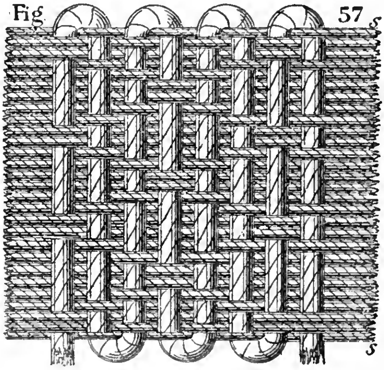


Fig. 56.

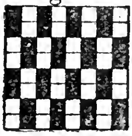
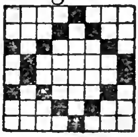


Fig. 58



passed through the eyes of one of the headles, and the other half were passed through the eyes of the other headle. Now, instead of dividing them and passing the threads through two headles only, if they were divided into four parts and each part passed through the eyes of a separate headle in proper order, then not only could the different varieties of cloth represented above be produced, but a great many other changes could be made.

In a similar way three headles may be used, but only to a very limited extent. Four headles are the least, although they are sufficient in number to show the principles upon which twills, satins, &c., depend and the means adopted by the weaver to make them.

By limiting the number of headles and threads, each of them may be shown, and the process made comparatively clear. In actual work the number of warp threads in each inch in the width of the

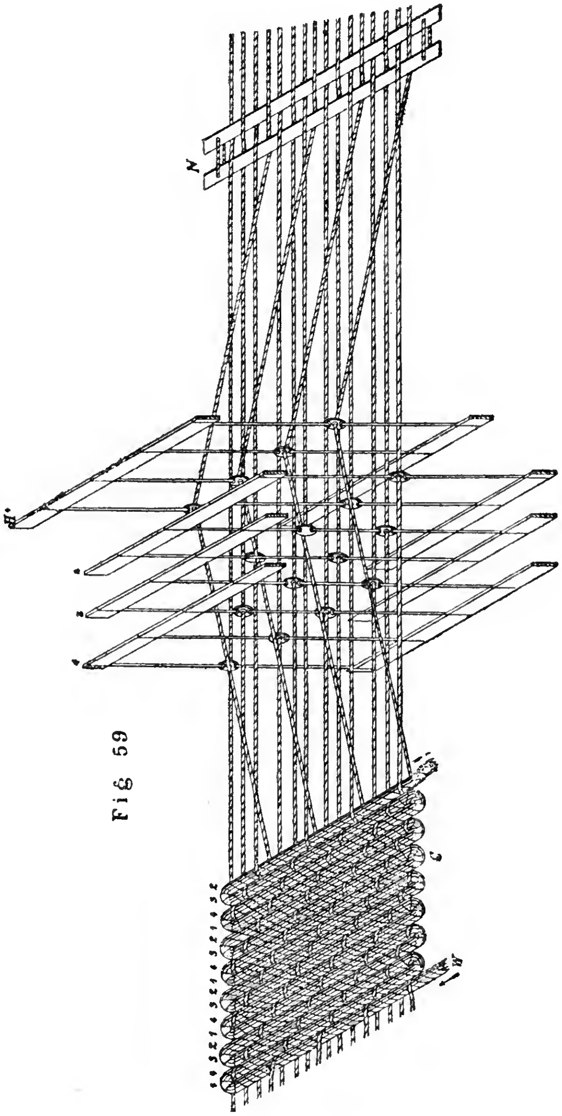


Fig 59

cloth may range from forty to four or six hundred, or many times more than it would be possible to show in a drawing. Therefore, instead of attempting to show several thousands of warp threads, sixteen will be amply sufficient to illustrate the present part of the subject.

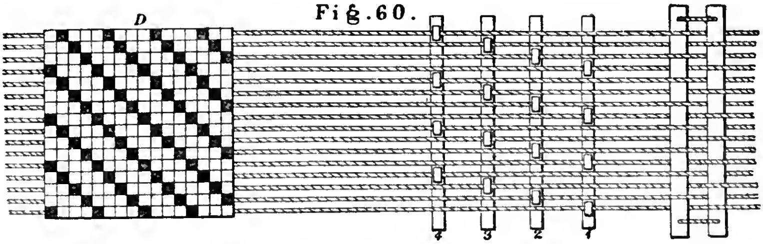
Fig. 41 represents a common hand loom fitted with four leaves of headles in a simple way. There are only sixteen warp threads shown, consequently each of the headles is provided with four eyes or leashes only.

The headles are suspended from four levers called tumblers or coupers, which work in the "top castle," or the top framing of the loom. To the lower laths or shafts of the headles weights are attached, as shown.

To the four treadles four long levers or marches are attached, and from the ends of these marches cords connect them with the tumblers, as shown. Now as each of the headles is attached or connected indirectly with one of the treadles, it follows that, by pressing upon any of the treadles, the corresponding headle will be raised, and, consequently, the four threads of the warp will be raised also, and a shed will be formed for the passage of the shuttle.

This will be more clearly seen in Fig. 59, which represents the headles and warp threads on a larger scale, and one of the headles, *H'*, is shown raised in the manner mentioned. In the same figure the course of the weft thread *W* may be traced, and the various warp threads under which it passes may be followed, and it may be seen which of the headles has been employed at each intersection of the weft thread. Thus the numbers 1, 2, 3, 4 on the weft threads correspond to the number of the headle which has been used when the weft was inserted.

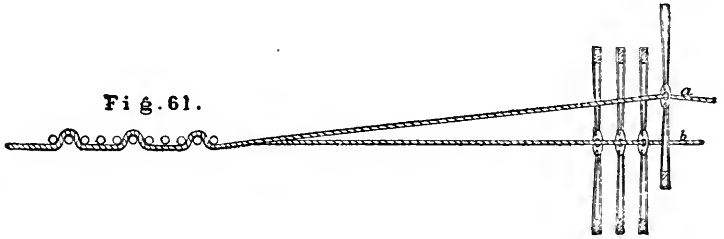
The lease or cross is shown at *N*, but the reed has been omitted in the diagram, in order to avoid unnecessary complexity. Fig. 60 is a plan of Fig. 59, in which the threads may be more distinctly seen. It will be noticed that *D*, Fig. 60, represents, as it would



appear on design paper, the cloth as shown at *C*, Fig. 59. A section of Fig. 59 is shown at Fig. 61.

Now, it will be seen that it is by raising the headles singly and in consecutive order that a twill, such as shown in Figs. 49 and 59, may be woven; but, on referring to Fig. 51, the order in which the headles have been raised has not been 1, 2, 3, 4, 1, 2, 3, 4, &c., but 1, 2, 3, 4, 3, 2, 1, 2, 3, 4. In this manner a zigzag may be formed. In Fig. 55 the cloth has been formed by raising two of the headles at once, or by attaching two of the headles to one of the treadles. The satinet shown in Fig. 53 may be woven by raising three of the headles at once in the order represented on the cloth. But the same thing can be done by weaving it with the face of the cloth downwards, and this is the usual custom, for by doing so only one of the headles is raised at a time instead of three. Thus not only two-thirds of the amount of friction on the warp threads is avoided, but the labour in raising them is saved also. Fig. 54 represents the design; and Fig. 53, the face of the cloth.

Fig. 61.



In Fig. 57 another variety is shown. Now, by observing the zigzag, Fig. 51, it will be seen that Fig. 57 is merely a zigzag doubled and reversed. It has been shown that a zigzag is formed by deviating from the regular or consecutive order of working the headles; if, in a similar way, the consecutive order of arranging the threads in the headles be made, the cloth, as shown in Fig. 57, may be woven.

There is still another system, perhaps the most important in weaving, to be noticed, viz., the method of weaving double cloth. As before stated, it is by this means that the manufacturer may not only make thicker and heavier cloths, but he is enabled to use the materials to the best advantage. Although the illustrations have been confined to the use of four headles only, the principle upon which it depends can be fairly represented.

Fig. 62 represents a piece of cloth composed of black and white warp threads placed alternately. At *a a* the weft-thread is shown to pass under the white and then the black threads alternately. At *b b* all the white threads have disappeared, and the black alone are represented; and if these were sufficiently numerous so as to cover the weft thread well, the surface of the cloth would appear black. At *c c* all the black threads have disappeared, and the white threads are thrown upon the surface instead. Thus a black or white surface can be woven at pleasure. Fig. 63 shows a section of the cloth; and it will be seen that when the white threads disappeared at *b b*, Fig. 62, they lay unconnected with the cloth or floated on the surface, and in the same manner the black threads float at *c c*, when the white threads are being used. In making the design for double cloth various signs or marks are used, showing the intersections that lie beneath the surface, so as to prevent confusion. In some kinds of figured weaving these floating threads are cut off, as may

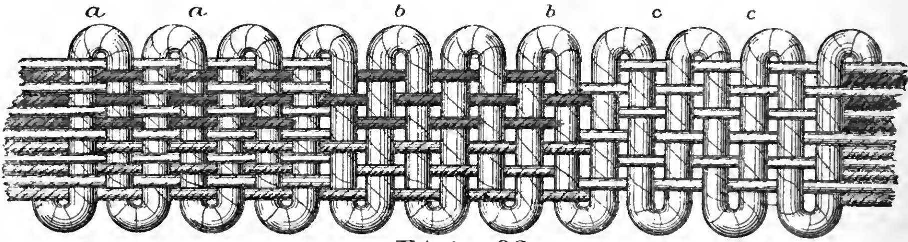
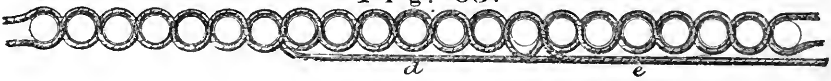


Fig. 62.

Fig. 63.



be noticed in figured shawls; but in such cases the loss cannot be avoided, although attempts have been made to do so.

Now, on comparing Fig. 64 with Fig. 62, the surfaces of both are alike; but, on comparing their sections, Figs. 63 and 65, a great difference appears. When either of the white or black threads disappear on one side of the cloth, they are not found floating underneath, but are being woven into another cloth; in fact, two separate pieces of cloth, connected at the edges or selvages, are being woven, forming a tube. If a few of the threads were at intervals interwoven from one surface to the other, the two cloths would then be bound together and form one compact piece, and the spaces *a a*, Fig. 65, would not exist. Or different sets of weft and warp threads may be inserted so as to fill the spaces *a a*, to which the upper and lower surfaces of the cloth could be attached without the threads passing entirely through the cloth to the other side. Three varieties of weft may in this manner be used. The central thread, which is hidden, whether weft or warp, is called the wadding, or stuffing, and cannot be observed on either surface of the cloth. Examples of this class of weaving are well shown in Figs. 332 and 333, &c.

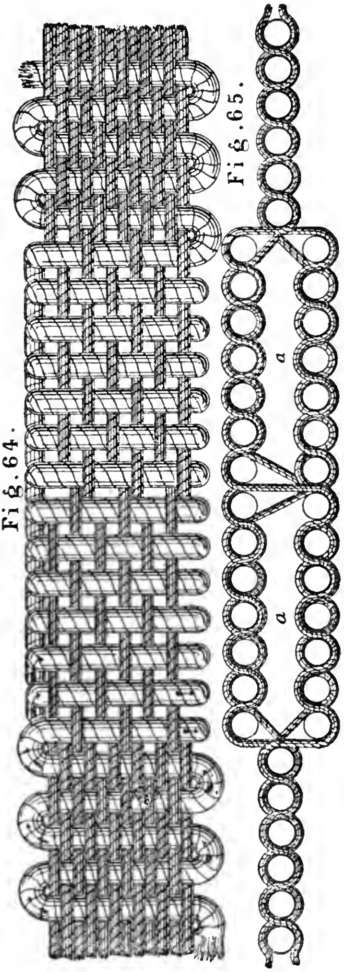


Fig. 64.

Fig. 65.

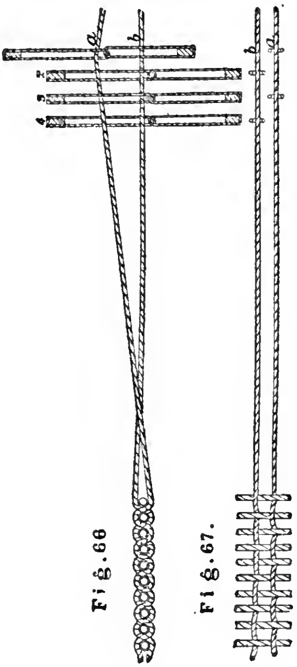


Fig. 66.

Fig. 67.

On referring to Figs. 49, 51, 53, and 57, it will be seen that there are two threads at each edge of the cloth which are intersected alternately, as in plain weaving, by the weft thread. Only two threads are shown, although in practice various numbers are used. If these selvage threads were not inserted, the edges of the cloth would be very irregular, and the weft would follow the course of the warp threads shown, instead of being woven firmly as in plain weaving. This may be understood by referring to Fig. 59.

When four headles are used and only one at a time is raised, it is evident that the selvage threads cannot be raised alternately unless by some special contrivance. The most simple way by which this can be effected is shown in Figs. 66 and 67. It will be seen that each thread is passed through the eyes of two leashes, viz., through the first and third or the second and fourth. The leashes shown are only clasped, and the eye is dispensed with, consequently the warp thread can move freely from the clasp to the top shaft of the headle. By this means, if the threads are arranged as shown in Figs. 66 and 67, they can be raised alternately as in plain weaving, for the thread *a* is not only raised by the headle No. 1, but by No. 3 also. The thread *b* is likewise raised by the headles No. 2 and No. 4.

It is upon this principle that the ingenious contrivances connected with compound harnesses or looms depend, and it has been shown here merely to complete the introductory description of twill and satin weaving.

Although the warp threads have been arranged in the preceding diagrams to show the method of weaving twills, &c., still plain weaving can easily be effected by them in case short portions are required, as at the commencement or end of the cloth. Thus the first and third headles would raise one-half, or the odd numbers of the warp threads, and the second and fourth headles would raise the even numbers, and plain or tabby weaving would be the result.

In very rich plain weaving additional treadles are used called "breaker" treadles, which perform a very important part in the operation of weaving. Owing to the great number of threads in the warp, sometimes upwards of 600 per inch, to raise half the warp threads at once would be almost impossible without some of the threads sticking together, and making an imperfect shed. Now a breaker treadle is for the purpose of raising one of the headles first, or one quarter of the warp, and this is done by one foot, whilst the other foot follows immediately with the treadles connected with both the headles to be raised. Thus the breaker treadle would raise No. 1 headle only, but the proper treadle would raise 1 and 3 together. Although two treadles are used they are worked so rapidly as scarcely to be observed, but they have the effect of *breaking* the stickiness of the warp, owing to its ever-crowded state, and hence the name and use of breaker treadles. Some weavers put greater strain on the warp to effect the same purpose, but it is a questionable plan, as will be hereafter shown.

CHAPTER VII.

SHEDDING MOTIONS FOR HAND LOOMS.

As the principles upon which twills, satins, &c., are formed have been shown, it now remains to describe the methods adopted by the weaver in arranging his loom for weaving them. Attention was confined to the uses that four leaves of headles only could be applied to, in order to avoid the complication which a greater number would necessarily cause in the figures. In the present case it will be better to adopt the same course, for it is only by limiting the number of sets of the working parts that complication and apparent confusion can be avoided in the diagrams.

In Fig. 41 is shown a common hand loom mounted with four headles, the manner in which these headles were connected to the loom being represented. Fig. 68, subjoined, represents the four headles as seen from the front of the loom, but all the other parts of the latter are omitted. As before described, the headles *H H* are each connected to a separate couper or tumbler *C C*, and thence by the long cords to the ends of the marches *M M*, and finally to the treadles *T T*. Each headle is held down by two spiral springs or two weights—or sometimes one weight only in the form of a lath or plate—but in this case by the weights *W W*. In this instance the loom is arranged to weave a single thread twill, as shown at Fig. 49, and at Fig. 69, annexed. For this purpose it is only necessary to connect one of the marches by a cord to one of the treadles, as shown; consequently only one of the headles can be raised at each movement of a treadle, and the operation of weaving the twill, shown, is simply to raise the headles in consecutive order as represented in Fig. 69. But it will be observed, on tracing the connexion of the treadles to the marches, and thence to the headles, that they are not placed in consecutive order, as shown in Fig. 69, but they are corded in a different order. The reason for this is, that, in working the treadles with his feet, the weaver could not conveniently press upon them in consecutive order without crossing one leg over the other. The weaver, therefore, adopts some other

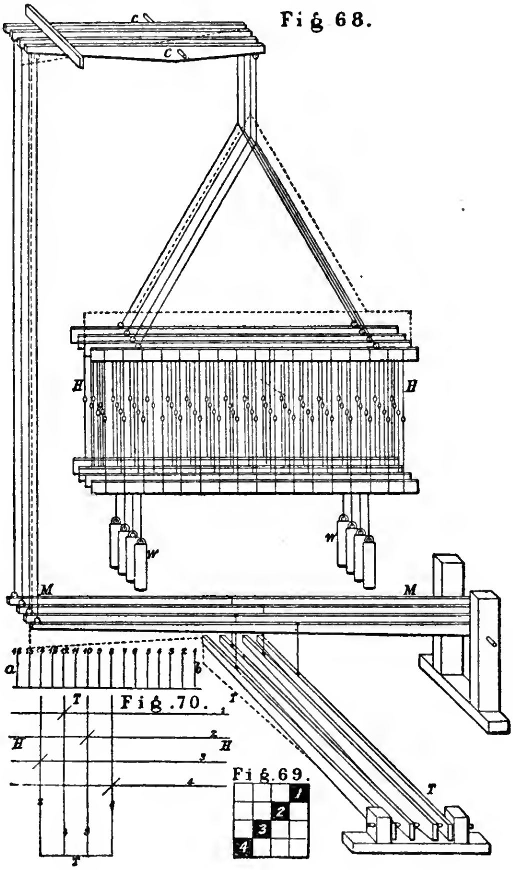


Fig. 68.

Fig. 70.

Fig. 69.

arrangement, to devise which he constructs a plan which will not only represent the draughting or entering of the warp threads through the headles, but show also the cording or the attachment of the treadles to the headles.

This he does in a very simple and effectual way, and in the present instance Fig. 70 shows the draught and tie-up, as it is called, for weaving the twill, Fig. 69. It is simply a rough plan of the headles and the treadles, in which the single lines *H H*[1] represent the four headles, and the lines *T T* represent the treadles. Near *H*[1] four numbers, 1, 2, 3, 4, are placed in a diagonal position. These numbers represent the first four warp threads (exclusive of the selvage), and show the order in which they are entered. At *a b* are added a few lines, representing an extension of the plan, and a portion of the warp threads, in order to show that the diagonal position of the numbers, placed by the weaver, corresponds to them; but it is not necessary for the weaver to place the lines *a b*, as the four figures are quite sufficient in this case, and they represent the order in which the warp threads are entered. On the lines *T* will be seen the figures 2, 4, 3, 1. These numbers represent the order in which the weaver can use his feet upon the treadles in the most convenient and rapid manner. Thus he treads the right foot first on the right outside treadle. This is, therefore, marked No. 1. The next treadle he can best use is the outside left one, and upon this he places his left foot. Consequently this is No. 2 treadle in the order of treading, and so on with Nos. 3 and 4, as shown on the plan, the odd numbers representing the right foot, and the even numbers the left.

Now, in Fig. 69 the first thread, or series of threads, are those in No. 4 headle; consequently the weaver puts a mark upon his plan at the intersection of No. 1 treadle with No. 4 headle. The next is No. 3 thread to be raised; therefore he marks the intersection No. 3 with No. 2 treadle, and these marks represent the tie-up or connexions to be made. In like manner No. 2 thread or headle is attached to No. 3 treadle, and No. 1 to No. 4 treadle. At first sight the order of the intersections gives little appearance of any consecutive arrangement; but it will be admitted that the arrangement and the plan are all that can be desired for the purpose. Any number of headles can be shown in this way, and one, two, or more of them may be shown attached to the treadles, according to the patterns to be woven.

It may be here mentioned that there are some cases which exact from the weaver no little amount of ingenuity for arranging the tying-up. If there are five headles to be used, instead of four, it is evident that with one foot he must work two treadles, and with the other foot he must work three, in passing over the treadles for each course. In doing this he slides upon the next treadle, say, from 4 to 5, whilst the other foot is moving to No. 1. This process is called "hopping." It can be avoided by using ten treadles, making the odd number even, for by so doing the five headles are worked twice over by working over the treadles once. This, however, increases the number of treadles. But there are cases where the weaver can diminish the number of treadles, *i. e.*, where the same headle or headles are repeated in the compass of one design.

Fig. 71 represents another form of connecting the headles with the

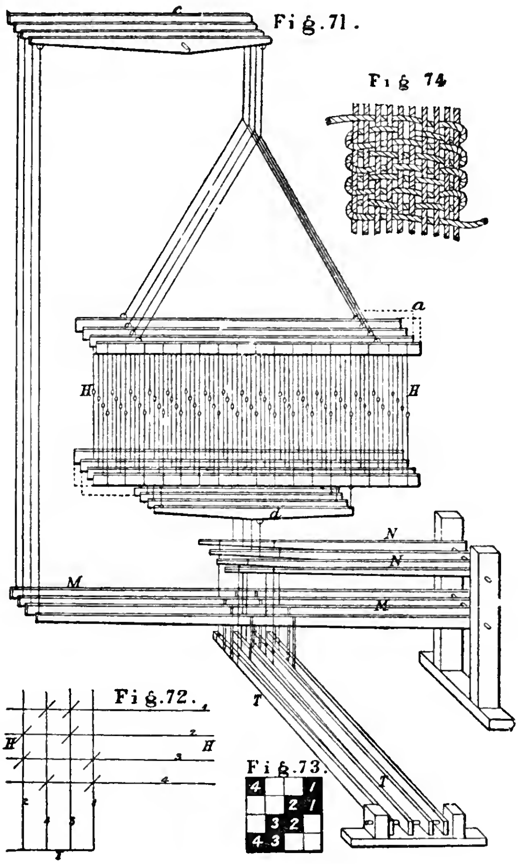


Fig. 71. Fig. 74 Fig. 72. Fig. 73.

treadles by means of a series of levers. In this instance the weights to hold down the headles are dispensed with, for one portion of the harness is made to balance the other portion, the action being similar to tabby weaving. It will be seen that, in this case, the long marches *M M* are connected to the headles in the same way as those in Fig. 68, and they raise the leaves exactly in the same way. Now the only difference is, that the remainder of the headles which are not attached to the long marches are all attached to the short marches or counter-marches, *N N*. The effect is that by pressing upon any of the treadles part of the headles rise, and the remainder sink. The connecting cords between the treadles *T T* and the long marches are shown with thick lines, and the cords to the short marches with thin lines, and it will be observed that each of the treadles is connected with all of the headles, but in different arrangement. The dotted lines *a* and *b* show the extent of the rising and falling of the two front and two back headles which would be caused by pressing upon the outer right hand treadle. Under each of the headles is attached a strong lath *d*, which is used when the headles are of extra length and require strengthening.

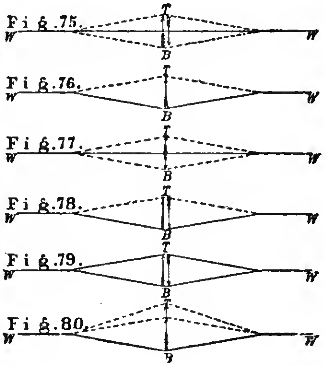
The draught and tie-up of Fig. 71 is represented in Fig. 72, and the design is a two-thread twill, as shown in Fig. 73, and as it would appear when woven in Fig. 74. Fig. 72 shows the connexions of the treadles with the long marches by the diagonal marks as before described, but there is no necessity for showing the other cords, for, as before stated, all the remaining cords are attached to the short marches.

The system, last described, applies best when the number of the leaves or shafts to be raised are equal in number to those which sink. Under these conditions the headles are equally balanced and worked with freedom. But where only one headle at a time, or a comparatively small number is raised, the system shown in Fig. 68 is preferable. In that system not only is one headle as it rises indirectly counterbalanced by that which is falling, but the greater portion of the headles remain stationary if they are not required—hence there is no friction upon them, or upon the warp threads which they govern.

The action of all contrivances for the purposes of forming the shed can be easily understood if the principles upon which they are based are first known. Shedding motions may be classed into about six varieties, which may be represented by Figs. 75 to 80. In all the figures *W W* represents the normal position of the warp threads, and the dotted lines represent the threads in motion.

In Fig. 75, *W W* represents the warp as in plain weaving with two headles only. The dotted lines show the form of the shed when open, and the arrows show that some threads rise direct to the point *T* from the bottom *B*, at the same time that the other threads fall from *T* to *B*. In this instance the threads move from top to bottom and from bottom to top without any stoppage, consequently it is called a through shed. It also counterbalances itself, and the motion is performed in the shortest possible time and with the least friction.

Fig. 76 represents the motion that would take place in working the headles as in Fig. 68, if worked with one foot only or one headle at a time. Here the line *W W*, showing the position of the warp, is slightly dipped by keeping the headles at a lower level, to counteract, to a certain extent, the opposite motion and tension that would be thrown upon the rising threads that would accrue if they were placed horizontally, as at Fig. 75. This motion is similar

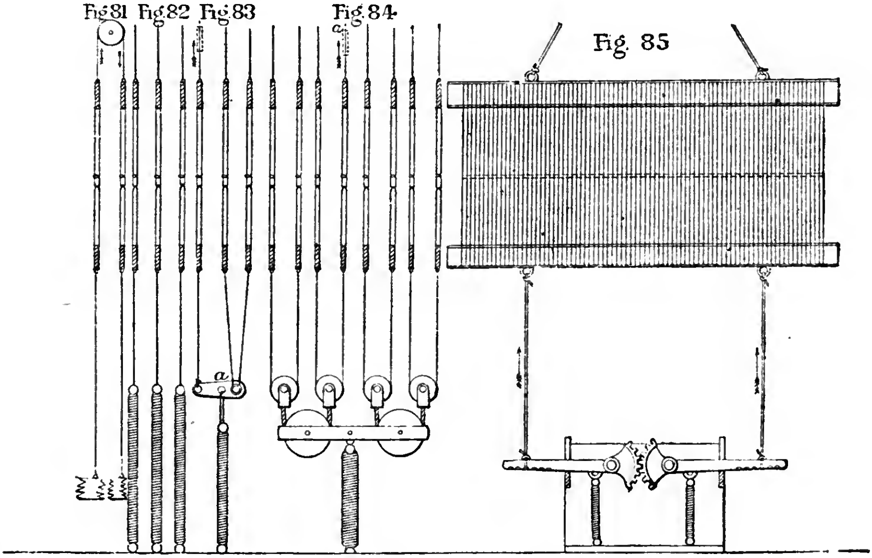


to that performed by the common Jacquard machine, and may be called a rising shed.

But if two of the headles were used simultaneously—one rising while the other was falling—as would be the case if two of the four treadles in Fig. 68 were worked with both feet, then the motion would be the same as represented in Fig. 78, where the arrows denote a rising and falling shed with the bottom stationary or standing. Fig. 77 represents the motion of the warp that would be caused by the arrangement shown at Fig. 71. In this case it is simply a rising shed with sinking bottom. Fig. 79 shows the warp stationary at both top and bottom of the shed, and those threads which are required to rise or fall, do so simultaneously. Therefore the top and bottom are stationary with rising and falling shed. Fig. 80 shows a double shed. This is used when two tiers of shuttles are used at one time. The most perfect of these motions is the through shed, Fig. 75; whilst the most imperfect are the rising sheds, Figs. 76 and 80. Their imperfection consists in taking double the time to be formed, and they do not counterbalance themselves as in the case of Figs. 78 and 79.

As a great variety of apparatus for forming the sheds require to have the headles held down by weights or springs, various contrivances are resorted to to avoid the direct action of either, for they operate more or less detrimentally on the action of the loom. Thus in Fig. 81 are shown the counterbalanced headles as in plain weaving; Fig. 82 shows three headles held down by three separate

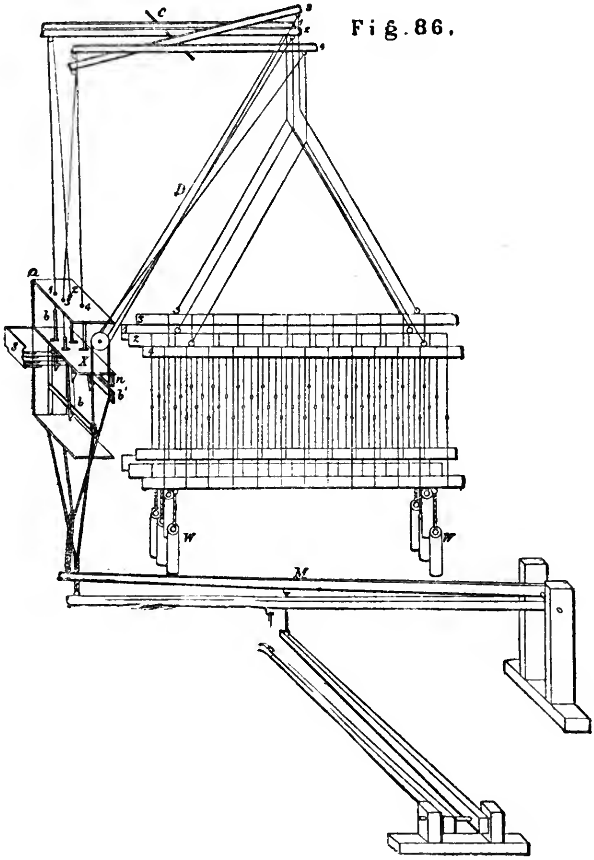
Fig. 81 Fig. 82 Fig. 83 Fig. 84 Fig. 85



springs, or weights may be used instead. Fig. 83 shows how three headles may be so held, that if one only of the healds is raised at a time the effect of the weights or springs can be reduced. Whichever of three healds is raised, the other two descend to the proper level, and the lever *a* with a pulley adjusts itself to the motions of any of the healds with ease and freedom. Fig. 84 is an extension of the same principle. It will be seen that any one of the healds, as *a*, can be raised, and although counteracted by all the rest, it only has its own share of the strain to overcome. This method can be extended to almost any number of headles. Fig. 85 shows an arrangement which requires two levers to each heald. This method has the advantage of keeping the heald parallel—and in case one spring should break, or only one be sufficient in strength, it can be worked all the same. This motion is applied to power looms.

The number of treadles that can be conveniently used in a loom is very limited, and rarely exceeds eight. The weaver, therefore, dispenses with them whenever it is possible to do so. This is generally effected by means of small machines which are worked by either one

Fig. 86.



or two treadles. At the present time small Jacquard machines are generally used for that purpose. But before entering upon the subject of these appliances there is one machine which must be described, for it forms a connecting link between the systems we have already described, and the use of those machines which are complete in themselves.

The machine alluded to is a shedding motion with the action similar to Fig. 78, viz., a rising and falling shed with a stationary bottom, and is represented in Fig. 86 attached to the healds, but detached from the loom. It consists of a box, *a*, which contains a number of wooden hooks which move in slots. In order to show them, one end of the box has been omitted in the drawing. Each hook is connected with a separate tumbler *c*, in such a manner that when the hook is drawn downwards it raises the headle to which it is fixed. After the hook traverses the slot board *x*, it passes through a ring or eye to which, on one side, is tied an elastic cord or spring *s*, while on the other it is attached to a cord that leads up to the opposite ends of the tumblers *C*. Two flat bars *b b′* are made to slide up and down in slots in the ends of the machine. These bars are each connected to a separate march *M*, and thence to the treadles *T*, and they are counterbalanced by having the connecting cords placed in the groove of the pulleys, one of which is shown at *e*. As the treadles rise and fall so do the bars to which they are connected. Each of the hooks is connected to the headles, according to the numbers shown.

Now, by drawing any one of the hooks forward, it is brought into contact with the corresponding bar, by which it is drawn downwards, and it at the same time raises one of the headles. It also pulls forward one of the cords *D*, and, therefore, the hook to which that cord is attached; consequently it throws the next hook into contact with the next bar, and the headle to which it is attached is then raised. Thus each headle is raised in the order in which the tie is made. Eight hooks are generally used, but we have shown only half that number. The board *n* has holes in it through which are passed the cords *D*, which draw the hooks forward, while the springs *s* replace the hooks in their former position.

This contrivance is known as the "Jack-in-the-box," and was invented by Theodore Jennings, of Bethnal-green, about the year 1840. Although the principle upon which it is based—viz., the application of one heald to select the next one to rise—was not new, still the modification shown is not only very ingenious, but well adapted for satin weaving, and it is much used in silk weaving at the present time.

CHAPTER VIII.

FIGURED WEAVING WITHOUT THE AID OF AUTOMATIC MACHINES.

Previous to the introduction of the Jacquard and other automatic machines, the weaver had to resort to a variety of contrivances—often of a very complicated nature—in order to enable him to produce figured or ornamental fabrics.

The ingenuity shown in these contrivances was often very great, and the success with which numbers of threads could be worked in various designs by means of only a few working parts is worthy of attention, for there is perhaps no other art, in which the requirements for such complication exist, and none in which greater skill has been shown in overcoming such obstacles. The general principles of weaving having been sufficiently explained, there will now be little difficulty in tracing the various modifications from step to step—when it will be found that the effect produced by the introduction of the Jacquard apparatus, and the great change it has given rise to, has been in no way overrated in its value.

When a loom is arranged to be worked by an automatic machine, all that is required in order to weave a new design is to make the alterations in the machine itself—equivalent to altering the position of the pegs upon the barrel of a musical instrument—either by changing the barrel, or using various sets of perforated cards. But in the case of a loom not provided with such a machine, the matter is quite different, the loom itself requires to be altered, or rather the tying up of the various cords and levers, and the warp threads in the healds have to be arranged accordingly.

There are several ways in which this can be done, each having its own advantages, according to the extent of the pattern to be woven, sometimes a few healds being sufficient, and at other times several hundreds being required. Even when these numbers are used, many contrivances are employed which increase their power to an extent scarcely to be thought possible. Numberless plans have been adopted according to the peculiarity of the cloth, or the pattern to be woven, but they may be classed under certain distinct systems which, when fairly understood, will render the subject clear.

They may be classified as follows:—

1. The use of healds in any practicable number, in regular or irregular order, as in weaving satins, twills, spots, or small figures.

2. In forming the healds into groups of two or more divisions, in such a manner that any of the divisions may be brought into action, each division having a distinct and separate control over the whole of the warp, at the same time each warp thread to pass through one eye or leash only of the healds.

3. In passing the warp through two separate harnesses, so that

Fig. 87.

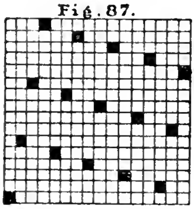
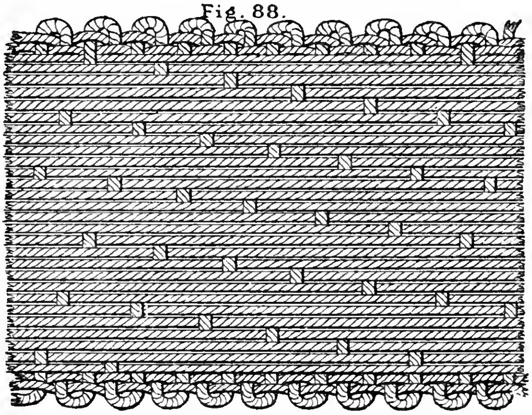


Fig. 88.



each thread of the warp passes through two eyes; both harnesses having a compound control over the warp, as in damask weaving.

There are other kinds of weaving, such as gauze, velvet, &c., but they are produced by entirely different processes to the above, and will be described separately.

As far as the use of four healds only were concerned, the principle has been shown upon which satins, twills, and zigzags, and double cloths are woven, these forming the first class into which we have divided the subject. But as four healds are very limited in number—in fact, the smallest number that could be used for the purpose—it will be desirable to show the use of a greater number of healds, and how they may be employed in the weaving of ordinary satins, &c.

In silk weaving as many as sixteen leaves and upwards are used in making very rich satins. Fig. 87 represents the order in which the intersections are made, and Fig. 88 shows the appearance of the face of a sixteen-leaved satin when magnified. The intersections only occurring once in sixteen times, the weft threads, although they may be of a different colour, are scarcely discernible in the face of the cloth. The warp threads, when very numerous and crowded together, naturally tend to cover over the few intersections, and the threads thereby give that smooth and unintersected appearance by which rich satins are distinguished.

Fig. 89 shows the arrangement of the intersections of the common

Fig. 89.

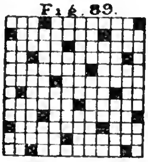
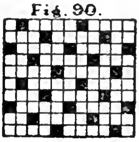


Fig. 90.



satin, which is woven with eight leaves, and Fig. 90 a satinet, which is woven with five leaves. Satins are usually woven with the face of the cloth downwards, for if this were not so, in the case of weaving a sixteen-leaved satin fifteen leaves out of the sixteen would have to be raised at every pick, and only one would remain at rest. On the other hand, with the face downwards, only one out of the sixteen is raised, whilst fifteen remain at rest, and thus the friction

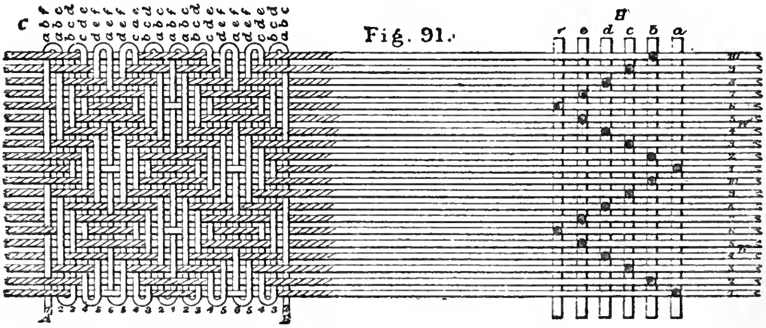


Fig. 91.

on the warp and the labour of the process is not only proportionately saved, but the appearance and quality of the cloth is improved.

The principle upon which the regular twills and zigzags are produced having been explained by the aid of Fig. 49, &c., in a former chapter, we shall now show how it is extended for the production of small figures. Fig. 91 is a plan of a warp with six headles, and shows a portion of cloth woven. No reed is shown, nor anything that would tend to complicate the figure, and it will be understood that only a few threads are represented, for the pattern in actual cloth would be simply repeated. *W* and *W′* show the warp threads which are passed through the eyes of the headles *H*, in the order shown by the circles, which represent a sectional plan of the headles at the line *B B*, Fig. 92.

Each of the headles, Fig. 91, being marked with letters, the effect they produce on the cloth can be readily traced at *C*, and, conse-

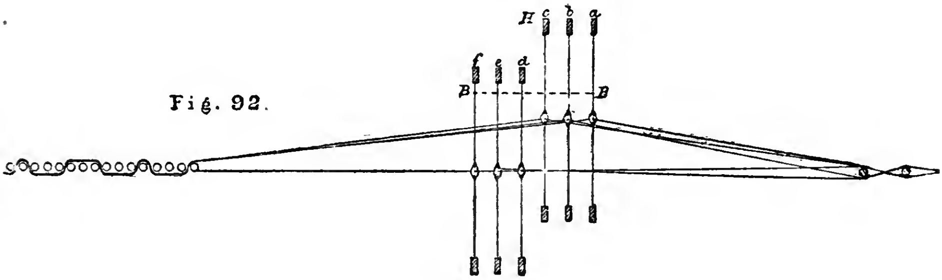


Fig. 92.

quently, the principle upon which the system depends. Thus the first pick of the weft A^1 has been inserted when the headles *a b f* have been raised; the second pick when *a b c* have been raised; and so on to the last pick—the letters at *C* being clearly traceable to the letters at *H*. Fig. 92 is a section of Fig. 91, showing the shed open.

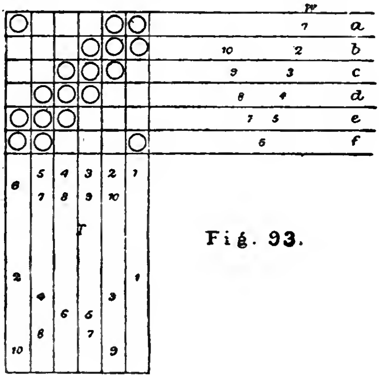


Fig. 93.

Figs. 91 and Fig. 93 represent the plan of the pattern woven as it would be shown by the weaver in order to arrange the loom.

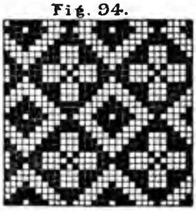
At first sight, there appears no clue to connect or associate the plan Fig. 93 with the pattern woven Fig. 91, but a little attention to the matter will be repaid by learning the ingenious and simple manner in which the subject is planned by the weaver. In a former instance lines with marks at their intersections were shown, but weavers also use spaces as well as lines for the purpose. Hence the circles in the spaces Fig. 93, correspond to the marks at the intersections before mentioned. Sometimes two or three descriptions of marks are used, and in this case the use of spaces instead of lines is desirable as affording more room and distinctness.

On comparing the warp threads *W* and *W′*, Fig. 91, with the figures 1, 2, 3, 4, &c., at *W*, Fig. 93, a resemblance is at once detected in the arrangement of the figures with the circles, representing the eyes of the headles *H*, Fig. 91. In short, the spaces marked by the letters *a b c d e f*, Fig. 93, represent the headles marked with the same letters in Fig. 91, and the order of entering the warp threads *W*, Fig. 91, is the same as shown at *W*, Fig. 93. In the same figure the treadles, six in number, are shown at *T*. The numbers above *T* represent the consecutive order in which the treadles are worked, which is simply backwards and forwards, and by this means the diamond form of the pattern is woven.

The small figures under the letter T show the order in which the treadles could be worked more conveniently—beginning with the right foot at 1, the left at 2, and so on. Therefore, after it is shown in what order the treadles have to be raised, as shown by the figures above *T*, the connexions between the headles and the treadles are "tied up," according to the convenience of the weaver for working them, as shown by the figures below *T*. The circles in plan, Fig. 93, show which of the healds are raised and correspond with the letters at *c*, Fig. 91. For instance, the first pick A^1 has been effected by raising the healds marked *a b f*, as marked at *C*. In like manner circles are to be found on the healds *a b f*, Fig. 93, where they intersect No. 1 treadle, which corresponds to No. 1 pick at A^1, Fig. 91. Consequently the treadle No. 1 is attached to and has raised the healds *a b f*.

A great variety of figures can thus be made with comparatively few headles, and combinations of figures can also be made; one example of which, Fig. 94, may be sufficient to give an idea of the system. In this instance a cross and a diamond are combined in alternate order, or the figures are "bosomed" together.

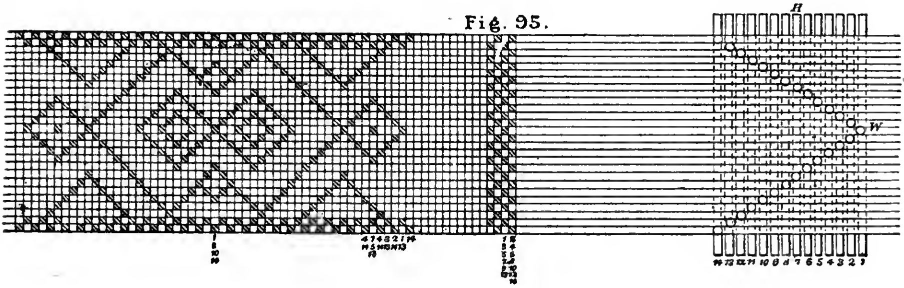
Fig. 94.



By another modification of the same principle a great variety of figures may be woven at pleasure. This is shown at Fig. 95, and can be conveniently used for forming spots, or small figures; hence it is known as spotting harness. As the figures and letters in Fig. 95 correspond with the descriptions given of Fig. 91, they scarcely need any further explanation.

When a considerable number of headles were used, such as in weaving with twenty leaves and upwards, it became necessary to adopt some means to dispense with the treadles, and we have already described one of the machines used for that purpose, viz., the "Jack-in-the-box." There is another machine of far greater range, the draw-boy, which was formerly used to a great extent. It will be described in connexion with the draw-loom, although it was equally

Fig. 95.



applicable to the weaving of smaller figures. It is now, perhaps entirely superseded, but as it supplied the principal means the weaver formerly had to assist him previous to the adoption of the Jacquard machine, it could not be omitted in a description of the old method of weaving. The machine was worked by two treadles, although in a more simple form one treadle was used, and instead of the healds being raised by the cords attached to the coupers and long marches, they were attached from the coupers, or top levers, direct to the draw-boy machine. But as the machine was of far more importance when used with the draw loom, its mode of action will be shown in connexion therewith.

CHAPTER IX.

DIAPER WEAVING.

The second class of weaving, according to the order into which we have divided the subject, consists in using two or more "divisions," or sets of harness. These are so arranged that any of the sets or "divisions" when used govern and alter the action of the remaining sets. This system is known as diaper weaving, and by its means very extensive designs may be woven for the purpose of table-cloths, shawls, &c. The silk weavers of Asia are supposed to have invented this system of weaving, and it was known in England in the eleventh century. It was called *diasper* by the Latins. Figs. 96 and 97 represent a plan and section of a diaper-harness in two divisions only, with the warp and a simple diasper pattern woven. The same pattern or design is also shown in Fig. 98.

On comparing the design in Fig. 96 with Fig. 98, it will be seen that each of the small squares of the latter figure represents sixteen intersections of the warp and weft, or rather the space for that number, for they are not shown in these figures. The white spaces may be filled up by weaving a twill, as shown in Fig. 99, which corresponds to one of the small white squares in Fig. 98; and Fig. 100 is the same twill, but on the reverse side, and corresponds with the small black squares of Fig. 98. Upon comparing the designs Figs. 96 and 98 together, the arrangement and object of the intersections will be at once understood; and in Fig. 98 it is not necessary to show the secondary intersections in detail, as in Figs. 96, 99, and 100.

In the plan, Fig. 96, the headles are shown divided into two divisions, *H* and *H'*. The headles are also marked with letters as in the former plans, and these letters correspond to the letters at *C* in the same figure. The entering of the warp threads through the headles is also shown, and the threads are numbered at *W*, corresponding to the entering.

Fig. 101 represents, as the weaver would show it and as before explained, the connexions of the healds with the treadles at the intersections marked with circles. In this plan the healds *H* and *H′* represent the two divisions, and the treadles *T* are likewise divided in two divisions, as shown in *A* and *B*.

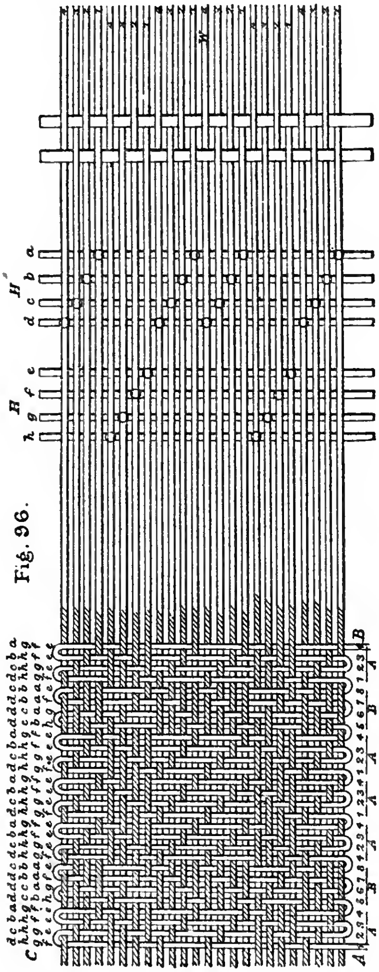


Fig. 96.

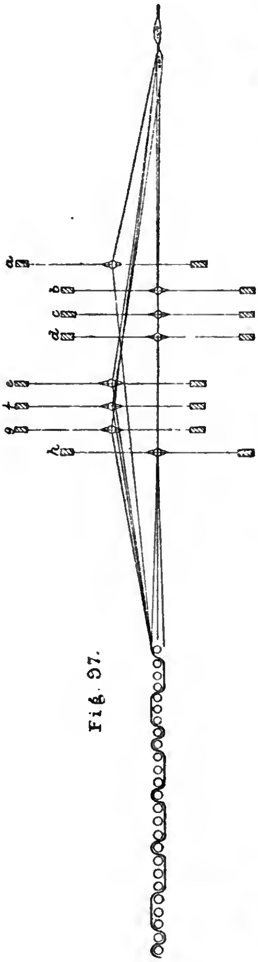


Fig. 97.

Fig. 98

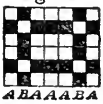


Fig. 99.

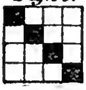


Fig. 100

In order to weave the pattern, as shown in Figs. 96 and 98, the treadles must be worked in the consecutive order from 1 to 28, as shown at *T*, Fig. 101. It will be noticed that the treadles in division *A* are first used, then those in division *B*, and so on to the completion of the pattern. But it must be observed that although the headles must be raised in the consecutive order shown, still the weaver would deviate from that order to suit the alternate action of his feet, as before explained. Figs. 96 and 98 show the parts of the pattern effected by each of the divisions or sets of treadles *A* and *B*, and the numbers of each of the treadles are given as they are shown at Fig. 101.

In other words, the eight healds forming the harness are divided in two divisions, and are connected to two divisions of treadles. If

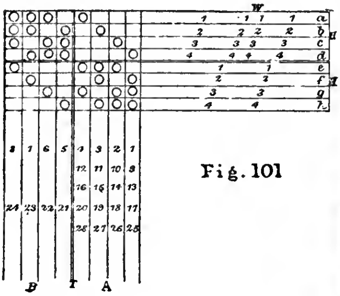


Fig. 101

Fig. 102.

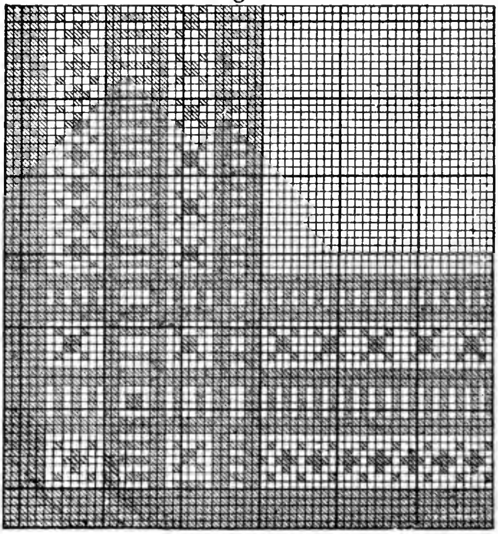


Fig. 103.

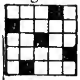
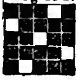


Fig. 104.



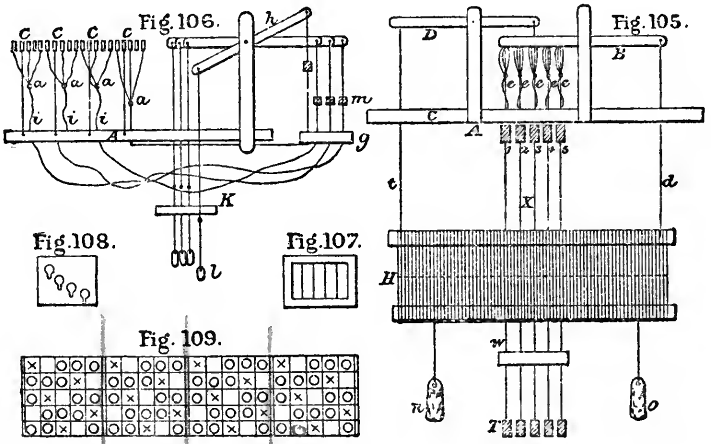
the division *A* of the treadles only be used, it will weave the cloth in two stripes formed by two different twills or satins, as may be desired, and all the headles would be employed. On the other hand, if the treadles *B* are used, they—being connected to the same headles, but in a different order—can be used to weave a reverse satin twill, &c., as may be desired, by using the same healds as the treadles *A*. The chequer or diaper pattern, therefore, is produced by changing or working at intervals each set of treadles in any order desired, or extent of interval between each change. If in regular and equivalent intervals a plain check would be woven, or plaid, or stripes may be woven instead.

When this method is understood it will be seen that it affords very extensive means for the production of large patterns. The example above given comprises the use of two divisions only; but the healds may be made in six or seven divisions, and their efficiency is thereby increased in far greater proportion than to the number of divisions used. Thus the efficiency of a harness with seven divisions would be greater in effect than two divisions only, or would increase in geometrical proportion.

It will, therefore, not be difficult to imagine that this system may be extended to the production of patterns such as shown at Fig. 102. In this figure also each square does not represent a separate thread, as was explained in the case of Fig. 98, but rather any requisite number, according to the size and kind of pattern to be woven.

Figs. 103 and 104 represent a common plan for breaking up into smaller divisions the squares as shown in Fig. 102. The dark squares in that figure would not, necessarily, represent a different colour, but a different kind of twill. Different colours are, however, often used in the warp and weft, and these can be varied at pleasure, independently of the form of the figure woven; but different colours have not to be considered at present, as they in no way affect the subject.

It will be evident that the use of several divisions with four or five treadles in each would be almost impracticable for the weaver to work, consequently a plan has been devised whereby the use of one set of treadles only is required, the different divisions being thrown in and out of action by a separate contrivance; and it is here that we again find resort to complicated but ingenious arrangements to overcome difficulties. In the matter to which we are now referring, the desired end is obtained by using one set of foot-treadles only, and substituting for the other treadles auxiliary levers which can, each set, be thrown in or out of action by a separate contrivance. By so doing, the weaver may have command over six or more divisions or series of levers, and still only use one set of treadles. In other words, he substitutes for the various divisions of treadles (excepting one set) a number of levers, or sets of levers, corresponding to the divisions of the treadles, and by throwing in or out of action, by means of connecting cords, any of these divisions or sets, he avoids the use of more treadles than are required for one set only. This plan is ingeniously carried out as follows:—Fig. 105 is a front view of the mounting of a loom, *C* being the top castle, and *H* the headles, twenty in number in this instance, or four sets of a five-leaved twill. *B* is a set of coupers, one for each leaf connected to it by the cords *d*, which are rising cords to raise the leaves, it being simply a rising shed. The ends of the coupers are seen at *C*, Fig. 106. There is another set of coupers shown at *D*, Fig. 105, equal in number to the former, and to which they are connected for the purpose of raising the opposite ends of the leaves by the cords *t*. In this case the marches are not placed below the levers, but above them, as shown at *A*, 1, 2, 3, 4, 5, or one for each leaf of the twill, a side view of which is shown at *A*, Fig. 106. Each of these levers is connected to a treadle below by means of the cords *X*, Fig. 105, which pass through the warp, and are held in position by being passed through holes in the board *w*. The weights *n* and *o* are the ordinary weights for sinking the leaves after they have been raised.



The plan Fig. 109 shows the connexion between the coupers *c c* and the marches or levers *A*. The crosses × in the plan represent where the tight cords *i i i* are tied to the levers *A*, Fig. 106, and the circles denote the slack ends which are tied to the rings *a a*. Where the squares are blank there is no necessity for any cords.

It will be seen that there is one couper in each set connected to each lever *A* by a tight cord, while one couper of each set has no connexion whatever with the levers, also there are three coupers of each set that are tied to the rings *a a a*.

From these rings cords pass down through the levers *A* and up through the box *g*, where they are tied to another set of levers, the ends of which appear at *m*. These levers are again connected to another set at *h*, to which the handles *l* are appended. Fig. 107 is a plan of the box *g*. On the cords by which the handles are suspended are knots, and these cords pass down through the board *K*,

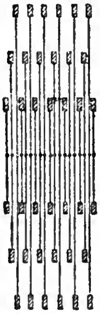
Fig. 106; when the handles are drawn, they are prevented from returning by their being placed in a narrow cut in the board through which the knots cannot pass, as shown in Fig. 108.

If all the handles are disengaged from the board *K*, and any of the treadles *T* be pressed, a twill may be produced of one thread raised and four sunk, for the coupers which are connected by the slack cords and those which have no cords will not be affected by the levers *A*.

Also, if all the handles were drawn down, and the knots held in the slots of the box *K*, it is evident that all the connecting cords would become tight, and when the treadles T were worked over all the coupers in the mounting would be sunk, and their corresponding levers raised, excepting those that have no connexion with the

Fig. 110.

Fig. 111



levers *A*; and in this case a twill would be woven with four threads raised and one sunk, which is the reverse of the other, as shown in Fig. 104 as compared with Fig. 103.

It will, therefore, be evident that if any one or two of the handles be lowered, the sets of leaves to which they are connected will produce a twill the reverse of those which are left up, and by this means a great variety of patterns can be woven by using one set of treadles only, these treadles governing the twenty leaves by the means of throwing in and out of connexion the separate divisions of the harness as described.

In 1801 Jacquard attempted to construct a machine upon somewhat similar principle to the above, the model of which is preserved in the Conservatoire des Arts et Métiers at Paris.

In the plan shown by Fig. 109 the use of spaces instead of lines shows the advantage of being able to use with clearness crosses, circles, or other figures, as may be desired by the designer and weaver, and by this means little difficulty is encountered in representing the arrangements required.

In the construction of all the healds we have hitherto shown, they are formed by stretching the leashes between two laths. This system does not admit of a large number being used in a loom, although by placing them in two or three tiers, as shown in section by Figs. 110 and 111, as many as eighty or ninety may be used, for the laths need not be more than ⅛ in. thick. But this number is quite inadequate to the quantity required in figure-weaving, where the numbers usually amount to 300, 400, 600, or 900, and upwards. Therefore, in forming the healds, the laths are entirely dispensed with, and single leashes, or several tied together forming a heald, are used instead. Small weights, called "lingoes," made of iron or lead wire, are attached to the end of each leash, and the leashes are held in position in the loom by being passed through holes in a board, sometimes, as in power looms, made in one piece, and in hand looms formed of thin slips inserted in a frame, similar to a school-slate, excepting that there are a number of slips; this is called the comber-board. These healds will be explained as we proceed, for it is upon the advantages they give of being placed in any desired order that a great deal of the power of the loom depends.

CHAPTER X.

THE DRAW LOOM AND DRAW-BOY MACHINE.

The third class of weaving, into which we divided the present part of the subject, consists in applying two separate systems of harness in the loom in such a manner that after the warp has been passed through one set it is passed through the second set, each set of harness having an especial duty to perform, although they both operate upon the same warp threads.

The first harness through which the warp passes is for the purpose of forming the pattern, as it were, on a large scale, and the purpose of the second harness is to break up this pattern into detail, and complete the necessary minute intersections. In other words, in the first instance the outline of the pattern is formed, and in the next case that outline is woven in detail, so that each thread is intersected or woven together, as in twill or satin, of any desired description.

At *A* and *B*, Fig. 112, the process mentioned will be at once apparent. It will be seen that at *A* the figure woven consists of not less than five threads in both warp and weft between each intersection, and in some places the figure runs nearly across the cloth without any intersection of the weft threads whatever. Still the outline of the pattern is formed, and it now remains to weave that outline into cloth of proper consistency, by giving the threads the requisite number of intersections for that purpose.

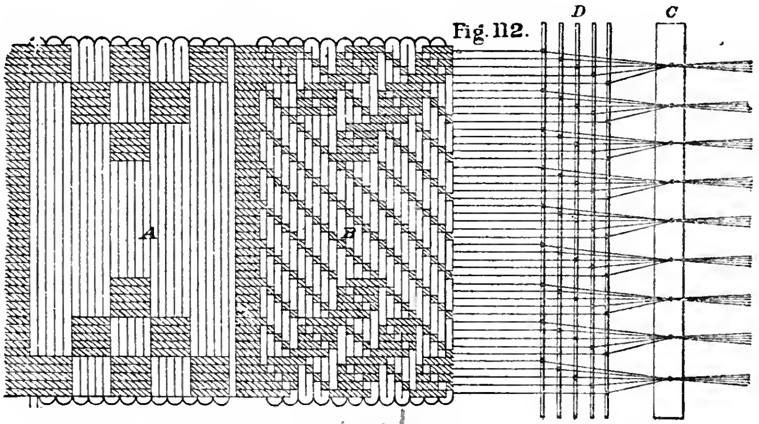


Fig. 112.

This is effected by passing the ~~weft~~ work threads, in groups of five, in this instance, through the eyes of the healds at *C*, and thence through the healds at *D*, where they are distributed, each thread having a separate eye. The eyes in these healds are made of considerable length, as shown in section, Fig. 113, where it will be evident that the leash *C* may be raised and lift the warp threads with it, as shown by the dotted line *d d*, without being obstructed by the eyes in the healds *D*. Consequently, if the leashes *C* are worked separately, and without working the headles *D*, they would raise the threads in groups and form the cloth, as at *A*, Fig 112.

Now we will suppose, on the other hand, that the healds *C* remain stationary, as in Fig. 113, it will then be seen that any of the healds *D* being raised will also raise the warp thread which passes through it. This is shown at *n*, Fig. 114, where the heald being raised has also raised one warp thread, although it is held down by the eye at *v* of the leash *C*, one thread being raised and four stationary. Again, if the leash *C* be raised, as at *w*, it will raise the warp threads quite independently of the healds *D*, but it will be observed at *e*, Fig. 114, the heald *c* being depressed has carried with it its corresponding warp thread, one thread being sunk and four raised of the five threads in the leash *C*.

Thus it is clear that the healds *C* may be raised at pleasure, and form any figure that may be desired, as at *A*, Fig. 112, but by applying the ground harness, *i. e.*, that which works the ground or detail intersections of the cloth, the effect produced will be as shown at *B* in the same figure. In this case the ground is a single thread five-leaf twill, and is worked by a rising and sinking harness, as shown in Fig. 114. The twill is reversed, as shown in the light and dark parts at *B*, and by exposing, more or less, the warp or weft, thereby the design is rendered distinct.

This system of weaving is known as damask weaving, and was

Fig 113.

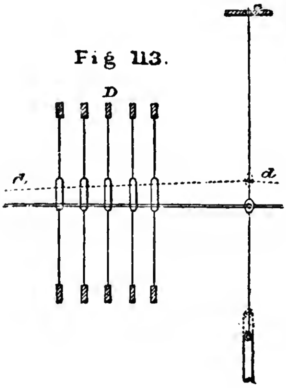
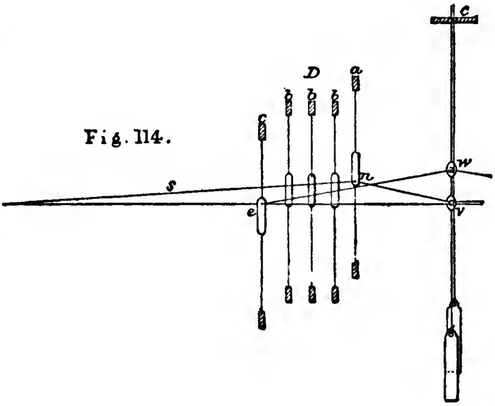


Fig. 114.



originally, it is believed, brought from Damascus, hence its name. It is said to have been introduced into England in the year 1567, during the persecutions by the Duke of Alva of the Dutch and Flemish weavers, who fled from their homes in consequence, and established this branch of weaving in various countries.

The loom in which damask weaving was effected is known as the draw loom, and, although there is perhaps no record of its introduction into England, it is very probable that it was at the period above mentioned.

Fig. 115, is a diagram of a draw loom, the same as shown in Fig. 112, and the letters in each refer to the same parts.

The leashes *C* pass through the holes in the comber board, as shown, for the purpose of keeping them in position, as before

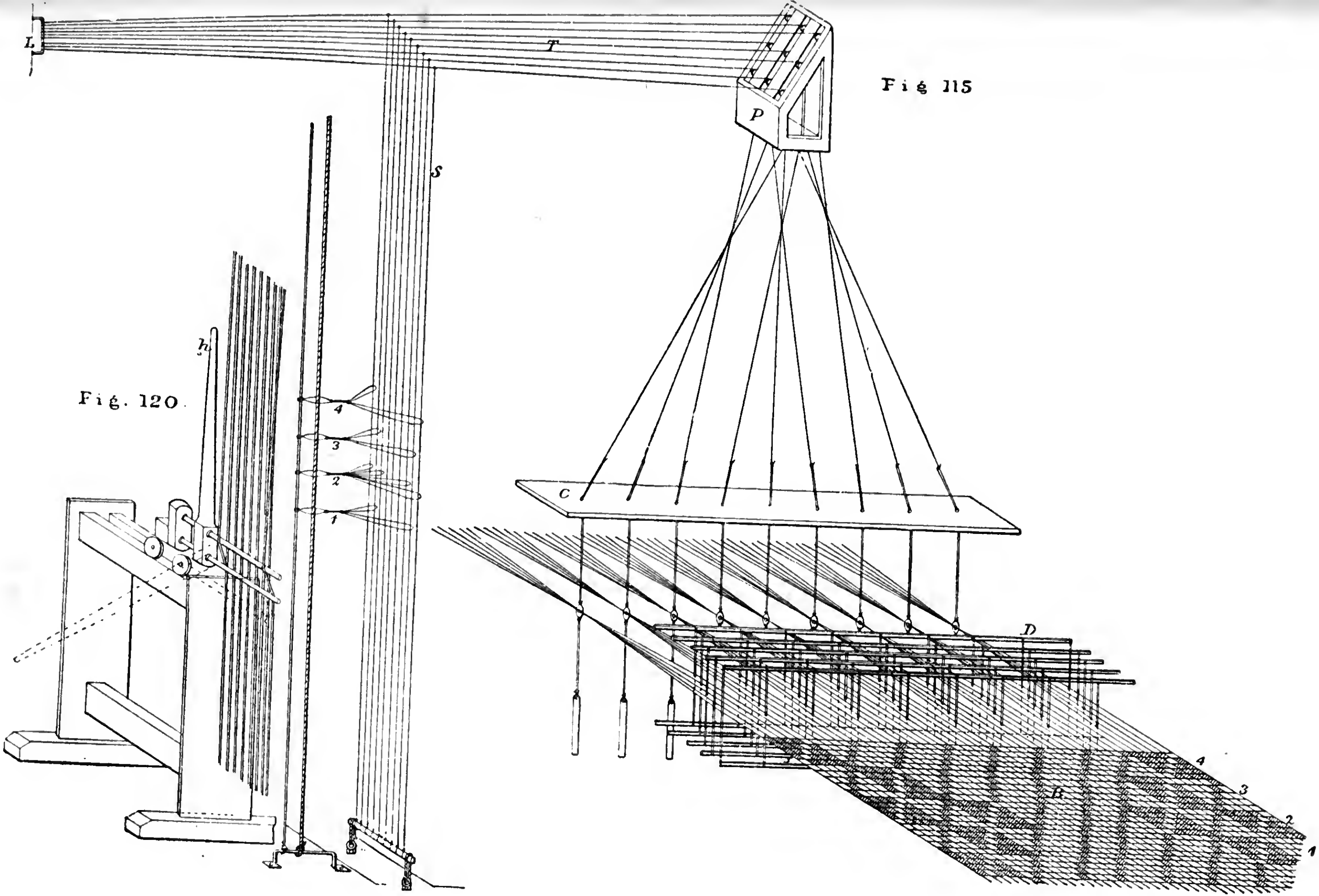
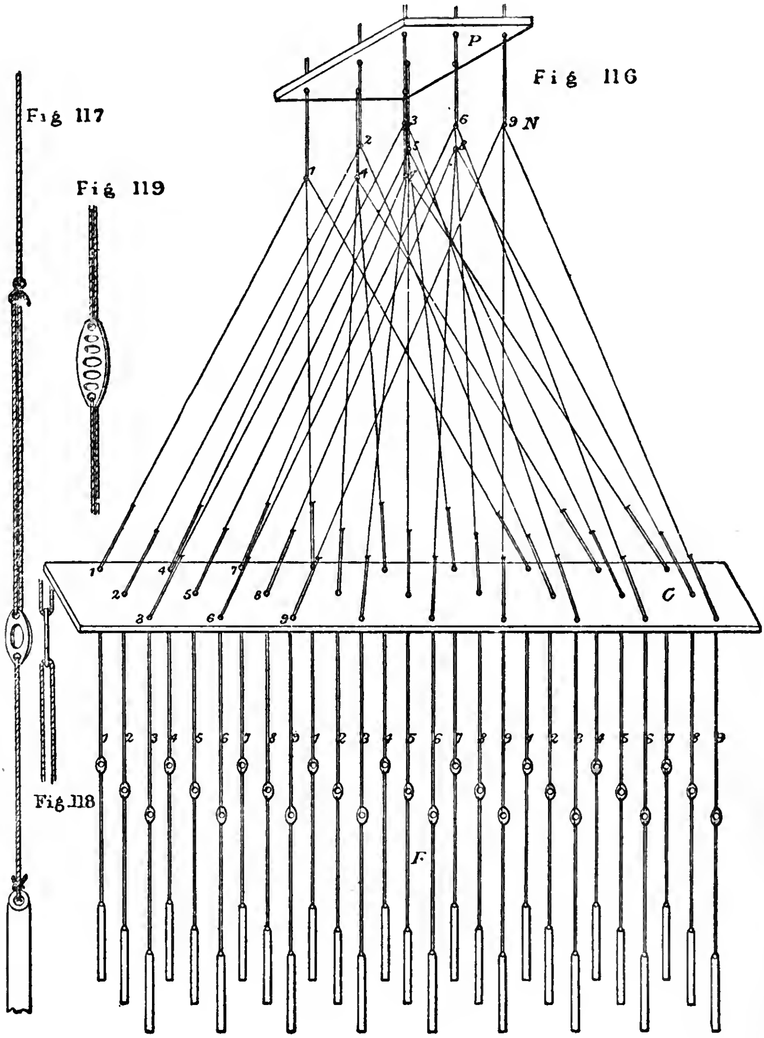


Fig 115

Fig. 120

explained. They are then carried upwards, and through the bottom board of the pulley box *P*, and after passing over the pulleys are collected together at the staple *L*. From the pulley box to the staple the cords, shown at *T*, are called the tail of the harness. They are



attached to another set of cords placed vertically at *S*. These cords form the "simple," and it is upon them that the pattern is arranged.

It will be observed that there are two strong cords placed vertically, which form an attachment and a guide to a number of loops marked 1, 2, 3, 4. By drawing or pulling any of these knots of loops it draws with it the corresponding simple cords, and these being grasped by the hand and pulled or drawn downwards, they raise the corresponding leashes *C*, and thus the shed is opened in the warp so far as this part of the harness is concerned.

The leashes or loops on the simple *S* correspond with the leashes to be raised at *C*, and the corresponding numbers, shown at *B*, show their effect. For instance, the simple cords, 4, being drawn, they are held down until the healds *D* have been worked over, and the result is that the two extreme squares, *B* 4, at the edges of the cloth, are woven with four out of five of the warp threads raised, whilst in the intermediate squares the reverse effect is produced. On comparing Fig 112 with Fig. 115 this effect will at once be evident.

In order to simplify the figure, only nine leashes have been shown in the diagram; as before stated, each leash really forms a heald of itself. But in actual weaving the pattern is repeated or arranged in some way to make the best effect with the least number of simple and tail cords. Fig. 116 shows the same arrangement as in Fig. 115, but it will be observed that the leashes are repeated three times over. The leashes, instead of coming down singly from the pulley box *P*, are connected together at *N*, and thence are passed through the holes in the comber board *C*, in the manner shown. The holes are placed diagonally in the board, so that equal spaces on plan for the warp threads may be secured, as shown vertically at *F*.

Fig. 117 shows a leash and weight or lingo attached, also the metallic, or glass, mail or eye; Fig. 118 is a corresponding side view. Fig. 119 shows a mail pierced with several eyes. This form of mail is necessary when several threads are passed through one mail. If the threads were all threaded through one eye they could scarcely be woven, but would get twisted and frayed by the working of the front or ground harness, and the obstruction would prove of the greatest disadvantage. Therefore it is usual, when several threads are used in one mail, to adopt the plan shown.

The weight of the lingoes, when some thousands are used, becomes great, and it was necessary that some means should be adopted to assist the draw-boy in raising them. The simple often consisted of three or four hundred cords, and as each of these cords had several leashes and lingoes attached, the constant lifting was attended with inconvenience. The friction of so many cords was almost equal to their weight, which made matters worse. To assist the draw-boy, as the weaver's assistant was called, a fork, shown at Fig. 120, was used. It was made to run to and fro upon a carriage, so that when the leashes of the simple were drawn outwards one spike of the fork was passed through the shed or opening formed, instead of the hand as previously described. The fork being depressed by means of the handle *h*, it caused the uppermost spike to fall, whilst the other remained stationary, and in this manner the cords were drawn downwards and held there until the weaver had worked the ground of the cloth by means of the front healds as already mentioned.

In the draw loom the pattern is arranged on the simple by means of leashes, as shown in Fig. 115. In this instance only four changes are required, but when several hundreds are required much complexity arises therefrom.

To escape the drawing of wrong cords or leashes, as before stated, was one reason why a machine was ultimately adopted to draw or work them instead of the weaver's assistant. Therefore the machine was brought to considerable perfection and they were made to draw from one to three or even four hundred leashes, in consecutive order. At first they were made to act with one treadle, but they were afterwards adapted for two treadles, which made their action much better for the weaver, besides giving them double the power by rendering them capable of working double the number of cords, one row on each side of the machine.

When they were introduced in Spitalfields the weavers hoped to reap great advantage from them, for instance they would save the draw-boy's wages. But they began to find they had adopted a mistaken notion. They found that if they had not to pay the draw-boy, they had to pay the manufacturers for the use of the machine, and after all they had an amount of work to perform more akin to "treadmill work" than weaving. Such was the evidence given before a Committee of the House of Lords, in 1823, upon the subject of the silk-trade.

The draw-boy and the draw loom, long after the Jacquard machine became known and used, were still held to by the weavers. The Society of Arts also encouraged improvements in them, but they were shortly to be put aside when the advantages of the new French draw loom, as the Jacquard was then called, became known.

The draw-boy machine was not only adapted to draw the tail cords of the draw loom, but it was also employed, as before stated, when considerable numbers of common healds were used, and the ends of the coupers were attached to the machine instead of being fastened to the long marches, as shown in Figs. 68 and 71. This will be readily understood when the action of the machine is shown.

Fig. 121 shows a common and simple form of the draw-boy. It is worked by the treadles of the loom *T* being connected to the marches *M*, and instead of the marches being attached to the tum-

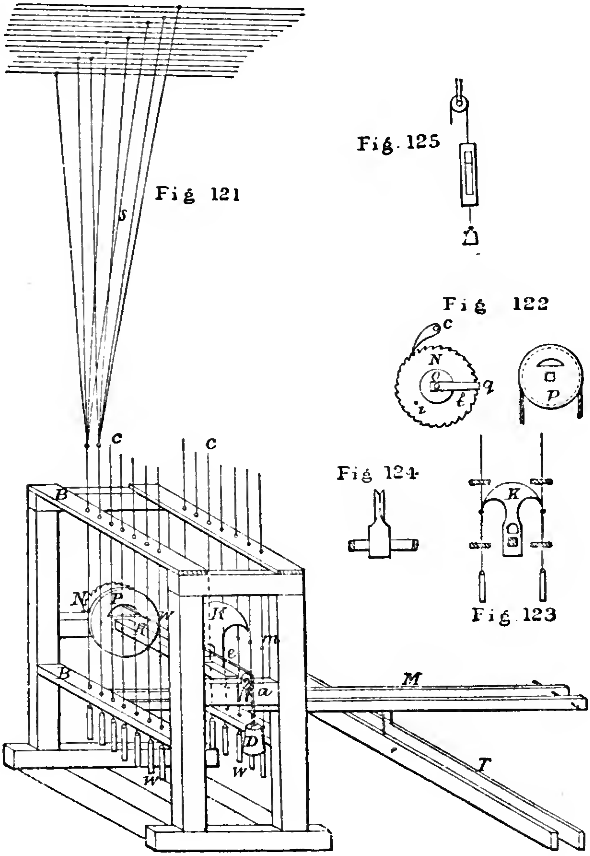


Fig. 121 Fig. 122 Fig. 123 Fig. 124 Fig. 125

blers or coupers on the top of the loom, they are connected to a cord which passes over the pulley *P* of the draw-boy. This pulley, therefore, causes the rocking shaft *R* to work, and with it the pecker *K*. The cords *C C* are passed through the holes in the boards *B B*, for the purpose of holding them in position, and they have knots or beads tied upon them at *m*, and weights *w* at the ends to keep them in tension.

The cords *S* being arranged so as to form the pattern by raising the healds, or drawing the tail cords as shown in this instance, are attached to the cords of the draw-boy at *C C*. To avoid complication, there are only two such connexions shown in the figure, although any desired number within the compass of the machine may be used.

Now it will be evident that when the shaft *R* rocks from side to side of the machine, it will carry the pecker *K* with it, and the groove and notch at the points of the pecker coming into contact with the knots upon the cords, draws them down alternately, first on one side of the machine and then on the other, until the pecker, as it slides along the bar, has passed all the cords. It is then released and returned to its first position by means of the weight *D* attached to the pecker and to the cord *e*. Thus the pattern cords, as they may be called, are worked over repeatedly, and by this means large numbers of healds may be used by the use of two treadles only.

At the end of the rocking shaft there is a ratchet wheel *N*, shown also at Fig. 122. Upon this wheel a pulley *o* is placed, and it is upon this pulley that the other end of the cord *e* is wound. The teeth of the ratchet wheel accord with the spaces that the pecker is drawn through, so as to bring it exactly into contact with the knots on the strings. There are two pins *t* and *z* fixed in the wheel *R*, and it is according to their distance apart, or relative position, that the extent of the longitudinal traverse of the pecker is determined. For instance, the bar *q* being attached to the pulley and the pulley being loose upon the axis of the shaft *R*, as the wheel *N* is advanced the stud carries the bar with it, until it comes into contact with the catch *c*, when it raises the catch and holds it up, thus allowing the wheel to reverse until the stud *z* comes into contact with the bar and puts the catch again into action. Therefore, the distance between the studs *t* and *z* is fixed according to the number of the cords *C C*, and depends upon the length of the pattern or design to be used.

Fig. 122 is an elevation of the pulley *P*, Fig. 121, showing the segmental hole through which the cord *e* passes.

Fig. 123 shows a section, and Fig. 124 an end view of the pecker *K*. The ratchet wheel *N* is moved by means of a catch shown at Fig. 125, which is simply a pin fixed in a slotted piece of wood. The pin forms the catch, and the slot acts as a groove for the edge of the ratchet wheel to work in, to keep the catch in position. The catch is attached to the marches and works vertically by means of the pulley, weight, and cord, as shown in the figure.

Such were the means the weaver formerly had at his command for performing the shedding motions of the loom. It will be seen that they all resolve themselves into tie-ups, for in no instance does a distinct mechanism appear, or one that was capable of alteration without affecting the cording of the loom.

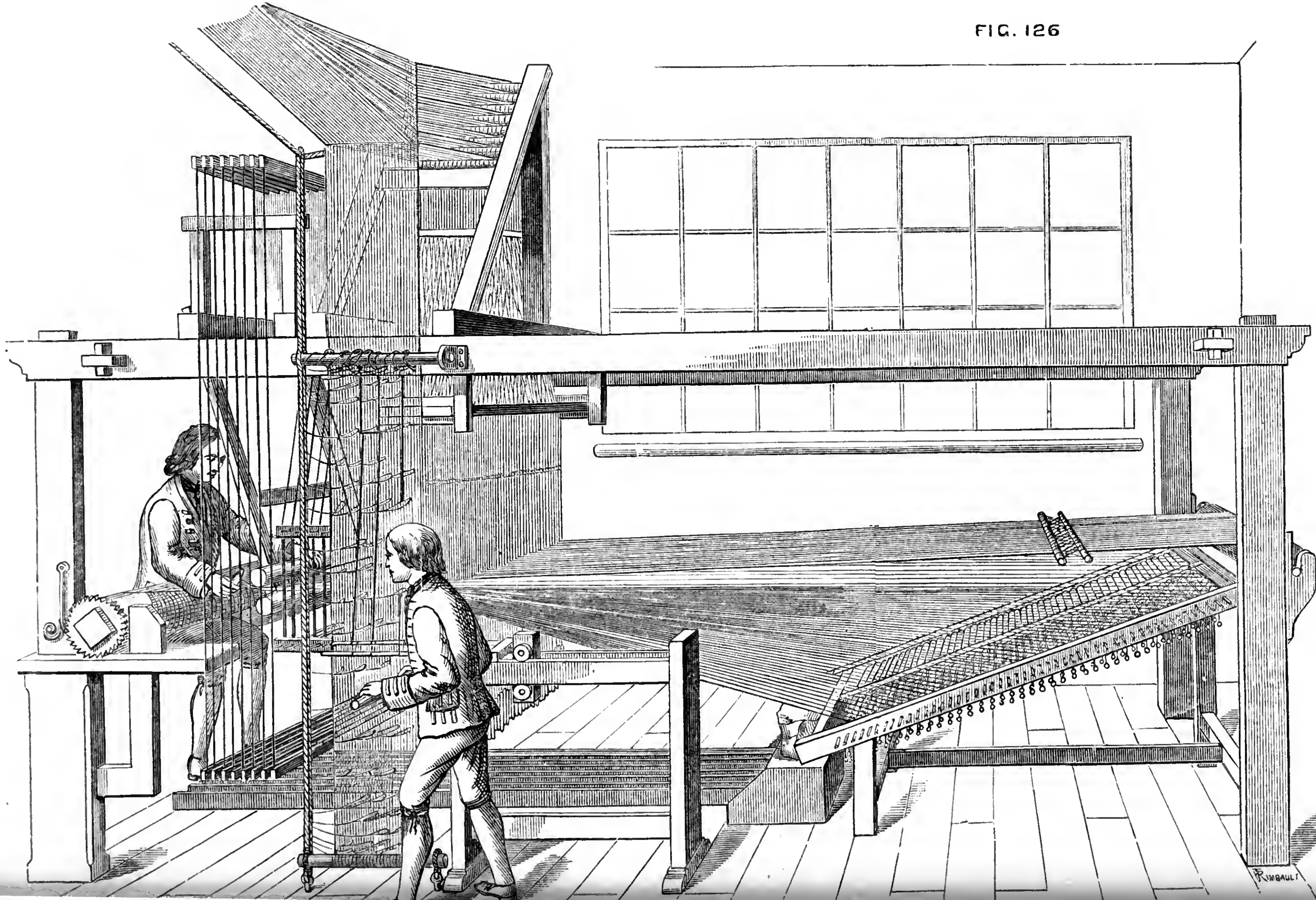
The Chinese have a rude description of draw loom in which the draw boy stands upon the top of the loom, and pulls up the neck cords.

It is not known to what country the invention of it belongs, but it is supposed to have been used in Damascus, and a knowledge of it brought to Europe by the Crusaders.

In a "Description of Manchester," published in 1783, it is stated that "when tufts were no longer an article of consequence, more figured goods were made for 'whiting,' and a great variety of patterns were attempted by weavers who had been employed in the declining branch, and had looms ready mounted for that purpose; but as figures made with treadles are confined to a scanty range, beyond which they grow too complicated, they had recourse to the working of them by draw-boys, which gave name to a new and important branch of trade. Some yard-wides being made and whited upon this plan were bought up, and were called for with such avidity that the utmost encouragement was given to ingenious weavers, and looms mounted for them at a great expense, which the employers advanced. In the course of trade since, great stocks of these draw-boys have lain upon hand, and there have been some great checks upon this article; but the variety of figures it is capable of exhibiting and distinctness of quality in the sorts, the many uses to which it is adapted, and cheapness upon the whole, have rendered it a standing branch of trade, although quilting, which is wrought by draw-boys upon an improved plan, has in particular rivalled it, with counterpanes and various kinds of corded dimities lately introduced. Much about the time when draw-boys were first made cotton velvets were attempted and brought to some perfection in the manufacturing part; cotton thicksets were likewise well manufactured, but there wanted the present methods of dressing, bleaching, dyeing, and finishing to give the perfection which they have now obtained."

Although frequent allusion is made respecting the invention of

FIG. 126



the draw-boy machine, and various persons have received credit for it, there can be no doubt that the contrivance is an old one, for so far back as 1687 a machine of this description was patented by one Joseph Mason. His claim was for "an engine, by the help of which a weaver may performe the whole worke of weaving such stuffe as the greatest weaving trade in Norwich doth now depend upon, without the help of a draught-boy, which engine hath beene tryed and found out to be of greate use to the said weaveing trade." Until a prior claim can be found, this contrivance of Mason's seems to be the first invention of the draw-boy machine.

In 1779 William Cheape patented a plan to dispense with the draw-boy machine by drawing down the simple cords, which were placed over his head, and to hold each cord in a notch whilst he worked over the treadles, in a similar manner to the plan shown in Fig. 106 for diaper weaving.

Before entering upon the subject of the contrivances that have almost entirely supplanted the above systems, it will be interesting to give a representation of a first-class draw loom of the last century, such as was used in France for the weaving of velvet figured damasks. In this loom, Fig. 126, four hundred pulleys are used, and, of course, a corresponding number of tail and simple cords. The fork lever and other improvements are supposed to have been made by M. Dangon in 1606.

There is also a frame capable of containing a thousand separate bobbins and warp threads, in addition to the warp itself, for the formation of the velvet pile. As each separate thread in figured velvet is consumed in various lengths, each thread is required to be wound off a separate bobbin, which is, in fact, a miniature warp beam. The frame containing them is shown placed beneath the warp of the loom. The fork for drawing the cords is also shown, and, taken altogether, the loom will, when contrasted with the Jacquard loom (see page 159), afford a most instructive instance of the advancement that has been made in this branch of manufactures during the present century.

CHAPTER XI.

THE JACQUARD MACHINE—INTRODUCTION.

Joseph Marie Jacquard was born at Lyons on the 7th of July, 1752. His parents were employed in some operations connected with weaving. At twelve he was put to a bookbinder, then to type-founding, and cutlery. At the death of his parents there was left to him a small property, which enabled him to commence figure weaving, but he was unsuccessful, and lost all. After he was married he occupied himself with schemes relating to cutlery, type-founding, and weaving. In 1792 he joined the Revolutionists, and on his return, in the following year, he and his son assisted in the defence of Lyons against the army of the Convention.

He first turned his attention to the machine which now bears his name in 1790. At first he did not succeed, but in 1801 he had completed it, and it was exhibited in the National Exposition, Paris, when he received the reward of a bronze medal for the invention. Although he had a patent for the machine, he made little by it; but Napoleon granted him a pension of 60*l.* (1500 francs), and the right to a premium of 2*l.* for each machine sold.

In the introduction of the machine he met with the greatest opposition. His machines were pulled down and destroyed, and the model publicly burned. A "Conseil des Prud'hommes" also opposed him. But after some years had passed, the machine proved to be of the greatest value, and on the spot where the model was burned a statue to Jacquard now stands. He died August the 7th, 1834.

It is generally taken for granted that he invented the application of perforated cards, and this, the great principle of the invention, is always associated with the name of Jacquard. Whether he was the inventor of any one of the parts forming the principle upon which the merits of the loom depend may be seen by referring to the "Report on the Paris Exhibition of 1855," Part II., page 150, "On

Machinery and Woven Fabrics," by the Rev. R. Willis, who states that M. Marin, Professeur de la Théorie des Fabrications, at Lyons, exhibited a series of nine models, showing the development of the Jacquard loom. These models, now (1878) in the Conservatoire of Arts, Paris, went to prove that M. Bonchon, in 1725, employed a *band of pierced paper* pressed by a hand-bar against a row of horizontal wires, so as to push forward those which happened to lie opposite the blank spaces, and thus bring loops at the lower extremity of vertical wires in connexion with a comb-like rack below, &c.

In 1728 M. Falcon substituted a chain of cards, and a square prism (known as the cylinder) in lieu of the band of paper of Bonchon. In 1745, Vaucanson suppressed altogether the cumbrous tail-cards of the draw loom, and made the loom completely self-acting by placing the pierced paper or card upon the surface of a large pierced cylinder, which travelled backwards and forwards at each stroke, and revolved through a small angle by ratchet work. He also invented the rising and falling griffe, and thus brought the machine very nearly resembling the actual Jacquard.

Mr. Willis adds, "The merit of Jacquard is not, therefore, that of an inventor, but of an experienced workman, who, by combining together the best parts of the machines of his predecessors in the same line, succeeds for the first time in obtaining an arrangement sufficiently practical to be generally employed."

This process of using perforations in paper or cards is the very life of the Jacquard apparatus, and it may be simply illustrated by Fig. 127, which represents the tail-cords of the ordinary draw loom, as already described, and S the leashes connected to the tail-cords. The simple cords are kept in tension by the lingoes or weights at the bottom of the leashes, which are shown at *w*; by this means they are kept in a vertical position. In a box or frame D are placed a number of horizontal wires or needles, each having an eye, made by turning a loop in the wire. The ends of the wires protrude a short distance through the front, or needle-board of the frame, and each of the simple cords is passed through the eye of a needle. Below the needles a knot or a bead is tied upon each of the cords, and opposite to these knots a comb-bar is fixed to a frame G, which can be depressed by means of a treadle, as shown.

Now, if a band of paper *p* be placed upon a roller *b*, and fixed into a frame *f*, and be pressed against the points of the needles that protrude through the front board of the box D, it will force back all the needles in the frame, and cause the knots or beads upon the simple cords to come into contact with the teeth of the comb. By depressing the comb, all the cords will be drawn downwards, for the knots or beads are made too large to pass between the teeth of the comb, consequently all the warp-threads will be raised. But by perforating the paper, and placing it upon a perforated cylinder, then wherever there is a hole in the paper opposite to a needle, that needle remains stationary, and is not affected; but if the paper has a blank space instead, then it will force back the needle and bring the knot on the simple cord into contact with the comb, by which it will be lowered and the warp-thread raised.

Thus any desired arrangement of design can be effected by corresponding perforations, and the extent of pattern is bounded only by the number of needles and the length of the band of paper. After the cords have been lowered, they recover their normal position on the paper being removed, and the cylinder being turned so as to present another series of perforations, the operation is repeated, each row of holes representing one drawing of the cords.

Fig. 127 may not exactly correspond to the description given by Professor Willis, but the action is in every respect the same, and can make little difference in the machine excepting in rendering it in a more simple form.

The invention of Bonchon was brought to comparative perfection, about the year 1745, by the celebrated mechanician Vaucanson. He at once dispensed with the tail cords and simple of the draw loom, and placed the perforated paper and cylinder on the top of the loom, in the place of the pulley box, and it is in this position that the Jacquard still remains.

Before entering further into the subject we will give an account of the introduction of the Jacquard machine into England, as given in evidence before a committee of the House of Lords on the silk-trade in 1823, by Mr. W. Hale and Mr. Stephen Wilson, also an account of its invention given by Dr. Bowring (afterwards Sir John Bowring) before a committee of the House of Commons in 1831-32.

Before a Lords' Committee on the silk-trade (vol. xiii., 1823) evidence was given by Mr. W. Hale a manufacturer of Spitalfields, to the effect that:—

"In making a tour through Switzerland and Italy in 1816, with my family, I was the first individual who saw it (the Jacquard loom).

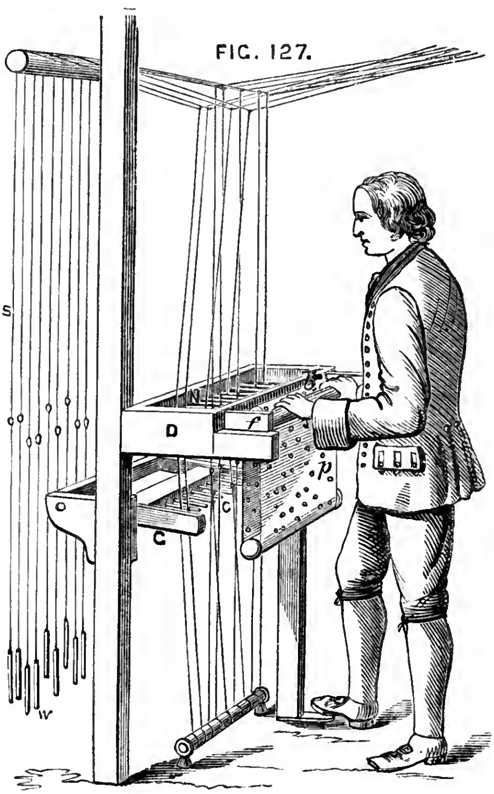
I communicated it to other manufacturers, and Mr. Stephen Wilson, after a time, went over and saw the loom, and has got a patent (?) for it."

"Is that improvement which Mr. Wilson introduced into the country in general use?"—"No."

"Is it confined to his own manufactory?"

"I am not aware that it is in use in any other manufactory but his own, but not in Spitalfields. I am told they have improved

FIG. 127.



upon it in Manchester or Macclesfield, but I am not aware that a single piece of goods has been made by it. Mr. Wilson, I think, has got two or three of the looms at Streatham, there may be more. It is a very great improvement, and I was very anxious to get it over, that the manufacturers generally, not myself, might take the advantage of it, and I did take measures to get another person to bring it over, not knowing that Mr. Wilson had succeeded, when I found he had got a patent for it."

Mr. Stephen Wilson before the same committee gave the following evidence:—

"Here are a number of works that have been made with it; this shawl has 1200 cords. I never knew a loom of that number of cords in Spitalfields. Here is another shawl with 600 cords. The weaver does all himself. It is also adapted to damasks, which is one of the heaviest kinds of work. Generally they are drawn every four shoots, but this is drawn every shoot, which makes it more difficult work. This pattern is three yards long, but it can be made of any length whatever. I have now a pattern on with 7000 leashes. If I am not too sanguine, my idea of this machinery is that it is of as much consequence to the silk manufacture of this country as Arkwright's machine was to the cotton, and that it will supersede a great deal of the machines now in use."

From the evidence given before the committee of 1832-33 it was stated by David Smith, a weaver of Coventry, that the first Jacquard machine used there was in 1823, and Mr. S. Cox stated it to be in 1824.

Before the committee of 1831-32, Dr. Bowring, in the reply to the question, "Do you know the history of the Jacquard machine?" gave the following interesting evidence:—

"The introduction and history of the Jacquard mechanism is certainly one of the most interesting and one of the most instructive facts connected with the silk manufacture. I was extremely desirous, having seen the beauty of the machine and the simplicity of its operations, of some conversation with its inventor, and accompanied by a number of gentlemen, I went to visit Jacquard, and was very much gratified at hearing from him a history of its invention, which is now generally recognized as one of extreme importance and value.

"He told me he was originally a straw hat manufacturer; his attention had never been turned to mechanical topics till the Peace of Amiens opened the communication of France with England; at the same time an extract from an English newspaper fell into his hands, in which it was stated that a society here offered a premium to any man who should weave a net by machinery. He told me that his thoughts were thus turned upon this subject, which, by the way, if there had been any interruption to intercourse would never have taken place; he did produce a net, which he threw aside for some time, and afterwards gave it to a friend as a matter of indifference. The net by some means or other got into the hands of the authorities, and was sent to Paris. When some time had passed and Jacquard had completely forgotten his production, he was sent for by the prefect, who said, 'You have directed your attention to the weaving of nets by machinery.' He did not immediately recollect it, but the net was produced to him, and that called it to his mind. The prefect said, 'I require you to make the machine which led to this result.' He asked three weeks for its completion, and brought it to the prefect, and desired him to strike with his foot, by which a mesh was added to the net. It was sent to Paris and an order came for his arrest. It was in Buonaparte's time, when things were done in a rash and very arbitrary way. He found himself under the keeping of a gendarme, and was not allowed to go home to provide himself with the necessaries for his journey.

"He was required at Paris, in the Conservatory of Arts, to produce the machine in the presence of inspectors, which he did.

"He was introduced to Buonaparte and to Carnot, who said to him with a menace of incredulity, 'Are you the man who pretends to do that which God Almighty cannot do, to tie a knot in a stretched string?' He produced the machine and showed its operation. This was Jacquard's first mechanical experiment. He was afterwards called in to examine a loom on which twenty or thirty thousand francs had been expended for the production of articles for the use of Buonaparte.

"He offered to do that by a simple machine which they were attempting to do by a very complicated one, and improving upon a model by Vaucanson he produced the mechanism which bears his name. He returned to his native town, a pension of 1000 crowns having been granted to him; but so violent was the opposition made to the introduction of his machine, that he had three times the greatest difficulty of escaping with his life.

"The Conseil des Prud'hommes, who are the conservators, *ex-officio*, of the interests of the Lyonnese trade, broke up his machine in the public place; the iron (to use his own expression) was sold for iron and the wood for wood, and he, its inventor, was delivered over to universal ignominy. It was only when the French were beginning to feel the effect of foreign competition that they were forced to employ this machine, which led to such great improvement in their manufacture, and, as everybody knows, it is now extensively employed through the whole of the manufacturing districts of France."

When this statement is compared with the account given by Dr. Cartwright of the invention of the power loom (see Chapter xx.) a marked difference appears. Dr. Cartwright's is a full and circumstantial account, and carries with it an unmistakable evidence of fact. But the account given by Jacquard dwells more upon the netting machine, and seems to avoid the real question at issue. He acknowledges the invention of Vaucanson, but after the subject has had fair consideration scarcely any other result can be arrived at than that given by Professor Willis, already quoted, viz., that Jacquard "must not rank as an inventor, but as a talented workman who has been able to carry out practically the inventions of others."

Of the first inventors of the Jacquard apparatus, namely M. Bonchon and M. Falcon, no information respecting them is given, but of Vaucanson the case is different, for his reputation as a skilled mechanic is well known.

Jacques de Vaucanson was born of a noble family, at Grenoble, in Dauphiné, 24th February, 1709. When a boy he exhibited a taste and a talent for mechanics, and succeeded in the construction of a wooden clock, which worked the time with accuracy. Afterwards, for the purpose of studying mechanics more fully, he went to Paris, where he made an automaton that played on the flute. This curious and ingenious machine having attracted much attention and admiration, he produced others even more wonderful, among which was a duck that swam, quacked, flapped its wings, and even swallowed and digested its food like a living animal. But besides these ingenious toys, Vaucanson also invented some really useful contrivances. Having been appointed in 1741, inspector of silk-factories, he introduced many improvements, and invented machines for weaving and dressing silk. He wrote in the "Journal of the Academy of Sciences," several admirable descriptions of machines he had invented, and had a very valuable collection of these and other objects connected with art and manufactures, which was unfortunately dispersed after his death in 1782.

As Mr. Stephen Wilson went over to France after being told by Mr. Hale in 1816 of the value of the new Jacquard machine, it is probable that he saw one very shortly afterwards. It is said that he procured one, and had it taken to pieces in France, so as to enable him to pack it in parts, and thus to smuggle it over to England. This may have been in 1817 or 1818.

In 1820 Francis Lambert patented a "new method of mounting, producing, removing, preserving, and replacing the figure in weaving gold lace," &c. This patent was really the Jacquard machine although not named, and it is the first patent relating to it in England. In 1821 Mr. S. Wilson obtained a patent for a machine for "reading in" the design and punching the cards for the Jacquard machine. In 1823 Mr. Wilson patented a modification of the apparatus, so as to dispense with the needles; but all attempts for that purpose have hitherto failed. The Jacquard was introduced into Coventry about the year 1822 by Mrs. Dresser, and it was also used at Tiverton about the same time.

Mr. James, in his "History of the Worsted Manufactures," says that Mr. J. Ackroyd introduced the Jacquard into Halifax in 1827, and bought it of Mr. Sago, Manchester. It was introduced into Horton, Bradford, in 1832, and Mr. Dracup commenced making such looms there in the following year. Mr. Thomas Ackroyd, of Horton, first applied the Jacquard to the power loom in the neighbourhood of Bradford.

CHAPTER XII.

THE JACQUARD MACHINE.

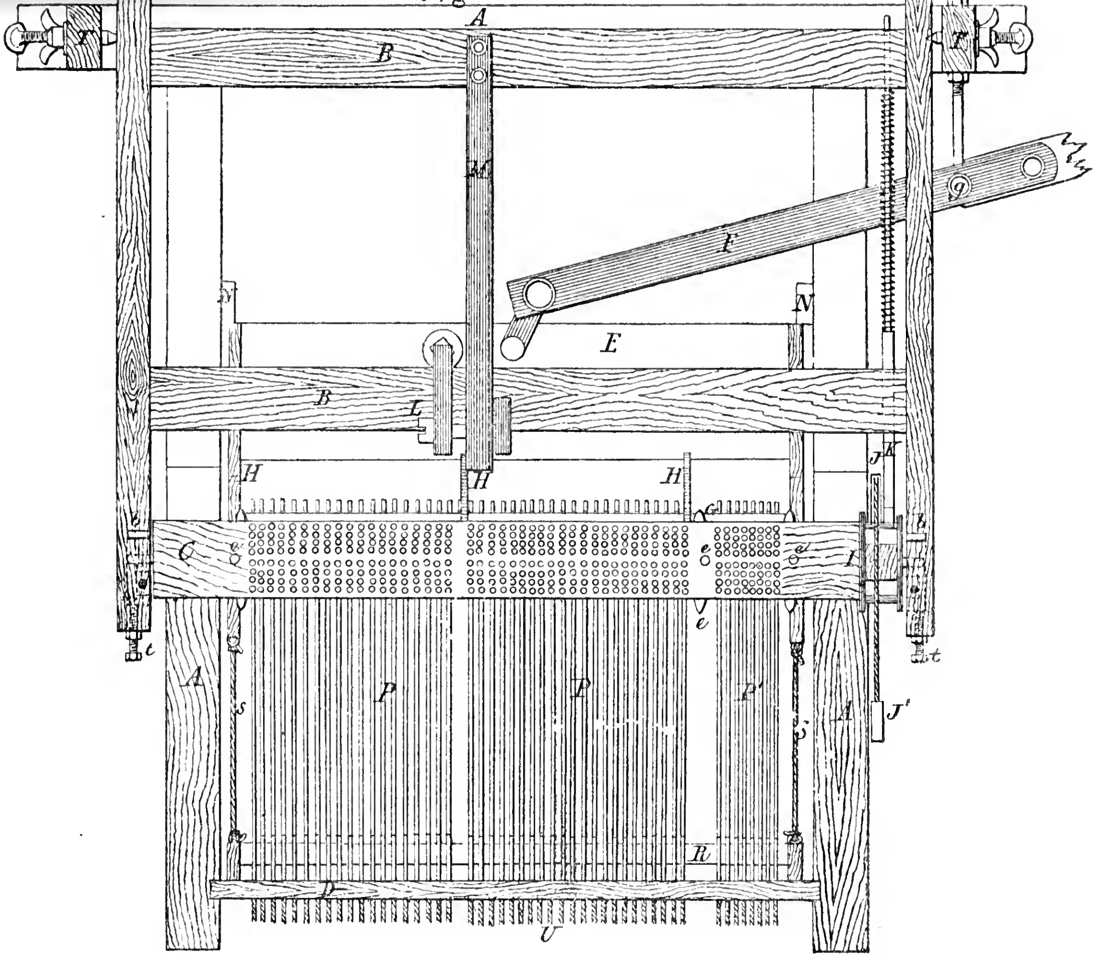
There is, perhaps, no machine more simple in its construction than the Jacquard machine, and when it is considered that it is almost unlimited in its extent and power—far beyond the compass of any other machine—it well deserves the high estimation in which it has, since its general introduction, been held. So simple, indeed, is it in its details that it will be the best course to describe the machine itself and its mode of application before any other class of automatic machine is explained. By doing so the principles of the most elaborate figured weaving may be readily shown, as well as the advantages and disadvantages of the machine in its operation, which have led to a great variety of modifications of more or less merit, in order to adapt the Jacquard apparatus to the power loom. The various descriptions of shedding motions, or machines for weaving small figures, will, also, be rendered clear and their actions understood, and by the aid of simple diagrams the principles of different looms will be far more easily explained than by any other means.

The Jacquard machine is simply a frame containing a number of wire hooks, which are connected direct to the healds of the loom. These hooks are raised according to the pattern to be woven—the pattern being first transferred from the design paper to the cards, which operate upon the hooks through the medium of needles. We have at present only to show how the hooks are arranged, and how they are operated upon by the cards. The effect they have upon the warp is either in a simple or direct manner, or by a combined action, similar to that already shown in the draw loom, illustrated by Figs. 112 to 115, and which will be explained afterwards.

Jacquard machines are made of various sizes and descriptions. Some contain only a few hooks, but the usual number is 300, 400, 600, and 900. The machines with 300 needles and hooks are used on power looms for weaving figured stuff goods, and the higher numbers are used on hand looms for weaving figured silks. Sometimes two or more machines are employed on one loom, and may be worked in various ways. We purpose now to describe an ordinary 400-needle machine—such as is in common use in silk hand-loom weaving—and afterwards to show the various ways in which it is usually applied for the production of figured silks. Machines intended for hand-loom weaving are usually made of wood, but for power looms iron is used.

Fig. 128 represents a front elevation of what is known as a 400-needle Jacquard—although it may be observed that there are more than that number of needles in it. Figs. 130 and 131 represent transverse sections, showing the parts in different positions. The letters in each figure relate to the same parts. The frame consists of the two ends, and the top piece *A A A*. The perforated board *D*, on which the hooks *P P* rest, is the bottom board, and not only constitutes a substantial part of the frame, but forms the guide for the neck cords *U*, which pass through it from the hooks to the healds or leashes of the loom. The hooks are held in position by the needles *W W*, which have eyes in them for the hooks to pass through, as may be observed, also, in Fig. 132, which shows a needle in two positions, viz., in plan and in elevation. The needles have a loop at one end,

Fig. 128



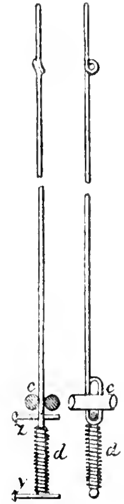


Fig 132


Fig 133

Fig 134


which allows of the pin *z* being inserted. The loops being passed between the strong wires *c c*, are held firmly, but with sufficient play for longitudinal motion to press against the spiral springs *d d*. The opposite ends of the needles protrude about ¼ in. through the needle-board *b*, Fig. 131. It is against this end of the needle that the cards *N* act, these cards turning upon the prism *C*, or cylinder, as it is technically called.

The hooks being passed through the needles—each hook having a separate one—it follows that when the points of the needles are pushed backwards the hook is also pushed. Where there is a perforation in the cards the needle is not pushed, but it passes through the card into the perforated cylinder, as may be seen in cylinder *C*, Fig. 130, where some needles have passed through the card, and the remainder have been pressed backwards against the springs.

Immediately above the hooks there is a sliding block, *E*, shown in section in Figs. 130 and 131, and in elevation in Fig. 128. In the latter figure a lever *F* is shown attached, with its fulcrum at *g*, suspended from a bolt secured to the cap *A*. From the block *E*, the plates *H* are suspended, and through these plates the bars *G*, made of strong hoop iron with feather edges, are passed. This portion of the machine is called the griffe, or griff, and its purpose is to raise the hooks. On referring to Fig. 130 the two needles which have been pushed backwards by the card, as shown, have also pushed back the corresponding hooks *n n*, consequently these hooks have been pushed away from the griffe bars above, and upon raising the griffe these hooks will remain stationary, while all the others are raised, as shown in Fig. 131. If a blank card, therefore, be pressed against the whole 400 needles they would all be pushed back, and none of the hooks would come in contact with the griffe bars; on the other hand wherever a perforation was made opposite to a needle, then the corresponding hook would be raised. This is, really, all that is required from the machine, viz., to lift any of the hooks that may be required for each pick of the weft or passage of the shuttle.

By placing the needles in tiers, as well as in rows, great compactness is obtained, and it is certainly very remarkable that this excellent contrivance should have been invented so far back as 1728 (as before related), and have remained nearly a century without any practical result.

The details of the machine may now be described. The small spiral springs (made of thin brass wire), are enclosed in a "spring box," shown in section at *x*, Figs. 130 and 131. The perforations pass completely through the wood, and the spring is held in the hole by means of the pin *y*. By removing one of these pins any of the springs in the corresponding tier may be taken out and replaced. Of course there is a separate pin for each vertical row of needles.

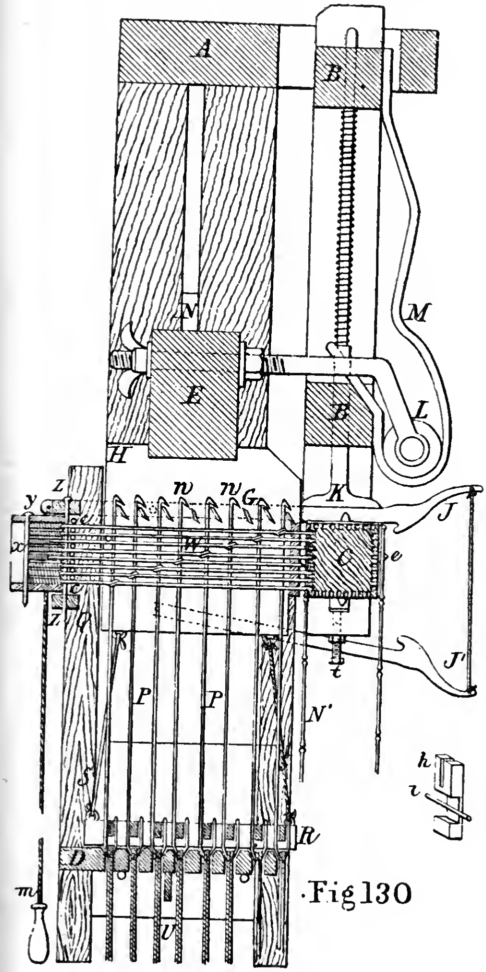


Fig 130

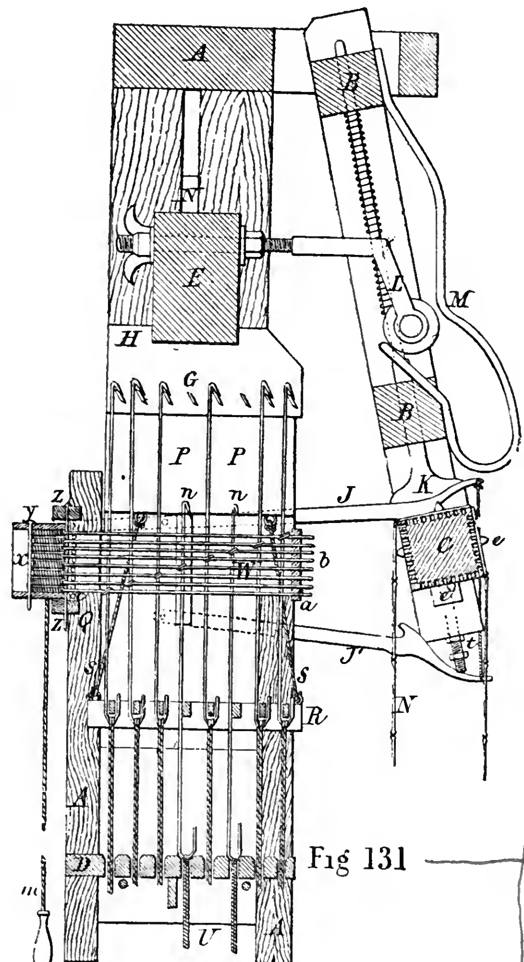


Fig 131

Not only can any one spring be taken out in case of any defect arising to it, but the whole spring box can be removed, for it is completely independent of the needles, as may be seen in the figures. The needles themselves are secured separately, as already stated, by means of the pins *z* and the wires *c*, which are inserted into a frame *Q*, as shown, and it is in this frame that the spring box is fixed.

It is of importance that the needles be kept with the eyes in correct position, otherwise, on the raising of the hooks, they would be liable to rub against the side of the eye, and "jam," thereby causing them to be bent. This bending would cause the hook to be thrown out of its perpendicular, and the result would be that upon lowering the griffe the bars would probably drop upon the top of the hook, and considerable damage would be rapidly done, if not immediately detected. Sometimes the needles wear out and break, consequently an easy method of replacing them is required. The weaver, notwithstanding the complicated mass, can readily replace them by withdrawing the pin *z*. To keep the hooks in position a wooden grate *R R* is made to fit into the lower bend of the hooks, as shown, and this grate ascends with the hooks—for it is suspended from the griffe by the cords *S S* at each corner of the grate. Those hooks which are not raised, remain in position on the bottom board, from the circumstance that the upper part of the holes upon which the hooks rest are hollowed out for the hooks to fit according to their proper position.

The "neck" cords attached to the hooks are not fastened on by a knot, but the cord is made into a double hitch, as shown in Fig. 134. If this were not so, the constant and rapid fall of the griffe and hooks would very quickly cut the knotty projections through.

This kind of fastening has also the advantage of being easily made, and in case one of the two cords were to break the other would still remain secure upon the hook.

The griffe has not only to raise the hooks as already explained, but it has attached to it a pulley *L*, which is made to slide in a curved or S bar, which is fixed to the frame or batten, in which the card cylinder turns. When the griffe is raised the pulley also ascends, and as it comes into contact with the convex part of the S iron it causes the cylinder to be thrown out from the machine or from the needles. During this motion the lantern upon the end of the cylinder, as will be hereafter described, coming into contact with the hook *J*, causes it to turn. There have been various other contrivances used instead of the S iron for the same purpose, such as knee-oint motions, which will be referred to hereafter, but for hand-loom purposes the simple S bar answers every purpose.

The griffe is shown separately, and detached from the machine, in Fig. 135. In this figure the slide *N* fixed at the ends of the block *E* are shown. Fig. 136 is an end view of same, and Fig. 137 is a plan. In the latter figure the ends of the frame *A A* are shown in dotted lines with the groove into which the slides *N N* work. This plan is often used in Jacquards for hand looms, and is approved merely for its simplicity. Fig. 138 shows another plan in common use for hand-loom Jacquards also. In this case, the slide works upon round bars fixed into the ends of the machine, in the position of the slots or grooves shown at *A A* in Fig. 137. The plan shown in Fig. 139 is that generally used for power-loom Jacquards. In this instance the griffe *E* is made of cast iron, and the slide bars are firmly fixed in the ends as shown.

Fig. 135.

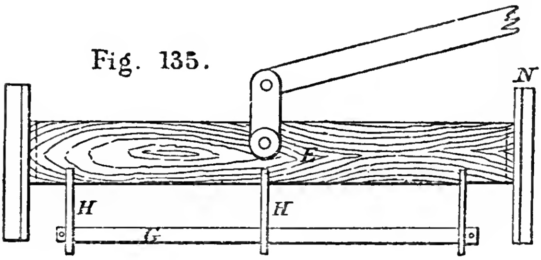


Fig. 136

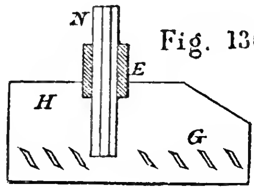


Fig. 137.

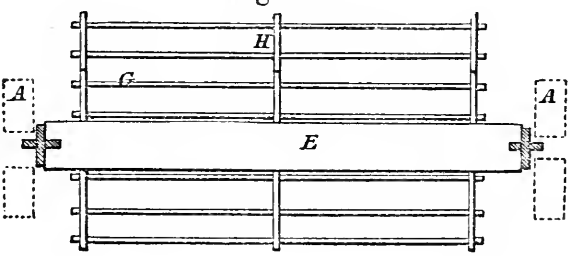


Fig. 138.

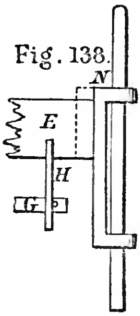
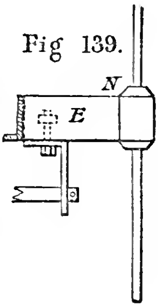


Fig 139.



This plan is by far the most perfect and the best adapted for steady and rapid motion required in power-loom weaving.

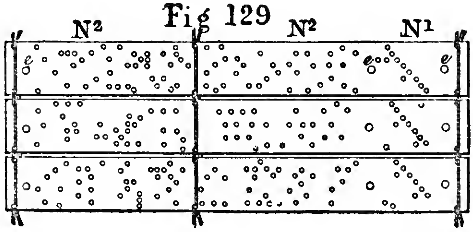
The cylinder *C*, upon which the cards revolve, is supported or carried in a "batten" or frame *B B B*, which is suspended on centre pins *T T*, Fig. 128. It has sufficient extent of vibratory motion to enable it to move the requisite distance from the needle-board *b* of the machine, and after coming into contact with the hook or catch it still moves until the cylinder is turned. In Fig. 128 a "lantern" *I* is shown fixed on the end of the cylinder *C*, which is provided with four pins, which the hook catches in order to turn the cylinder.

The action of the cylinder will be best seen in Figs. 140 to 142.

In Fig. 140 the cylinder is shown when pressing the card against the needle-board and needles. In these diagrams the catches are shown upon a different principle to that shown in Figs. 130 and 131, where they are simply catches connected with a cord at their ends. The cord *m* is attached to the top catch, and when the weaver requires the cylinder to reverse or "turn back," he pulls the handle, and it raises both the catches, thus throwing the bottom catch into contact with the lantern and reversing its motion. But for power-loom Jacquards the plan shown in Fig. 140 is preferred.

In this case the bottom catch raises the top one by means of the pin *l*, as shown by the dotted lines. Fig. 141 shows the cylinder thrown about half-way out, and Fig. 142 when it is turned a quarter of a revolution. Now it often happens that before the cylinder completes the turn, and stops on edge similar to the position shown in Fig. 141, that the edge of the cylinder would be brought into con-

Fig 129



tact with the needle-board, and produce more or less damage. To prevent this from occurring an additional catch, *V*, is placed upon the same fulcrum as the lower catch *J'*. This catch is held up by means of the spring fixed at the end of it, as shown. When the cylinder is being turned the catch *V* gives way, in consequence of the spring, and then resumes its normal position, as shown. Now, it will be evident that in the case of the cylinder being placed in position, Fig. 141, the lower pin in the lantern would come into contact with the point of the catch *V*, and would, therefore, be turned "square on."

The cylinder is kept in position by means of a presser *K K*, shown in the diagram, and this presser, or as it is technically called the "hammer," is forced down by means of the spiral spring as shown.

On referring to Fig. 129, the three cards represented show the way the cards are laced together. The large holes *e e e* are for the purpose of fitting upon the pegs *e e e* of the cylinder as shown in

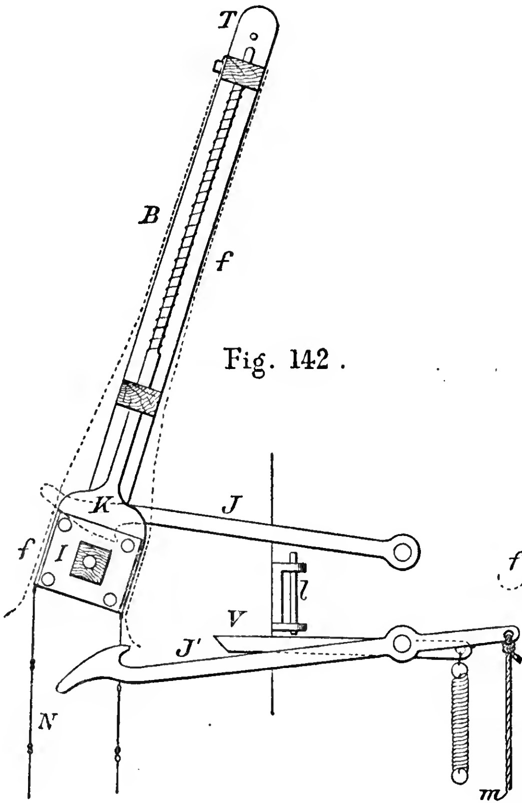


Fig. 142.

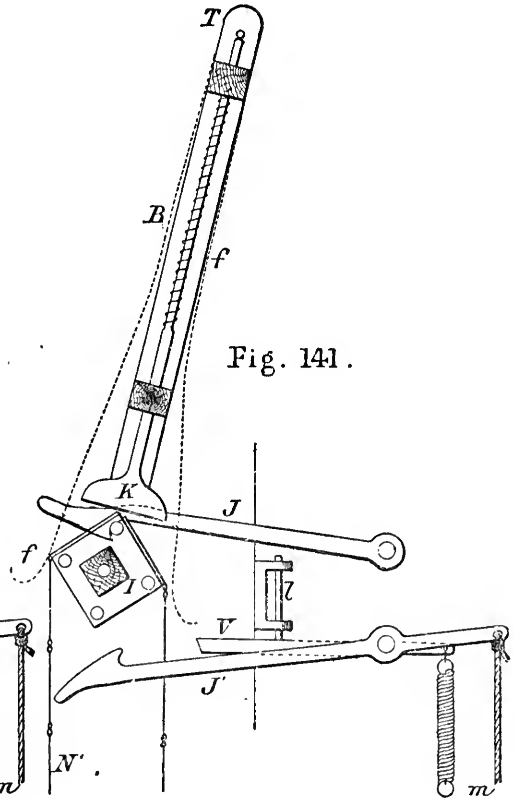


Fig. 141.

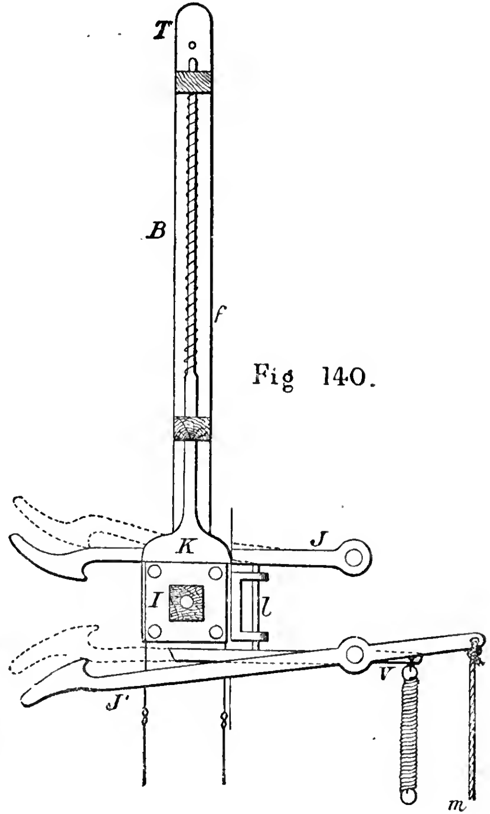


Fig 140.

Figs. 130 and 131. These pegs are made adjustable, for the slightest movement of the card would prevent its coming into exact position against the needle-board, therefore it requires very exact and sure means to press the cards against the needles correctly.

It will be noticed in Fig. 131 that the cards *N′* hang loosely, and do not touch the cylinder on the side next the needles. Thus there would be a great liability for the card to strike the needles out of its proper position. This is in power looms an important though simple matter, for the cards would be liable to stick upon the pegs, if forced against the needle-board wrongly, they would possibly get wound round the cylinder, and not only get torn or destroyed, but in their motion the needles would suffer. To avoid accidents of this kind flat springs are used, of just sufficient strength to hold the cards against the cylinder on both sides. The position of these springs is shown by the dotted lines in Figs. 141 and 142.

When not more than 100 or 200 cards are used, they are allowed to fall into a curved tin frame placed beneath the cylinder, but when larger numbers are used they are made to fold into a "festoon" form. This is done by attaching a wire about 2 in. longer than the cards at the junction of about every twenty cards. The cards fall between two curved wires, but the wires attached to the cards being longer than the cards themselves cannot pass between the curved wires, consequently the cards remain suspended, and fold together in a very compact manner.

This will be observed in the drawing of the ordinary silk loom, Fig. 143.

In Fig. 128, it may now be mentioned, that the hooks *P P* correspond to the purposes of the leashes shown at *C*, Fig. 115, and the hooks P^1 correspond to the purpose of the healds, as shown at *D* in the same figure. In the case of the Jacquard machine, now described, means for working the compound harness of the draw loom is thus provided for, as we shall hereafter find. But these additional hooks are by no means applied to all Jacquards, and they are shown here in order that a complete machine should be represented. Thus a glance at the cards Fig. 129 will show at the part N^1 a consecutive order of arrangement, while the portion N^2 is irregular. This arises from the fact that the part N^1 forms the "ground" of the cloth, and the part N^2 the outline or figure.

Previous to describing the action of the machine upon the warp, we have given in Fig. 143 a representation of a hand loom, such as is used in Spitalfields, and other figured silk-weaving districts. It will be observed the machine occupies the position of the pulley box of the old draw loom. In fact, it has simply replaced the draw loom apparatus. The lever for raising the griffe, passes over the weaver's head, and to the end of it is attached a cord connecting it with the treadle.

The needle wire is generally made of No. 15 or 16 B.W.G., and the hooks of No. 14 and 15. Formerly the Jacquard maker straightened the wire from the ring or coil, but the wire-drawer now supplies, in a much more perfect manner, the straight lengths cut as required.

The needles are placed at about $\frac{1}{4}$ in. apart. The holes in the spring-box, &c., are very truly drilled by means of almost self-acting drilling machines, and the various hooks, eyes, and bends, are made by very simple and ingenious tools which insure them to be exactly of a size, and taken altogether, with the thousands of wires, it forms a wonderfully compact and perfect machine.

There are several matters concerning the working of the Jacquard that we have purposely left unnoticed until the machine itself was described. Let it be supposed that the griffe be raised without any hooks upon it. Now when it is lowered, and the hooks are not pushed back, the inclined face of the griffe bars will strike against the face of the hook and force it backwards until the bars have passed below the points of the hooks. Then upon raising the griffe it carries the hooks up with it. Upon lowering the griffe again, let it now be desired that all the hooks should be pushed off by means of a blank card placed upon the cylinder. It will be found that the card strikes the needles before the hooks have landed upon the bottom board, consequently the weight upon the hooks adds to their friction, and they require a greater force to push them off the bars. The most perfect action would be if the griffe could be allowed to drop to its full extent before the cylinder was pressed against the needles, for it would save much wear of the needles and the cards also. But to accomplish this two motions are required, viz., a rotary motion, by a cam, or crank to raise the griffe, and another cam upon the same shaft to press the cylinder; by this means the objectionable action would be overcome. This plan has for some time past been adopted in power-loom Jacquards, as we shall hereafter describe.

In Fig. 130 at *h*, one of the brasses, into which the cylinder works, is shown. It is held in the slot made in the batten by means of the pin *i*. In Fig. 128 slots are shown in front of batten at *b b*. The cylinder is put in or taken from the batten by the gudgeons being passed through these slots. The dotted lines show the position of the brasses, and the adjusting screws to regulate their height. The screw centre pins at the top of the machine, upon which the batten is supported, afford the means of adjustment in a lateral direction. The hammer is held up by means of a small catch which is placed in a notch in the hammer bar when the cylinder is removed, otherwise the hammer would be forced out of the frame by the spring.

Jacquard machines have various names applied to them, such as "machine," "engine," "jigger," (expressive of its noise when working), &c. They are modified in a great variety of ways; but after we have shown the system of working the machine, these modifications will be easily understood.

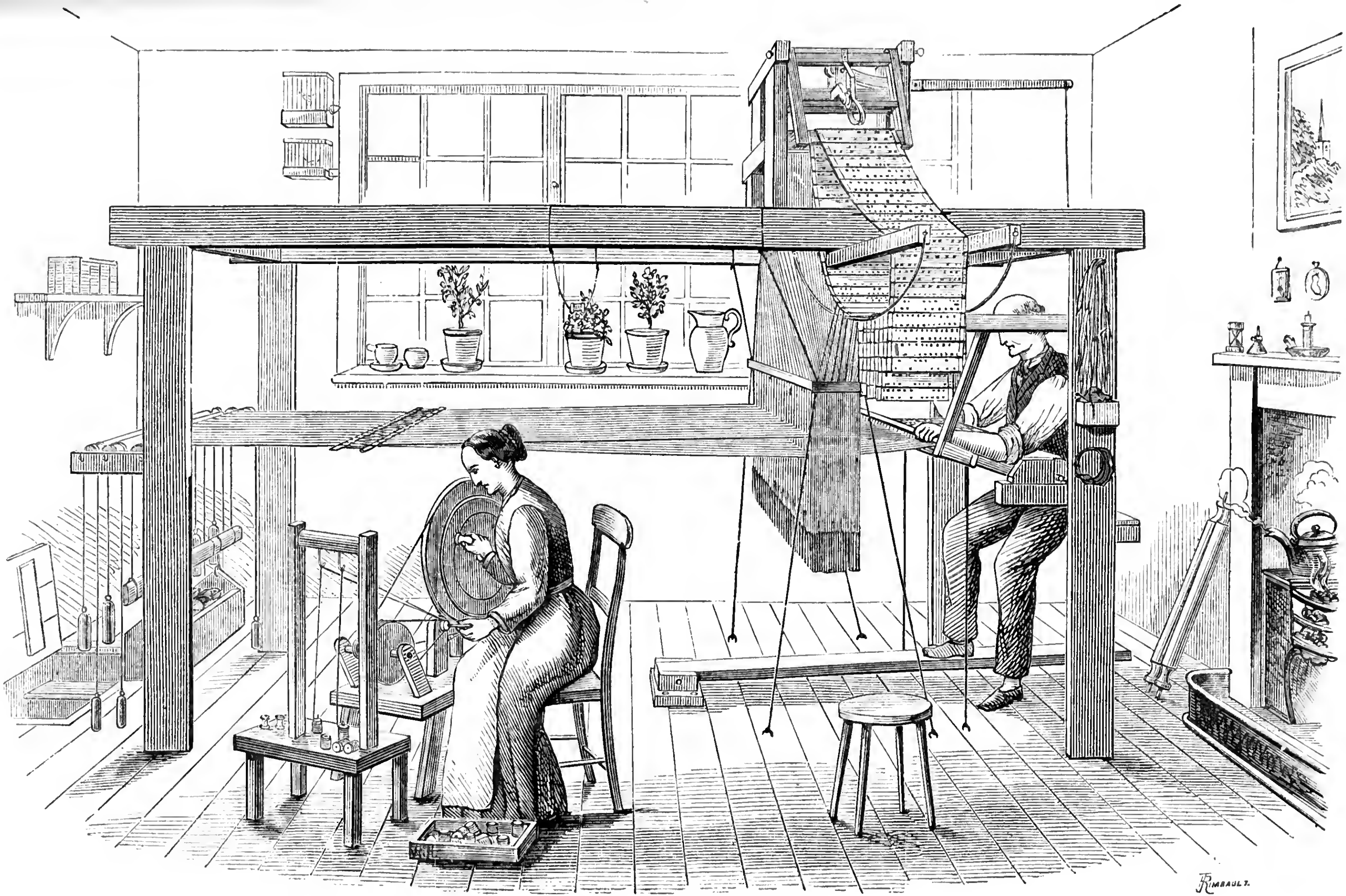
CHAPTER XIII.

THE JACQUARD HARNESS.

In Chapters xi. and xii. we have shown that the Jacquard machine is simply a frame containing a number of wire hooks, and these hooks can be raised in any required number or order corresponding to the warp threads to be raised for the passage of the shuttle and the formation of the patterns to be woven. For instance, when the selected hooks are raised, they also raise the warp threads to which they are connected, and after the shuttle has been thrown through the shed made thereby, the hooks are lowered to their former or normal position, and a fresh selection is made for the next throw of the shuttle.

Before the paper duty was taken off, the cost of cards was far more severely felt than at the present time, and many attempts were made to substitute other materials and contrivances to avoid the expense. Bands of thin paper were tried, and several other methods, which we shall hereafter allude to; but at the present time, owing to the reduction of cost, it does not appear likely that any contrivance will supplant the ordinary cards, and these are used both in single and double action machines with perfect success.

We purpose now to describe the action of the common form of


RIMBAULT

the machine and the different ways it is applied, when the purpose of the various modifications above alluded to will be easily understood.

Fig. 143 represents a common hand loom mounted with a 400-needle Jacquard, such as is generally used for the production of the rich figured silk used for gentlemen's scarves. The cloth is woven in widths from 24 in. to 36 in., but we will assume it, in this instance, to be of the narrower width. The number of warp threads vary considerably, but 400 threads per inch in width is a common number, and that would amount to a total number of 9600 threads—exclusive of the selvage—in the narrow width of 24 in.

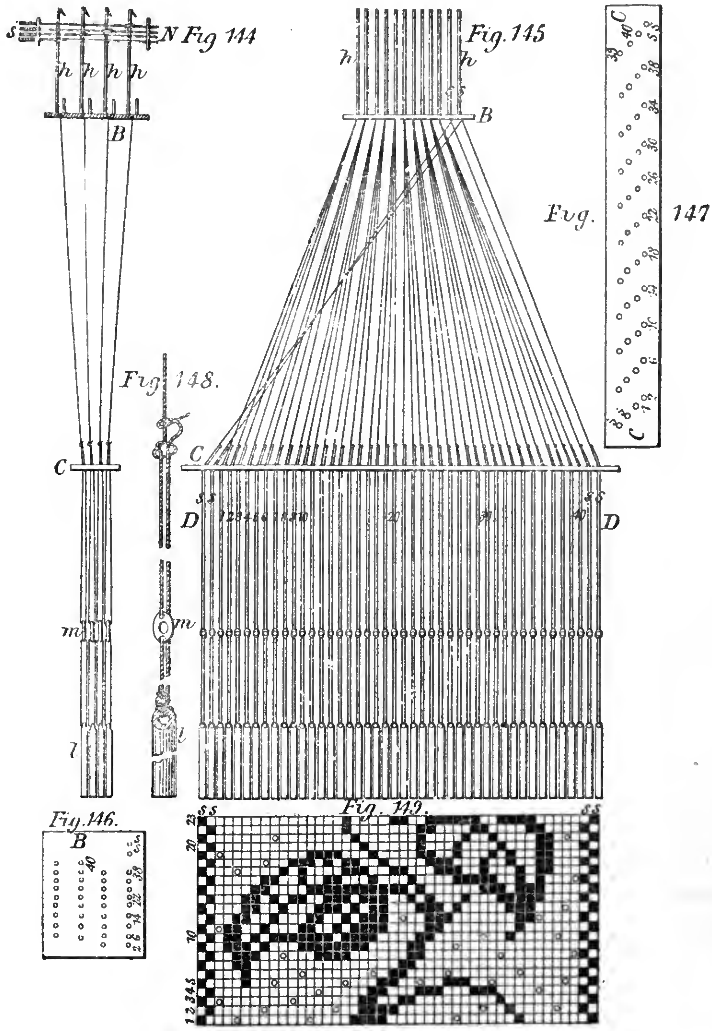
If each of these threads was provided with a separate hook it would of course take 9600 hooks—a number quite unknown in practice. But whenever a loom is supplied with a separate hook for each warp thread, it is the most perfect, and is capable of producing every form of design. The loom is, therefore, comparatively perfect when each thread has a separate hook. But as this could scarcely be carried out in practice, various means are adopted to make the loom as effectual as possible with the smallest number of hooks. The various ways of doing this may be divided as follows:—

1. A repetition of the same figure.
2. A repetition, by reversing the figure, as in weaving the two opposite borders of the cloth.
3. The use of compound harness, as already described in Fig. 112.
4. A modification of the compound harness called the "split harness."
5. Various combinations of the above systems.

Now, it will be evident that the most perfect loom—so far as its capability of weaving elaborate figures is concerned—is the most simple, for it merely consists in having a separate hook for every thread of the warp, and no complication exists such as is found in the systems above alluded to. We shall only represent one row or line of hooks in each case, so as to avoid the complication that a representation of eight or twelve rows would give rise to; also show the hooks in the most direct position to connect them with the warp threads. For instance, on referring to Fig. 143, it will be seen that the Jacquard is placed with the cards hanging over the side of the loom, but in power looms the cards usually hang over the warp. These positions require a different method of connecting the leashes or cords from the hooks to the warp threads in order to bring them in consecutive order, and to make the arrangement as direct and free as possible. There are many ways of tying up the harness to effect this, and different names are given to them, such as the "London tie-up" and the "Norwich tie," alluding to the places where they originated or were mostly in use. But whatever method may be adopted, the most direct plan is always attempted, and tying up the harness, or "building the monture" (mounting of the loom), often gives rise to a considerable amount of ingenuity on the part of the designer and weaver, for the perforations of the cards must follow in consecutive order the tying up of the harness, and sometimes this order runs longitudinally—row after row—upon the cards, and sometimes vertically. This, however, in no way affects the principles upon which the matter depends, although it is necessary that it should be stated here before showing the action of it in detail. The harness used in silk weaving is made of fine specially made thread, and soap-stone or French chalk is sometimes used to prevent the friction of the threads from wearing them away, and at the same time to prevent them sticking together, and causing defects in the weaving. Strong thread is used in power looms, and it is usually dressed so as to resemble cat-gut. This is effected by dressing or soaking it, the principal ingredients being linseed oil, tallow, and bees'-wax, with other things, according to the experience of the harness builder. When so prepared a harness will last for several years, and wear exceedingly smooth.

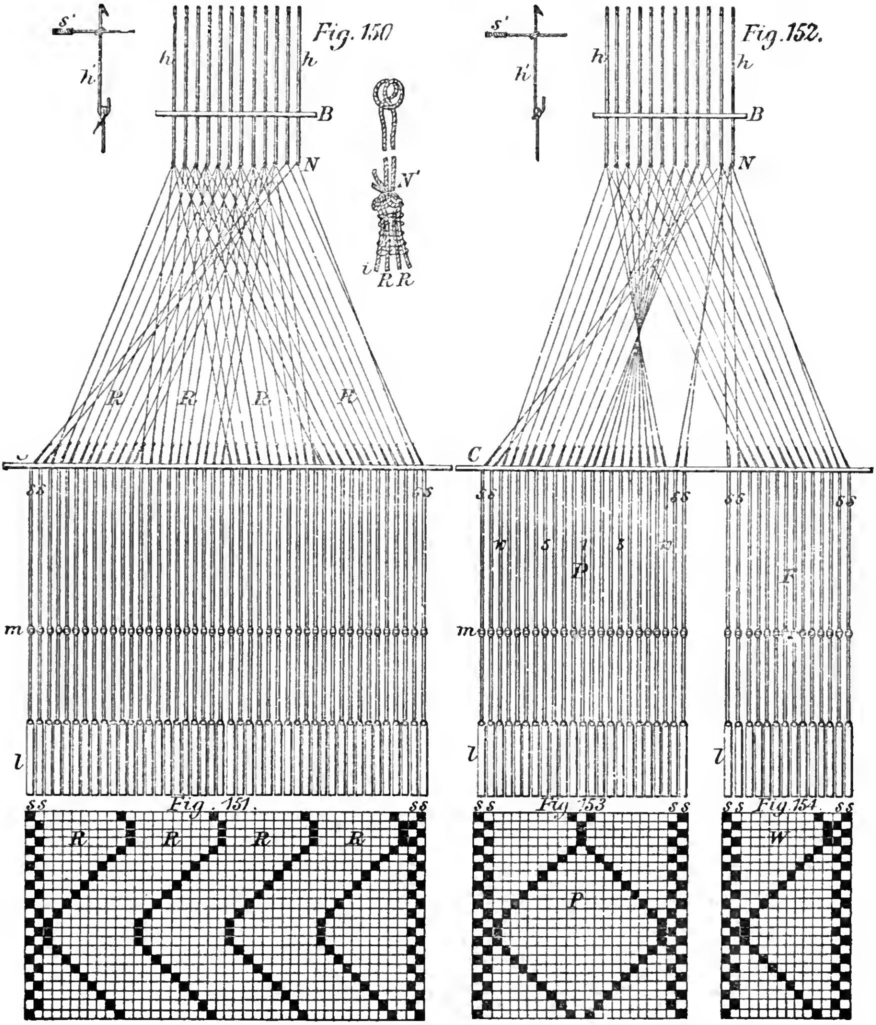
Fig. 144 represents an end elevation of a Jacquard machine and harness, and Fig. 145 is a front elevation of the same. It contains forty hooks, and each hook is connected to one thread only of the warp, excepting the two hooks which are used for forming the selvages *S S*.

They rest upon the bottom board of the Jacquard, *B*, which is the only portion of the machine necessary to represent, and the leashes which are attached to the hooks pass through the board to the comber-board *C*, where they are also passed through in the order required for the warp. The mails are shown at *m*, and the lingoes or weights at *l*. In Fig. 145 it will be seen at *D D* that the leashes descend in consecutive order, from 1 to 40; but the hooks *h h*, being arranged in four rows, require some means to connect them in the most direct manner to suit the consecutive order arranged in the warp. In this instance the hooks are numbered. See Fig. 146, which is a plan of the board *B*, upon which the hooks rest, and Fig. 147 is a plan of the comber board *C*, through which the cords pass. Now, by comparing the figure 144 to 147, in which all the letters and figures refer to the same parts, the connexion of the hooks with the mails to govern the warp may be traced.



It follows, therefore, that if any of the hooks are raised, they will also raise the corresponding warp threads, and the figure upon the cloth will be formed accordingly. Fig. 149 shows a design or piece of cloth that could be woven by the harness—the black squares may represent the warp, and the white squares the weft—and by raising the hooks accordingly the cloth may be woven. The design shows the extent of twenty-three cards, and thirteen warp threads are raised, in the last shoot, exclusive of the selvages

On the design will be noticed the small circles on the squares.



These are merely placed instead of shading the squares, in order to show that these intersections are the necessary intersections called the "ground" to give firmness or bond to the cloth, and they are drawn so as not to interfere with the rest of the figure. In this instance the intersections represent an ordinary eight-leaf satin ground, and the cards would require to be perforated for each of the intersections. A twill or satin ground of any other kind may be substituted, but fresh cards would have to be made or "cut." In compound harnesses the ground is formed by self-acting means, as we shall presently describe.

The selvage cords are attached to the hooks *S S*, and these hooks are raised alternately, as may be observed at *S S*, Fig. 149, and form a plain or "tabby" selvage. Only two threads are shown on each selvage, but it will be apparent that any number may be used by simply attaching in proper order more leashes to the two hooks *S S*.

Fig. 148 shows on a larger scale one method of attachment of the mail to the leash, &c.

It will be evident that when many thousands of warp threads are required, that other means must be used than to provide a separate hook to each thread. In weaving figured stuff cloths, having from sixty to seventy threads per inch, and in other fabrics, the harness has a number of threads attached to each hook, and in this way the pattern is repeated six or eight times across the surface of the cloth. Fig. 150 shows a harness of this kind, in which ten hooks are used, and where the pattern is repeated four times. *R R R R*, Fig. 151, shows its effect upon the cloth, for whatever figure is formed upon the cards it would be repeated four times on the cloth.

In this instance we have only shown one row of hooks *h h*, an end elevation of which is shown at *h'*. The leashes *R R* are attached to the neck cords, as shown enlarged at *N'*, where it will be seen that the leashes *R R* are stitched together in a flat form, to allow of their being raised without obstruction from the adjoining necks. The selvages are formed in a similar manner as in Fig. 145.

Fig. 152 shows what is known as a point harness, and consists in twisting or reversing the leashes in such a manner that any design consisting of two similar parts, such as a diamond or square figure of a shawl, may be woven by merely cutting half of the design or one border upon the cards. This will be understood by reference to Fig. 153 at *P*, which shows the effect the point harness would have upon the design, shown at Fig. 151. In this arrangement it will be noticed that all the hooks have two cords each, except that which governs the centre or point leash, which is a single leash to which the others converge.

At *F*, Fig. 152, it is shown that the same hooks may be attached to a separate warp or piece of cloth, and it is in this mode of separation that ribbons, &c., are woven, or where narrow figured stripes are interwoven with plain weaving. Thus the effect from one set of hooks, Fig. 152, is represented at Figs. 153 and 154.

Some idea may be formed of the manner in which weaving is generally carried on in Spitalfields at the present time from the sketch at page 159. The weaver's cottage is provided with large windows on the first floor, which is usually only one room—extending from front to back of the cottage. There are two looms generally in the room, one at each window.

The framework of the loom, perhaps, always belongs to the weaver, but the machine and harness (the Jacquard) more frequently belongs to his employer. The warp is fetched from the manufacturer's warehouse, and very often returned woven with a variety of differently coloured weft, so as to produce from the same cards such effect as may be desired.

It is often remarked of the weavers that many traces of their French extraction may be observed, especially in their fondness for flowers and singing birds. Still the English character is quite as often shown.

Formerly the Spitalfields weavers had a good reputation for various studies, such as entomology and botany, and it is not a very long time since a "Mathematical Society" was held at a house near Spitalfields market. Indeed, the well-known mathematician, Thomas Simpson, who became professor of mathematics at Woolwich, in the last century, worked at his trade as a weaver and taught mathematics to the weavers of Spitalfields. He was born at Market Bosworth and was brought up as a weaver. After working at Nuneaton and Derby, he removed to London, when he ultimately obtained the honourable appointment alluded to.

In 1765 the Spitalfields weavers, owing to the general use of foreign manufactured silks, became exceedingly riotous, and the Government were induced to prohibit the importation, which act remained in force till 1826 when a duty of 30 per cent. was substituted.

In the year 1773 an Act was passed called the "Spitalfields Act," for the settlement of wages, so as to prevent disputes between masters and workmen, and prices for weaving were fixed, at which each description of silk fabric was to be paid for in the London district. Unfortunately for the silk trade of Spitalfields this policy favoured the country manufacturers, for they very shortly competed with them, and beat them in their own markets. It was not, however, till the year 1824, that the Act was repealed, but it was then too late for them to recover their prestige; and from that time to the present the business has gradually declined. Not only was the home competition to be encountered, but owing to the reduction of the duties on foreign silks in 1845, and their total repeal in 1860, a still further difficulty was thrown in the way, and the trade of this once famous district is now but as a shadow of its former importance.

Before the Act was passed the prices paid for weaving were arranged between master and man as well as could be expected, and printed "Lists" were provided. But notwithstanding their mutual agreement disputed cases continually occurred, and the Act above named, was obtained to prevent further misunderstandings. One of the "List of Prices" was published in the year 1769, "At the expense of those manufacturers, who were subscribers for carrying on the work." It is entitled, "A List of the Prices in those Branches of the Weaving Manufactory called the Black Branch and the Fancy Branch, together with the Persians, Sarsnets, Druggets, Modes, Fringed and Italian Handkerchiefs, Cyprus and Draught Gauzes, and plain and black laced Nets."

The prices were fixed and settled by a number of masters and men on behalf of themselves and those whom they represented, and their names are given. The "List" comprises twenty-eight pages, and concludes with a curious composition of verses the last four lines of which are as follows :—

"May upright masters still augment their treasure,
And journeymen pursue their work with pleasure;
May arts and manufactures still increase—
And Spitalfields be blest with prosperous peace."

In the International Exhibition, 1873, Messrs. Norris and Co. exhibited a Spitalfields loom weaving a rich damask from the design of the late Owen Jones. There were 29,088 warp threads. The design when woven was 28 inches long, and required 9312 cards weighing 5½ cwts., for its formation. To cut these cards the design on ruled paper measured 16 feet by 9 feet 3 inches. Portraits and pictures have been frequently produced of such excellence that they have all the appearance of fine engravings.

CHAPTER XIV.

COMPOUND HARNESS FOR THE JACQUARD LOOM.

In the last chapter the method of applying the Jacquard apparatus in its most simple form was shown, and it was evident that each hook having but one thread to raise in each figure woven, that the extent of the pattern or figure was confined to the number of hooks in the machine, except in using the point harness, where an apparent advantage was obtained.

In Fig. 112, the principle upon which a compound harness is formed is shown, as applied to the draw loom for the weaving of damasks. In that instance the effect produced was that five threads were raised by each leash or cord instead of one, consequently five times the width of pattern was produced. This system suited very well for the production of table-cloths and curtains, and whenever large designs were required, but for smaller and more exact figures it was not so well adapted. The Jacquard machine is often used in exactly the same way as the draw loom above alluded to, and instead of the draw boy (as shown in Fig. 126), holding the raised threads while the weaver worked the headles, the griffe is raised with the required hooks, and held in that position until the headles are worked over. In power looms this raising of the griffe at every fifth or eighth pick, or whatever number of headles are used, gives rise to many contrivances to effect the intermittent motion with as easy and quick a change as possible.

Soon after the introduction of the Jacquard, two very valuable contrivances were applied to the harness, based upon the principle of the draw loom as before mentioned. But they have this difference, in the draw loom the drawing of the cords was done every fifth, eighth, or whatever number of picks were desired, but in the new contrivances the cords are drawn at every pick, and from two to eight times the effect of the Jacquard machine may be produced. The first is for weaving rich silk damask, and operates like the draw loom damask harness; and the second is generally used in weaving the richest silks now made, and is termed the split harness, or "shaft monture."

These two plans are peculiarly adapted for the work they are employed in, for when it is considered that about 400 warp threads and upwards, are used in each inch in width of the warp or cloth, and only about one-fifth of that number in the weft, it follows that for the intersections to be equal in the warp and weft, five threads of the warp may be raised together in order to accomplish that effect. But the richness or fineness of the face of the cloth would be lost thereby. Now it is the object of the manufacturer to keep on the surface of the cloth the fine threads, and to do so he must be able to intersect the threads separately, and not in numbers of two or upwards. Therefore he requires that the machine shall be able to raise every alternate thread if desired, or the power to intersect every third, fourth, or eighth thread as may be desired for the formation of the ground or body of the cloth. This part of the subject, however, is the especial business of the manufacturer and designer, rather than of the weaver, although the loom must be made capable ot producing every effect desired by the designer, upon whose ability the beauty and soundness of the work greatly depends.

The application of headles to the Jacquard damask loom of this description, although it is the same in principle to the headles when applied to the draw loom, is very different in other respects, as will be seen by comparing the two systems. Figs. 155, 156, and 157 represent a front elevation, a side elevation, and a plan of one row of hooks only of a Jacquard applied to this kind of harness. The same letters and numbers refer to the same parts in each of the figures. The warp W is divided into ten portions of four threads each, and each of these portions are passed through the ten mails or eyes M^1 to M^{10}, Fig. 157. After they leave the mails they are passed through eyes of the four headles H^1 H^2 H^3 H^4 in consecutive order, as shown in the same figure. These headles are raised by the hooks h^1 of the Jacquard, as shown in Fig. 156, and it is in this portion of the harness where the difference between the two looms above mentioned exists, and it displays an amount of ingenuity, when combined with the Jacquard, not easily to be surpassed.

Each headle is attached to two of the hooks h^1 by means of a cord passing under a pulley, as shown at p^1 p^2 p^3 p^4. If both the hooks attached to one of the headles be raised they will lift the headle to the full extent, but if only one of the hooks be raised, then the headle will be raised only half the distance, as will be evident on referring to the headles H^3 and H^4, in which case H^3 is raised half the distance that H^4 is raised. The eyes in the headles are made much longer than usual, and of sufficient length that when any of the headles are raised half way it does not raise the warp thread which passes through it. But if the headle be raised to the full height

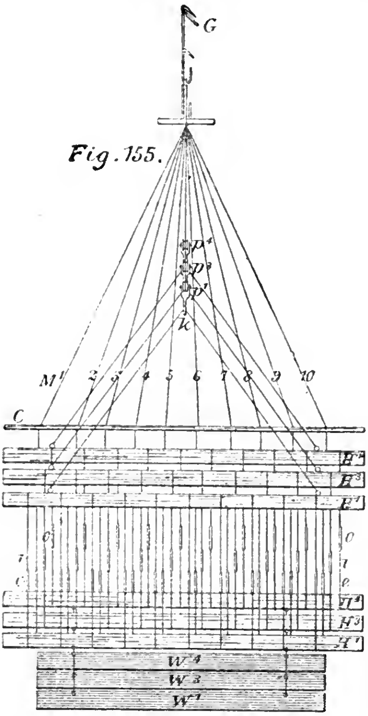


Fig. 155.

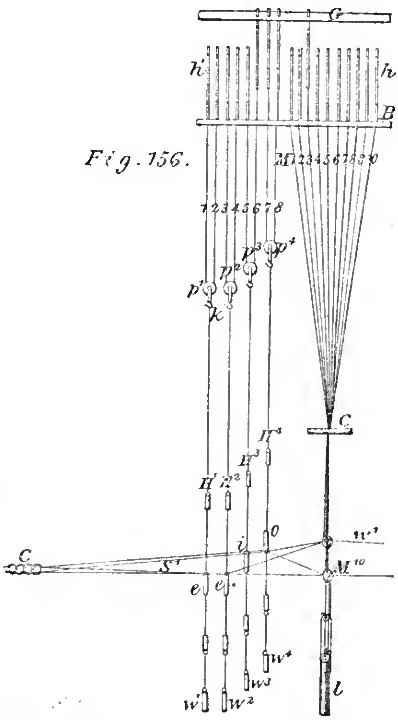


Fig. 156.

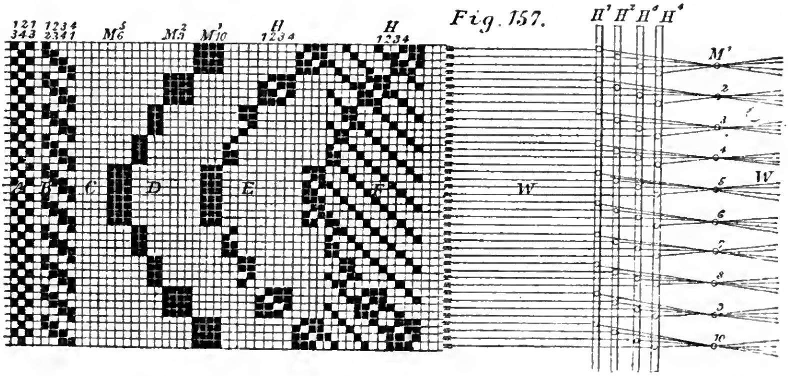


Fig. 157.

then it lifts the warp thread and forms the shed, as shown at S^1, which has been formed by the thread raised by the eye in the headle H^4.

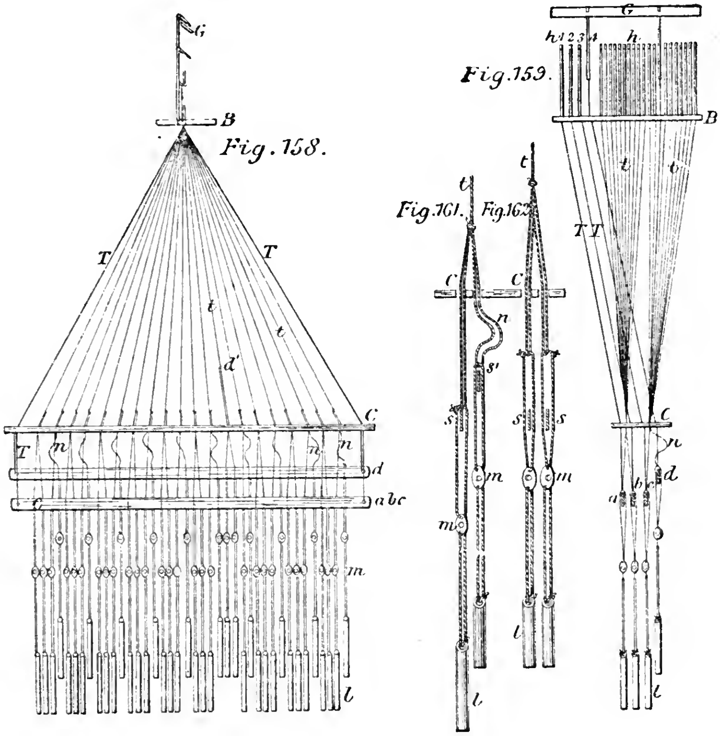
Now it will be seen that when all the headles are at their lowest position, none of the warp threads can be raised, so as to form a shed, by the mails M^{1}—^{10}. On the other hand, when all the headles are raised to their full height, the mails M^{1}—^{10} have still no effect upon the warp threads. But if all the headles be raised half high, as shown at H^{3} Fig. 156, then the mails M^{1} may raise the warp threads in any required order.

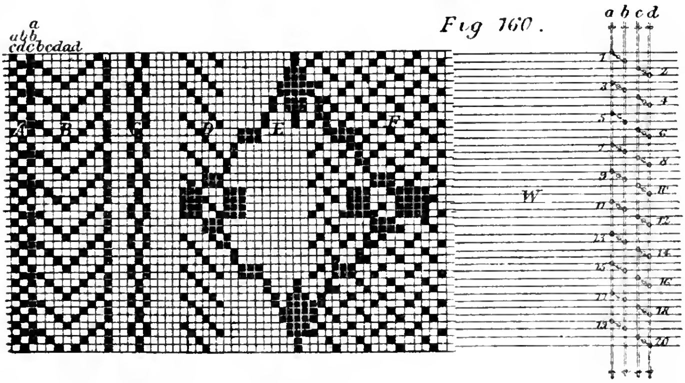
The effect of the separate and combined operation of the two harnesses may be traced to the design, or cloth, shown at *A B C D E F*. At *A* the alternate threads have been raised by means of the headles 1 3 and 2 4 and form "tabby" or plain weaving. At *B* the headles are raised in a different order, as denoted by the numbers at the edge of the cloth. At *D* the headles have been raised and held stationary, and the effect of raising the mails alone is shown. At *E* the same arrangement is shown, but in this case the headles have been depressed, singly, and in consecutive order, thus forming a twill on the surface of the figure formed by the raising of the threads by the mails *M*. At *F* the same order is not only continued as at *E*, but the headles have been raised to their full height in consecutive order as well as being lowered. Thus the outline of the figure is formed by the mails *M*, and the minor intersections, forming the ground of the cloth, are made by the headles, and whatever outline or figure so formed is made, the headles have the same effect. In this manner, according to the number of headles, any kind of twill, satin, or other ground can be made, and one design may be woven with an endless variety of effect by simply altering the order or working of the headles to form the ground either on the surface of the figure or the plain portion or ground of the cloth.

The above contrivance entirely dispenses with a separate set of treadles to work the shaft harness. To alter the ground without affecting the design the cards can be used in two sets; thus the space on the cylinder to work the shaft hooks 1 to 8, Fig. 156, may have a separate set of cards, or a small Jacquard can be worked in conjunction with the Jacquard that forms the figure.

The "shaft monture" is to dispense with the front harness altogether by forming loops in the leashes below the comber board, and inserting in them thin iron shafts, by means of which the ground could be worked without the aid of separate headles.

It appears to have been the invention of Mr. W. Rooke, of Hope Town, Bethnal Green, for he received a reward of 5*l.* from the Society of Arts in 1835, upon the occasion of his sending a model of the monture to the society. It is very probable that the society, at the time, were not aware of the value of the invention, for the reward given seems very inadequate for the services rendered to the silk manufacture by this contrivance.





Rooke also received another reward of 5*l.* for an invention to apply "swivels" to the broad loom, which being in common use we shall hereafter describe; and on another occasion he appears to have sent to the society a model of an improvement in horsehair weaving. Rooke's plan was to work the iron shafts by a small Jacquard independently of the Jacquard in connexion with the monture. But its power was more limited than the full mounted damask harness, for it could not sink any of the raised threads to bind the figure.

The split harness is an important improvement upon Rooke's invention, and it is ascribed to Mr. James Gough, also of Bethnal Green. Fig. 158 represents a front elevation of the split harness. Fig. 159 shows a side elevation, and Fig. 160 is a plan of the same. In each figure the same letters and numbers refer to the same parts.

The hooks of the Jacquard are divided into two divisions in the same way as in the damask harness, as shown at h and h^1 h^2 h^3 h^4. Each leash is passed through the comber board c in the usual way, but it is at this point where the alteration takes place. Figs. 161 and 162 give an enlarged plan of the leashes and the way the split is formed. It will be seen that the leashes t connected to the Jacquard are here attached to two separate leashes which pass through the comber board, and each of these leashes is looped through another leash s which has a mail and lingo attached, as shown at m m and l l. It follows that whenever any of the leashes t are raised two warp threads are also raised, viz., the two adjoining threads. Preferably the first and third and second and fourth may be connected so that the hooks can draw or weave tabby independently of the shafts. Through the loops of the leashes s a "shaft" or flat enamelled hoop iron bar is placed, so that when the bar is raised it lifts with it all the leashes upon it and the corresponding warp threads. In Fig. 159 four only of these bars are represented, but in practice 24 are generally used. Each bar is connected to a hook by the strong cords T, shown also in Figs. 159 and 143.

In Fig. 160 the pairs of leashes are still more clearly shown at 1, 2, 3 to 20, and the shafts a b c d to which they are looped.

Now whenever any of the hooks h are raised to form the pattern, the cloth will be woven with double threads at each intersection, and the figure can be varied to a distance of $\frac{1}{200}$ in. at each step, *i.e.*, when 400 threads per inch are used in the warp. At the same time those threads which are not raised to form the figure by the hooks h can be raised by the shafts by means of the hooks h 1, 2, 3, 4, and by raising these shafts in any desired order so the ground of the cloth will be woven. In other words, the pattern can be woven to a fineness of two warp threads at each intersection without being affected by the shafts, and the remainder of the cloth can be woven as plain cloth with every alternate thread intersected, or in twills, satins, or other required ground, according to the number of shafts that may be employed.

With four shafts and twenty pairs of leashes, as shown in Fig. 160, the effect that may be produced will be noticed at *A B C D E* and *F*. At *A* "tabby" is woven by raising the shafts *a c* and *b d* as shown. At *B* a zigzag is woven by raising the shafts in the order denoted by the letters. At *E* the pattern is formed by raising the leashes only. At *D* the leashes are raised and the shafts also, in this case the ground is woven as a single-thread four-leaf twill. At *F* the ground is a four-leaf satin or broken twill.

When the leashes are raised by the shafts the upper part of the split leash is slackened as shown at *n* Fig. 161, but it in no way causes any inconvenience in working. In Fig. 158 one of the leashes is shown raised at d^1 by the hook *h*, shown on the griffe bar *G* Fig. 159, and one of the shafts *d* is also shown raised in Figs. 158 and 159.

In the split harness, as in the shaft harness before described, a separate set of cards for working the ground can be used, so that it can be changed at pleasure. Or a small Jacquard may be worked in connexion with the larger one for that purpose. If a separate set of cards be used at one end of the cylinder to work the hooks as at P^1, Fig. 128, the cylinder is shown adapted to receive them. Although, as shown in Fig. 129, the two sets may be connected as at N^1 and N^2, and form one set of cards only. In the use of a separate set of cards for the ground of the cloth, a considerable saving is effected in the cost of the cards, for the ground requires but a few only. This saving, however, is of disadvantage to the weaver, for it gives extra trouble in working two sets.

Compound harnesses can be modified in various ways without affecting the general principle above described. For instance, if the weights W 1—4, Figs. 155, 156, are insufficient to hold down the warp threads, levers can be connected to draw the headles down, as in Fig. 71. Again, instead of using long eyes in the leashes, as shown at *e i o*, Fig. 156, *two sets* of headles with *clasped leashes* may be used, one set to draw threads down and the other to raise them. But this plan, though often used, overcrowds the loom. See Figs. 66, 357, &c.

CHAPTER XV.

TISSUE WEAVING—SWIVELS.

THE general principles upon which the harness or mounting of the loom is constructed for the formation of the figures upon the cloth having been shown, it is now necessary to describe how the same is employed when various colours of weft are to be used for the purpose of making the design to the best advantage, and with the greatest economy of materials to be used. For instance, if the warp and weft consist of materials alike in colour and texture, then the figure would show in a manner similar to the appearance of the woven figures upon white linen table-cloths, not very distinct but still quite observable. If the warp be composed of a different material to the weft, then a much greater distinctness is produced, although both warp and weft may be alike in colour. This effect may be noticed in figured stuffs, which are composed of cotton warps and worsted weft. Again, if a different coloured warp and weft be used a far more distinct appearance will be produced, as shown in coloured table-cloths.

A great variety of effect may evidently be made by varying the colours of the warp itself, by arranging it in stripes, &c., as previously alluded to; but the best effect is produced by using various kinds of shuttles, as will now be shown, when the advantages to be derived from their use will be apparent.

In Fig. 41 a loom with drop boxes for using two or more kinds of shuttles was shown for weaving plaids or other goods requiring two or more separate colours. In such cases each shuttle supplied a substantial portion of the thread or weft to form the cloth. Now, in distinction to that class of weaving there is a widely different one, viz., where separate shuttles are employed to produce the figure upon the face of the cloth resembling embroidery, and the figure so produced has little or nothing, in its texture, to do in the forming of the substance of the cloth. In fact, so distinct are the threads kept, that only just sufficient intersections are made to keep them held together. They float or flush upon the surface of the cloth rather than form a component part of its substance. It is known as tissue weaving, and the richest figured silks are produced by its means.

Let Fig. 163 represent a portion of figured silk such as made for scarves, as before alluded to. Fig. 164 is the reverse side of the same cloth. It is supposed to have been woven by a Jacquard machine with 400 needles, such as we have already described, and composed of 400 warp threads per inch in width; thus the spaces P and P' are 2 in. wide each, for in consequence of the split harness being employed, the 400 needle machine governs 800 threads or double the width of cloth, as before described.

The face of the cloth, Fig. 163, shows that the plain portion, or ground, is woven to form a twill; but any other ground, as described

Fig. 163.

Fig. 164.

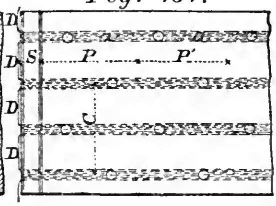
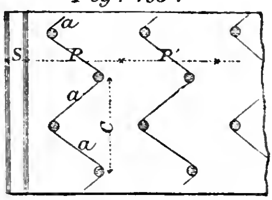


Fig. 165.



in the last Chapter, may be substituted by altering the working of the harness shafts without affecting the figure itself.

A simple circle or spot is the figure shown to be produced, but it may be designed as a flower as at A, or a running flower as at B. In either case the full width of the figure that could be woven would be equal to 2 in. or the spaces P and P', Fig. 164. The space C shows the extent or length of the pattern in this instance, which would take about 200 cards to produce. The threads D D are seen to run across the cloth with a broken appearance, which is to show that they intersect the body of the cloth at certain distances merely to bind them together, otherwise they would float perfectly loose, or "pick-overs," and detached from the cloth in the spaces betwixt the spots. The thread D D is, therefore, the thread that forms the spots, and the shuttle which has inserted it is only used in the line of spots, and is merely inserted to throw upon the surface a different colour or material to that which forms the ground of the cloth.

Now, upon comparing Fig. 165 with Fig. 164, a marked difference appears. The thread which forms the figure, or spot, in this case, Fig. 165, simply runs from one spot to another, and only the single thread as shown at *a a* travels, and it is merely the length of that one thread that is lost or of no use in the body of the cloth.

In Fig. 164, on the other hand, the floating threads at *a a* have really been thrown away, for they are of no practical use. Thus, it will be evident, a considerable saving may be effected by adopting the plan of weaving shown at Fig. 165. It is effected by the use of separate shuttles for each line of spots, and the shuttles are only brought into use where the spots are required.

There are, consequently, two methods that can be used for flushing or throwing the thread to form the tissue figure, namely, by ordinary shuttles thrown across the whole width of the cloth, or small shuttles used at the requisite intervals.

The first of these methods may be distinctly understood by referring to Fig. 166, where the piece of cloth shown at Fig. 163 is represented as it would appear in the loom. The loom is provided with two shuttles, one of which—namely, that which inserts the thread to form the figure—is seen entering the shed at *r*, the ground shuttle being in the other or lower box, but the thread leading from it is seen at *x*.

The face or right side of the cloth is woven downwards, as shown at *T*, where the corner of the cloth is represented as turned over, and, as before explained, is woven in this manner for the purpose of raising only as few of the lingoes and threads as possible at each shoot, which would otherwise have to be raised in case the cloth was woven with the face upwards. Therefore, where the spots are being formed, more threads of the warp are raised, and the thread now inserted by the shuttle, as shown, will be more exposed, and appear distinctly on the under side of the cloth. Between each spot a few threads only are shown raised, and these threads are those, before alluded to, which are required only to bind slightly together the tissue shoot with the back face of the cloth.

In the same figure the lower portion of the Jacquard harness *m m* is shown, and the comber board *C* through which it passes. The strong cords *E E* are the cords which raise the shafts *s* of the split harness. One of the shafts *s'* is shown raised, and the slackening of the leashes by so raising them is also represented.

The ordinary drop boxes for two shuttles are shown at *b b*, which are raised by the lever *d*, according to the shuttle to be used. At *H* are shown several small bobbins with a little of the various colours of the weft that may be used, that is, when several kinds are employed. They are called tokens, and are raised by the Jacquard hooks attached, so as to remind the weaver which shuttle to use. This plan is, however, only practised occasionally. At *P′* an iron bar termed a presser is shown. It is held downwards by means of the cords, shown also in Fig. 143. Temples are not required for this description of work, but a press bar cannot be dispensed with. The great number of 400 threads per inch passing between the reed are liable, when raised, to stick and not to fall back freely to their proper level. The bar has the effect of throwing sufficient strain upon them to prevent them sticking or remaining partially up, and thus allow the shuttle passing above instead of below them.

It is in this manner that rich figured silks are generally woven, and several shuttles may be used, and the figure may cover the whole surface of the cloth. But the use of smaller shuttles for the production of small figures or spots not only gives a better appearance to the figure by throwing it more prominently upon the surface of the cloth, but saves, as before observed, a considerable amount of the silk. Certainly, the amount saved is not altogether gained, for the weaver is paid considerably more wages for weaving with them; but the saving is still sufficient, besides the improvement in the appearance of the cloth, to induce manufacturers to adopt them whenever convenient.

Small shuttles are used in conjunction with the larger ones, and consist of three kinds :—

1. Small shuttles, called swivels, fitted in a movable frame.
2. Ditto, called circles, fitted in a movable frame.
3. Ditto, used separately by hand.

Fig. 167 represents an ordinary fly shuttle batten fitted with swivels, and engaged in the same kind of work as that shown in Fig. 166.

The swivels are fitted into the frame *d d*, which is simply an addition to the common batten, and can be attached to any loom. It can be raised or lowered by the lever *h*, acting upon the two levers *i i*. Upon the frame *d d* are placed two slides *m*, into which are fixed pegs, and by sliding backwards and forwards these slides, by means of the knob *k*, the swivels are moved to and fro. In this instance, the Jacquard having raised the threads to form the spots, the swivel frame is lowered, and by moving the knob k to the right hand and then to the left, the swivels may be passed underneath

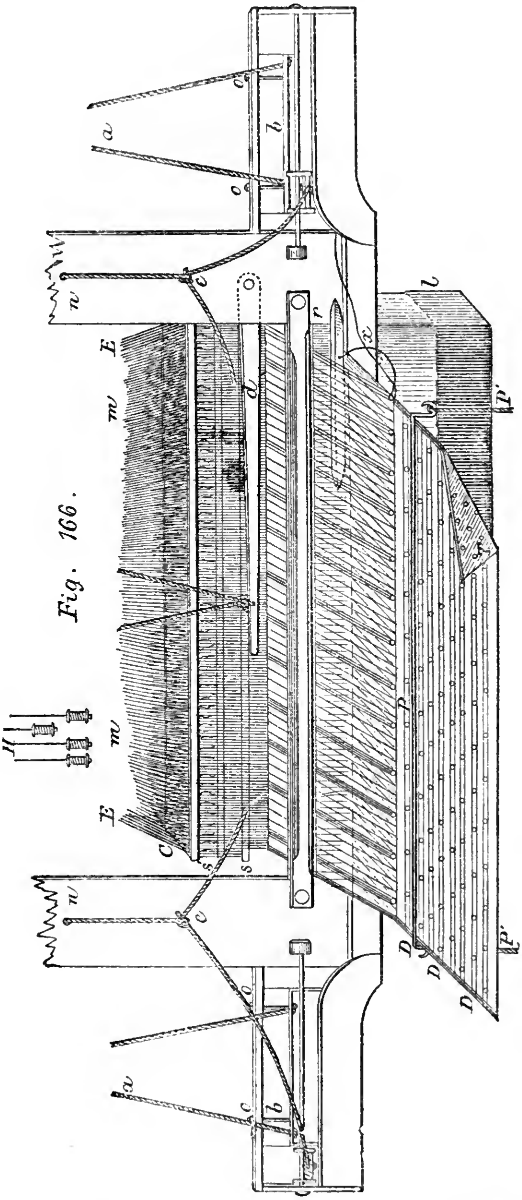


Fig. 166.

the threads the requisite number of shoots until the figure is woven —the ground shuttle being used alternately for the formation of the ground of the cloth in this process as in the former.

On the surface of the cloth several detached small shuttles are shown. Now, if it were desired to give better effect to the appearance of a figure, say the flower *A*, Fig. 163, by introducing

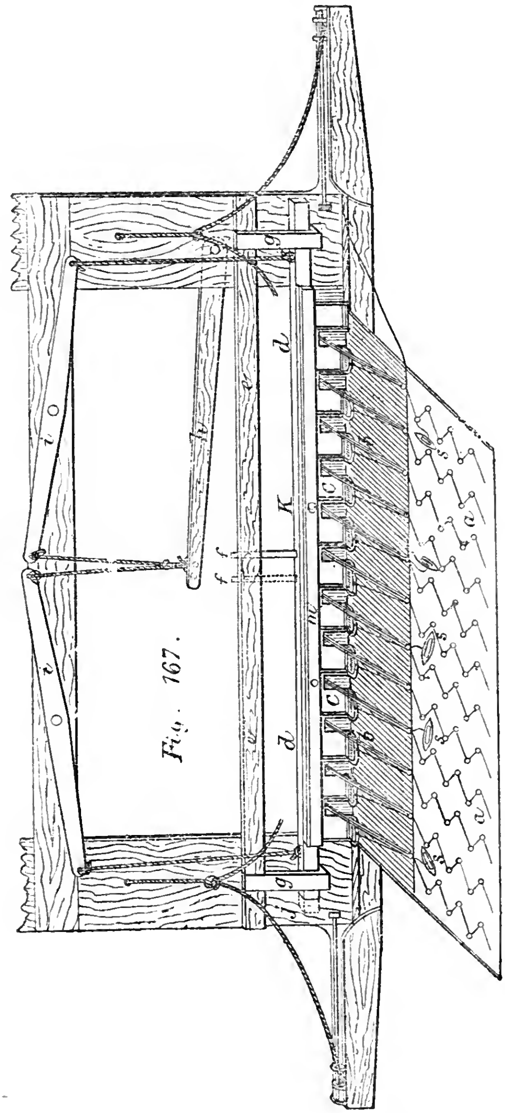
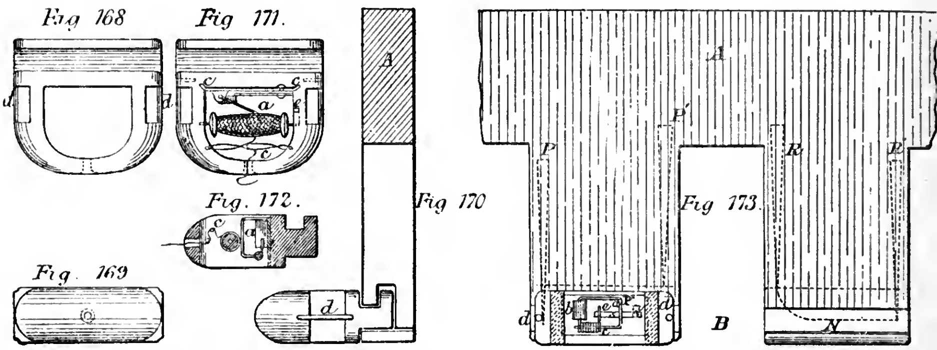


Fig. 167.

only one intersection of a different colour, then it could be done by merely passing them through by hand, as may be seen.

The frame *d d* is capable of being moved laterally, as shown at *j* and at *f* and f^1. By this means, when the lateral alteration of the position of the figure takes place, the swivel frame is moved so as to drop the swivels in the places or openings in the warp made for them. When the frame is so moved, a spring locks the peg *f* fast until the next removal. No threads between the spots need be raised in this case for binding the tissue thread, as was shown in Fig. 166, for they are not required.

In Fig. 167 twelve swivels, or small shuttles, are shown fitted in the frame *d d* fixed to the front of the batten, which corresponds to the number of spots or figures to be woven in the width of the cloth. Fig. 168 represents a plan of one of the swivels, and Fig. 169 a front view, showing the eye through which the weft passes. In all shuttles the eye is formed of china ware, glass, or metal, and is fixed firmly into the box wood, which is the material generally used for



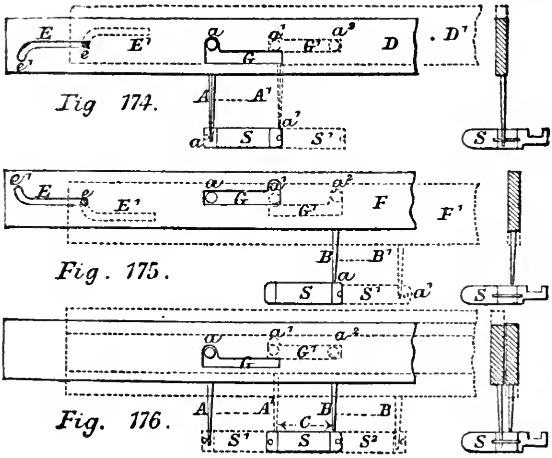
shuttles. At *A*, Figs. 170 and 173, a portion of the plank or grooved wood, into which the swivels slide, is shown.

In the former figure an end view of the shuttle is seen, with the groove and lip upon the plank and swivel. At *d* is a wire staple, seen also on both sides of the swivel in Figs. 168 and 171.

Now, on referring to Fig. 167, it will be evident that the swivel must slide freely under the raised threads, or across the space shown at *B*, Fig. 173, and it must pass without any obstruction or contact with the warp threads. This is effected in the following manner:—

There are two sets of pegs fixed into two slides. One slide by means of the pegs—there being one peg for each swivel in each of the slides—advances or pushes the swivel across the gap or opening in the plank *B*, into which the warp threads are raised, and immediately it arrives at the opposite side it is caught by the peg in the other slide bar and drawn clearly through the opening. At *P*, Fig.

173, is seen in dotted lines the position of the peg at the commencement of the movement, and at P′ is shown the same peg in its position after it has advanced the swivel, so as to land it on the opposite side *N*. When it has reached that position, the peg *R* descends behind the staple *d*, and draws the swivel completely across the opening, and of course into the same place as the swivel which has last occupied that space, but which has been pushed further on. Thus, by the combined movement of pushing and drawing the swivel and raising and lowering the pegs, the operation of throwing the swivel, or shuttle, is not only effectually done, but it cannot stop in its course. If the movement were to be so imperfect as to cause any stoppage of the shuttle during its passage across the opening,



it would often give rise to serious damage to the warp, for it would be "trapped," or stick between the threads, and on the next blow of the batten the threads would be cut or broken.

The slides into which the pegs are fixed are moved by means of a peg working into a groove formed in each of the slides. When one slide has been advanced to the appointed distance, it is stopped, and thrown out of gear or contact; at the same time the other slide has been held stationary, and then thrown into gear or contact.

This will be understood by referring to the diagrams Figs. 174, 175, and 176. Fig. 174 shows the first slide in elevation and section. *D* shows its position at the commencement of its motion, and *D*′, in dotted lines, the termination of its motion. The peg *a* is shown as working into the groove *G*, and is in the slot at the commencement of the groove. Now, on moving the peg from a to a^1, it will carry with it the bar D to that distance, but no further. The bar at this point rises, and the peg, being released from the slot, continues its course to the end of the groove G, and terminates its motion at a^2.

Fig. 175 represents the second bar, which is placed behind the bar Fig. 174, and it is made with the slots in a reversed position. Both bars are worked by the same peg a (seen also at K, Fig. 167), but are shown separately in Figs. 174 and 175, but in Fig. 176 they are shown in connexion. It will be evident that (see Fig. 175) when the peg a is moved from a to a^1, the bar F will remain stationary, for the peg is traversing the groove during that time, but when it arrives at a^1 the bar falls, and the peg, entering the slot, carries the bar forward to a^2. The pin a, therefore, by being moved backwards and forwards, causes the two bars to be moved as required for the movement of the shuttles, which is represented in all the Figs. 174 to 176 at S.

In Fig. 174 the peg A is shown to have moved the shuttles to the position S^1, and in Fig. 175 the shuttle is carried further on by the peg B to the position shown at B^1. The combined action of the pegs is seen in Fig. 176, where the shuttle is represented in the middle of its traverse, or at the point to which the peg A has pushed it, and the peg B commences its motion to draw it the remaining distance.

In Figs. 174 and 175 a peg e is shown working into the slot or groove E. There are two grooves in each bar, one at each end; but only one is shown in the diagram, to avoid complexity. The groove in the bar F is curved in a reverse manner to the groove in the bar D. The purpose of the peg e and the groove E is that they not only assist in raising and steadying the bars when moved by the peg a, but when each bar has traversed its allotted distance, the pin e prevents the pin a from carrying the bar too far. This may be observed by referring to Fig. 174, where, in moving the peg a to a^1, the slot E has advanced to E^1, and the peg e, being stationary, has prevented the bar being carried farther through, the slot e^1 having arrived at the pin. The slot being curved, of course corresponds with the motion of the traversing pin a, and assists in the vertical motions of the two bars.

The details of the swivel are shown in Figs. 171 to 173. Fig. 171 shows a plan of the swivel with the weft bobbin fixed in it, and Fig.

172 represents a section of the same. Both figures are about two-thirds full size.

The bobbin is fitted upon a wire spindle, one end of which is inserted into a hole, and the other end into a slot or groove, shown by the dotted lines at *e*. The bobbin spindle is held sufficiently firm in the groove by means of the presser *a*, which presses against the bobbin, and not only holds it in position, but the friction caused by the pressure prevents the thread from being unwound too easily. Another view of the spring and presser is shown at Fig. 172, a thin brass plate which is firmly fixed into the back of the swivel by means of the ends being inserted into saw cuts, as shown at *c c*, Fig. 171. Upon the plate there is a boss (Fig. 172), through which a hole is drilled for inserting the presser *a*. The presser is formed by turning a spiral tube at one end of a fine wire, and after passing the long end through the boss in the form shown, it is inserted into the wire tube to give the presser sufficient rigidity. The other or short end of the wire forms a stud, against which a thin flat spring *s*, which is rivetted at *n* to the brass plate, presses.

These pressers are of various forms, but the one shown, being easily made, can be repaired by the weaver when out of order, and well answers the purpose it is intended for.

At *c*, Figs. 171 and 172, the weft thread is seen to pass between a loop made of horsehair, which is fastened to the shuttle through holes bored at the sides.

The purpose for using the horsehair is of some importance, for it not only, by the slight friction it gives upon the weft thread, keeps it in position, but by the weft being properly inserted between the loops by slightly twisting the hair, as shown at *c* in Figs. 171 and 172, it has a tendency to take up or coil the slack of the weft. But this will be better understood when the details of the circles or modification of the swivel is shown, and which will be next described.

CHAPTER XVI.

CIRCULAR SWIVELS—LAPPETS.

THE small shuttles called "circles," are an elaborate substitute for the simple swivel, over which they have certain advantages. In the first place they can be put into less compass, consequently more can be employed in a given width of cloth. Two sets may also be employed by placing them back to back, thus being able to use two kinds of weft with them. With swivels this would scarcely be possible owing to their greater size, although, when first introduced by William Rooke (the inventor of the shaft monture), he placed two sets of swivels back to back in this manner. Circles appear to be a French invention, and are generally made in Lyons or Paris. They are sometimes entirely composed of metal—brass and steel—and they are fixed to the front of the batten, opposite to the reed, in the same manner as the swivel frame. They are lowered down into the shed in the same manner, and are used in every way the same and for a similar purpose as the swivel.

The principle of their action consists, as their name implies, in moving in a circular path, the shuttle itself being formed something like the shape of a horseshoe, upon the front of which is placed the weft bobbin. The warp threads being raised through the opening and into the centre part of the shuttle, it is then revolved by means of a rack motion, which, when in proper order, works exceedingly easy, and is very suitable for the purpose. In addition to this, the bobbins are made to work in a perfect manner, for the weft thread has not only a constant amount of tension put upon it, but the slack is drawn back to the extent of several inches with ease.

These circles are more costly than swivels, and require great care in using them, which may account for their not being so generally adopted.

Fig. 177 represents the front of an ordinary batten with fly shuttle, similar to that shown at Fig. 167. At the front and upon the swords

m m are screwed two brackets, through each of which a sliding bolt is made to work freely. At the lower part of the bolts there is a slot or pocket, into which the bar a a' fits. At the end a' the upper part of the slot is open, to allow of the bar being taken completely out or to be moved laterally, and there is a knife edge at the bottom

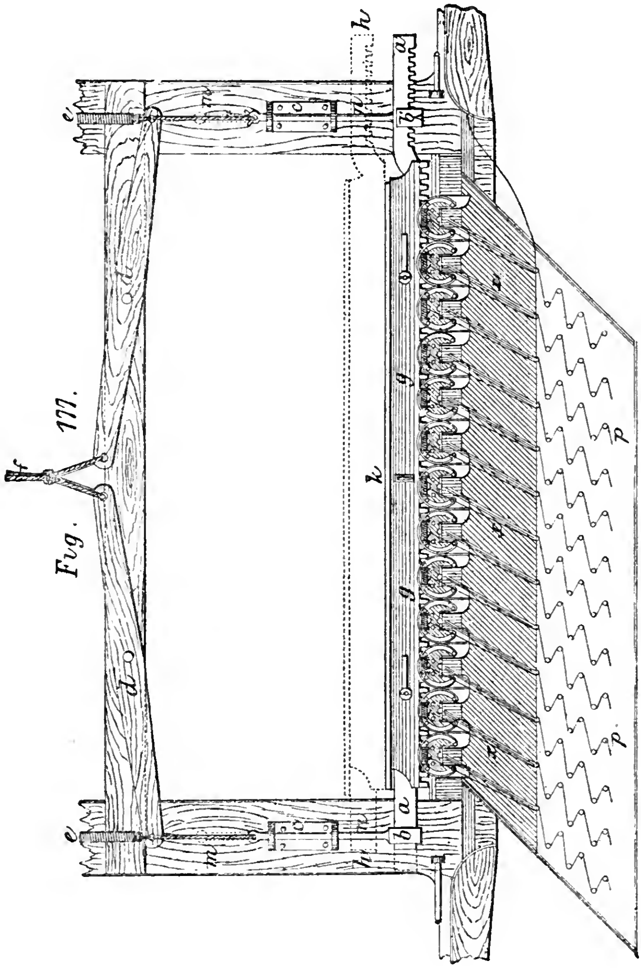


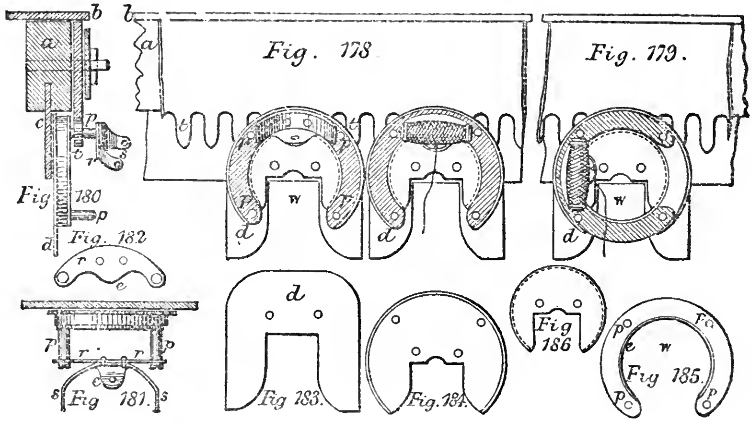
Fig. 177.

of the slot b', upon which the notches in the bar at a' may rest. These notches are simply for the purpose of adjusting or regulating the lateral position of the circles when weaving the spots.

The bar a a' is shown as lowered down into the shed by means of the two levers d d. The cord f is fastened to a hook in the Jacquard, so that whenever the hook is raised it depresses the bar *a a′* to the position shown.

Now by moving the knob *k*, which is fixed upon the rack plate *g g*, the circles are made to revolve completely round the raised warp threads *x x*, and when the Jacquard is next lowered the hook attached to the cord *f* is lowered, and then the bar *a a′* will be lifted by means of the springs *e e* clear of the shed, ready for the fly shuttle to be used for the formation of the ground of the cloth, as before described in the case of the swivels.

The zigzag or diagonal position of the spots or figures *p p* are the same in this instance as in Fig. 167, and when the bar *a a′* is moved laterally, to correspond to the shed, the particular notch at *b′* is



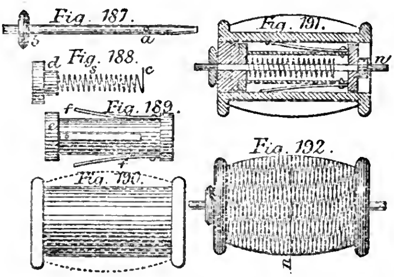
selected, and the bar is dropped upon the knife edge before mentioned.

By having a number of notches, as shown, these positions may be made gradually, and thus may produce a running figure, such as shown at *B*, Fig. 163.

Fig. 180 shows a half-sized section of the bar *a a′*, upon which the circles are placed. It is composed of a wood bar *a*, upon which is screwed the brass plate *b*. A plate *c* is fitted into the wood *a*, upon which the plates *d d* (see also Figs. 178 and 183) are screwed.

Upon these plates the frame plates carrying the circles are secured, which have flanges turned up round the edges to keep the circles in position, as seen at Fig. 184, which represents a plate, and Fig. 185 a circle or shuttle. There is a rebate *e* sunk in the inside edge of the circle, into which the cover plate, Fig. 186, fits, to hold it loosely in position on the frame, Fig. 184. There are four pins *p p p p* fixed to each circle, as shown in Figs. 180, 178, and 185, which being geared into the rack teeth *t*, Fig. 178, cause the circle to be revolved when the rack is moved. Thus, Fig. 179 represents a quarter revolution of a circle only, but by continuing the motion of the rack a whole revolution can be made, and in this manner the circle revolves to the right or left, according to the motion of the rack, and when the threads for the formation of the spot are raised, they occupy the centre of the circle, as shown at *w*, Figs. 178, 179, 185, and the bobbin is thereby passed beneath them.

The bobbin spindle is held firm enough to prevent its turning in the bracket *s*, Figs. 180 and 181, which is secured to a plate *r r* fixed upon the pins *p p*, see Figs. 181 and 182, and the thread passes from



the bobbin through the eye *e*, which is made in the lower side of the plate *r*, Fig. 182.

The bobbin and spindle is a very neat and ingenious contrivance, and is represented considerably larger than full size in Figs. 187 to 192. Fig. 187 is a spindle upon which is fastened a brass disc *b*, and there is a hole drilled through the spindle at *a*. Fig. 188 shows a double collar to which is attached a thin wire spring. The collar is made to fit loosely on the spindle, Fig. 187, and the end *c* of the wire spring *s* is inserted into the hole *a*. Fig. 189 is a barrel, which is fitted with four weak springs in the manner shown at *f f*, and the collar *e* is bored to fit tightly upon the collar *d*, Fig. 188. Fig. 190 is the bobbin, the dotted lines representing the outline when filled with weft. The bobbin fits upon the barrel, Fig. 189, and the springs have just sufficient power to cause a slight friction when the thread is drawn off.

Fig. 191 shows a section of the bobbin when fixed upon the barrel and spindle, and the barrel is there shown fixed and held in position by the nut *n*.

Now it will be evident that if the weft thread be drawn as at *n* n^1 Fig. 192, the spring Fig. 188 will give way to its full extent, but if the thread be drawn beyond the power or stretch of the spring, then the friction of the springs *f f* upon the barrel will be overcome and the thread be unwound; but the spring Fig. 188 has the effect of always taking up, and therefore keeping in tension the irregular strain upon the thread caused by the various motions of the circles. The thread may be unwound and rewound in this way several inches without the barrel springs *f f* giving way, and thus cause an equal tension of the weft thread during the process of weaving, which is a matter of great importance in the production of all woven fabrics.

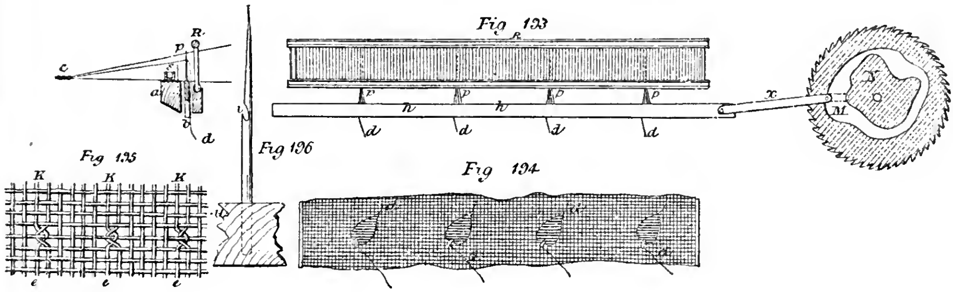
In using either the swivels or the circles, the operation being the same, they may be raised or lowered by means of a lever as at *h*, Fig. 167, or by the Jacquard as at Fig. 177. The reed and batten is in no way affected by the application of either contrivance, with the exception that the weaver holds the batten by either an extra cap or by the top piece of the frame *e e*, Fig. 167, instead of the cap over the reed, for it will be evident that the position of the slides, &c. at *d d*, Fig. 167, would prevent him from holding the batten in the usual way.

Swivels have been repeatedly worked upon power looms for the production of silk spots, or figures upon alpaca and stuff dresses, and attempts have been made to work them at the same time that the ground shuttle was being worked. To do so, it requires that two separate sheds should be made by raising the warp threads for the swivels at a higher level than usual, whereby both ground shuttle and swivels could pass at the same time. See Fig. 300.

Before swivels were introduced, a system of weaving was used for producing figures upon the surface of the cloth by means of needles placed in a sliding frame. Each needle was provided with a separate thread, and when the shed was opened for the passage of the shuttle the needle frame was raised so that the threads could be intersected by the weft thread with the body of the cloth. But it is evident that the threads could only be bound at the edges of the figures so formed, and they consequently hung loosely or floated on the surface. Two or more bars could be employed in this manner, so as to extend the design. They were placed immediately in front of the reed, so that the shuttle could pass in front of them, a row of wire pegs being placed so as to prevent the shuttle touching them. They were raised when required in a similar, although a reverse manner, to the lowering of the swivels. The pattern was formed by means of a ratchet wheel, placed at the end of the batten, and a groove in the side of the wheel was cut in such a manner, that when it had completed a revolution the pattern was woven. Thus the operation was repeated, and the figure formed without aid of the Jacquard or other machine for producing the figure. This plan, applied to ordinary power looms, is at present much used in Scotland, and known as lappet weaving.

Fig. 193 will show the principle upon which it is worked, and represents a front elevation and section of the lappet frame with four needles only fitted to a loom. In both figures the letters refer to the same parts.

The needles *p p* are fixed in the guide or bar *h h*, and each needle has a thread *d d* passed through the eye near the point of the needle.



When the frame is raised the needles pass through the warp at the back of the shuttle *s* and guide pins, but in front of the reed *R*, consequently on the passage of the shuttle the needle thread is bound in the cloth by the weft thread. The frame is then lowered, and moved right or left as desired, and again raised, and so the figure is produced; but the threads, as before stated, are only bound or intersected at the edges of the figure. The lateral motion to form the figure is regulated by the groove *M* in the ratchet wheel *N*. The pin upon the end of the connecting lever *x*, being worked alternately from side to side of the groove, regulates the distance of the traverse of the needles; in fact the groove is really the development of the pattern, and a fresh one is required for every new pattern. The ratchet wheel moves one tooth for each pick of weft, and contains as many teeth as the extent or length of the pattern.

Grooves may be placed on the circumference of a drum cylinder in like manner, or two or more grooves and needle bars may be used. The threads *d d* are supplied from a beam or beams beneath the loom, and Fig. 194 will show the kind of work produced—where the threads float from side to side of the figure without any intersection with the cloth—although the pattern may be so arranged as to make intersections to a small extent in the intermediate distances.

At Fig. 195 a modification of the lappet apparatus is shown. In this case the needles were not supplied with separate threads, but when the shed was raised certain threads were left down, so that when the needles were drawn across the under surface of the cloth they came into contact with them, and after carrying them a given distance the needles were then raised and by means cf a notch cut in the side of the needle, the threads were also raised out of their normal position. This plan caused a kind of cross weaving something similar to gauze weaving, and the effect produced may be represented in Fig. 195, which shows that the warp threads *e e e* have been raised and occupy the place of the warp threads *K K K*. The needles were formed, as seen in Fig. 196, and were inserted in a slide bar similar to those before described. The notch *i*, during the lateral motion of the needles taking hold of the warp threads purposely left down for them, carried them laterally the appointed distance, and then raised them to form the crossing of the threads.

In this way one or more threads could be moved and crossed by each needle, according to design made by means of the Jacquard or other similar contrivance, but in the figure only one thread has been moved by each of the three needles used in the space represented.

Numerous modifications of the above systems have been made with more or less success, but the simple swivel and circles as described seem to answer every purpose in a most effectual way, and are generally used for weaving small figures.

CHAPTER XVII.

CROSS WEAVING.

PREVIOUS to the application of the Jacquard apparatus to lace machinery, gauze and net weaving was much practised, but at the present time it is not so often used in silk weaving, although it may at any time be again extensively employed, as very beautiful fabrics can be produced by it.

There is one purpose to which it is often applied which is of considerable advantage — viz.: to form artificial selvages to cloth when woven in wide widths, and afterwards cut up into narrower pieces. Brunel (Sir M. I.) so far back as 1802 took out a patent, No. 2663, for weaving narrow fabrics by cutting wide widths, in which he says, "in all cases adopted to prevent its ravelling out in washing, and of any breadth not exceeding ten inches." As no drawing accompanies the specification, the description is not very clear, but it does not appear that he used cross weaving, or gauze, as at the present time.

Cross weaving, as its name implies, enables the weaver to twist the warp threads more or less around each other, after the manner of lace, but more limited in extent. It is called *gauze*, a name supposed to be derived from Gaza, a city of Palestine, where this method of weaving is said to have been originated or practised.

Fig. 197 *A, B, C, D*, represents four kinds of gauze. The warp threads of the first are marked *a* and *c*. The threads *a a* will be observed to twist alternately from one side of the threads *c c* to the other, and at each crossing they are held in position by means of the weft threads *w w*, which intersect them at the crossings.

In the second example, 197 *B*, the same process is gone through, but with this difference, every alternate thread twists the reverse way. This, however, is merely a matter of arranging the harness. The third, 197 *C*, shows the thread *a a* exactly the same as in the first; but in this case, instead of its twisting round one thread only, it twists round three, as will be seen on referring to the figure.

Now in each of the cases shown the cross thread, or "whip," as it is called, merely twists half round the adjoining thread or

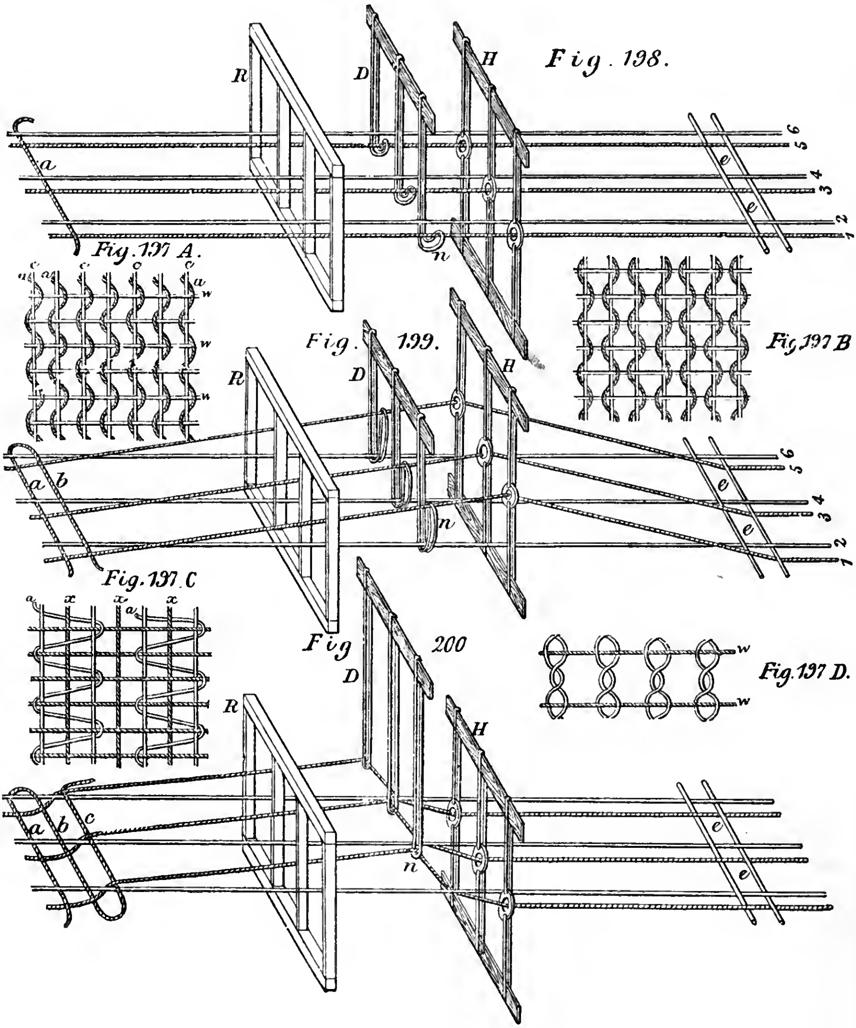


Fig. 198. Fig. 199. Fig. 200. Fig. 197 A. Fig. 197 B. Fig. 197 C. Fig. 197 D.

threads, and not a whole turn. But in the example 197 *D*, the threads are shown to make a complete turn or twist round each other, and are held in that position by the weft threads *w w* as in the former instances.

The principle upon which the cross or twist depends will be best shown by means of the diagrams, Figs. 198, 199, and 200. The numbers and letters refer to the same parts in each figure.

In Fig. 198 six warp threads only are shown numbered 1 to 6. The threads 1, 3, 5 are passed through mails in the leashes of the headle *H*, and thence through loops called "doups" fixed to a headle, as shown at *D*. These doups will be noticed to pass beneath the threads 2, 4, 6.

The warp threads pass forward through the reed *R*, and thence to the cloth beam, which, however, it is not necessary to show. By this arrangement the threads 1, 3, 5 are passed through two eyes, in the headles, but the threads 2, 4, 6 are passed through none whatever, and are merely held in position by the lease or cross *e e* and the reed *R*.

Fig. 198 shows the warp at rest, or in its normal position. Fig. 199 shows the headle *H* raised, and the weft thread *b* passed through the shed formed by the headle. Fig. 200 shows the headle *H* lowered to its first position and the doup headle raised.

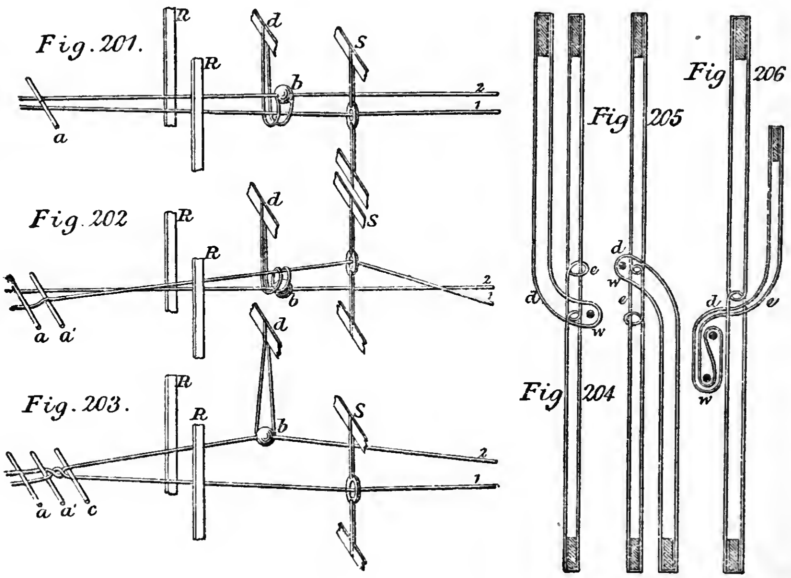
Now it will be observed in Fig. 200 that the doups have drawn the threads 1, 3, 5 underneath the adjoining threads 2, 4, 6, and consequently effect a half twisting of the threads, as may be seen at *c*. This, therefore, when repeated, is the simple process of cross weaving, and we have now to follow it through various modifications, but still dependent upon the principle shown.

Figs. 201, 202, and 203 show how the threads are made to twist completely, or a whole turn, round each other. It is effected by carrying the doup not only under the thread 1, but over it, and then to clip the thread 2. In this case beads are shown at *b*, in each of the figures through which the warp and doup threads pass. But beads are not used now, having been dispensed with many years ago. Still, they had certain advantages, and it may be as well not to omit showing them in this instance, although the complete twisting of the thread as shown can be effected just the same without the beads on the doups.

As in the case of the half twisting of the threads last shown, the complete twisting is accomplished by first raising the headle *S* and then the doup headle *d*, and the twisting so effected is held in position by the weft thread shown at *a a′* and *c*.

R R represents two of the dents of the reed; and it may be here noticed that all such threads in gauze weaving intended to cross each other must pass through the same opening in the reed, otherwise they could not be twisted. The distance between the dent or teeth of the reed in practice may be one thirty-fifth or one fortieth of an inch only, although we are compelled to show them many times that distance apart. Therefore, when it is remembered that the threads lie so near together, the care required for working of the doup leash will be better understood.

But notwithstanding the apparent simplicity of the operation of gauze weaving, as above represented, there would be found in practice a difficulty in keeping the doups in order, for, as shown, they hang loosely from the headle, shaft, or lath, and have no strain



or tension upon them similar to an ordinary headle, which is provided with a shaft at the bottom as well as the top of the leashes. Certainly when beads were used they gave a slight amount of tension to the doups, but to overcome the difficulty in order to work the loom as fast as this kind of weaving will allow, a plan is adopted of using an additional headle merely for the purpose of supporting and guiding the doup leashes, and has nothing to do with the twisting of the threads. Let Fig. 204 represent an ordinary headle with eye below the knot *e*. Then the doup leash *d* is shown to pass through the eye in such a manner that it cannot be separated from the headle, for it is linked in the bottom loop of the eye. Now the whip thread *w*, shown in section, is held by the doup against the side of the eye, but the doup cannot draw the thread any further, although the whip thread, when the doup is slackened, may be moved to some distance from the eye. Fig. 205 shows a set of doups attached to the lower shafts of the loom, so that rising and falling sheds may be used, as in plain weaving. Fig. 206 represents the doup for effecting a complete twist to the warp threads when attached to a clasp leash. In each instance the doups are arranged upon a shaft, and it follows that the whole of them must work at one time, consequently nothing but plain gauze either in continuous or broken lengths could be woven.

In Fig. 206 the doup leash *e* does not clasp the eye at *a*, as in Figs. 204 and 205, consequently should the whip thread to which it is connected break, the doup would become loose from the standard, and would have to be replaced. This, however, was the plan used before the method of clasping them was adopted.

In figured gauze weaving it is necessary that any single doup or any assortment of them, or the whole of them may be brought into use whenever required, otherwise figured gauze could not be produced.

By describing how this is accomplished in the Jacquard loom, the principle of the action of Figs. 204 to 206 may be easily understood, as gauze work is produced by it in a peculiarly simple and ingenious manner.

Fig. 207.

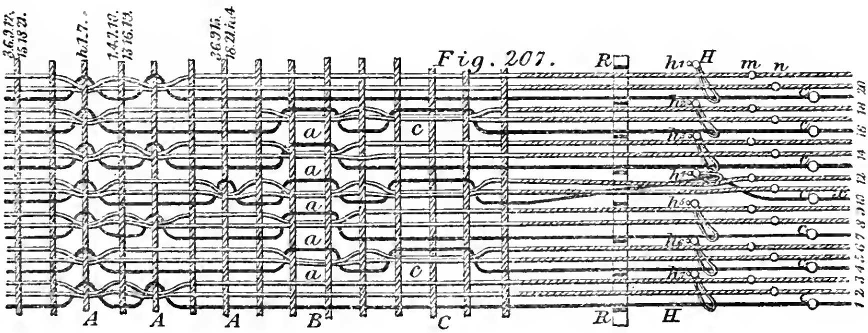


Fig. 207 may represent a plan of a portion of gauze as it would appear in the loom. At *A*, *B*, and *C* three different kinds of twisting are shown. In the first instance the whip thread is twisted half round the two adjoining threads and only one shoot of the weft is made. At *B* the whip thread is retained in its position while two shoots of weft are inserted, and at *C* three shoots are passed through before the whip thread returns to its normal position.

Now to use twistings as at *A* in connexion with fine silk weaving would be almost impossible, for there would be no room for the threads, consequently spaces such as at *B* and *C* are used. It does not follow, also, that the whip thread should pass under one thread only, but two, four, or six threads may be used, and the whip thread itself may be composed of two threads. But in the figure we have assumed that there is only one whip thread to two warp threads.

Figs. 208, 209, and 210 form a diagram of a front elevation of the harness shown on plan at *H H*, Fig. 207; and Fig. 211 represents a side elevation of the same. In all five figures the same numbers and letters refer to the same parts.

Fig. 208 represents four ordinary Jacquard leashes with mails and warp threads, &c., of which *a* is one; this latter being connected with the doup *h*, controuls the whip thread to enable it to be drawn under the warp threads by means of the doup *h*.

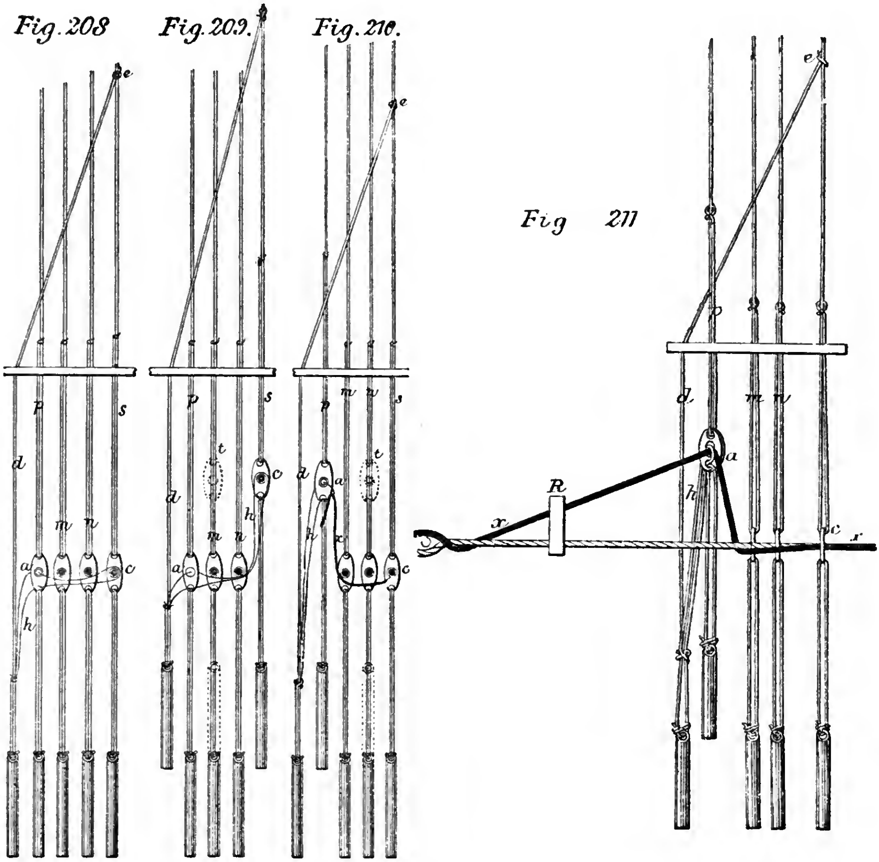
The doup is attached to a "dead" leash *d* as shown, and this dead leash is attached to a whip leash at *e*. The whip thread *x* not only passes through the mail or eye in it at *c*, but through the doup also. See Fig. 211, *a* and *c*.

The leash *p* corresponds to the additional headle previously alluded to, to support the doups, and it will be seen in the figures that the doups pass through the mail in a similar manner to that described in Figs. 204 and 205.

Now Fig. 208 shows the three warp threads in their normal position, governed by the leashes *m n* and *s*. These leashes can be raised in any order required for plain or figured weaving; but whenever the leash *p* is raised, it draws with it the whip thread as shown at *x* Fig. 210.

The mails *a* and *c* are employed much closer together than we show them, consequently the effect of the dead leash *d* is not so apparent. But it will be seen that it effectually holds the doup in position, and by being connected to the standard leash at *e* whenever the standard is raised, the dead leash is raised also, otherwise the whip thread would be strained by the tension of the doup. See Figs. 209 and 211.

In plan 207 the warp threads are numbered in consecutive order from 1 to 21: every third thread is a whip thread, and is passed first through the mails c c, and thence through the doups h^1—^{7}. The doup h^4 is shown drawing with it the whip thread underneath the threads 11 and 12, represented also at Fig. 211, by which means a



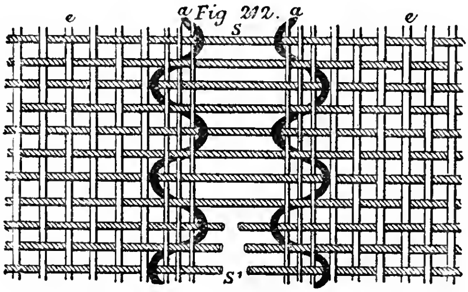
gauze spot is formed. Now, by referring to the numbers at the margin of the cloth they show the numbers of those warp threads &c., that have been raised to produce the effect. For instance, h^1—^{7} means that the mails h^1—^{7} have been raised to form the twistings or gauze spots shown at that position.

The diagrams will better explain the process than any written description, especially as each motion has been represented in them. It may be mentioned that the reed *R R*, Fig. 207, shows the set of three threads passing through each space, otherwise, as before observed, they could not be twisted round each other. The whip thread is usually made stronger than the other threads, or used doubled, so as to counteract the strain of the threads round which it is twisted. When four or six threads are used then the strain becomes far greater, and requires considerable judgment in their use.

The application of gauze to the formation of selvages may now be readily understood. When the cloth is being woven the place where it is intended to be cut has had no threads passed through the reed; in other words, one of the dents, or spaces, has been left empty. On each side of this empty dent gauze threads are used to form the selvages, by means of a doup, as at *D*, Fig. 198.

Fig. 212 represents a portion of plain cloth woven, showing the gauze selvages, with the whip threads *a a*. At *S*' a portion of the cloth is shown cut, and it may be readily imagined that when the threads are entwined firmly and compactly together, that a very

Fig 212.



serviceable substitute for a genuine selvage can be made, and by this means narrow strips, such as velvet ribbons and scarves, can be woven at much less expense than where they have to be woven in separate pieces. Contrivances for producing the same effect by the use of small bobbins are often used, but it does not appear that there is any special advantage over the above plan.

Net weaving is an extension of the same kind as gauze weaving, and therefore more complicated. In fact the whip thread is made to pass over much wider distances than in gauze weaving, where it is confined to the space of one dent only. To accomplish this effect the whip doups are placed in front of the reed, and not at the back, as in gauze, consequently they form a mass of complicated harness apparently impossible to use. To give an idea of this class of work, which is now perhaps completely superseded by lace-work, Figs. 213 and 214 show an elevation and plan of a fair specimen of net-work. The reed *R R* is shown in front of the gauze harness H^1 and H^2, and at the back of the whip threads forming the figure. The tying up of the harness is shown at *T*, where the connexions between the treadles and headles may be seen represented in the usual manner. The Figs. 213 and 214 are taken from Murphy's excellent treatise on weaving.

In all figured gauze weaving it is evident that those threads

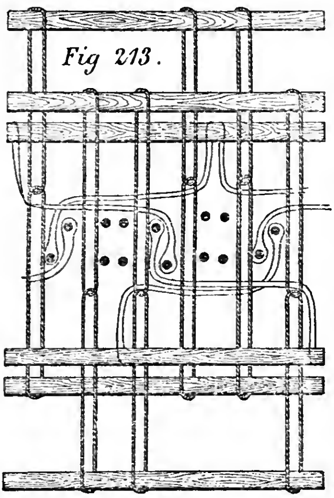


Fig 213.

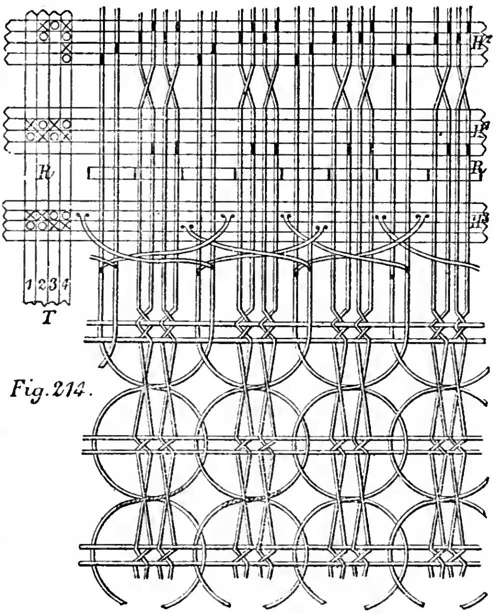


Fig. 214.

which are twisted round the others must be used in greater or less lengths according to the amount of twisting. In arranging the loom, therefore, means must be provided accordingly for separate bobbins or small warp beams to be used. This matter was alluded to in the description of the damask loom, Fig. 126, and we shall now show how these small warp bobbins or beams are weighted so as to throw a constant tension upon the threads, and allow of various lengths of thread being used.

There are several ways in which this can be effected, but we give three, viz., Figs. 215, 216, and 217. In each figure a front and an end view is shown.

Fig. 215 shows the plan adopted in the loom Fig. 126, where each bobbin is provided with a groove, round which is wound a cord to which a weight *w* is attached. When the warp thread *c* is unwound it draws the weight *w* upwards, until it falls over the top of the pulley and resumes its former position, which is shown at *w* and w^1. The weight thereby always causes a strain upon the warp thread, and the plan is a very effectual one. The bobbin is supported on the spindle *s*, which is of wire and is passed through the bobbin.

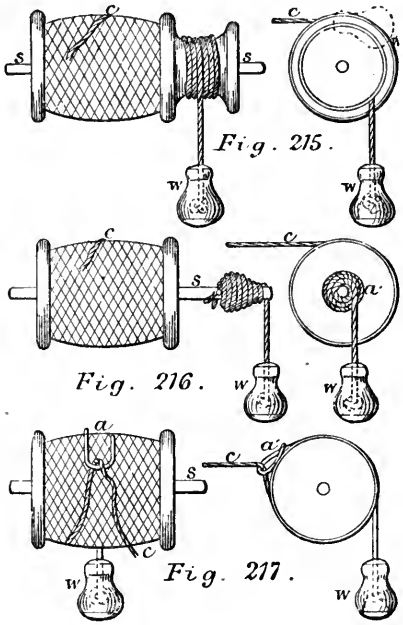


Fig. 215.

Fig. 216.

Fig. 217.

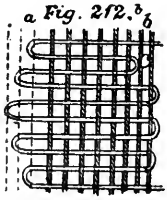
In Fig. 216 the cord is coiled on the spindle, and instead of being carried over the top of a pulley the cord slips off the end of the spindle, as at *a*. This plan also causes a constant tension upon the thread *c*.

The plan Fig. 217 is more adapted for coarse or stronger threads, such as are used in carpet weaving. In this case the weight is attached to a hook which rests upon the bobbin at a^1, and the warp thread *c* being passed over it cannot be unwound without a constant friction and back-strain to take up the slack after each movement of the harness.

In recapitulation it may be said that gauze weaving merely consists in the employment of additional leashes to the ordinary leashes of the loom, and these leashes, which may be used in any required number, have the power to draw one or more warp threads across the path of one or more of the adjoining threads.

The selvages of ribbons are sometimes formed with loops either in a straight line or variegated. They are called "pearl edges," and are effected by means of temporary warp threads, of horse hair or of wire. Fig. 212 *b* shows a portion of a selvage so woven; at *b* the permanent warp threads are shown as woven into the cloth, but at *a* the warp threads are of short lengths, in fact horse hairs. They are raised to intercept the weft in any way desired, and as one end (at the back of the headles of course) of the hair is

Fig. 212. b

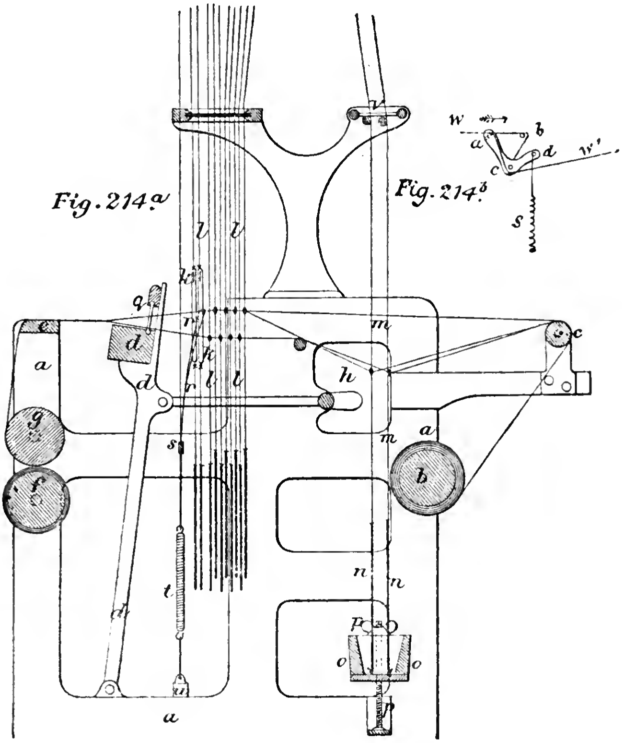


made fast, the cloth draws itself away from the other end as it is woven—the hair merely being held in the cloth for a few inches only. It will be evident that many uses may be made of false or temporary warp threads, as in fringe weaving.

In the description of the Levers Lace Frame another variety of temporary warp thread is shown, called a "lacing thread."

As an example of the application of cross weaving to the power loom, Fig. 214 *a* represents a harness for fancy weaving, patented

Fig. 214a. Fig. 214b.



December, 1876, by Mr. Aldred, of Macclesfield, and is for "a special style of fancy weaving by which three or more fabrics may be produced by one operation, viz. plain, leno, float, or twill in geometrical or other patterns, or figures."

In the section of the loom shown, *a* represents the framework of the loom; *b*, the warp beam; *c*, the back bearer; *d*, the batten; *e*, the breast beam; *f*, the cloth beam; *g*, the take-up roller; *h*, the crank shaft. A single or double lift Jacquard machine may be used, the front row of hooks being attached to wire couplings *k*, and the middle runs attached to the cords *l*, to work the brocade portion of the harness. The back rows are attached to work the cords *m*, connected to the mails of the elastic cords or tensors *n*, fastened to the frame *o*, which is adjusted by the screw *p*.

Only one warp beam *b* is used for the whole warp, and vibrators are dispensed with, as well as compensating shaft, &c. The warp is drawn through the Jacquard harness singly, and through the reed *q*, two or more threads in each dent. Half of the warp is drawn singly through the mails of the tensors *n*, and through a portion of the brocade harness, and the other half is drawn through the other portion of the brocade harness. This portion works freely between the other mails, the ends passing through the mails of the tensors, and also through the slip healds *r* of the fine wire couplings *k*, one or more in a group; so that when leno is made, one or more of the elastic cords are raised, and one or more of the corresponding wire couplings, and so reverse the crossing from right to left by lifting the next end or ends, which pass freely between the mails.

The slip healds *r* are connected to the shaft *s*, which is lifted at every pick of the loom to ease the warp, and is again tightened by springs *t*, connected to the shaft *s*, and fastened to a rod *u*. The groups of threads are drawn in through the slip healds (doups), as in ordinary cross weaving, so that any number of leno threads may be crossed to the right or left of the ground thread next to it, so as to form leno or open lace fabric.

The fine wire couplings through which the double or single loops of the slip healds are passed are used instead of the ordinary mails, thus saving any sticking of the leno threads, and so preventing the breakage of the warp.

To keep the leno threads at a proper tension, whether crossing or not, they are passed through mails attached to the cords *m*, which pass through the horizontal reed *v*, and connected to the elastic cords *n*, thus giving a direct action, and doing away with cranks and even compensating bars and weights.

Mr. Aldred claims: 1st, the fine wire couplings in connexion with the slip healds; 2nd, the elastic cord tensors; and 3rd, the general arrangement, &c.

It will be evident that in many cases the whip thread, as in lappet work, will be used in greater lengths than the warp threads round which it is drawn, therefore not only has a greater supply of thread to be given, but the slackness must be taken up, or a proper elastic tension put upon it to suit the various motions. This is done in other ways besides those shown in Figs. 191, 192, 215, &c., the most common, when a number of threads are used, being the vibrator shown in Fig. 162 *b*, which is simply a shaft provided with arms at each end to carry a rod. The threads are passed under the shaft *e*, and over the rod *a*, so that by means of the spring *s*, a constant tension to take up any slackness is thrown on the threads, as shown by the direction of the arrow and dotted lines, showing the threads to be moved from *a* to *b*.

CHAPTER XVIII.

PILE FABRICS—VELVETS—CARPETS—CHENILLE, ETC.

THIS class of weaving includes velvets, Brussels carpets, fustians, &c. It consists in the formation of loops on the surface of the cloth, and if the loops are cut through they form a brush-like surface to the cloth known as velvet. If the loops are left uncut, similar to the loops on Brussels carpets, then it is known as terry velvet.

The loops may be formed either by means of the warp threads or the weft threads, and they are called the pile.

The richest description of velvet made, with the exception of Dutch, Genoese, and specially made velvets, is known as "collar" velvet, for gentlemen's coats. The pile threads are of silk, but the weft is often of cotton, and velvets so woven are said to have cotton backs. Cotton makes the body of the cloth firm and suitable for the purpose, so that the inferior material is not used on the score of economy alone.

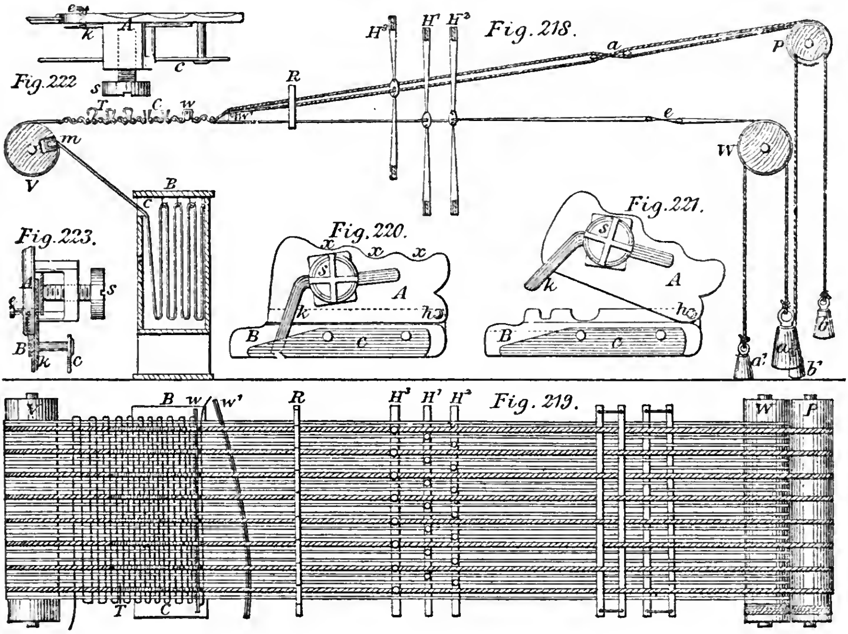
Of velvet nothing is known as to its origin. The oldest is the beautiful crimson cape embroidered by English hands in the 14th century, and now kept in the College of Mount St. Mary, Chesterfield. It is attributed as well as satin to Central Asia or China, the earliest place to weave it in Europe being the south of Spain. Yet the name "Velluto" is said to point out Italy as the market through which it was got from the east.[1]

Velvets of this kind are woven in hand looms of the ordinary description, as far as concerns the harness of the loom. But it is provided with two warp beams, one for the pile threads and one for the ground. The cloth beam is provided with a peculiar contrivance, for the velvet as it is woven must not be wound like ordinary cloth upon the beam or it would "lay" or crush the brush or pile threads. Consequently when the velvet has nearly completed one revolution of the beam the cloth is unfastened and again attached to the beam.

[1] Rev. Daniel Rock.

As it is a very slow and tedious class of weaving, only about a yard a day being made, this unfastening of the cloth does not consume so much time as it would do if repeated often.

Let Fig. 218 represent a section of a velvet loom, showing all

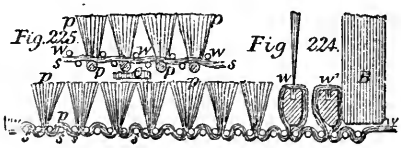


the working parts necessary, but omitting the framing. *W* is the ordinary warp beam supplying the threads for the body of the cloth. *P* is the "pole" (corruption of pile) or the pile beam, which contains the pile threads. *V* is the cloth beam, showing that it has made three-quarters of a revolution, and *B* is a closed box to contain the velvet as it is unwound from the beam. At *T* will be seen loops rising from the surface of the cloth, and at *C* the loops are shown cut through at their upper surface. These loops are made by inserting thin wires into the shed, which are beaten up with the cloth similar to ordinary weft threads. One of these wires is shown thus woven in the cloth at *w*, and at w^1 another wire is being inserted.

Now between each insertion of the wires three shoots of weft are thrown into the cloth, and well beaten together, otherwise the pile threads after they were cut would draw out. Fig. 219 shows a plan of Fig. 218, and the same letters and numbers refer to each. In the plan the wire w^1 is shown placed in the shed of the warp, and will be driven up by the reed *R* in the same manner as the wire *w* has been. When both wires have been firmly bound into the cloth by the weft threads, the first one is cut out by means of a knife fixed into a frame and called a "trevette," and it is again inserted. Thus only two wires are used, and they are cut out alternately by means of the trevette. The instrument is well suited for the purpose, and when it is considered that the wires are inserted from 50 to 60 times, and upwards, per inch in length of velvet woven, and three times that number of weft threads, it will be evident that great exactness of the operation is necessary, or the slightest error or carelessness would cut the warp threads out of the loom—a circumstance by no means unknown to most velvet weavers. The wires, which are made with a fine groove for the point of the knife to enter, are very truly made, and the blade of the trevette must be "as right as a trevette," or such beautiful work as velvet could not be produced.

Figs. 220 to 223 show the trevette. The knife *k* is fixed into a frame *A*. This frame is hinged to another frame *B* at the point *h*, so that the weaver can open and sharpen the knife easily. The knife is held firmly by the screw *s*, and at the back of the frame a small adjusting screw *e* is placed to regulate the distance of the knife from the steel frame *B* against which it is placed. See Figs. 222 and 223. The frame *A* is of brass, but all the rest is of steel. The indentions *x x x* are for the fingers to fit in, a requisite precaution to insure accurate hold of the instrument.

The use of the trevette is shown in the enlarged sketch, Fig. 224,

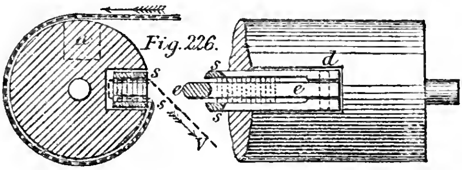


in which the knife edge is seen entering the wire *w*. *B* and *C* are the bottom portions of the trevette, and rest upon the warp and cloth as shown. The trevette is held in the right hand, and drawn from the left to right. It is pressed against the flat side of the outside wire *w*', which forms the guide or fence, and the knife is regulated to fall into the groove of the inside wire *w*. When upwards of sixty insertions of the wires per inch are made, an idea of the perfection of workmanship required for the purpose may be realized.

About six times in length of the pile threads are used to what are required for the "back," which, of course, arises from the formation of the loops. Much less strain is also put upon the pile threads by the use of smaller weights, as shown at *b* and b^1.

The wires, see w^1, Fig. 219, are slightly curved, for they are better in this form for the weaver to insert, for he glides them upon the convex side through the shed, and being curved also insures that the right side of the wire—the grooved edge—is always uppermost. The wires being only about $\frac{1}{20}$ in. deep, are easily driven straight by the reed. They are made of brass wire about the size of an ordinary pin, and recover their curvature after being driven straight by the reed.

Fig. 226 shows the cloth beam with one of the many contrivances



for holding the velvet. A large slot is cut in the beam, and three strong laths are placed into it. The middle lath *e* has a number of needle-points, about $\frac{1}{4}$ in. apart, fixed through it, these points extending to the side laths *s s*, as shown in the figures. Now the velvet is pierced by these needle-points and held fast, as may be noticed by tracing its course shown by the dotted lines. The side laths are hollowed out to allow space for the velvet.

After leaving the beam the velvet is hung up by means of pin hooks in the box *B*, Fig. 218, which keeps it free from injury. The warp and pile threads may be traced in the figures as well as the weft. The headles, Figs. 218 and 219, shown at H^1 and H^2, work the ground or warp threads by raising each half of the threads alternately as in plain weaving. The headle H^3 raises the pile threads at every fourth change.

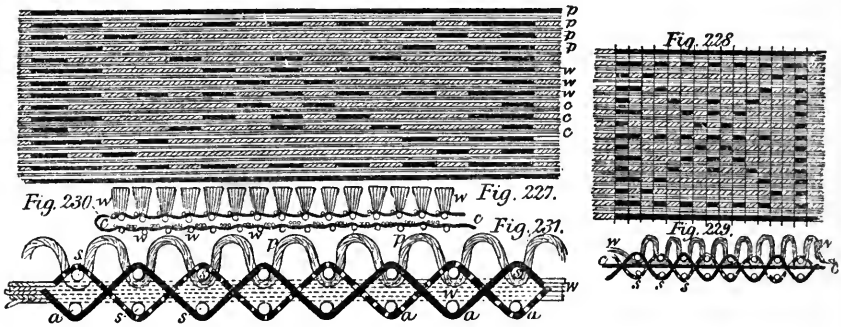
Singular as it may appear, when the work is taken from the loom the weaver frequently places it upon a table, and by means of a sharp common razor literally shaves or mows the whole surface of the pile, in order to remove any stray filaments of extra length and improve the face of the cloth. Or it may be shaved in the loom.

Fig. 225 shows a section of the velvet through the line of warp threads, in which *s s* is the weft, *w w* the ground or warp threads, and *p p* the pile. Fig. 224 is a section at the side of the cloth, and the letters refer to the same parts. In these figures the actual formation of the cloth is represented, excepting that the pile threads are usually made thicker or doubled.

Brussels and other pile carpets are made upon the same principle as the velvet above described, but generally the pile is not cut, consequently round wires are used instead of grooved ones, and they are drawn out from the side of the cloth.

There are two descriptions of Brussels, one in which the pile threads have had the pattern printed upon them previous to weaving, and the other in which the threads are used dyed in separate colours.

The first kind is known as tapestry carpets, patented in 1832, by Mr. Whytock, of Edinburgh, and forms a comparatively simple and cheap manufacture when compared to Brussels carpets. Let Fig. 227 represent the warp and pile threads with the pattern printed



upon the pile threads. The pile threads are marked *p p* and the ground threads *w w*, these lying between and under the pile threads. About five of these warp or ground threads are used to each strand of the pile, which may be seen in section Fig. 230. Now when the threads are woven together the pile is contracted to nearly one-third of its length in consequence of the loops, and the distorted figure, as printed, becomes of the intended proportion. Thus Fig. 227 becomes, when woven, Fig. 228.

A section of the cloth is shown in Fig. 229, and in all the figures 227 to 230 the same letters refer to the same parts. The threads *c c* do not intersect with the weft, but merely lie between the warp threads *w w*, and form a bed or ground for the pile to rest upon. The wires used are generally six or more in number, for if only two were used the loops would scarcely resist the strain of drawing the wire, the greater number causing greater firmness to the cloth to resist the strain. Brussels carpet is a very different affair. A great variety of threads of different colours are required, and they are selected by the action of the Jacquard machine to form the pattern. They are wound upon separate bobbins, for each colour is used in various lengths. See Fig. 217.

Let Fig. 231 represent a section of a Brussels carpet. The threads *a a* are the warp threads, and *s s* the weft. Where there is only one thread in the tapestry carpet there are five or six in the Brussels; thus the five threads are shown at *w w*, and as the various colours are required they are drawn to the surface to form the loops whilst four-fifths of them remain in the body of the cloth. The great number of pile threads, and being made of wool and not of hemp, as the warp and weft are, causes the Brussels carpet to be much thicker and softer, the colours brighter, and altogether a superior fabric to the less costly tapestry, as the difference in price attests.

In Cochrane's carpet loom (1874) the wires are inserted and withdrawn from opposite sides of the loom simultaneously, and increased speed is claimed for this invention.

Various combinations of the warp and weft for the production of new kinds of fabrics are frequently patented. Fig. 237*a* is a section of a double faced carpet patented by Mr. Webster and Mr. C. Meserole,

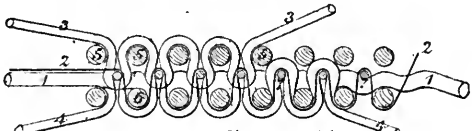


Fig 237.a

of New York. The wires shown at 5, 5, are for forming the pile on one side of the cloth, and 6, 6, is the thick filling on the other side. The coarse warp is shown at 1, 1, and the fine at 2, 2. The top worsted warp is shown at 3, 3, and the bottom at 4, 4. The fine weft or filling is shown at 7, 7.

The body of the Wilton carpets is made similar to a Brussels, but the pile is cut as in velvet weaving. "Kidderminster" or "Scotch" carpets are not pile fabrics, but are made similar in principle to that of double cloth.

Mr. C. Dresser, in his treatise on carpets,[1] observes that "the Egyptians made their carpets by picking out from a piece of coarse linen, which was already woven, certain weft threads, and by sewing

[1] Published by Mr. Stanford, 1877.

tufts of coloured worsteds to the warp threads, sufficient of the weft threads being allowed to remain to knit the warp threads together. Some of the simple kinds of cotton carpets of India are formed in the most primitive way, but these are without 'pile' of any description. Warp threads are placed horizontally, and the loom is without treadles or reed. The weft threads are thrown across by the weaver, and are brought together by a small hand comb. A similar loom, only placed vertically, is employed for the production of certain Indian carpets which have a looped surface, and some of the richly figured cotton carpets from Wurringal, Deccan, are wrought in this simple manner, every loop of the variously coloured cottons being brought up by the hand of the weaver. In such cases he has the drawing of the pattern by his side; but by much practice he is enabled to form the designs without reference to it. Persian carpets, whether wrought in Persia, India, or elsewhere, are formed upon a vertical frame, on which warp threads are arranged. Upon these tufts of woollen yarns are knotted, and over each row of these tufts a wool thread is passed to bind them. Turkey carpets are made in the same manner, and so are French tapestries; only in the latter a 'shuttle needle' is used in attaching the woollen threads to the warp. The manufacture of Axminster carpets is a mere modification of the Persian method, for the worsteds are only knotted to the warp threads. They derive their name from a town in Devonshire, but the seat of manufacture has long been removed to Wilton. The first seat of the Brussels carpet manufacture in England was at Wilton, where it was introduced from Belgium about a century ago. Kidderminster now supplies the great majority of such carpets, although they are made at various other places. Wilton carpets are similar to Brussels, except that the pile is cut as in velvet weaving. Brussels may be made of five or six threads or frames, but it frequently happens that portions of the threads are cut out and not bound in the body of the cloth, in which case the carpet is reduced in substance and quality."

Both cut and terry velvets are now woven in power looms, and the various methods adopted for the purpose may be best understood by the following diagrams.

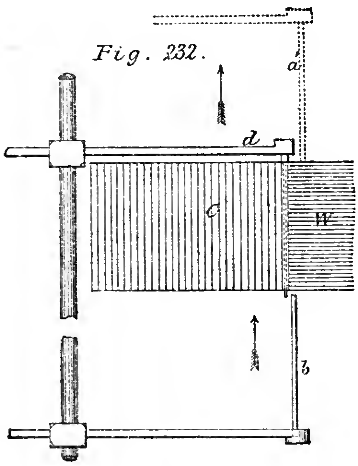
Fig. 232 shows one of the first attempts at weaving terry ribbons by power, patented by Mr. Thompson, of Coventry, in 1842, but only one ribbon is represented, that being sufficient for the purpose. In this instance two wires or "tags" are used. They are fixed into side levers, and are regulated and moved to follow the motion of the cloth. In the diagram *W* is the warp, *C* the cloth, and *a* and *b* the velvet wires. The wire *b* has been withdrawn, and advanced to the front of the wire *a*, ready to be inserted again into the shed. The wire *a* is then withdrawn, and moved in a corresponding manner, as shown by the dotted lines *a′*. Thus the wires are woven into the cloth and withdrawn alternately.

But this plan was found defective from the circumstances before alluded to, namely, that two wires are not sufficient for weaving terry velvet fabrics. Many attempts were, therefore, made to use several wires, and at last with success. Fig 233 shows the plan patented by Mr. Collier, of Halifax. In the diagram *W* and *C* represent the warp and cloth, into which a number of wires are placed. The outside wire has been withdrawn from the cloth and moved to the front, to be again used, as may be traced by the dotted lines and arrows at *n* and *n′*

This motion really follows the action of the weaver in the process when the hand loom is used for the purpose.

In 1855, Mr. Weild, of Manchester, took out a patent for an in-

Fig. 232.



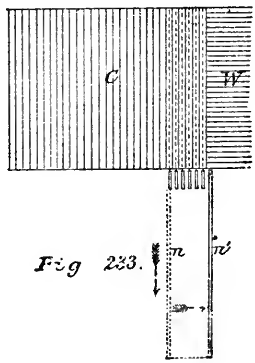
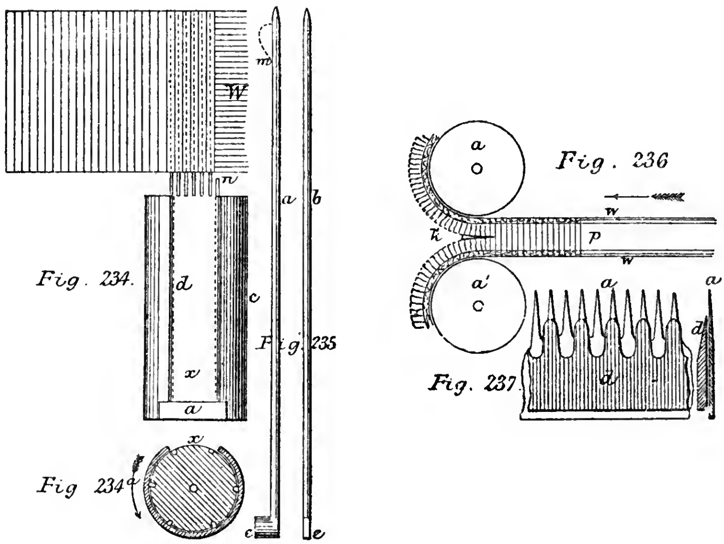


Fig 233.

genious and effective plan for inserting and withdrawing the wires, which is somewhat similar in its action to the circular shuttle boxes used in power looms. Mr. Weild places a cylinder at the side of the loom, upon the surface of which several grooves are cut for the reception of the wires. Now the distance between any two of the grooves corresponds to the distance between the first and the last wire in the cloth, consequently by means of catches and a slide the wires are inserted and withdrawn at each intermittent motion of the cylinder. This will be understood better by reference to diagram Fig 234, which is a plan, and Fig. 234 *a*, an end section of the cylinder. It will be seen the cylinder is enclosed in a tube, the upper surface *x* of which is left open, so that the wires can drop into the grooves, and then be carried round to the front of the cloth as required. A carrier or slide *a* provided with catches, &c., pushes and draws the wires at the appointed times.

Fig. 235 shows one of the wires in two positions *a* and *b*. They have, as in Mr. Collier's loom, a flat wedge-shaped head at one end,



for the purpose of holding it in position and for the catches to take hold of during the various movements.

In both cases, Figs. 233 and 234, the wires are for weaving terry velvet; but wires are used with a thin knife-edge fixed upon the end, as shown in dotted lines at *m*, Fig. 235, when the velvet is intended to be cut. On withdrawing wires of this kind the knife cuts the loop. This plan of cutting the pile is an old French invention, used for cutting the pile of coach lace, and making rugs.

Another class of velvet and plush weaving very often used is to weave two pieces of cloth one above the other, and the pile threads, passing from one piece to the other, connect them together. If these threads are cut, then two pieces of cloth with velvet surfaces will be produced. Fig. 236 shows two warps w and w', with the pile threads p passing from one to the other.

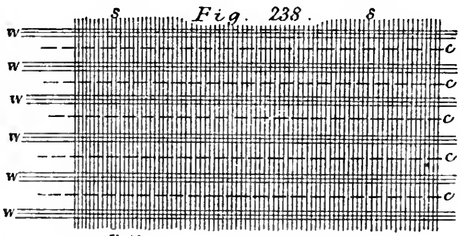
At k there is a thin knife-blade, which is made to move rapidly between two beams a and a', and as the cloth is woven and advances, the pile threads are cut and the two separate pieces are wound upon the beams. Mr. Lister, of Bradford, has done much to bring this kind of loom to its present perfection. Instead of a knife or blade being used, a plan of burning the pieces asunder by means of a platina wire heated by electricity has been patented.

In double velvet weaving there has been one great difficulty to contend against, namely, to keep the two pieces of cloth at an equal distance apart. To do this an exact supply of pile thread, and of one given tension, must be supplied at each shed of pile threads, otherwise any additional strains would draw the two pieces nearer together, and the pile would be irregular. To prevent this sometimes wires are inserted at short intervals, which act as distant pieces, but their use is evidently undesirable.

The cutting-knives are of various kinds, and are sharpened on stones as they pass over the sides of the loom in their rapid movement. A knife similar to the serrated blades of a mowing machine has been patented by Messrs. Shaw, Ditchfield, and Knowles, the long teeth of which enter between the two pieces, whilst the lateral movement of the top blade cuts the pile threads. See Fig. 237 which shows the movable blade d upon the fixed blade a.

A modification of pile weaving is made by using chenille weft. Chenille is a fringed thread, and when used as weft, the filaments of fringe protrude through the interstices of the cloth, and produce a

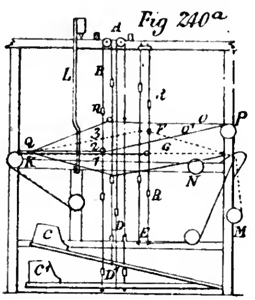
Fig. 238.



fur-like surface on the cloth. Fig. 238 shows a simple method of making chenille, which is weaving a piece of cloth with a small number of warp threads, and then cutting into strips as at c. The warp threads w, best woven as gauze, bind the weft threads s together, and when twisted form a cord, as at Fig. 239, which, when woven in the cloth, appears as at Fig. 240; but it is woven in conjunction with ordinary weft according to the cloth required.

Messrs. Tomkinson and Adam, of Kidderminster, obtained a patent in October, 1876, for an improved chenille loom, in which they use two treadles only instead of six, as previously used. By this means they open three sheds at one time, consequently there is much less friction on the warp.

Fig. 240*a* represents a section of their loom, in which there are four warp beams. Now, the warp threads shown in dotted lines remain stationary, and are not moved by the treadles, for they pass through the headles secured to the brackets *E*, excepting at the completion of the rug or piece, when the plain cloth forming the hem of the fabric is woven, when the upper warp threads are lowered to the level of the lower warp shown in dotted lines.



By this means three sheds, 1, 2, 3, can be opened, and the different warps may be made to intersect each other in various ways by means of two treadles *c* and *c'* only. The two uppermost warps, *o o*, are the pile binding warps, and *h* the ground warp; *q*, the spike roll; *L*, the batten; and *k*, the chenille fabric.

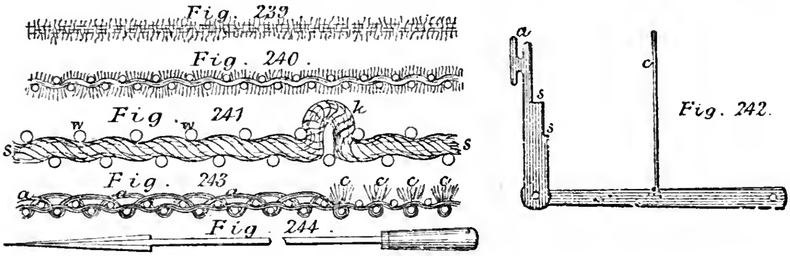
The system of forming two sheds and using stationary warps has long been applied, and three sheds are used in elastic web looms, where they are of great advantage. See Figs. 264, 331 to 333, and 344 to 350.

Two or three tiers of shuttles can be thrown simultaneously in narrow looms without difficulty through two or three sheds, and in hand looms they may be thrown separately. In power looms for carpet weaving, &c., with two sheds, it becomes a more difficult question, for a temporary race must be made for the upper shed or sheds.

In Webster's loom (1872) a temporary race is formed by means of "fingers," inserted and withdrawn at proper times, and two shuttles may be thrown separately or simultaneously.

Fig. 241 shows one method of raising the loops or "knobs," as they are called, on counterpanes, in which *k* represents one of the knobs. It is formed by means of small levers with slots in them to raise the weft thread. Fig. 242 shows the notch or slot at *a*, and *c* is the cord attached to the Jacquard to raise the thread where required. A number of these levers are used, but they are only raised at long intervals. The plan shown was patented by Mr. Myerscough in 1840. The steps *s s* are stops to regulate the height of the loop to be raised.

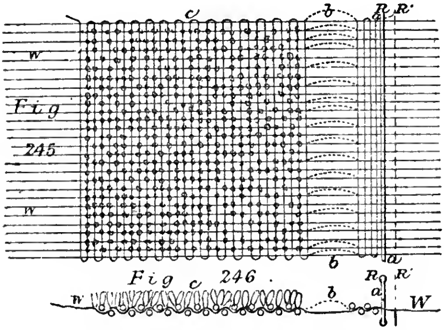
Figs. 243 and 244 show the method of fustian weaving. It was

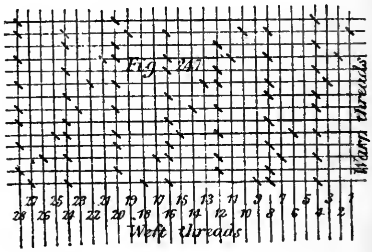


woven so early as the thirteenth century, and was made for under sheets for bed-clothes. The pile is merely the floating weft threads *a a a* woven to form loops parallel to the warp threads. After the cloth is woven it is placed upon a table, and by means of a long rod, at the end of which is a sharp blade, the loops are cut by inserting the point under the loops, and pushing the blade rapidly forward by hand. The loops are shown cut at *c c c*. There is a guard placed on the lower side of the knife to prevent it piercing the cloth. See Fig. 244. Many attempts have been made to cut fustian by machinery, but it is attended with many difficulties, and is still done by hand, the work being carried on in the small towns and villages in the neighbourhood of the manufactories.

The system of cutting fustian was invented nearly four centuries ago, for in 1494 an improvement was introduced in the manufacture of fustians, which at that time were brought in the rough state from abroad and finished here. An Act says, "fustians brought from beyond sea should be the most profitable cloth for doublets and other wearing cloths used by the common people of this realm, and formerly they were truly wrought and shorn by the broad shear and no other deceitful means. Now, diverse persons have with undue sleights and means imagined and contrived instruments of iron, with which irons, in the highest and most secret parts of their houses, they strike and draw the said irons over the said fustians unshorn, by which means they pluck off both the nap and cotton of the said fustians, and break commonly both the grounds and thread asunder; and after by crafty sleeking they make the same fustians appear to the common people fine, whole, and sound. And also they raise up the cotton of such fustians, and then take a lighted candle and set it in the fustian burning, which singeth and burneth away the cotton from the said fustian from the one end to the other down to the hard threads, instead of shearing; and after that they put them in colvers, and so subtley dress them, that their false work cannot be espied without it be by workmen shearers, or by weavers of the same; and so by such subtleties, whereas fustians made into doublets were wont and might endure by the space of two years and more, will not endure now whole by the space of four months, to the great hurt of the poor commons and serving men." Shearing only was to be practised.

A system of raising pile threads without the aid of wires is also adopted for weaving towels, &c. See Figs. 245 and 246, showing a plan and section of this kind of weaving. *W* is the warp, *C* the





cloth, *R* the reed. There is seen at *a* next the reed a few insertions of weft at little distance from the body of the cloth. Now, by slackening the pile beam, and forcing the batten forwards, loops will be formed, as shown at *b*, where the reed has moved from *R'* to *R* in its progress towards the cloth.

Thus a few shoots are woven in to bind the pile threads, and then by carrying the batten forward, the pile threads are carried forwards, but not the warp threads, which remain intact.

In order to raise the pile threads for the production of particular kinds of fabrics, numberless plans are used for the purpose, and the tie-up or draughting of the pattern is sometimes patented. Thus, Mr. Smith, of Ripponden, patented in 1873, amongst other designs, "a pile produced by the weft firmly secured, so that the cutting and dressing does not loosen the pile, and the fabric will be equal to seal-skin." Fig. 247 is a copy of that portion of Mr. Smith's design.

CHAPTER XIX.

THE DUTCH LOOM—THE BAR LOOM.

The common hand loom for weaving ribbons was formerly known as the Dutch engine loom, and it was also called the swivel loom. Before it was invented, ribbons were woven in small looms, and only one ribbon was woven at once. But by means of the swivel loom from 8 to 10 or 30 to 40 ribbons, according to their width, could be woven, consequently it was an invention of great importance, and its introduction caused a considerable amount of trouble, as will be presently seen.

More than a century ago, and long before Dr. Cartwright's time, the swivel loom had been made self-acting, for all the principal operations of the loom were made automatic. The shedding of the warp, throwing the shuttle, and beating the weft together were effectually accomplished by means of cranks, tappets, &c., almost in the same manner as used at the present time.

These improvements appear to have been carried out both in France and England, at about the same time. They really formed the first successful application of power to work the loom instead of the usual operations of the weaver. In fact, the history of the swivel loom, and the application of the bar, &c., to it, is the history of the first successful attempts at power-loom weaving, and on that account it deserves more than usual attention.

The "bar" loom, or the "a la bar" as weavers often call it, was introduced in the following manner, according to the evidence of Dr. Bowring before a select committee on the silk trade in 1831—1832. The question asked was, "Whether the bar loom had been introduced subsequently to the Jacquard loom, and if its introduction had met with similar difficulties?" His reply was, "Yes; that it was a Swiss invention, and it was taken into the neighbourhood of St. Etienne by two brothers, who were themselves persecuted and abandoned to extreme misery; the last of them died not long ago, in a hospital, in consequence of the obloquy and neglect to which he was subjected. Since then the use of the bar loom has become nearly universal in the immediate neighbourhood of St. Etienne."

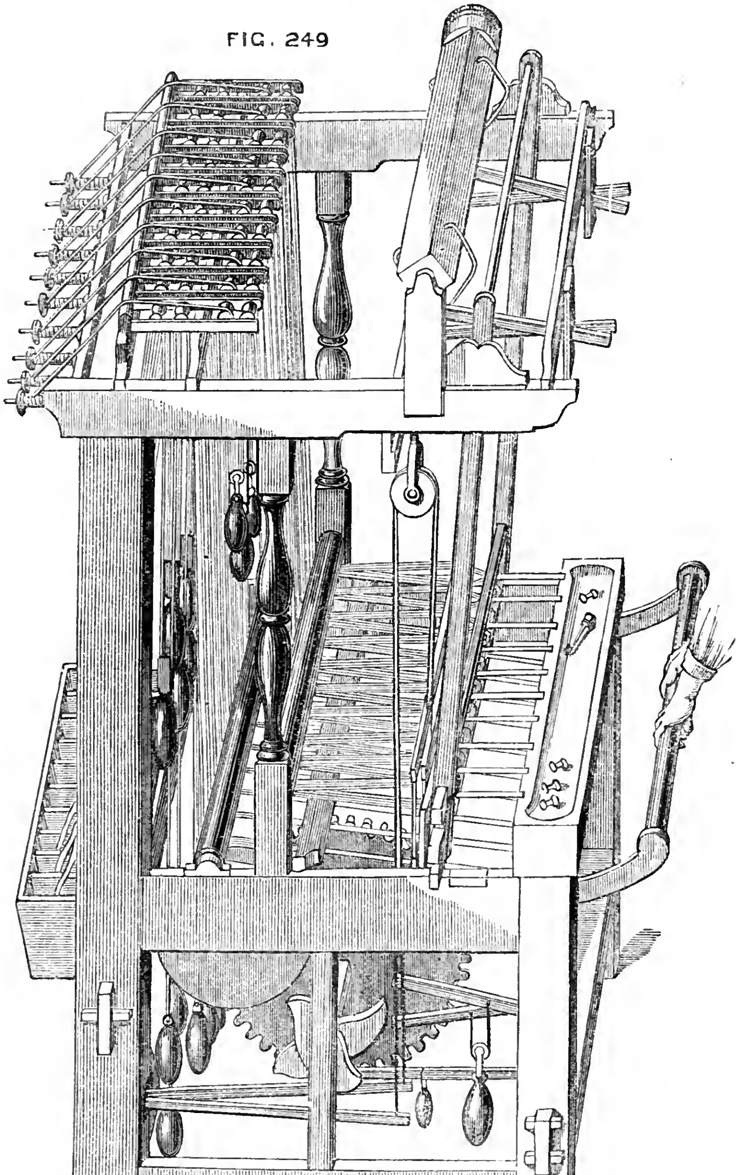
According to this evidence the loom was introduced in the early part of the present century, or since the introduction of the Jacquard loom. But both of the great French Encyclopædias, Diderot and D'Alembert's, and the "Encyclopédie Méthodique," give detail drawings of the loom thirty years before that time. Therefore Sir John (then Dr. Bowring) must have been misinformed on the subject.

It will be preferable to give the history of the Dutch loom first, and then refer to what is known concerning the improvements made in it. For this purpose Beckmann's account is more than usually clear and interesting, from which it appears "that it is probable the ribbon loom had its rise in the Netherlands or Germany, either about the end of the 16th or the beginning of the 17th century, although Mr. Jacobson believes the Swiss invented such looms. The oldest account with which he was acquainted seems to be in favour of Germany and the 16th century.

"Lancellotti, in a work published at Venice in 1636, says, Anthony Möller, of Dantzic, relates that he saw in that city about fifty years before a very ingenious machine, on which from four to six pieces could be wove at the same time; but as the council were afraid that by this invention a great many workmen might be reduced to beggary they suppressed it, and caused the inventor to be privately strangled or drowned. Who this Anthony Möller was I do not know; but that he saw a ribbon loom at Dantzic is beyond all doubt. If the date of the printing of the book be taken as the time in which Lancellotti wrote, there is reason to believe that there was a ribbon loom at Dantzic about 1586; but it appears to me that the book was written in 1629, which would bring us to the year 1579."

"The next oldest information," continues Beckmann, "with which I am acquainted is that given by Boxhorn, who says, 'About twenty years ago some persons in this city (Leyden) invented a weaving machine, on which one workman could with ease make more cloth than several others in the same space of time. This gave rise to rioting amongst the weavers, and to such loud complaints that the use of the machine was at length prohibited by the magistrates.' According to this account Leyden was the place of its invention;

FIG. 249



but in order to determine the time it would be necessary to attend to the following circumstance. Boxhorn's 'Institutiones Politicæ' have been often printed. He gave lectures on the subject, and gave verbal illustrations of it to his scholars, one of whom in 1641 carried a fairly written copy of the work to Germany, and gave it to Professor C. F. Frankenstein, who caused them to be printed for the first time at Leipsic in 1658 and again in 1665. In the passage above quoted are to be found the statements which are appended. Hence there is reason to conclude that the ribbon loom was known in Holland about 1621.

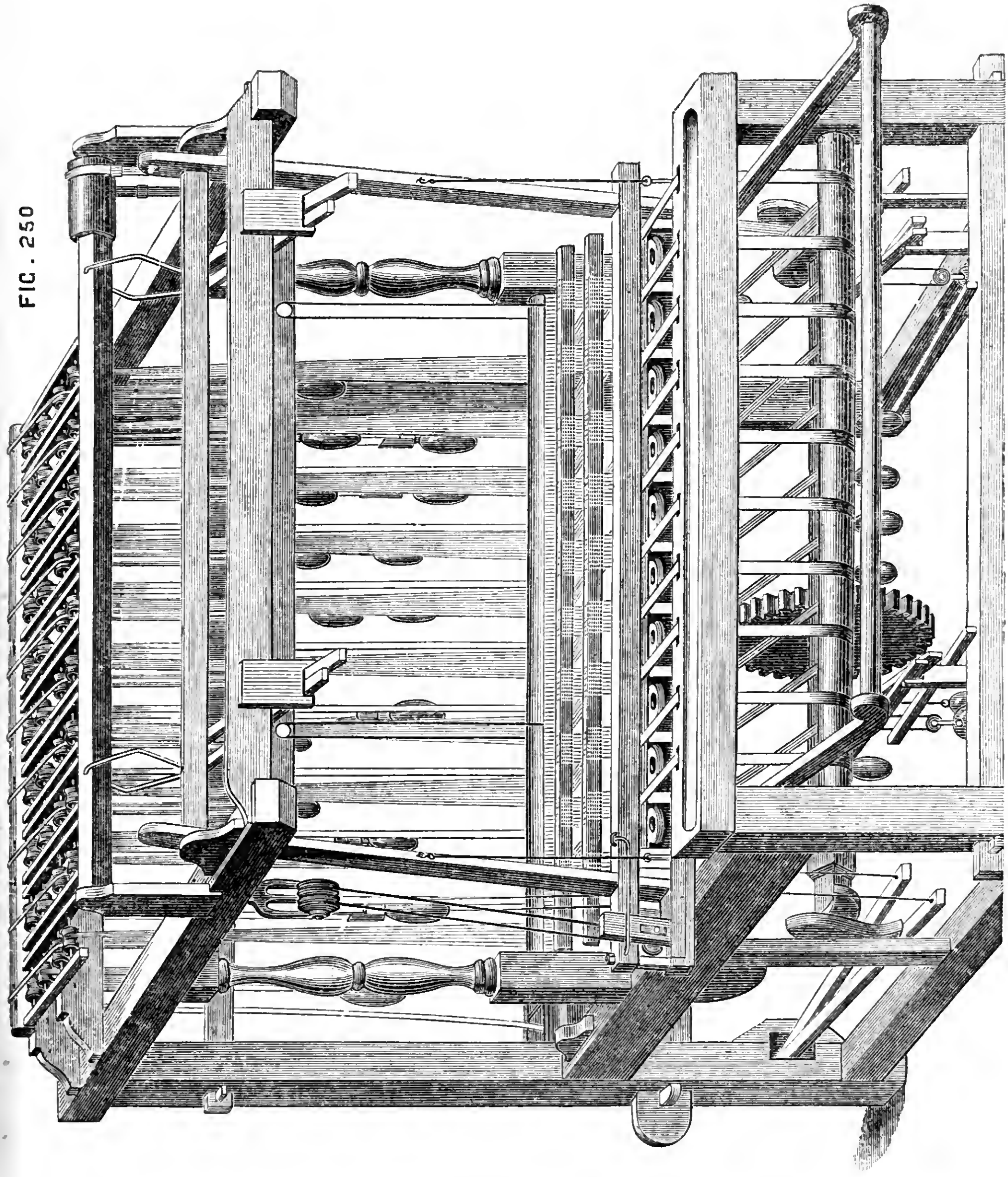
"It is some confirmation of Boxhorn's account that the States General as early as the 11th of August, 1623, if they did not totally prohibit the use of the ribbon loom, as commonly asserted, at any rate greatly circumscribed it. The proclamation for that purpose may be found in the Groot Placaet Boeck, a valuable collection published at the Hague, in seven large volumes, between the years 1658 and 1746. Nothing further, however, is found there respecting the history of ribbon looms—which are called "lint-molens"—than that they had been in use for several years, to the great injury and even total ruin of many thousands of workmen who were accustomed to weave ribbons on the common loom. This prohibition was renewed in 1639, and again in 1648, as appears in the same work. In 1661 the use of them was extended a little longer, and defined with more precision. They were prohibited in Nuremburg in 1664, also in the Spanish Netherlands in the same year.

"In the year 1665 there was to be seen at Frankfort-on-the-Maine a loom which of itself wove all kinds of lace, tape, &c., provided the silk or yarn was properly arranged in the usual manner; but if a thread happened to break, it was necessary that some one should again join it by means of a knot. The year following some person in that city applied, not only to the council, but even to the emperor, for permission to establish such a loom, but was not able to obtain it.

"In 1676 the ribbon loom was prohibited at Cologne, and the same year some disturbance took place in consequence of its being introduced into England. It is probable that Anderson ('History of Commerce') alludes to this loom, when he says, speaking of the above year, "As was also brought from Holland to London the weaver's loom engine, then called the Dutch loom engine." He, however, praises the machine without describing it, nor does he mention that it occasioned any commotion.

"In 1681 it was declared by imperial authority that the prohibition of ribbon looms was both useful and necessary. This was followed in 1685, by an Act of the Council of Frankfort. The Council of Hamburg, it is said, ordered a loom to be publicly burnt, and

FIG. 250



Charles VI. ordered the prohibition of 1685 to be renewed in 1719, though some mercantile people strongly opposed the measure. In 1720 the Electorate of Saxony issued a general prohibition, but all these coercive means were ineffectual, and the ribbon loom, being found useful, has become common. Saxony revoked its prohibition in 1765."

The first account of any improvement in the swivel loom is given in the specification of a patent granted to John Kay and John Stell in 1745. It is the same Kay who invented the fly shuttle, and as this patent contains perhaps the first description of tappets, &c., applied to a loom which would be likely to meet with success, it is unfortunate that no drawings accompany the specification.

The patent is dated 1745, No. 612, for a loom for weaving tapes, and it is in the names of John Kay, of Bury, Lancashire, and John Stell, of Keighley, York. It says,—

"The new invention to be added to the Dutch engine or loom now used for working the before-mentioned goods in narrow breadths is by fixing in the lower part of the said engine or loom a rowler beam, or round piece of timber, that passes through the length of the said engine or loom, and turns round upon its axis at each end, and at a certain distance from one end of the said rowler or beam is fixed a pin made of wood or iron, the said rowler or beam being in part enclosed in a second or other hollow rowler, which moves or slides in a loose position upon the first mentioned rowler or beam, and is at pleasure fixed to the first by means of a notch that receives the aforesaid pin, and is by a tender or handle capable of being moved to and again, or to the right hand and left; which motion, the first rowler or beam being supposed to turn round, sets the said engine or loom to work or stoppeth it at pleasure.

"There are likewise fixed in the sliding beam or hollow rowler at proper distances sundry tapits, which, when the said two rowlers or beams turn round, perform the office of treading the necessary treadles, and move the batten or lath, and by the help of the other piece of timber or part of the machine fixed upon the aforesaid batten or lath, in the form of the letter T or angle, which plays upon an axis at the centre of the top or head, and by two treadles annexed to the extremity of each uppermost angle, the aforesaid tapits laying hold and treading down the treadles aforesaid, and throws over the shuttles to the right hand and left by means of the lowermost or third angle being annexed to a certain part of the said engine or loom, called a driver, and is further assisted by a balance or weight, and the batten being struck to the piece or web by a weight and spring closeth the shoot and completes the work, and the said engine may go or be worked by hands, water, or any other force."

In 1760 Joseph Stell obtained another patent, No. 753, for "weaving figured and flowered silk ribbons, and other sorts of figured goods made in narrow widths, so as to work a great number at one time." He then proceeds to describe the application of jacks, tumblers, cranks, tappets, and one or two draw-boys to form the figure. There are no drawings to this specification either.

The next account of the swivel loom appears in Diderot and D'Alembert's Encyclopædia, 1762, which contains excellent engravings of the loom, also of the "bar" loom. In 1786, the "Encyclopédie Méthodique" contains additions to the above, and the "bar" loom is represented with the weaver working it. See Fig. 249.

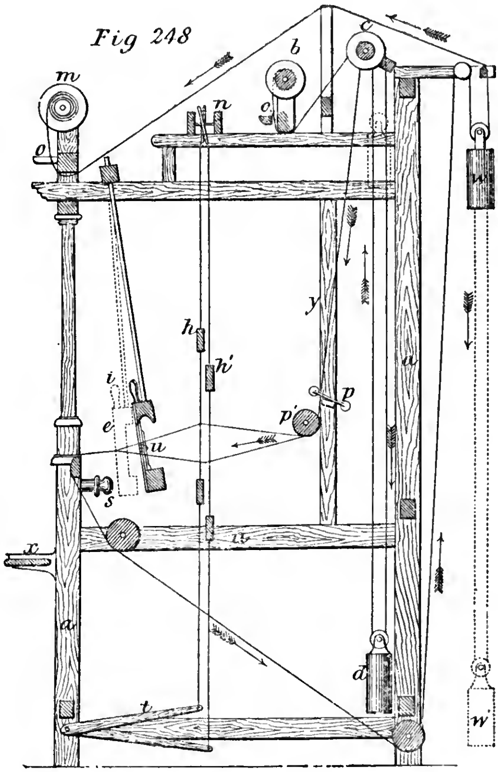
Mr. Baines, in his "History of the Cotton Manufacture," states that "about the middle of the eighteenth century a swivel loom was invented by M. Vaucanson, and in 1765, a weaving factory, probably filled with those looms, was erected by Mr. Gartside at Manchester, but no advantage was realized, as a man was required to attend to each loom."

Now, as it is stated in Kay and Stell's patent, that the loom may be worked by "hands, water, or any other force," in short a power loom, and as Kay was at that time well known throughout the manufacturing districts of Lancashire and Yorkshire, it may be possible that the looms Mr. Gartside used were of Kay's invention, and not Vaucanson's loom. Kay's specification does not mention the application of the "bar," and it was probably intended to be worked by a handle or pulley. On the other hand it is very likely that Vaucanson invented the "bar," (which is simply an extension of the two crank arms, to which a cross bar was connected, by means of which the weaver turned the crank shaft of the loom), and at the same time he probably invented the wheel and rack motion for the shuttles, which is still in use.

The bar loom was lately, and perhaps is at the present time, in extensive use, and it can, as before stated, scarcely be considered in any other light than the first successful power or automatic loom.

The frames of the most improved ribbon looms of the present day are still arranged upon the plan of the old Dutch engine or swivel loom. The shuttles are driven, however, by the wheel and rack, and not by the driver, as before Vaucanson's time. The more recent improvements in the loom have been the application of the Jacquard machine and the employment of several tiers of shuttles for using various colours of weft. Other minor improvements have been made, but they in no way affect the principle of the loom. The most important of them was perhaps the invention of the double peg slides, to draw the shuttles through instead of being jerked

Fig 248



through by the driver, as in the old Dutch loom. This peg motion is a cheap and effectual one.

The principle of the peg motion has been shown at Figs. 167 to 176 (see page 181), where swivels exactly the same as in the ribbon loom have been applied to the broad loom for the weaving of the spots on the cloth, which is in every way similar in effect to weaving separate ribbons, except that they are woven in with the body of the cloth.

A section of a common swivel loom is represented in Fig. 248, which probably differs very little from the original invention. A number of ribbons, say from ten to thirty, may be woven at once according to the length of the shuttles used, but the loom being shown in section, only one ribbon is seen.

The loom is provided with as many reels or small warp beams as there are pieces of ribbons to be woven, also with a similar number of cloth beams, upon which the ribbons are wound as they are woven. If this were not the case, every piece must be supplied with weft at every throw of the shuttles, and should one of the pieces fail to receive any weft, there would be great difficulty in turning back so as to keep all the pieces alike. In weaving plain ribbons the weft may be broken and pieced again at any interval, for the ribbon does not travel unless the weft is supplied. The reed in beating up the weft actually pushes forward the ribbon as it is woven, each beat of the batten pushing the ribbon, according to the thickness of the weft and the tension there is upon the warp and cloth beams.

In the figure let *b* represent one of the warp reels from which the warp for one piece of ribbon passes over the pulley *c* and downwards to the weight *d*, which has a pulley under which the warp passes, and then continues its course over a second pulley at *c*, thence under a cylinder or beam at p^1, and through the headles h^1 and *h* and the reed *u*. After it is woven it returns under the loom in the direction of the arrows, and under another weight *w*, and is finally wound on the reel *m*.

Now if both the weights *d* and *w* be equal, it follows that the blow of the reed will beat the cloth up with a force equal to the friction to be overcome, caused by the silk passing under and over the various pulleys and rails; and as the weight *d* rises, the weight *w* falls, carrying with it the ribbon as it is woven. Thus by altering the relative proportion of the weights, more or less tension can be put upon the cloth, and the ribbon may be woven with more or less compactness in consequence.

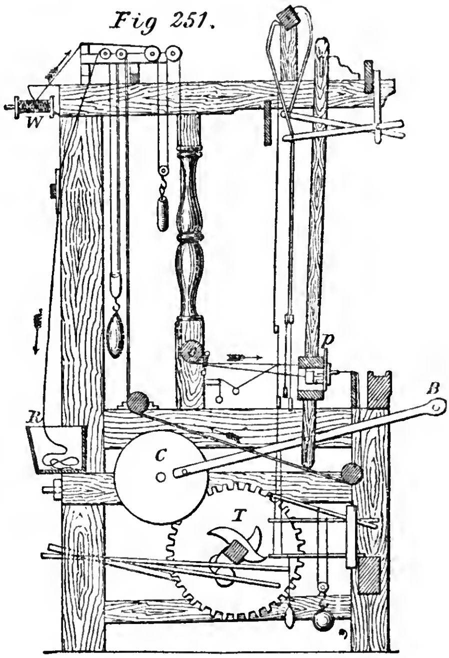
When the weights have arrived at their full extent of motion, they are replaced in their former position by slackening out more warp and winding up the woven ribbon. Small wedges or other contrivances are used at *o o* to hold both the warp and cloth firmly during the process of weaving.

The weaving is performed by means of headles and treadles in the usual way, but in this loom the weaver can arrange or dress his warp to a certain extent without leaving the front of the loom, for the warp passes through a small reed or comb *p*, and by moving it upwards to y the threads can be placed in proper order.

The shuttles, or swivels, are arranged in a batten and slide between two flat plates or "planks." They are "jerked" across the opening, and consequently through the shed, from side to side alternately. Each shuttle alternately occupies the place of the adjoining shuttle.

Fig. 252 shows a portion of the batten in front elevation, and Fig. 253 shows a corresponding section. The warp w passes through

Fig 251.

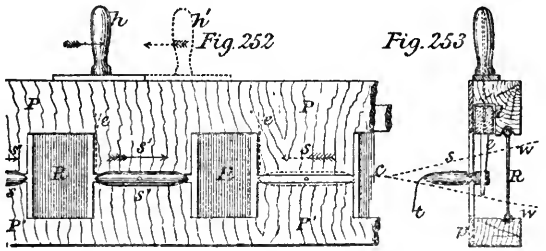


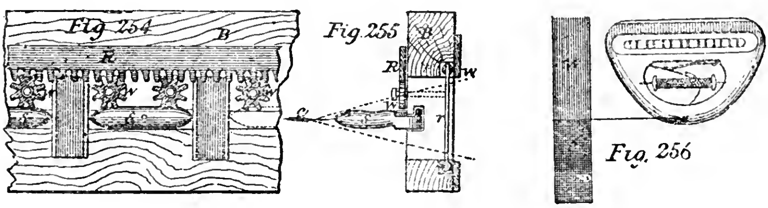
the reed R to the cloth c. The shuttles s s slide in the openings formed by the planks P P and P' P', and are thrown across the openings by means of the driver d, which is a bar of wood in which pegs e e e are fixed to strike the shuttles from side to side. The driver is moved by means of the handle h, which is shown also in dotted lines at h' at the extent of its motion.

Figs. 254 to 256 show the method of throwing the swivels by means of the rack and wheel motion. This motion seems to have been invented in France, about the middle of the last century, as before stated.

The shuttles *s s* have a small rack inserted, and they are geared in the star wheels *w w*. These wheels are worked by the rack *R*, and as this rack works all the wheels by its alternate motion (see Fig. 254), the shuttles are thrown from side to side of the openings through the warp *w*. The advantage of this motion is that the shuttles are forced completely and surely through the shed, and are not liable to stop half way, as when driven by the driver used in the Dutch loom.

Fig. 256 shows a plan of a shuttle as originally used in the rack and wheel motion, which is still the most important method used at the present time in ribbon looms, although modified in certain ways.



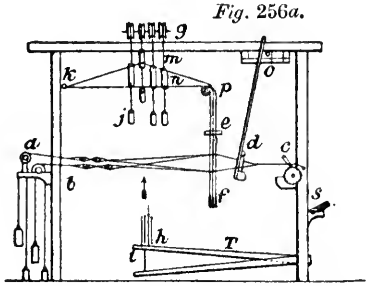


The bar loom shown in Figs. 250 and 251 is worked by hand, by means of the handle or bar *B*, which is connected to the extensions of the connecting rods working on the crankshaft *C*. This crankshaft works the tappet shaft *T*, which is named from the circumstance that the various tappets or cams for opening the sheds and driving the shuttle are worked by it. In other respects the loom is similar to the Dutch, although the passage of the warp and ribbon is modified to a certain extent, as shown.

The small hand loom for weaving single pieces of ribbon, fringe, gimp, ties, &c., is very ingeniously arranged, and based on the draw-loom principle. It is a very old contrivance, and is at the present time extensively used.

Fig. 256*a* shows a section of the loom, in which *a* and *b* represent two warps and beams which are being woven. The reed is shown at *d*, and *c* is the cloth beam, *s* the seat, and *T* the treadles. So far the loom is similar to the ordinary hand loom.

Fig. 256*a.*



On the top of the loom a number of pulleys *g* are placed on each side. In this instance eight are used, or four on each side; but twenty and upwards can be used. Each pulley has a corresponding treadle *T*, and a cord *h* is attached to each treadle and carried over a pulley, terminating with a weight *j*. Before the cords reach the weights a loop is formed in them, as shown at *n*. Another series of cords are attached to a staple *k*, and carried over the pulley or roller *p* and attached to either headles or leashes of the loom, after passing through the comber board *e*. In this case leashes and lingoes are shown attached.

Now the pattern is formed by passing such of the cords connected with the headles as are intended to be raised by each treadle through the corresponding loop; and when the treadle is depressed, as at *i*, it will raise the headle or headles by drawing the cord as at *m*.

Therefore the pattern is arranged simply by threading the cords *k* through the loops as desired, and as each treadle opens a different shed a great variety of patterns may be made with comparatively little trouble.

CHAPTER XX.

THE POWER LOOM—M. DE GENNES—BARBER'S LOOM—DR. CARTWRIGHT—ROBERT MILLER—WILLIAM HORROCKS.

In the last Chapter it was shown that the ribbon loom had been made to work automatically about the middle of the last century, and was the first loom made to work by power. But the term "power loom" is usually understood to mean a loom to weave wide cloth such as calico, and in fact it was to weave calico by power that Dr. Cartwright set himself the task to accomplish.

The power loom must be adapted to perform the various operations of the weaver, and these are as follows:—To open the shed, to throw the shuttle, to beat the weft together, to wind up the cloth as it is woven.

Although these are the only operations required to weave, there are many circumstances that must be attended to in order to make the best use of the loom. In plain weaving to open the shed and beat together the weft threads is a simple matter, but in case the weft thread should break, the loom would continue to move unless some contrivance was used to stop the loom without the assistance of the weaver, and in case the shuttle should fail in being thrown through the shed into the opposite box and should stick in the shed, then serious damage would be done to the warp if there were no means to stop the loom suddenly. The winding up of the cloth in constant and regular intervals must also be effected, or as the cloth beam became filled the cloth would be wound up faster in proportion to the diameter of the cloth beam.

All the above operations could be accomplished in the ribbon loom with much less difficulty than in broadcloth looms. The shuttles could be easily and safely thrown through the shed without danger, and the winding up of the ribbon as woven is very ingeniously carried out by a plan that could scarcely be adopted in a wide loom. Therefore the problem to be solved to weave wide cloth was a very different one, and it now remains to be shown how it was accomplished.

The first mention or suggestion that is known relative to weaving by power is given in the French *Journal des Savants* for the year 1678, a copy of which was printed in the "Transactions of the Royal Society of London." In these works a model of a "New machine for making linen cloth without the aid of a workman" is shown and described. It was presented by M. de Gennes, an officer of the French navy, to the Royal Academy.

Fig. 257.

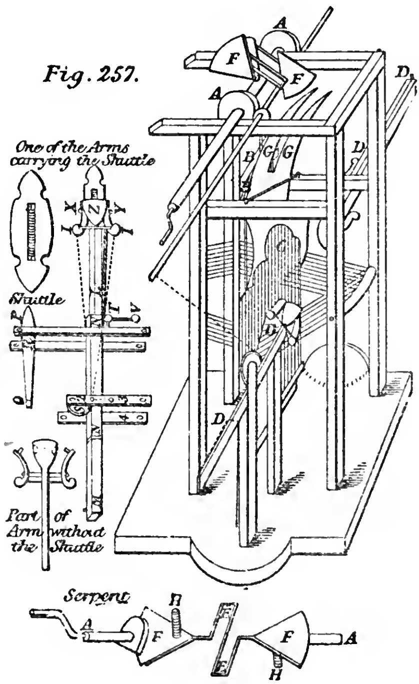


Fig. 257 is a copy of the drawing, which is inserted here on account of its being the first known attempt at power weaving, and not from any practical value it possesses. The crankshaft is called a "serpent," and the shuttle is inserted in a lever, and carried half-way through the shed, where it is received by a corresponding lever on the opposite side of the loom. Cams are shown to work the headles, and in this instance, although of little practical use, they are probably the first application of tappets to looms.

The next, and probably the first most important attempt to construct a self-acting loom, was made by Vaucanson, in 1745. This loom is of full size, and is now carefully preserved in the Conservatoire des Arts et Métiers, at Paris. It not only is provided with his great improvement on M. Bonchon's invention (see page 141), but it contains a friction roller taking-up motion almost exactly as shown in Fig. 264. These two inventions are now in common use.

The loom was driven by means of a handle, which is fitted to work a shaft on which are placed a number of tappets. These tappets gave motion to the healds and the Jacquard machine, for the harness is arranged as in Damask weaving. A cylinder covered with perforated paper to form the pattern is used, but only one row of needles. This plan was patented in 1822, by the celebrated Richard Roberts, who was perhaps not aware of Vaucanson's loom.

The shuttle was intended to be driven in the same way as in De Gennes's loom above shown, viz. by being carried through the shed by means of levers provided with sockets to hold the shuttle. Now John Kay's fly-shuttle had been patented at least twelve years before Vaucanson's loom was made, and had become of use in England. But Vaucanson was possibly not cognizant of it, or he might have adopted it. Had he done so, the power loom would probably have made its way at least half a century earlier than it did.

The next attempt appears to have been made by "Robert and Thomas Barber, of Billborough, Nottingham, gentlemen," who took out a patent in 1774, No. 1083, for "Machinery for preparing, spinning, and weaving fibrous substances," &c.

The specification is accompanied with a drawing of the loom, and it is particularly interesting from the circumstances that the picking shafts, with the sticks, cams, and studs, are arranged the same as in the most approved modern looms, although they act by winding up and releasing springs as in some excellent looms now in use. The date, it will be noticed, is eleven years earlier than Dr. Cartwright's first patent, but it is probable the doctor knew nothing of the matter.

Fig. 258 is a copy of Messrs. Barber's drawing attached to the specification, and their own description of the invention is also given as follows :—"*L, L, L, L,* represents the layth or swing of a common loom, with the sley in it, which strikes the threads up, &c. 1, 1, a square shaft fixed upon the low rails of a loom, set short of being perpendicular under the layth. 2, a cog wheel, which gives motion to the whole when it is moved by a water-wheel, or a wheel turned by horses, air, or fire. 3, 3, two wheels, with each a piece cut out to make them catch upon the arms 5, 5, and hold them forward until the return of the sluice suffers them to flirt into them again. 4, 4, two upright shafts with spindles at top and bottom, each of them two arms. These shafts stand on the outside of the loom. 5, 5, the two low arms in the shafts 4, 4, with each a castor for the wheel catches, to press back and continue holding till the cut part comes

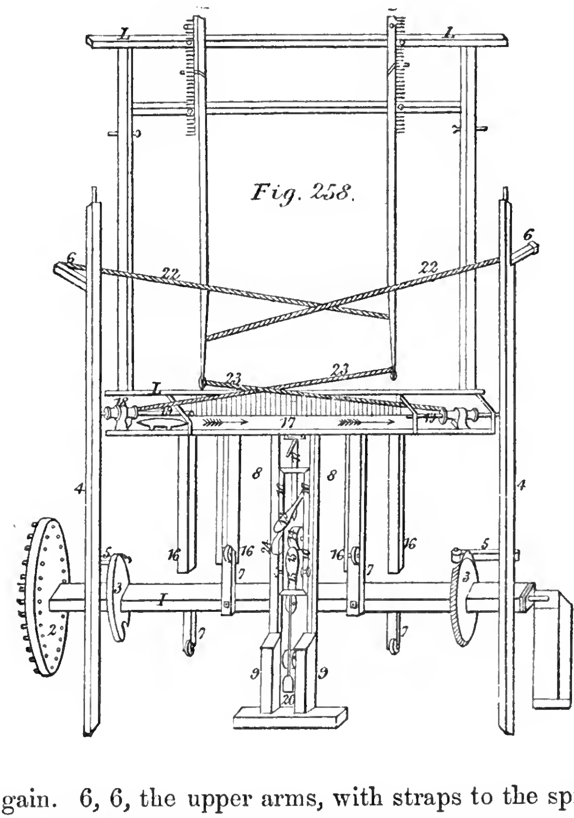


Fig. 258.

round again. 6, 6, the upper arms, with straps to the springs. 7, 7, 7, 7, four arms, with wheels in the points, to press down the traddles. 8, 8, the flat or top part of a frame (mark'd with red ink), fixt up almost as high as the bottom of the layth 1, and goes under it; the other end comes back to two uprights, 9, 9. 9, 9, two standards, which also supports the weights and the carriage. 10, 10, a carriage to run backward and forwards occasionally upon frame 8, 8, having four small wheels running in groves in 8, 8, where dotted. 11, an iron catch, axled, held down at tail by a spring. 12, a spring to hold down the iron catch. 13, an iron stop for catch to lay hold upon, fixed to the layth bottom. 14, a wheel fix'd in the carriage. 15, 15, two lavers fixed upon opposite squares of main shaft, which, moving circular, roll the carriage up untill the catch lays hold of layth. 16, 16, 16, 16, four traddles, with ends coming forward almost under the main shaft. 17, the bed of the layth, or bottom on which the shuttle passes. 18, 18, two triggers, which slip on wires to strike the shuttle. 19, 19, two wires, which carry shuttle triggers. 20, 20, a weight, which, fix'd to a strap running over a wheel, pulls back the carriage. 21, 21, two springs fix'd upon the layth. 22, 22, two bandages from the upper arms to the springs. 23, 23, two bandages from springs to shuttle triggers. 24, a button fix'd on frame. 8, traps of spring. 12, the motion. The cog wheel, being moved by the main power, turns the shaft gently round. Two of 7, 7, press down the two of 16, 16. One of the lavers, 15, rolls up carriage 10, whose catch lays hold upon 13. The laver quits the wheel by its circular motion, and the weight 20 strikes forward the layth to the work, at which time the spring is trapt of by 24, and, being released returns one of the 3, 3, having the cut-out place upwards. 5 is pluckt back into the adjutage by 21, and its bandage 22, which is buckled at point of 6. At the same instant the bandage 23 plucks 18, which drives the shuttle to the opposite side. Thus one course is wove in half a revolution, &c."

It does not appear that Barber's loom was ever brought into use, and nothing more is heard of a power loom until 1785.

By the invention of the fly shuttle, and the addition of the "tappet shaft" to the narrow goods or Dutch loom, a great step had been made towards the application of motive power to weaving. The spinners could not supply yarn in sufficient quantity to keep the looms at work. In addition to this increased demand for yarn, the hosiery trade required further supplies, in consequence of the invention of the rib hosiery frame by Jedidiah Strutt, and other modifications of the Lee stocking frame. This increased demand led to the grand series of inventions used in the spinning of cotton.

When it was found that the cotton spinners were able to supply all the requirements of the weavers, and there appeared to be a probability that the weavers would be unable to use the yarn as fast as it was spun, it became apparent that an advancement was requisite in the process of weaving.

This was perhaps first accomplished by Dr. Edmund Cartwright, of Hollander House, Kent, who obtained his first patent for a power loom in 1785. The circumstances which led him to apply himself to the invention of a new mode of weaving are best related by himself, in his well-known letter to Mr. Bannatyne, as follows :—

"Happening to be at Matlock in the summer of 1784, I fell in company with some gentlemen of Manchester, when the conversation turned on Arkwright's spinning machinery. One of the company observed, that as soon as Arkwright's patent expired so many mills would be erected, and so much cotton spun, that hands never could be found to weave it. To this observation I replied that Arkwright must then set his wits to work to invent a weaving mill. This brought on a conversation on the subject, in which the Manchester gentlemen unanimously agreed that the thing was impracticable; and in defence of their opinion they adduced arguments which I certainly was incompetent to answer, or even to comprehend, being totally ignorant of the subject, having never at any time seen a person weave. I controverted, however, the impracticability of the thing, by remarking that there had lately been exhibited in London an automaton figure which played at chess. 'Now you will not assert, gentlemen,' said I, 'that it is more difficult to construct a machine that shall weave, than one which shall make all the variety of moves which are required in that complicated game.'

"Some little time afterwards a particular circumstance recalling this conversation to my mind, it struck me that, as in plain weaving, according to the conception I then had of the business, there could only be three movements, which were to follow each other in succession, there would be little difficulty in producing and repeating them. Full of these ideas I immediately employed a carpenter and smith to carry them into effect. As soon as the machine was finished, I got a weaver to put in the warp, which was of such materials as sail cloth is usually made of. To my great delight a piece of cloth, such as it was, was the produce. As I had never before turned my thoughts to anything mechanical, either in theory or practice, nor had even seen a loom at work, or knew anything of its construction, you will readily suppose that my first loom was a most rude piece of machinery. The warp was placed perpendicularly, the reed fell with the weight of at least half a hundredweight, and the springs which threw the shuttle were strong enough to throw a Congreve rocket.

In short, it required the strength of two powerful men to work the machine at a slow rate, and only for a short time. Conceiving, in my great simplicity, that I had accomplished all that was required, I then secured what I thought a most valuable property by a patent —4th of April, 1785. This being done, I then condescended to see how other people wove; and you will guess my astonishment, when I compared their easy modes of operation with mine. Availing myself, however, of what I then saw I made a loom, in its general principles nearly as they are now made. But it was not till the year 1787 that I completed my invention, when I took out my last weaving patent, August 1st in that year."

Dr. Edmund Cartwright was born in 1743, at Marnham, Notts, near which place his family had been long established. He was sent at the age of fourteen to University College, Oxford, and during the vacations was under the private tuition of Dr. Langhorne, the well-known editor of "Plutarch's Lives." Shortly afterwards he published several poems and contributed to the "Monthly Review." In 1779 he removed with his family to Goadby Marwood, in Leicestershire, where he had been presented to the living, and he devoted himself principally to reviewing new works, amongst which may be mentioned "Johnson's Lives of the Poets."

His first attempt at mechanical invention occurred in 1784, which he so graphically describes in his letter above cited.

In 1786 he devoted himself to improvements, which include metallic packing to the piston in the steam engine, which he patented in 1797 and 1801. In 1789 and 1790, he took out patents for his combing machine. These patents were infringed upon, and although he, with great difficulty and annoyance, established his claim to the invention, he does not appear to have gained anything by it; but in 1801 he petitioned the House of Commons for an extension of his patents.

Bread-making and brick-making machines were invented by him, and he patented the making of moulded bricks for arches, &c. Rope-making machinery also occupied his attention.

He established a weaving and spinning factory at Doncaster, in 1786, in which free scope could be given to every description of mechanical experiment, but it was relinquished in 1793, after expending 30,000*l.* in the enterprise. As a compensation for his loss, a grant of 10,000*l.* was allowed to him in 1809, by the Government. In 1791, he contracted with Messrs. Grimshaw, of

Manchester, for the use of 400 of his looms. They built a mill for the purpose, and twenty-four of the looms were set to work. They are said to have performed their work well, but shortly afterwards, the factory was burned down, it is believed by a mob. It was to this misfortune that Dr. Cartwright dates the origin of his mis-

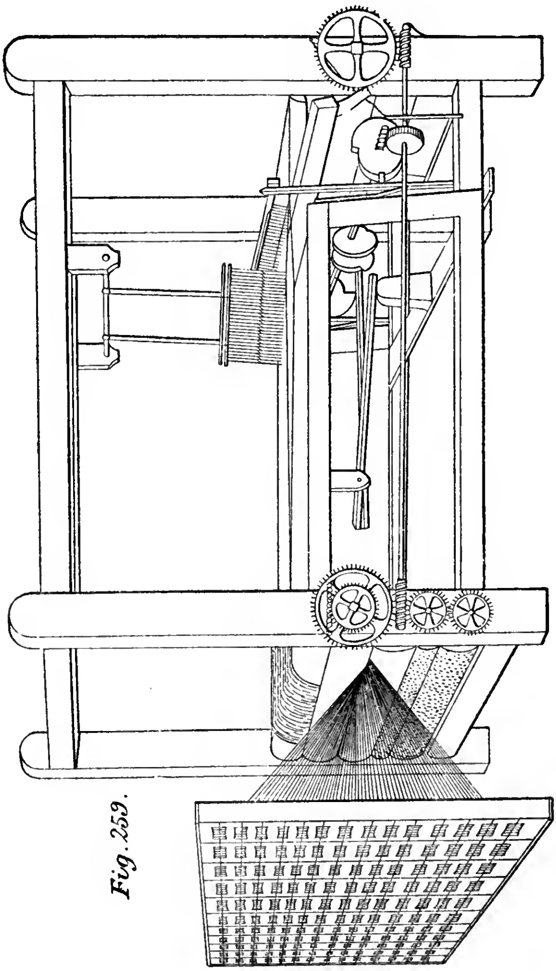


Fig. 259.

fortunes, and he became unable to protect his patents from being infringed. It was proved that in one mill alone six sets of combing machines on his principle had been employed for seven years, each set realizing 1100*l*. per annum, but no royalty had been paid to the doctor.

In 1805 he received the Gold Medal of the Board of Agriculture for his Essay on Manures. This remarkable man died at Hastings, 30th October, 1823, and was buried in Battle Church.

Dr. Cartwright's loom, Fig. 259, deserves more than usual attention, for his patent is so full of curious details which he believed he could carry out, that it is no wonder he failed in doing so. He had evidently looked at the problem before him from a theoretical point of view, and for almost every contingency as well as action in the operation of plain weaving, he had provided plans by which they might be accomplished. Some of these details show great ingenuity, and have since the doctor's time been successfully carried out. For instance, he says in his specification:—

"F is the movable frame having the part adjoining to the lathe supported by loops on two rods fastened to the lathe, and the outer part supported by loops on two rods *e e*, *f f* fastened at each end upon a board lying under the warp, and on which rod it glides. It vibrates with the lathes, and at every vibration passes under hooks, which are severally suspended upon each thread, and which are strung upon the rod *g g*. Note. If a thread breaks, the hook which was suspended upon it drops down upon the board lying under it, and catches the frame, which is made bevel-edged for the purpose of slipping under the nose of the hook, the lathe going to while the frame is held by the hook. The pulley E is turned round and an oblique direction given to the lever D. In this direction it strikes, or is wedged against the inside of the lever C, which is thus forced from the wheel A; and as the lever C carries the socket B along with it, the socket and the wheel are disunited, and the machine stopped. Note, the pulley is brought back to the place by a coiled spring, like the main spring of a watch, in the inside of it. The coiled spring serves also to keep the movable frame steady to its place. G is a small staple in the shuttle swinging upon a wire *h h*. The velocity of the thread passing under it prevents the staple from dropping below the bottom of the shuttle. If the thread breaks the staple drops, and in its passage catches the hook H, which projects a little above the floor of the fly or board on which the shuttle runs. H is a hook connected by a wire to the lever D. The hook swings upon a centre at *i*. When caught by the dropping of the staple G it gives an oblique direction to the lever D, and consequently stops the machine. I is the principal axis, at one end of which is the worm *k* working upon the wheel *l*, and giving motion to the axis *m m*; at each end of which axis is a worm, each worm giving motion respectively to the two wheels K and L. Note. The wheel *l* works upon a round part of the axis *m m*, which it puts in motion by being connected with the movable square socket M. When the square socket is drawn off, which it may be, by the lever N, the axis *m m* stands still, consequently the cloth does not wind up. This will be necessary should the shuttle at any time pass without carrying any woof along with it. K is a wheel fast upon the axis of the cyinder O O, which, by binding in its revolution against the cylinders P P and Q Q, either one or both of them, takes up the cloth as it weaves. L is a wheel connected with the axis of the cylinder *r r*, which lets off the yarn in the same manner as the wheel K takes up the cloth. Note. The wheel L revolves upon a round part of the cylinder's axis, and is kept to its place by the endless screw *a*, and working upon the wheel β, which is fast upon the square part of the same axis. By means of the endless screw the yarn is made slacker or tighter, as occasion may require. M is a square socket connecting the wheel *l* with the axis *m m.* Note. By varying the number of teeth upon the wheel *l*, as also by varying the number of teeth upon the wheels K and L, the cylinders take up and let off faster or slower, and consequently more or fewer threads may be put into any given space according to the discretion of the operator; hence the work is made invariably uniform. N N the wheels which force back the laths. O O the springs which throw it to. P P are the wheels which force up the rods S S. To each rod is joined a wire, the extremity of which lies against the back of the corresponding picker. When the rods are alternately set at liberty from the wheels P P, the springs U U strike and the shuttle is thrown. Note, the wheels P P have that part immediately following the place where the rods strike off formed spirally like a screw, for the purpose of drawing up the rods to their places again. Q Q are the pickers gliding in grooves, and having springs. V V gradually pressing as the picker recedes from the shuttle against the sides of the frame in which they slide, and thereby preventing the shuttle from rebounding. R R, are the wheels or tappits that work the treadles that draw down the yelds or harness, and open the shed; see Fig. 1. S are the temples closed by the springs *w w*; T are the temples opened by the treadles *x x*, which are pressed down by the cogs Y Y upon the wheels P P. Note, when the temples are open, the space from the points *z z* is less than when the temples are closed. Note, also, that when the cloth is set at liberty from the temples it contracts. In proportion as it contracts the temples must be made to open more or less so as to keep the points *z z* in contact with the selvedge of the cloth, that when the temples close the cloth may be stretched out again to its proper dimensions. U is a trough for containing the composition for dressing the warp. N is a cylindrical brush revolving within the trough U, and feeding the cylindrical brush W. W is a cylindrical brush conveying the dressing composition from the feeding brush to or against the lower yarn cylinder. Note, the cylindrical brushes receive their motion either from a wheel upon one of their axes which lies under the worm working upon the wheel L, or from a wheel upon the axis of the lower yarn beam working upon a wheel on the axis of the upper cylindrical brush, which wheel conveys the motion to a wheel on the axis of the lower cylindrical brush. X is a dry brush for working the dressing composition into the yarn, and laying the filaments of it smooth.

"Y is the yarn bobbin frame, which may be substituted for the yarn beam at the discretion of the operator, from which the cloth is woven without the trouble of winding, warping, or beaming. Z is a box or drawer for receiving the cloth."

The detail drawings accompanying the above specification are very crude, and would rather confuse than assist the description so clearly given, and for that reason they have been omitted here. Now the first part of the above-described details of the patent refers to the contrivance to stop the loom when a warp thread breaks, and it will be granted that to accomplish the feat of doing so by automatic means, when any single thread of the two or three thousand that may constitute the warp, breaks, must necessarily call forth no ordinary amount of skill. But although the doctor may not have succeeded practically in carrying out his ideas, it is gratifying to know that the principle upon which the contrivance is based is now successfully applied to the warping frame. See Fig. 355.

In his various patents he describes a method for stopping the loom when the weft thread breaks, and let-off and take-up motions for the warp and cloth beams. Temples for stretching the cloth laterally as it is woven, or rather to keep it from contracting, which thin warps and heavy weft are liable to, are mentioned, as well as other matters which have since taken many years to bring to perfection. At that time it was customary to size or dress the warp in the loom, but the doctor not content with this, in addition, attempted

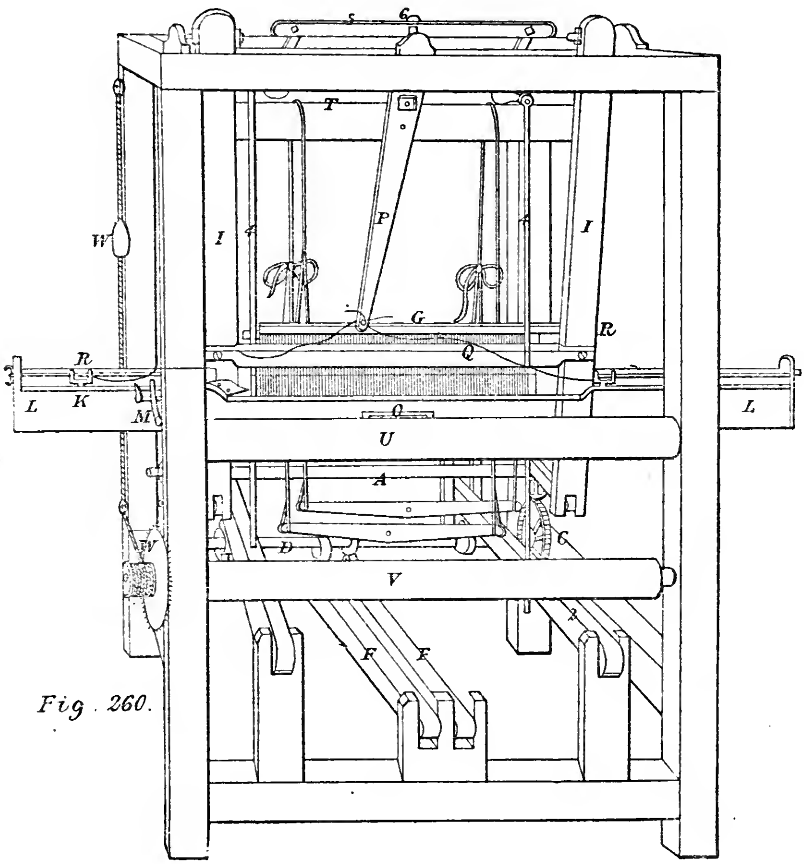


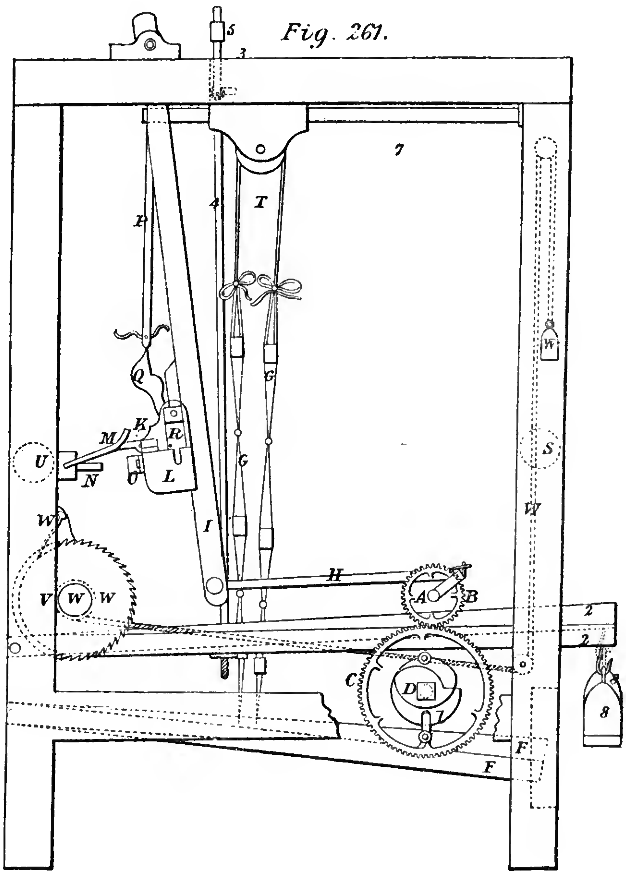
Fig. 260.

to do away with warping by weaving the threads direct from the reels or bobbins, as may be seen on referring to the figure (259).

Other inventors, who followed the doctor, very wisely kept more within compass, and confined themselves to those motions only which were actually necessary. Even then it took twenty years to prove that the power-loom had any advantage over the hand loom.

In Mr. Horrocks's loom, shown in Figs. 260 and 261, are "two spiral wheels on shaft D; 2 2, levers, to which weights 8 8 are hung; 3 3, cranks (pulleys and chains will answer the same purpose); 4 4, rods of iron or any other material passed through cylindrical apertures in levers 2 2, and secured with a nut. These rods having room to play through the levers prevent the one acting against the other; 5, a cross piece connecting the cranks 3 3, with 6, a crank,

Fig. 261.



fixed on 7, a shaft; 8 8, weights, which being attached to levers 2 2, they are alternately raised by the revolution of the spiral wheels on shaft D, and depressed by falling from the longest to the shortest radii of the same. The rods 4 4, being connected with the levers 2 2, and joined to the cranks 3 3, which are connected with the crank 6 by means of the cross piece 5, the crank 6 works on the shaft 7 as a centre. To this shaft is fixed the lever P, to which are tied the cords *Q*; these cords are tied to the pickers *R R*. Now, supposing one of the levers 2 to be on the longest radii of one of the spiral wheels 1, by the revolution of the said wheel it would drop to the shortest radii of the same. This would move the cranks 3 3 and 6, and consequently the lever *P*, with a sufficient force to throw the shuttle from one box to the other, and the depression of the other lever 2 would throw it back again."

Mr. Horrocks states in his specification that he claims only those parts of the loom that are marked on the drawing in figures, and not those marked with letters. The take-up motion being marked with letters he certainly does not claim, but he uses them; and there may be good foundation for Mr. Radcliffe's complaint. Neither of them were aware that Vaucanson had, more than fifty years previously, devised the most perfect contrivance for that purpose, or much of their trouble might have been spared. See Chapter xxxv.

Several improvements were subsequently made by Mr. Horrocks in his loom, and it became of wide-spread use; but he was unfortunate, and reaped but little advantage from them.

CHAPTER XXI.

PROGRESS OF POWER LOOM WEAVING—ALMOND'S LOOM—THE "DANDY" LOOM—OPERATIONS REQUIRED IN POWER LOOM WEAVING.

At the present time there are in the United Kingdom not less than 700,000 power looms, producing about 15,000 miles of cloth daily, and giving employment to 300,000 weavers. To perform the same amount of work by the old process of hand-loom weaving would require, at a moderate estimation, about one million additional hands. Thus the saving of labour effected by the power loom amounts to the vast number of one million of workpeople, or a far greater number than the whole productive population of London.

Yet this great advantage, which is of the highest national importance, has been obtained within a comparatively short period, and it needs no comment to extol the benefit thus conferred upon the country further than to show by what means and by whom such great results have been achieved.

It unfortunately occurs on the introduction of new processes whereby a great increase of production is obtained, that a considerable amount of suffering is often caused thereby to those who follow the old methods and are incapable of adapting themselves to the new. They must either compete with the new system—in case they cannot adapt themselves to it—or find some other employment, often very different from their old occupation. In this way the hand loom weavers struggled for years—successfully at first, but they were gradually and surely overtaken in the unequal race of machinery against manual labour.

But the introduction of the power loom was not like the introduction of machinery to many other trades, where a complete revolution is sometimes made in a comparatively short time. It was, on the other hand, an innovation of an exceedingly slow growth, and it is questionable whether, taking all things into consideration, it had any advantage over the hand loom during the first twenty years of its progress, or only fifty years ago.

It may be assumed that power-loom weaving was an accomplished fact at the commencement of the present century, yet its progress was so slow that in the year 1813 there were only 2400 such looms in operation. But from that time they began to be more generally adopted, for there were, according to Mr. Baines,—

	In 1820.	1829.	1833.
In England .	12,150	45,500	85,000
In Scotland .	2,000	10,000	15,000
Power-looms.—Total	14,150	55,500	100,000

showing a rapid increase. Yet during this period the number of hand looms employed in the cotton manufacture are said to have increased also, and in 1833 they were computed to amount to 250,000. But from that time they have gradually had to succumb, and are now only employed on such work that would afford no advantage in applying the power loom to produce. In some instances the application of power for weaving certain fabrics has failed and the old system has been returned to.

The number of power looms employed in the United Kingdom in 1874, according to a report made to the House of Commons (see appendix) was as follows:—

Factories.	England & Wales.	Scotland.	Ireland.	Total.
Cotton . .	431,389	29,171	2,558	463,118
Woollen . .	45,025	11,758	307	57,090
Shoddy . .	1,437	—	—	1,437
Worsted . .	75,591	6,156	—	81,747
Flax . .	5,264	18,529	17,827	41,620
Hemp . .	22	—	—	22
Jute . .	897	7,058	308	8,263
Hair . .	53	—	—	53
Silk . .	9,759	226	17	10,002
Elastic . .	2,633	30	—	2,663
Sundries . .	390	1,267	39	1,696
Total . .	572,460	74,195	21,056	667,711

It is probable that in the present year 1878, the total number amounts to not less than 700,000.

As regards the number of power looms in other countries at the present time, there does not appear to be any available statistics relating to them; but if it be granted that they bear a similar proportion to the number of spindles employed as they do in the United Kingdom, then the grand total may be estimated as follows :—

looms

1860 - Canada = 260 looms

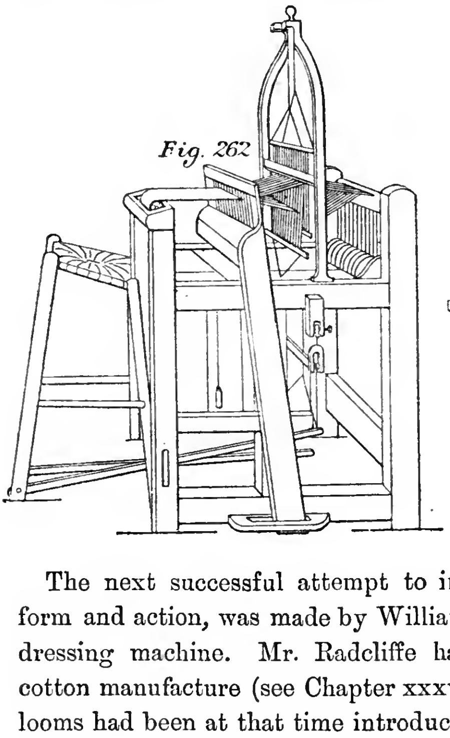
England	600,000
Scotland	78,000
Ireland	22,000
India	11,000
United States	175,000
France	82,000
Germany	80,000
Russia and Poland	41,000
Switzerland	32,000
Spain	30,000
Austria	28,000
Italy	14,000
Belgium	13,000
Sweden and Norway	5,000
Holland	4,000
Total	1,215,000

The value of power looms with the necessary buildings, steam-engines and auxiliary machines, are variously estimated according to the size and mountings of the looms, but they would probably average at £25 per loom, representing a total value of upwards of thirty millions sterling for the above number.

The advantages that the power loom possesses over the hand loom is in its greater productiveness, and the complete saving of manual labour, for while the irksome and laborious part of the work is being done by power, the weaver is occupied in attending to the replenishment of the shuttles, and keeping the warp in order. By this means one weaver may in most cases attend to more than one loom, as in calico weaving, but that of course, would depend upon the nature of the work.

The first attempts, as already shown, at weaving by power were made by adapting the common hand loom for that purpose. Its form, however, was very unsuitable and awkward, and a long time elapsed before a more convenient one was arrived at. Yet strange to say so early as 1771 a hand loom (see Fig. 262) was exhibited and worked before a committee of the Society of Arts, which strongly resembles in form the common power loom of the present day. This loom was invented by a Mr. Almond, and the Society awarded him fifty guineas for the new modification. It was, perhaps, the first loom with an inverted batten, and it is curious to note that the fly shuttle was not included in it, although it had been invented and used nearly forty years previously. Mr. Almond's loom was doubtless unknown to the pioneers of power loom weaving, or they might have taken advantage of its compactness of form, as more adapted for their purpose than the common loom.

Fig. 262



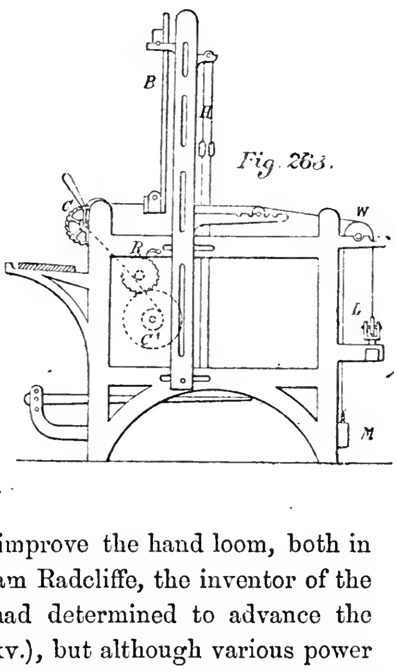
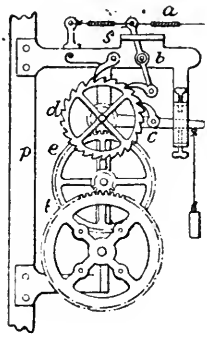


Fig. 263.

The next successful attempt to improve the hand loom, both in form and action, was made by William Radcliffe, the inventor of the dressing machine. Mr. Radcliffe had determined to advance the cotton manufacture (see Chapter xxxv.), but although various power looms had been at that time introduced, he did not appear to have much faith in them, so he confined his attention to the improvement of the hand loom. At first he made it of the compact shape shown in Fig. 263, and he afterwards moved the cloth beam from the ordinary position at C, and placed it beneath the warp as at C^1, and added to it a ratchet wheel take-up motion, as shown in dotted lines. This was effected in 1802, and is the motion he charged Mr. Horrocks with having unfairly made use of. Mr. Radcliffe's loom was long known as the "Dandy loom," and became of very general use. It resembles the common power loom, used for weaving wide and heavy fabrics.

Various kinds of take-up motion have been applied to the hand-loom before and since Mr. Radcliffe's time, but they differ very slightly from each other. The one sometimes used in silk weaving is a French contrivance called a "regulateur," as shown in Fig. 263 *a*. It is fixed to one of the front posts of the loom *p*, and consists simply of a train of wheels, *d*, *e*, *f*, the last one *f*, being secured to the cloth beam. The ratchet wheel is provided with a pawl and spring, and two levers with catches. The top lever and catch *b* may be connected to the batten by the wire *a*, which has a drawback spring attached at *s*. If the catch and lever *c* is used, it can be regulated by the set screws shown.



Mr. Almond's loom may be said to represent the common power loom, now in general use for weaving light and narrow fabrics, such as calicoes, stuffs, &c., when stript of all its self-acting movements. In working a loom of this kind every movement depends upon the weaver. He winds up the cloth by means of a lever and a ratchet wheel, and regulates the weight or tension on the warp beam as it decreases in diameter. The shuttle is thrown from hand to hand, and the shed is opened by means of the treadles, and at the same time the weft is beaten together by means of the reed.

Now these five motions are all that are absolutely requisite for the process of weaving both in the hand loom and the power loom, the only difference being that in the power loom they are performed automatically. But in the power loom other contrivances are applied in addition to the above—for the purpose of relieving the weaver from giving unremitting attention to the working of the loom. The first and most important of these is the weft-stop motion, by means of which the loom is stopped immediately the weft thread breaks, or the shuttle requires a fresh bobbin. The second is the application of a self-acting temple that does not require to be moved, as is the case with the common hand loom temple. Various other contrivances have also been, from time to time, added to the loom for the purpose of assisting the weaver, such as stopping the loom on the breaking of a warp thread; but it is questionable whether any advantage would be derived from them. Such additional mechanism would increase the complication of the working parts of the loom to a greater extent than perhaps would be found of real service, and in consequence they are rarely adopted.

In carpet and velvet weaving additional apparatus to the loom are required for raising and cutting the pile, and in fancy weaving various contrivances are used, but they are not necessary adjuncts to the power loom, excepting for the purpose for which they are absolutely required.

Power looms differ from each other in size and strength, according to the nature of the material or fabric to be woven, consequently the variety of form and combination of parts are exceedingly numerous. But as all looms depend upon the few motions above mentioned, it will only be necessary to consider the nature of each one separately, and the most approved methods of carrying the same into effect. By so doing the action of the most complicated loom will be rendered clear and simple.

Motion is given to power looms of every description by means of a shaft, provided with fast and loose pulleys, but sometimes with clutch couplings, called the crank shaft. From this shaft all the motions of the loom are derived. Two cranks are formed upon it, provided with crank arms or connecting rods to work the batten. It is also provided with one or more pinions, to give motion to shafts and tappets for driving the shuttle and working the headles. In some of the early power looms cams were used to move the batten back instead of cranks, and the reed was drawn forwards again, to beat together the weft threads, by means of springs. But by that plan, although it would prevent damage to the warp, excepting what might be done by the force of the springs when the shuttle was "trapped," the action was irregular and defective.

In the common power loom for weaving plain cloth, such as calico, or when a Jacquard or other machine is applied to it for weaving figures, only two shafts are required. First, the crank shaft above mentioned, and, second, the tappet shaft for giving motion to the picking sticks and headles.

Thus in Fig. 251, the crank shaft *C*, gives motion to the batten *p*, and to the tappet shaft *T*. Also in Fig. 261, the crank shaft *A*, gives motion to the batten *L*, by means of the crank arm *H*; and to the tappet shaft *D*, by means of the wheels *B*, *C*. The tappets or cams *b*, on the shaft *D*, give motion to the headles *G*, and the picking stick *P*, by striking against the levers or treadles *F*, *F*, and 2, 2.

For each alternate motion of the shuttle and the headles the batten must strike against the cloth; consequently the tappet shaft *D*, must only move at half the speed of the crank shaft *A*.

Formerly motion was frequently given to looms by means of friction and other clutches, but fast and loose pulleys are now generally used.

Power loom weaving is usually performed in large well lighted sheds, and in many instances more than a thousand looms are arranged under one roof. They are usually placed in groups of four placed back to back, so that free access can be had round each group. Lines of shafting pass over the looms at regular intervals. Where figured weaving is carried on, "gantrees," or two light beams (see *l l*, Fig. 315, and Fig. 314), are fixed over the looms, to support Jacquard machines. One horse power is usually required for every eight or ten looms, and it is of great importance that the speed should be regular. All the operations in connexion with weaving are frequently carried on in the same establishment, such as warping, sizing, beaming, winding, designing and card-cutting, measuring and folding, &c., &c. One overlooker is required to superintend about thirty looms. They are not only skilful weavers, but are frequently found to be ingenious and good mechanics.

CHAPTER XXII.

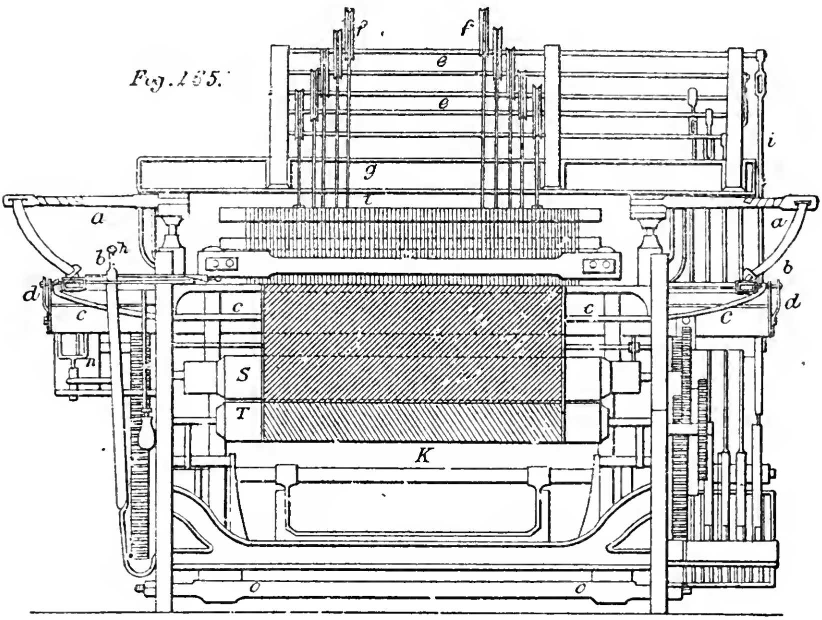
THE COMMON POWER LOOM—TAPPET MOTIONS—BOWMAN'S—ROBERTS'S—WOODCROFT'S—SCHOENHERR'S—HATTERSLEY AND PICKLES'.

A FRONT elevation of an ordinary power loom as used for weaving cotton, worsted, and alpaca fabrics is shown in Fig. 265, and an end elevation of the same in Fig. 266.

It is fitted with five sets of tappets, levers, and shafts, for working five headles, so that any cloth with a ground requiring that number of headles and five changes of shed can be woven by it. By fitting the loom with more or less than that number of headles and levers, a great variety of satins, twills, &c., may be produced, although seldom more than eight sets and eight changes are used on this system. In plain or "tabby" weaving only two headles and tappets are required, and in that case they are placed upon the cam or tappet shaft, which gives motion to the picking sticks. But when more than two headles are used, then a separate tappet shaft is required, and it is usually placed at the end of the loom, and is driven by a separate intermediate pinion as at *K*, Fig. 266.

Motion is given to the loom Fig. 265 by a strap working on the pulley *n*, fixed at the end of the crank shaft, from which shaft all the motions of the loom are derived. At *a a* are shown the two picking sticks, with straps connected to the pickers placed on spindles for driving the shuttle, in a similar manner to the ordinary hand loom

Fig. 265.



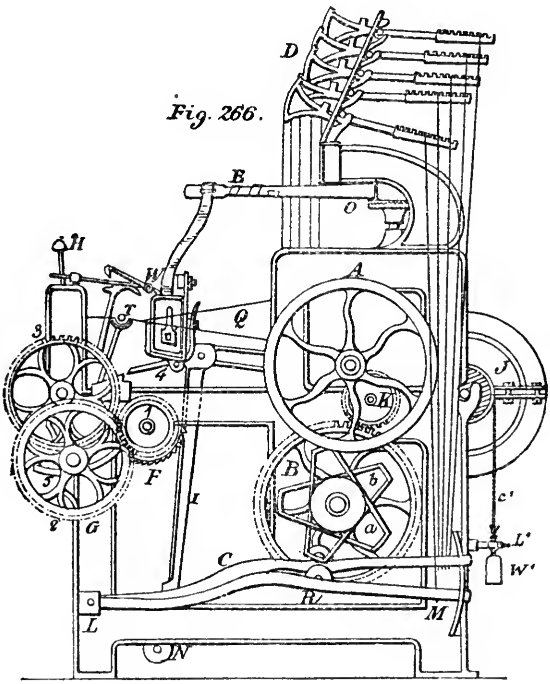
fly-shuttle. A strap *c c* extends across the shuttle race, as shown, and is kept in position by means of staples. The ends of the strap are looped on the picker spindles at the back of each picker, so that when the shuttle is driven to the opposite box, it forces back the picker and the strap also, which operates as a buffer and gradually checks the force of the shuttle. It is consequently termed the "check strap."

The warp beam *J* is provided with a lever L^1 seen in end view, upon which the weight W^1 is made to slide so as to vary the amount of tension on the warp by means of the cord c^1, in a similar manner to the hand-loom method, excepting that instead of using a small counterpoise attached to the other end of the cord c^1, it is generally tied to a part of the frame of the loom.

The warp, after being passed through the headles and reed, and woven in a similar way to ordinary hand-loom weaving, is carried over the breast beam, and thence under the sand or friction beam *S*, and finally wound upon the cloth beam *T*.

Each of the above-named parts of the loom, as well as the weft stop motion, &c., will be described separately, and the common tappet motion, shown in the figure, for working the headles will be first alluded to.

Fig. 266.



The headles *i*, Fig. 265, are each attached to a pair of levers *f f*, fixed upon rocking shafts *e e*, shown also at *D*, Fig. 266. Each of the shafts is also provided with a lever placed at the end, to which is attached a rod connecting it with the corresponding treadle, as shown at *M*, Fig. 266.

The headles are held down by means of springs, such as those shown in Fig. 85, and they have power sufficient to draw down the levers *D*, Fig. 266, and keep the treadles *M*, raised as shown at *C*. The required number of cams or tappets *a*, *b*, are placed upon the shaft of the wheel *B*, turned by the pinion *K*, which receives its motion from a pinion fixed on the crank shaft of the loom, at the back of the balance or hand wheel *A*.

Now during five revolutions of the crank shaft, which works the batten or lathe of the loom, the tappet shaft and wheel *B* revolves but once; consequently on the completion of five picks of the shuttle or revolutions of the crank shaft, the five changes of tappets have operated on the treadles *C*. Thus by a tappet striking against any of the rollers *R* attached to the treadles, which have their fulcrums at *L*, causes it to be depressed, and the corresponding headle is drawn upwards and thereby forms the shed for the passage of the shuttle.

The ends of the treadles *C* are passed through slots, or a grate *M*, to keep them in position. In the figures the front headle is shown raised, but it will be evident that two or more can be raised at the same time by arranging the tappets accordingly.

This kind of tappet motion is the most simple kind of shedding motion, but as it operates in the manner shown in Figs. 68, 76, and 267, it is not the best for fine or tender warps. The action shown in diagrams 75 and 77 is preferred, therefore various modifications of this system have been made to effect it in a simple manner, so as to make the shed rise and fall simultaneously, and thereby throw less strain and friction upon the warp by giving it a steadier and easier motion.

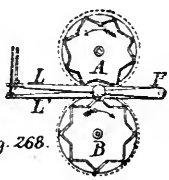


Fig. 268.

Fig. 268 shows Mr. Bowman's modification for that purpose, which he patented in 1820. Two sets of tappet wheels or plates *A* and *B* are employed, or two to each treadle. Now, as the wheels revolve together, the treadles or levers *L* L^1, which have their fulcrums at *F*, and are connected with the corresponding headles by cords, will be either raised or depressed by means of the cams or projections on the wheels, and in this case eight changes can be made by one revolution of the wheels, and a rising and falling shed be obtained.

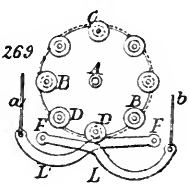


Fig. 269

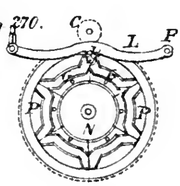


Fig 270.

The method adopted by Mr. R. Roberts, patented in 1822, is shown in Fig. 269, in which two levers or treadles are used to each headle, connected by the cords *a* and *b*, so as to raise and lower the headles simultaneously. Each pair of treadles is operated upon by a wheel or tappet plate revolving on its axis *A*. To these plates the required number of tappet pullies are fixed as shown.

The peculiarity of this motion consists in the formation of the pullies—each one being double, or two separate ones may be used of different diameters. If the smaller one be bolted next to the plate *D*, the lever L^1 will rise and the lever *L* will fall, because the larger or outside pulley depresses the lever *L*, and consequently raises the lever L^1. Therefore upon fixing the pulleys against the plate depends which treadle is to be raised, for by placing the larger side the lever L^1 would be depressed and the lever *L* raised, one of the

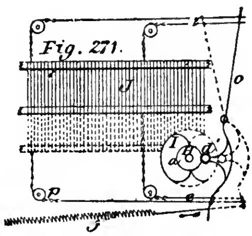


Fig. 271.

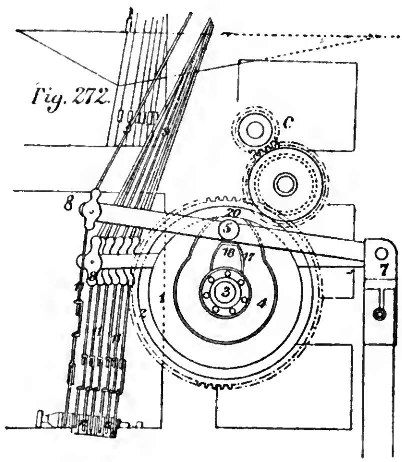


Fig. 272.

cords *a b* being attached to the top of the headle and the other to the bottom of it, and thereby raising or lowering it with certainty.

Fig. 270 shows Mr. Woodcroft's tappet motion, in which the same effect is obtained by using change plates, and bolting them to the tappet plates. By this means a groove is formed, and the treadle lever being provided with a stud or roller to run into the groove, the headle may be raised or lowered as desired, according to arrangement of the built-up groove in the plates,—there being a separate plate for each headle.

Fig. 271 shows the tappet motion used in Schoenherr's loom, in which *O* is the treadle lever operated upon by the tappets *I* and *II*. The roller a^1 fixed to the treadle is constantly pressed against the tappets by means of the spring *j*, and the headle *J* is raised in a parallel position by wires e and chains P, passing over and under the pulleys as shown.

A shedding motion on a similar principle to Fig. 270, was patented in 1876 by Messrs. Hattersley and Pickles, and is shown in Fig. 272. The levers have antifriction rollers 5, fixed upon them to run in the groove 4 of the tappet plate 1. A gap is left in the rim of the groove at 20, opposite the cam 18, so that the lever and pulley can be removed when required without disturbing the plate. C is the crank shaft; 7, the fulcrum pin of the levers; 2, the tappet plate driving wheel; 9, 11, and 12, the rods and levers connecting the upper and lower parts of the headles; 8, coupling plates.

In the tappet motion shown at 268 and 270 the connexion with the headles may be made in a similar way to that described and shown in Figs. 265 and 266. In that shown at Fig. 272 the headles are drawn down by the levers shown in end views at 12, so as not to be dependent upon springs, although that plan may also be applied to the motions 268, 269, and 270.

Tappet motions, as will be evident, are limited to the working of a few headles, and the number of changes or picks also rarely exceeds six or eight. They are heavy and cumbersome, and to change the pattern gives a considerable amount of trouble. On the other hand they are steady and firm in motion.

It is asserted by some that the changes which can be made, say with six plates and six tappets on each plate, amounts to many millions of millions—in fact to forty-two places of figures—a number quite incomprehensible. Certainly the tappets may be changed, or permutated to that extent, one in the place of another, as in the changing of places of any two pegs, one for the other, in a barrel organ; but it does not follow that the pattern or the tune would be altered thereby. The number of patterns that can be made by them is really very few in comparison.

Tappets are made of various shapes according to the idea of the loom maker; the aim being to produce a gradual and not a sudden opening of the shed, and when open to cause it to dwell a short time, to allow time for the passage of the shuttle. But the shape is of little consequence compared with making the shed too deep, and thereby throwing great strain upon the warp. In order that the shed should be opened evenly at the shuttle race, the headles are required to be raised at various heights from front to back—the front one being raised to a less height than the back one; and to adjust them accordingly. The end levers attached to the rocking shafts are provided with notches for the purpose of fixing the connecting rods to the treadles at proper distances, as shown in Fig. 266.

The number of changes that can be made by means of tappets, as above described, is evidently very limited, but to increase the number various methods have been adopted for fixing tappets on endless bands passing over pulleys and allowing each row to strike or press against the levers as they revolve. Chains, bands, and tappets for this purpose have been applied in various ways, but they have been superseded by small machines, or shedding motions, as hereafter described.

The connexions between the levers against which the tappets strike, and the headles, may be made in various ways, either by levers, cords and pulleys, or rocking shafts.

CHAPTER XXIII.

WARP AND CLOTH BEAM MOTIONS—ELASTIC LOOM—SCHOENHERR'S TAKE-UP—COMMON LET-OFF MOTION—GOULLIOND'S—SCHOENHERR'S—BELLEARD'S—HALL'S—LORD'S.

In power loom weaving it is absolutely necessary that the cloth should be taken-up or wound upon the cloth beam with perfect regularity, otherwise the texture of the cloth would be irregular. To accomplish this some means must be adopted to equalize the rate, or speed, of the take-up, for if the cloth were simply wound as upon an ordinary cloth beam it would increase the speed of the take-up as the cloth increased the diameter of the beam. In this case the number of shoots per inch of cloth would continually decrease and a marked difference in the quality of the cloth would be observed on comparing the extreme ends of the web.

This defect existed in all the early power looms, and it was not overcome until the common friction or sand beam motion was adopted. Yet strange to say Vaucanson so early as 1745, or nearly a century before the principle was adopted, not only saw the necessity for an equality of motion, but he provided means to effect the same, and his loom now (1878) in the Conservatoire des Arts, at Paris, contains friction beams or rollers similar to those shown in Fig. 273. Therefore, the invention of this the most simple and effectual take-up motion now in common use must be granted to Vaucanson.

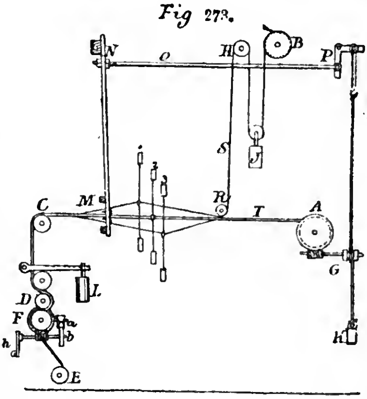
The warp beam should also be supplied with means to allow the warp to be delivered at either a given rate of speed or with a constant and even tension upon it. To deliver it at an even rate so as to exactly correspond with the take-up motion would be a hopeless task, although it has been frequently attempted. All that can be expected is to be able to maintain an equal tension by so regulating the weighting of the beam that no more strain shall be thrown upon the threads when the beam is nearly empty than when it is full. The importance of this subject is alluded to in Chapter xxxvi.

An excellent example of these two motions is used in a modification of the ribbon loom when applied to the weaving of elastic webs as used for side springs of boots. This fabric is generally composed of two warps—india rubber and silk. The india rubber is woven into the middle of the cloth, so as to be hidden by the silk warp and weft—in a similar manner to double cloth weaving. Now as the india rubber must necessarily be woven with a considerable degree of tension upon it and of constant amount, if possible, it follows that a suitable motion should be applied. For instance, if two yards of india rubber be stretched to three yards and woven at that degree of tension the letting-off motion must give off only two yards whilst the take-up receives three yards. At the same time the silk warp is being used at another degree of speed. This class of weaving may be done by using one, two, or even three tiers of shuttles thrown simultaneously.

Fig. 264 represents a section of a loom with two tiers of shuttles sliding in planks, as in the common ribbon loom. Two sheds are formed for them, as shown at *M*, and the shuttles are thrown, by preference, in opposite directions by means of a double peg or other ribbon shuttle motion. (See Figs. 174—176.)

The india rubber warp threads are wound upon the reel *A*, and after being passed through the middle headle, No. 2, are carried forward through the reed and over the breast beam *C*, and thence round the rollers *D* and *F*, which are pressed together by means of a weight and lever *L*. Now if the worm and wheel *G*, be regulated so as to deliver the thread at two-thirds of the speed it is taken up at by the worm and wheel and drawing rollers *D* and *F*, the relative speed will be maintained—excepting that as the reel *A*, becomes unwound it will become of less diameter and the delivery will be less in proportion. On the other hand, the take-up rollers *D* and *F*, being constantly of the same diameter, they take up the cloth as woven at one uniform rate. In this case the take-up motion is comparatively perfect, but not so as regards the let-off.

Fig 273.



The let-off motion shown is actuated by means of a rod *O*, connecting the bell crank lever *P* to the batten at *N*, which at every movement raises the cord and weight *K*. The cord is passed once round a small pulley on the worm shaft, which it turns on being drawn upwards, but when the cord is drawn downwards the weight is made so light as not to be sufficient to turn the pulley back again, consequently the cord slips over the pulley without moving it. Imperfect as this motion may seem, it can be regulated by a sliding pin on the crank lever to great nicety, and it is found to work well.

As the web is woven, to prevent it falling on the floor after passing the take-up rollers it is wound on the reel *E* occasionally by the weaver. The silk warp is wound on the reel *B*, and passes under the pulley of the tension weight *J*, and over the pulley *H*, and thence under the roller *R*, to the headles and reed. Half of the warp is passed through the headle 3, and the other half through the headle 1.

Now as the headle 2 remains stationary, it follows, if the headles 1 and 3 be worked as in ordinary weaving, that instead of one shed being formed there will be two sheds, for the india rubber warp divides the single shed as shown. Therefore, two shuttles may be used—one above the india rubber and the other below it—when the result will be that a cloth surface will be woven on both sides of the india rubber.

As the warp *S* is woven, the weaver lifts the pawl on the reel *B*, and slackens out a fresh supply.

In looms of this description several pieces are woven at once, as in ribbon weaving, and each warp has a separate let-off motion, but the take-up motions are all moved by one bar, shown in section at *a*, which carries catches to turn each of the ratchet wheels fixed on the worm shafts *b*. By this means, should any of the pieces be carried forward without weft being supplied, or other defect, it can be turned back by the handle *h*, independently of the other pieces.

The take-up motion as applied to the power loom was at first simply a ratchet wheel with a catch and pawl and geared into a wheel fixed at the end of the cloth beam. The catch to turn the ratchet wheel was connected in any convenient way to the batten. The defect of this plan was, as before mentioned, that as the cloth was woven it increased the diameter of the beam so that it continually increased the rate of the take-up, thereby making the cloth of a less compact texture as the beam became filled.

This difficulty was ultimately overcome by using two beams, the first one being covered with emery or sand to give it hold upon the cloth sufficient to draw it up as woven. After passing partly round the sand beam it is wound upon the cloth beam placed beneath but held against the sand beam by means of levers and weights, as shown in Fig. 314, in which *m* is the sand beam, and *n* the cloth beam which is held upwards by levers and weights, one at each end of the beam. One of these is shown at *o*, upon the end of which the cloth beam *n* rests. Thus the cloth beam is turned by the sand beam.

The ratchet wheel motion to turn the sand beam is shown at *F*, Fig. 266, connected with the train of wheels 1, 2, 3, the latter being fixed on the shaft of the sand beam and the middle wheel 2 being the change wheel to alter the speed according to the cloth to be woven. The catch of the ratchet wheel is attached to a lever and worked from the batten in any convenient way.

In many cases three pawls are used instead of one, which have the same effect as the use of a finer-pitched ratchet wheel.

Instead of the beam being covered with sand, emery, or card, an improved method is to use an iron cylinder or a wooden one covered with an iron tube. The iron is grooved both lengthwise and across, so as to form a series of sharp points with sufficient friction hold to draw the cloth forward.

This arrangement takes up the cloth with perfect regularity and is well adapted for its purpose.

The take-up motion in Schoenherr's Loom is shown in Fig. 274. The ratchet wheel *X* is fixed upon the cloth beam *c*, and motion is given to it by means of the catches 1 and 2, attached to the end of the lever *Y*. To the lever *Y* is fixed the arm 4, at the end of which is a pulley to work in the slot of the lever 5. Motion is given to the lever 5 by the rod 8 being attached to any suitable working part of the loom. On the under side of the wheel there is a pawl 3, and a bell-crank lever and weight *k*, which are connected by the rod 7 to the lever *Y*.

The cloth after passing over the breast beam *F*' is carried under the beam *c* and over the friction beam *H*, as shown by dotted lines. The action of this take-up motion is regulated by moving the rod 8 in the change holes of the lever 5.

In hand looms the let-off motions require to have the weights

Fig. 274.

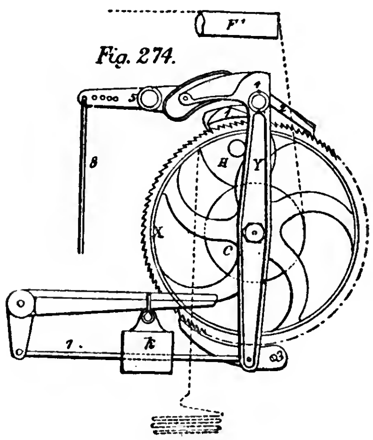
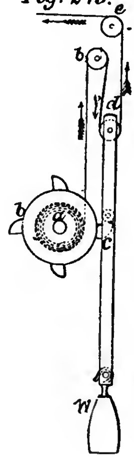


Fig. 275.



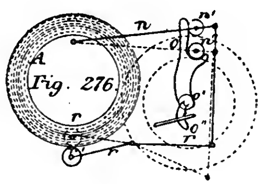
reduced as the warp beam becomes less in diameter—that is in case the weaver thinks proper to do so. In power looms this operation is the same unless a self-acting apparatus is used. Perhaps the method of weighting used in the ribbon loom as shown in Fig. 273 is the most perfect of all let-off motions, for the tension on the warp is nearly always the same. But it has the defect of not being self-acting, and requires the warp to be slackened out at intervals. To obviate this a curious and ingenious letting-off motion was patented in 1868 by M. Alphonse Goulliond, stay manufacturer, of Paris. It is applicable to narrow or ribbon looms, and meant to supply the place of the motion shown at *H*, *J*, *B*, in Fig. 273.

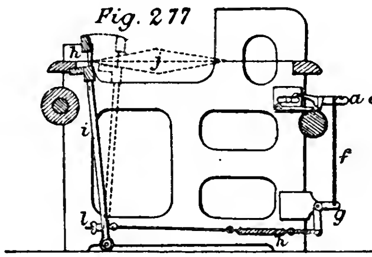
The warp is contained on the bobbin *a*, Fig. 275, and passes over and under the pullies *b*, *d*, *e*. The pulley *d* is placed between two laths, at the end of which the weight w hangs. In the middle of the laths is placed a roller c, against which the teeth or projections b, on the reel a, are caused to press by the action of the weight.

Now as the warp is drawn forward during the operation of weaving, as shown by the arrows, the laths and weight are raised, and ultimately the pulley c, rises out of the reach of the tooth pressing against it; therefore a quantity of warp is released, and the lath and pulley falls and catches against the next tooth. Thus the let-off is intermittent.

This motion also gives a much nearer approach to a constant degree of tension on the warp than may appear at first sight.

Shoenherr's let-off motion is shown in Fig. 276, in which A re-





presents the warp beam. At the end of the lever r is a wooden roller r', made to press against the under side of the warp beam, and at the other end of the lever is a rod connecting with the lever n, to which is attached a roller as shown. This roller is pressed against the vertical lever $o\ o''$ by means of a weight acting on the opposite end of the lever n. The lever $o\ o''$ has its axis at o' and below that point is attached a rope, or brake, to the warp beam.

Now it will be evident that as the warp beam decreases in diameter the pressure pulley on the lever n will fall from n' to n'', and in consequence the even tension on the lever n will be regulated so as to throw upon the brake connexion between o' and o'' an even pressure. The effect produced by this motion is seen in dotted lines—the larger circle showing that the pressure is the same as when at the lower position of the roller n.

A let-off motion based upon a somewhat similar principle to M. Goulliond's was patented in 1874 by Mr. Belleard, in which a weighted lever is made to fall from one tooth to another of a wheel fixed on the end of the ordinary warp beam. Two of these levers and wheels are used—one at each end of the warp beam, so as to act alternately, and be in constant action.

A modification of this principle was also patented in 1877 by Mr. J. Hall, of Preston, and shown in Figs. 277—279.

At each side of the loom two levers, *a a'*, are placed, on each of which are fixed studs *b*, which press upon the notched wheels *c*. Each lever has a slot made in it, so as to slide on a stud *d*, and to allow of a sliding motion. The notched wheels and the levers are so arranged that they operate in rotation and not two or more at one time. Each of the wheels is therefore provided with two series of teeth, so as to break joint or act alternately. The outer ends of each pair of the levers *a*, are connected by cords or wires *f*, attached to bell-crank levers, one of which is shown at *g*, Fig. 277. The other end of the bell-crank lever is connected by a wire and spring to the sword of the batten at *l*.

By this arrangement the warp *j* will have more tension upon it when the reed *h* strikes the cloth. To prevent the levers travelling

Fig 278

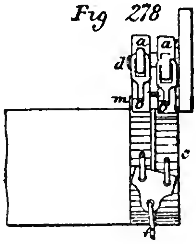
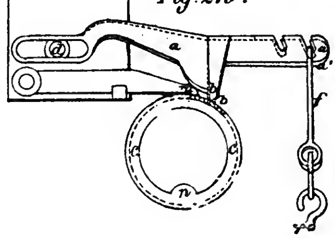


Fig. 279.



too far upon the wheels, a wedge or lever with an inclined end *m* is placed, upon which the levers *a* are raised out of contact with the teeth of the wheel, and thereby fall back to the next tooth. To prevent the notched wheels turning on the beam, a key is fixed at *n* to secure them.

In Fig. 314 a let-off motion is shown that was patented in 1877, by Mr. Lord, of Crawshaw Booth.

In this motion the warp beam is fitted with a toothed wheel which gears into a pinion fixed on the same axis as the break pulley *v*. To the axis of the vibrator *y* is fixed a lever with a rod connecting it at 2 with the long lever *u*, to which is attached the spring *s* and the lever *t*, which presses against the yarn on the warp beam, thereby forming a guage as to the diameter of the warp beam.

The brake *w* has a rod attached, the top of which comes under and at the back of the axis of the vibrator *y*, to which it forms a rest or fulcrum. The tension is regulated by the spring *s*, which draws down the vibrator *y*, and holds the brake *w* fast. As the warp is taken up in weaving, the pressure upon the vibrator increases and ultimately raises the end *y*, which at the same time releases the pressure on the brake *w*; for the vibrator at that moment is brought down to its bearing, and rests upon the pin and takes the weight off the break—thereby allowing a portion of the warp to be delivered. The vibrator then rises and the pressure is again put upon the brake as before. Thus the action is intermittent as far as the let-off is concerned, and the weight is adjusted by the lever *t* rising as the warp beam decreases in diameter, and therefore slackens the effort of the spring *s*.

CHAPTER XXIV.

THE FORK AND GRID WEFT STOP MOTION—STOP ROD—LOOSE REED.

Amongst the earliest attempts to weave by power it was found necessary that some contrivance should be provided in order to stop the loom whenever the weft thread broke or became exhausted. Dr. Cartwright in his second patent, 1786, not only tried to accomplish this feat, but endeavoured to stop the loom on the breakage of a warp thread also, as described in Chapter xx. The last-named object would be of doubtful advantage, for any apparatus to accomplish it would encumber the loom and give more trouble than it would be worth. On the other hand, to stop the loom when the weft thread broke was absolutely necessary in order to work the loom to advantage. If no means were provided for the purpose, the motion of the loom would continue without weaving, unless the weaver was constantly on the watch. His services would thereby be in a great measure fruitless, and the loss of time to turn the work back, in order to commence at the place the weft thread was broken, would be a great drawback to the success of the loom.

The task so evidently required was not an easy one to accomplish, and it took in time nearly half a century to overcome the difficulty. A contrivance had long been in use which could stop a machine on the breaking of a thread (see Chapter xxxvi.), but to apply one to the power loom was not so easy of attainment. The first attempt that led to the plan now generally adopted is said to be the one patented by Messrs. Ramsbottom and Holt in 1834, in which a grid and wires were used, for which contrivance the origin of the fork and grid motion is claimed.

This invention was improved upon by Messrs. Kenworthy and Bullough, and patented in 1841, and perfected when the brake was added to it by Mr. James Bullough in 1842.

Respecting this excellent invention, Mr. Gilroy, in his work on weaving, states in allusion to it that, "This motion originated with us in the beginning of the year 1831, at which period we applied it to a power loom for weaving Marseilles quilts; and the patents obtained in England by Mr. Bullough and Mr. Ramsbottom for modifications of it, of course belong to us. We made still further improvements upon it in 1836 and 1838, for which we obtained patents in 1839, in the name of Moses Poole."

From this statement it appears that Mr. Gilroy claims to be the original inventor.

The fork and grid weft stop motion is shown in Figs. 280 to 282.

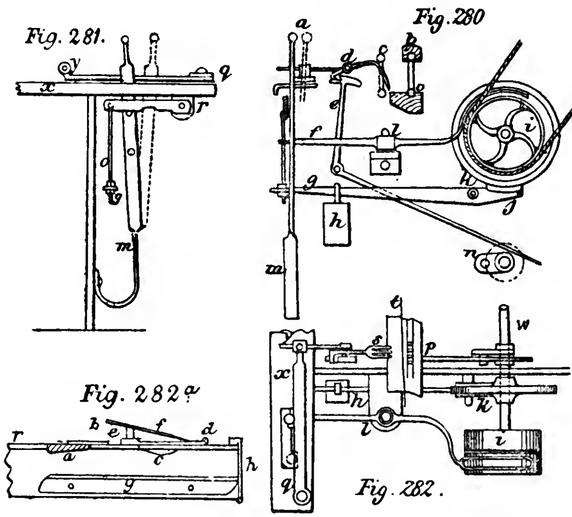


Fig. 280 is a section; Fig. 281 a front view; and Fig. 282 a plan.

In Fig. 280, *i* represents the driving pulley of the loom; *k*, the brake; *n*, the tappet shaft, upon which a tappet is fixed to raise and throw back the hook of the vibrating rod *e*; *b* is the reed and batten; and *p* is a grate placed at one end of the reed, through which the prongs of the fork *s* enter as the reed advances to *c*. The fork is freely balanced on the pin *d* of the adjusting lever *y*. See Figs. 280 to 282.

The loom being put in motion by means of the spring handle *a*, Fig. 280, shown also at *m*, Fig. 281, which is drawn forward from the position shown in dotted lines, and held in that position by a notch in the frame, as shown in plan, Fig. 282; it follows that if the hook on the vibrating lever *e* comes into contact with the hook on the fork, as shown, it will draw the fork backwards, and, consequently, the lever *x*, Fig. 282, to which it is fixed. At the same time the lever *x* pushes the spring handle out of the notch, or detent, when it immediately returns to its normal position, as shown in dotted lines, Fig. 281, and thereby throws off the strap from the fast to the loose pulley by means of the fork lever *l*.

Now, so long as the weft thread is not broken and lies on the shuttle race, as shown at *t*, Fig. 282, it comes into contact with the fork at each alternate beat of the reed, and pushes it back; *but when the thread is absent or broken, the fork is no longer pushed back*, consequently the two hooks come into contact with each other and draw back the lever *x*, as before stated, and stop the loom.

It will be evident that the strap, when thrown off, would not cause the loom to stop instantly; therefore a brake is applied for that purpose. In Fig. 280 the brake is shown at *j*, fixed on the lever *g*, supported on its fulcrum pin *k*. Upon the lever a weight, *h*, is placed, and the end of the lever is held up by a bolt, *o*, Fig. 281. This bolt hangs from a lever, *r*. Now, when the spring handle is in its normal position, the lever *r* falls and puts the brake into operation; but when the handle is moved to put the loom in motion, it raises the lever *r* by means of a pin, and thus lifts the brake lever and releases the brake.

The fork motion is placed on one side of the loom, consequently it only acts at every other pick. But two forks, sometimes connected by a light rod, have been placed on both sides, so as to stop the loom at every pick if required, but this plan is scarcely required. Electro-magnets have also been proposed to effect the stoppage of the loom on the breaking of a weft thread, in a similar manner to the method adopted in some spinning machinery. So long as the thread remains unbroken, it is made to keep the magnet and its armature apart; but when broken or absent, they come into contact and stop the loom.

In addition to the weft stop motion there should be a contrivance to stop the loom when the shuttle fails to be thrown through the shed, for should it remain in the shed or be "trapped," it would be struck by the reed and the warp would in most cases be seriously damaged. There are two ways in which this can be avoided—either by means of a stop rod, or by making the reed loose, so as to give way when it strikes the shuttle.

The stop-rod motion is the one most in use, and was adopted almost at the commencement of power loom weaving. It is said to have been originally used in 1796 by Mr. R. Miller, of Glasgow, in his loom known as the "Wiper" loom, and it was then called the "protector," although a stop motion was patented by Richard Gorton in 1791.

The action of the stop rod is simply to raise a catch every time the shuttle enters either of the shuttle boxes, and thereby prevent the catch from falling or coming into contact with a stop.

In Fig. 314 the end of the batten is seen in section, showing the reed and shuttle, also the catch *j* and the prong *p*, which are welded to a rod which passes under the shuttle race from one end to the other. Fig. 282 *a*, shows a plan of one of the shuttle boxes where the prong (*p*, Fig. 314) is shown at *e*.

At *c* is a "swell" or curved lever hinged at *d*, against which the prong *e* is forced by the thin flat spring *f*. Now when the shuttle enters the box it forces the swell backwards, and consequently raises the catch *j* above and out of reach of the stop. Therefore, whenever the shuttle is absent from either of the boxes, the catch falls and the loom stops.

Before the application of the brake to the stop-rod motion by Mr. John Sellars in 1845, the catch was made to come into contact with a stop formed on the framing of the loom, and, as might be expected, it often caused considerable damage. But by making the catch to come into contact with a loose stop *F* in connexion with a brake the objection was overcome.

The brake is shown in Fig. 314 at *q*, with a lever attached, at the end of which a stop called the "frog" *F* is fixed. When the catch strikes the frog it causes the lever to draw the brake suddenly and firmly against the brake wheel *a*. The brake was originally applied by Mr. Sellars on the front side of the wheel which occasioned a complicated action compared with that of Fig. 314.

Although the loom would be stopped when the catch came into contact with the frog it would be still necessary to throw the strap upon the loose pulley. This is done by simply attaching a short pin to the frog as shown in Fig. 314, by means of which when the frog is driven back by the catch *j*, it strikes against the spring handle at *m*, and throws it out of the notch, and stops the loom.

The loose reed was invented by Mr. Jas. Bullough, and patented in 1842. By means of this contrivance the reed is caused to give way upon coming into contact with the shuttle when it was "trapped" or stopped in the shed.

Figs. 283, 284 and 285, represent the batten and reed in section. A rod is placed under the shuttle race in a similar manner to the stop rod, and it is provided with prongs connecting it with a loose bar of wood, to hold the reed in its place as shown at *m*. At one end of the rod a lever *n* is placed, at the end of which is attached the roller *p*. This roller runs upon the bent spring *a*, when the shuttle is in action, and keeps the reed in position. There are wedge-shaped studs fixed to the frame in front of the batten as shown at *d*.

Fig. 283

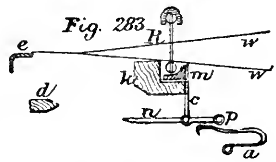
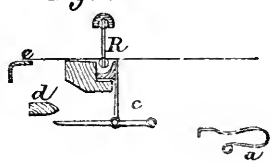


Fig. 284



Now, so long as the shuttle does not stick in the shed the reed is kept in position by the spring *a*, also when out of reach of the spring the catch *n*, coming underneath the wedges *d*, still keeps the reed in position, and prevents the blow against the cloth from overcoming the reed. But when the shuttle is struck, as shown in Fig. 285, the reed gives way, and the catch *n* ascends above the wedge *d*, and it thereby assists the shuttle in throwing the reed back.

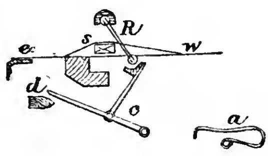


Fig. 285.

This motion is not adapted to heavy cloths—but various modifications of the principle have been introduced to make it suitable for general purposes.

In loose reed looms the stop rod motion and swell is intended to be assisted or dispensed with. The swell has a double purpose to perform, namely to hold the shuttle in the box and to raise the stop and catch, therefore it is still necessary to hold the shuttle and provide means to throw off the driving strap of the loom when the shuttle has stuck in the shed. In Fig. 282, the entrance of the shuttle box *a*, is made to form a "flap" pressed against by a thin spring *b*. The shuttle can easily push past the flap, for the spring is merely made strong enough to prevent its rebound. A stop rod to throw the spring handle out of action may be also attached, and numerous modifications of these simple contrivances have been from time to time introduced. But the common stop-rod motion as above described, is in general use, and is well adapted for ordinary looms. When run at high speed a greater degree of safety would probably be obtained by the loose reed system, and many attempts at improvement have been made to overcome the difficulties attending it.

CHAPTER XXV.

SHUTTLES OF VARIOUS DESCRIPTIONS—PICKING MOTIONS, ETC.

THE common power loom shuttle differs from the hand loom fly shuttle but very little except in size. A good specimen of one is shown in section at Fig. 286. It measures 12½″ long, 1½″ wide, and 1⅛″ deep, and weighs exclusive of the bobbin 9¼ ounces. A fair specimen of fly shuttle (see Fig. 29) as used in silk weaving measures 11″ long, 1″ wide, and 1″ deep, and weighs only 3 ounces. When bobbins are used in the power loom shuttle the tongue or spindle upon which they are fixed forms a split spring at the ends of which are slight projections to hold the bobbin upon it, as shown in Figs. 286 and 287, where *e* represents the fork and *d* the stops. When a fresh bobbin is supplied the fork is raised as in Fig. 286 as high as the pin *a* will allow; but the flat spring *b* always pressing upon the end of the fork keeps the bobbin within the shuttle.

Shuttles are usually made of box-wood, and have hardened steel points or tips inserted at the ends, as shown at *c*. The tang attached to the tip is not usually driven into contact with the wood, but a short length of wire coil is inserted first, of sufficient size to fill the hole, and the tip is then driven firmly into the coil which expands but slightly and does not split the wood.

Shuttles are made in various forms and sizes, according to the purposes for which they are required and the thickness of the weft to be used. Sometimes they are provided with rollers so as to run lightly. Many attempts have been made to construct them of thin sheet metal and other materials as a substitute for box-wood. But at the present time nothing appears likely to supplant the common form and structure of the shuttle shown in the following sketches.

To save expense in rewinding the cops of cotton yarn as they are taken from the mule spindles they are frequently placed upon a similar spindle in the shuttle. In this case the thread, having no

Fig. 286.

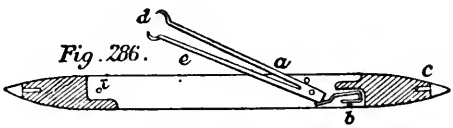
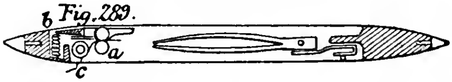


Fig. 287.

Fig. 288.

Fig. 289.



bobbin or tube to support it, has no cohesion further than the winding and crossing of the threads over each other gives it. Consequently the cop is not only liable to be broken in fixing it upon the shuttle spindle, but owing to the severe concussions it is subjected to in the operation of weaving, it is often broken by that means also. This defect prevents the thread from being unwound freely, for it is liable to stick at the broken part of the cop, therefore breakages of the weft, and waste arising therefrom, often occur.

To prevent this, various improvements in the spindle have been made, and one inventor proposes to remove the upper part of the mule spindle and transfer it with the cop upon it direct to the shuttle. Another plan is shown in Fig. 288, which represents a shuttle recently patented (1877) by Mr. D. H. Chamberlain, of

Boston, U.S., consisting in the use of a tubular spindle upon which is placed a metal "sleeve," to hold the cop.

To the end of the sleeve is secured a slender rod or wire which passes through the hollow spindle. The end of this wire is provided with a head, between which and a support in the hollow spindle is placed a compressible coiled spring. The cop being placed on the sleeve, it is at liberty to move forwards when struck by the picker, and thus to prevent its damaging the cop. In this shuttle the spring to hold the spindle down is placed over the end of the spindle, and not below it, as in Fig. 286 and 287.

A shuttle for weaving wire or other substance requiring an equal tension, as shown in Fig. 289, was patented by Mr. R. C. Rayson, Manchester, 1875.

For this purpose the ordinary eye of the shuttle is dispensed with. A pair of small rollers, *a*, are used for the thread or wire to pass between after leaving the bobbin, and the tension on the thread is regulated by the amount of pressure given to the rollers. The thread leaves the shuttle below the grooved or guide roller *c*, and it is claimed for this plan that the wire, or strong thread, can be delivered with much greater regularity and safety than by the ordinary method.

The weft bobbin is generally turned with a groove at its largest end, as shown in Fig. 287. A wire pin fixed across the shuttle allows the groove to fit upon it and thereby assist to keep the bobbin in position on the spindle. The pin has been accidentally omitted in the sketch, but its position will be evident.

When a bobbin is changed in the shuttle, or when the weft thread breaks, the thread or end is put near the eye of the shuttle and drawn through by placing the shuttle to the mouth and drawing the breath. As this operation occurs very frequently, it has long been believed to have an injurious effect upon the weaver, for it cannot be done without inhaling small fibres of cotton or dust connected therewith. Attempts have therefore been made to thread the shuttle by mechanical means, but it necessarily adds, however simple, some kind of connexion to the shuttle which may be liable to get out of order. An ingenious contrivance has been patented by Messrs. Stutter, Stubbs, and Corrigan (No. 3870, 1876) which may be called a weft "sucker"—for by producing a partial vacuum it draws the weft through the eye in a similar manner as when done by the mouth. Fig. 290 shows the apparatus. The cylinder *a* is fixed to the framework of the loom by the bracket *b*, cast or fixed to the disc *e*. The internal cylinder *d* has a weighted cover *c* placed at the top, to which is fixed a central suction tube *f*, having holes *g*, *h*, near the top of the internal cylinder *d*. The eye of the shuttle is placed to the mouth-piece *j*, and the end of weft placed against the eye. Then, when the shuttle is pressed upwards, a sufficient vacuum is caused to draw the thread through the eye.

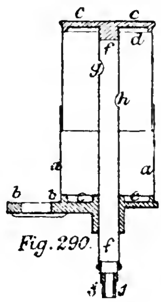


Fig. 290.

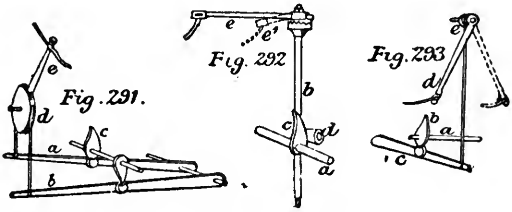
The "fly-shuttle" method as originally invented by John Kay, in 1733, is the means adopted to propel the shuttle in the power loom, to which it is equally well adapted as to the hand loom, although many other plans have been attempted.

The various means for propelling the shuttle are as follows:—

1. Thrown from hand to hand.
2. By the hand fly shuttle loom.
3. By various cam-picking motions in the power loom.
4. By the ribbon loom driver.
5. By „ „ „ peg motion.
6. By various wheel motions.
7. By means of a magnet drawn beneath the shuttle.
8. By means of a carriage upon which the shuttle rests.
9. By means of gravity.
10. By a screw motion.
11. By levers to carry it through the shed.
12. By pneumatic force.
13. By inclined planes and scroll motions.
14. By springs.

The motion now most generally used is shown in Fig. 292, and in Figs. 265 and 266. A vertical shaft *b* is placed at each side of the loom—one to each picker—upon the top of which the picking stick *e* is secured. The stick is held in a socket that can be adjusted by means of the toothed surfaces of the socket plate being fixed where desired—the teeth preventing the position being altered by the repeated blows given to the picker. On the tappet shaft *a*, a cam is fixed, which strikes against a cone-shaped roller *d*, and thereby gives the requisite action to the picking stick, as shown at *e e'*. The cam *c*, and the cone *d*, are bevelled, so that the surfaces in contact are flat throughout the motion, and never on sharp edges. The origin of this motion appears to have been in Messrs. Barber's loom (see Fig. 258).

The motion shown in Fig. 291, was formerly much used, and is



used frequently in ribbon looms at the present time. In this plan the picking stick *e*, is carried by the pulley *d*, and motion is given to it in opposite directions, alternately by the treadles and strap worked by the cams and pulleys *c*. This motion is generally placed under the warp, but was placed above it as shown in Fig. 260, which is a modification of it. It was first used in Mr. R. Miller's loom (Glasgow, 1796), called the "Wiper" loom; the cams *c*, *c*, being technically called wipers at that time.

A method commonly employed in broad looms in which the batten is suspended, is that shown in Fig. 293. In this system the picking stick *d*, hangs over the picker. Motion is given to them by means of a cam *b*, fixed on the tappet shaft *a*, which strikes the roller *c*, on the lever as shown, and by means of a rod connected to the picking stick at *e*, causes the stick *d* to be driven forward, as shown in dotted lines.

The picking sticks, Figs. 292 and 293, are brought back to their normal position by means of spiral springs fixed to any convenient part of the picking sticks or the shafts carrying them.

The motion of the stick, Fig. 292, being a portion of a circle, operates rather disadvantageously; for the blow being heavy, causes a twisting strain on the pickers when checking the momentum of the stick. To prevent this Messrs. Platt use on their looms a spring shaped like the letter D, with a strap attached, forming the straight part or string to the bow. It is fixed on the loom in such a position as to receive the picking stick at the termination of the blow, and thus relieve the picker from the strain. The middle part of the stick is made to strike the strap. But looms may often be adjusted to prevent this defect.

In Todd's loom the picking sticks are attached to each of the swords of the batten, and the ends pass through grooves made in the bottom of the shuttle boxes. The pickers are fixed upon the ends of the sticks. In this plan the picker straps and spindles are dispensed with.

In one of the earliest power looms the two pickers were connected together by means of a thin lath extending under the shuttle race from one picker to the other.

Numerous plans have been proposed for propelling the shuttle by means of springs, which system originated with R. and T. Barber (see page 231). Each picking stick is provided with a spring or series of springs, and as these can be wound up by a gradual action of the loom, it was believed that less power would be required to drive the shuttle by their means than is required by the sudden action of a tappet motion. One advantage would certainly accrue—namely the blow given to the shuttle would always be of the same force whether the loom was driven fast or slow, and many of the defects arising from an irregular driving motion would be overcome, such as driving the shuttle out of the loom by too great a force, or throwing the loom off through the shuttle not having sufficient force to press back the swell, &c. In some instances the springs after being wound up were held by trigger motions, and these were released at properly appointed times. In other cases a spiral cam winds up the spring and releases it at the highest point of the cam. For instance, if the cam *c*, Fig. 292, be made to press against the cone *d*, and at the same time to push back a strong spring, then, when the nose of the cam has passed the cone, the spring would be free and withdraw the picking stick in an inverse manner to striking it. By this means the blow would be always equal, and not vary according to different speeds at which the cam may be driven. Yet, notwithstanding this advantage, the system does not appear to come into very general use.

In 1834, No. 6613, Messrs. Luke and Mark Smith obtained a patent for picking from the crank shaft, and thereby preventing the loss of power arising from reducing the speed from the crank to the picking shaft. This plan was to affix inclined planes to the peripheries of fly-wheels—one at each end of the crank shaft, so as to strike against a stud fixed upon a picking shaft connected to each picking-stick. By this means the loom could also be turned backward without moving the pickers. This plan was afterwards modified, and in 1843, Mr. Luke Smith adapted a "scroll" or curved grooved plates fixed to the inner side of each end of the loom. In the grooves of each plate is placed a curved piece of metal, which actuates a slide on the fly wheel; on this slide is a stud, which, when the piece of metal is in the outer groove of the plate, strikes against a finger on an inclined rod to the reverse end of which the picker strap is attached, and throws the shuttle; but when the piece of metal is in the inner groove the stud passes clear of the finger, and the shuttle is not thrown. Therefore the action consists in making the metal piece to traverse the inner and outer grooves alternately, so that it causes a contact with the picker at every second revolution with the crank shaft. This plan was again modified by Mr. W. Smith, who obtained a patent in 1873, for fixing the "scrolls" to the fly wheel instead of to the ends of the looms as above described.

Mr. P. Ewart in 1813 obtained a patent for giving motion to looms by the pressure of air or steam acting upon pistons or bellows attached to the loom; and in 1862 and 1864 Mr. C. W. Harrison obtained patents for the "pneumatic" loom. Mr. C. Richardson has also taken patents out for a somewhat similar contrivance.

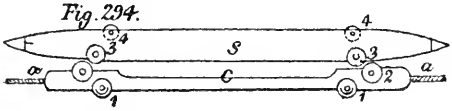
The application of compressed air for driving looms or parts of the loom, such as the shuttles, does not seem to have met with success, although considerable ingenuity has been displayed, and numerous attempts have been made to carry it into effect. When applied to the shuttle, a cylinder with piston is provided for each shuttle box, and as the air is compressed in the cylinder, it is made by means of suitable valves to impinge against the end of the shuttle. The plan is analogous to the spring picking already alluded to.

In a patent obtained by Joseph Meeus, 1844, it is proposed to squeeze the shuttle through the shed by pressing the warp threads upon the tail end of the shuttle. He also suggests the application of a magnet to act upon an iron shuttle—an idea that has engaged the attention of several inventors since that time. Other motions have been attempted, such as screwing the shuttle through the shed by placing a screw below the warp, and allowing the thread of the screw to pass between the warp threads and carry forward the shuttle: also the use of levers to carry the shuttle, as in De Gennes' loom (see Fig. 257).

An ingenious method of driving the shuttle was patented by Mr. James Lyall, of New York, in 1868, and improvements on the same in 1870 and 1872. The peculiarity of this invention is that the shuttle is drawn through the shed upon a carriage, and not by the propelling force of a picker. The carriage *c*, Fig. 294, is provided with rollers 1, 1, and runs in a groove made in the shuttle race below the warp. It is drawn backwards and forwards by cords, *a*, *a*, attached to a lever placed below the warp.

The rollers 2, 2 project slightly above the race, and the shuttle *s* being provided with rollers, 3, 3, it is held in position by them.

Fig. 294.



As the carriage is drawn along, the warp passes between the rollers 2 and 3, and does not prevent the movement of the shuttle; but to make the action more certain rollers, 4, 4, are fixed on the upper part of the shuttle, so that a plate fixed on the underside of the reed cap prevents the shuttle from rising, and therefore ensures its passage through the warp.

CHAPTER XXVI.

JACQUARD APPARATUS AND EXAMPLES OF VARIOUS SHEDDING MOTIONS—HATTERSLEY AND SMITH'S—ECCLES'S—THE METHOD OF WORKING THE JACQUARD MACHINE ON THE POWER LOOM—CYLINDER MOTION.

SINCE the introduction of the Jacquard machine into England, numerous modifications have been attempted in order to improve and economize the working of it, as well as to adapt it to accomplish a variety of purposes. For instance cords have been applied instead of wires—paper instead of cards—electricity instead of perforated paper—and various other contrivances, of more or less importance, have been made to adapt it to the power loom.

The motion of the common Jacquard is represented in Fig. 295, which is a diagram showing its action upon the warp. The cloth and warp beams are shown at a and b; the cylinder and needle board at i and j; the spring box at k, and the raised griffe bar at g^1. The shed is opened by lifting the hook, which raises the warp thread from c to d; and in order to make the next shed, the hook or hooks must descend, and a fresh selection made before the shed can be opened again. Thus it takes twice the time that plain weaving requires to open the shed, for in that case one part is rising whilst the other is falling, and time is not only saved but the additional friction and unequal strain upon the warp is avoided. In order to lessen the strain on the warp threads as much as possible, the warp is usually sunk in the position shown at c, Fig. 296. It has been sometimes asserted that by placing the warp in the position represented in Fig. 297, the shed may be opened with less strain upon it, consequently in some looms the warp and weft beams, or rails, are placed at different heights, as seen in the sketch. But in

Fig. 295.

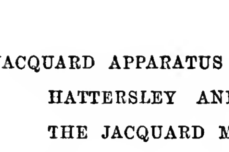


Fig. 296.

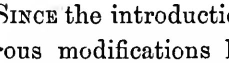
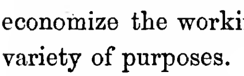


Fig. 297



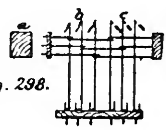
every case, unless the healds are placed at right angles to the general level of the warp, a constant sliding motion of the warp threads must take place in the eye of the leash or mail, as indicated by the lines *a*, *b*. Therefore any irregularity or deviation from a right angle would be attended by a constant sawing motion, which cannot but be detrimental to the warp.

incorrect

The construction and action of the common Jacquard machine having been previously described, it now remains to show various modifications of it, some of which are specially intended for power loom purposes; and it may be here remarked that lags or cylinders with pegs, or any other substitute for cards, may be applied without affecting the action or principle of these contrivances. Levers, slides, cords, &c., may be also substituted for the wires. Therefore it is the action or motion, and not the construction of the machines, that is now to be considered; for it will be evident that various modifications may be made in each machine without affecting the principle upon which it is based.

In Fig. 298 a Jacquard is shown, with a double griffe and one set of needles, but with two sets of hooks. The same cards by this means can produce a similar pattern, in double cloth weaving, on both surfaces of the cloth; for the griffe *b* being connected with one of the warps, and the griffe *c* with the other, it follows that they can be worked separately, and thereby act upon two series of warp threads alternately. In this plan the hooks *b* are pushed off the griffe, but the hooks *c* are pushed on.

Fig. 298.



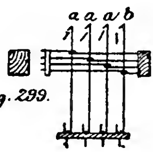
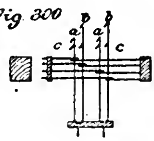


Fig. 299.

Fig. 300



In the Paris Exhibition (1878), in the French department there is shown a hand loom mounted with a quadruple Jacquard, or four separate Jacquards fixed in one frame. Two sets of the cards fall on one side of the loom, and two sets on the opposite side. The harness is built for one machine only, but the whole four machines are concentrated and connected to it. By this means any one of the machines can be thrown in or out of action, or any two can be so combined. In this way the pattern may to a certain extent be varied at pleasure. It does not, however, appear to possess any advantage beyond the novelty of the contrivance. Machines with wooden hooks instead of wires, as used in Austria, are also shown in the Exhibition.

In Fig. 299 a Jacquard provided with movable griffe bars is represented. The object intended is to form the ground of the cloth by means of the griffe instead of the shaft harness, as shown in Fig. 158. Thus, if all the bars remained in the ordinary position, and nothing but the outline of the figure be cut on the cards, then to work the ground, whether twill or satin, separate shafts must be used. But by throwing the griffe bars out of position in consecutive order, the hooks will be missed, as shown at *b*, and a twill, or a satin or other ground, may by this means be formed, according to the number of griffe bars and the order in which they are pushed by the action of the cards. Of course that is assuming the harness is tied up in the requisite order necessary for this method.

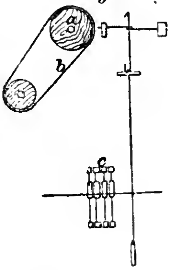
The Jacquard represented in Fig. 300 is provided with double hooks, *a*, *b*, of different lengths. By this arrangement two sheds, one above the other, can be formed, so as to enable swivels to be used at the same time the ground shuttle is working. This plan was patented by Messrs. Howarth and Pearson in 1868. One griffe only is used, the bars of which are shown, and as it rises it takes the shortest hooks first before it reaches the longest ones, consequently the short hooks raise the top shed for the swivels.

Numerous methods have been tried to dispense with the use of cards, and thereby effect a saving in the expense of working. A favourite plan was to use a continuous sheet of paper, and several patents were taken out for machines intended for that purpose. It will be remembered that paper was used in the first instance by M. Bonchon in 1725, but it has never been found to withstand the wear and tear of actual work. When applied, the machines were necessarily of delicate construction and liable to get out of order.

Martin's machine (1850) was a good specimen of a paper applied Jacquard, and machines are now (1878) shown in the Paris Exhibition worked with paper.

A curious and ingenious application of canvas or wire cloth instead of cards was patented in 1843, No. 9994, and a specimen of a loom on that plan was exhibited in the Great Exhibition, 1851. Let Fig. 301 represent a loom with one set of needles placed in a line through the needle-board, and as near together as possible. One or more rows of hooks could be used, but only one row is shown in the diagram. Two rollers are used, upon which a canvas band *b* revolves, and as it passes over the top roller *a*, it is made to press at short intervals against the needle points. Upon the canvas is painted the desired pattern with a thick varnish or paint capable of resisting and pushing back the needles, which the canvas itself, being of an open texture, was unable to do. At *c* a shaft harness is placed in the way usually adopted, and already explained. Now it will be evident that the pattern on the canvas would actuate the needles in the same way as cards, but the breaking up of the ground and figure with any desired twill or satin would be necessary, and that is effected by the headles *c* in a similar manner to damask weaving.

Fig. 301.



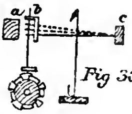


Fig. 302.

Vaucanson's loom (1745), with paper placed upon a cylinder acting against one row of wires, was mounted and provided with a shaft harness, as shown at *c*, in this manner. The barrel machine with pegs, and the comb machine, are also mounted in the same way.

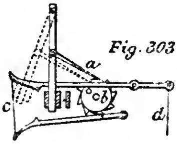


Fig. 303.

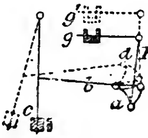


Fig. 304.

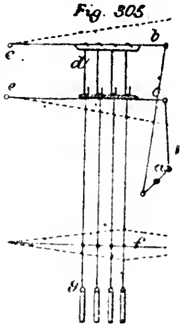
Another plan patented in 1857, No. 2599, is shown in Fig. 302, in which the ground is worked by the machine, and not by separate headles. This is effected by placing the pattern, cut out of leather or card, on a cylinder, either in one or more thicknesses, so that when pressed against a set of needles, placed vertically, they would raise them either in one or more tiers in height, as shown, according to the pattern on the cylinder. On the cylinder *a* is placed a set of cards, or the cylinder may be purposely perforated instead, and several kinds of twills or grounds may be used. Now, as the pattern cylinder when raised also raises with it the needles, it follows that the horizontal needles governing the hooks are raised also; and being raised to two or more different heights, they are brought into contact with different twills or ground work, as perforated in the cylinder *a*, and thereby the ground is formed not only upon the figure, but the ground of the cloth also, for the lowest level forms the ground of the cloth. Block patterns for lace machinery, looms, &c., had been previously tried on a similar plan, but the system has not hitherto been found to answer satisfactorily.

In Fig. 303 a plan is shown whereby one or more cards may be repeated, or turned back, as may be desired, according to the arrangement of the pattern, and it is done without any attention being required from the weaver. A ratchet wheel *b* is fixed on the side of the machine, and it is turned one tooth at each movement of the Jacquard batten by the catch *a*. On the wheel a peg is placed—or several if required—which raises the top catch as it passes it. Now it may raise it merely high enough to prevent the bottom catch coming into contact with the cylinder lantern, or if allowed to come into contact the cylinder would be reversed for one or more turns, according to any desired arrangement.

Fig. 304 represents one of the best batten motions as applied to the Jacquard previous to the new system of working as described in Fig. 314. The griffe is shown at *g*, and it is also seen raised at *g'*. The batten *c* is connected to a triangular lever by means of the lever *b*. Another lever, *d*, connects the lower part of the triangular lever to a projecting bolt fixed to the griffe. Now when the griffe is raised the batten is thrown outwards, as shown by the dotted lines. This motion was well adapted for power loom Jacquards, but for hand loom purposes the old system of pulley and S iron works well, and is still applied.

In using a harness or healds which take up considerable space, the shed is very unequally raised when the griffe is raised horizontally. In such cases the back heald, farthest away from the reed, would not raise the shed at the shuttle race so high as the front healds would. To avoid this defect the griffe bars can be made so as to produce an even shed. In single griffe machines this defect is overcome, as shown in Fig. 305. In this case the griffe bar *b*, hinged at *e*, can be raised by levers as denoted by the dotted lines, and the effect on the warp *f* is shown. The bottom board is made to descend in like manner, and as it is hinged in a similar way as the griffe, a proper shed is formed. Not only so, but by connecting the griffe lever and the bottom board lever to a rocking shaft, as at *a*, the harness or lingoes *g* become balanced, and an easy and steady motion obtained. The warp *f* in this way is kept level, and when the shed is opened it forms a rising and sinking shed.

Fig. 305



The plan of making the shed as above shown is sometimes attempted in hand loom mountings by tying the cords to the levers at a greater or shorter distance from the fulcrum, and by this means the weavers improve matters as well as they can.

It had long been observed that the action of the draw loom, barrel loom, and Jacquard loom were but "one-legged" or one treadle motions, and had not the advantage of a two treadle or rising and falling shed. Consequently many attempts were made to place these machines on a better footing, and the draw-boy machine, being the oldest one, was the first to be tried. The first draw-boy machines attached to the draw loom were one-treadle machines, but ultimately two treadles were used as shown in Fig. 121. Afterwards attempts were made to counterpoise the draw-loom, harness so that one shed could rise whilst the other was falling, and thereby balance each other, as in Cross's machine (about 1816). But the draw loom does not afford much scope for such improvements, and is widely different to the barrel and Jacquard machines, therefore it was altogether neglected.

After the various double treadle draw-boy machines were introduced, the barrel machine, an old contrivance, underwent an alteration in the same direction, for in 1818 Benjamin Taylor obtained a patent for an improved barrel loom by employing two barrels, one on each side of the loom, the harness having a double neck, "and as one lash falls the other rises, and by the falling of the one the weight assists the other in rising." This was the principle of Cross's counterpoise harness, but as far as mere counterpoise went, the advantage was of no account, for a counterpoise can be put on in a very simple manner. It was the *simultaneous action and saving of time, friction*, and many other advantages that were gained which the inventors had in view. Taylor's loom does not appear to have come into use, but a small Jacquard machine, or dobby, was introduced in the silk trade in 1830 by Mr. S. Dean, of Spitalfields, based upon the same principles, and, in fact, similar in action to the draw-boy machine before referred to. Mr. Dean was rewarded by the "Society of Arts" for his invention, but Jennings' shedding motion, previously described, supplanted it.

Fig. 306 represents Dean's invention, which consists in using two griffes *d* and *e*, suspended from a strap passing over a pulley *c*, which is connected by cords to the two treadles. There are two cylinders *g* and *h*, and if cards were used, the odd numbers were placed on one cylinder and the even numbers on the other, and they operated on the hooks *a* and *b* alternately. The spring box *f* was placed in the middle of the machine. This machine was employed to work a shaft harness *j*, for weaving satins, &c., and one set of the hooks were attached to one part of the healds, and the other set to the other part.

Now it will be seen that one shed can be raised by one of the griffes whilst the other shed is preparing; but as the same thread or heald in satin, and other weaving to which these machines were applied, does not require to be raised twice in succession, they performed their work easily. In cases where the same heald or threads are required to be raised more than once, then they were not so well adapted; but if they were required to do so, two of the hooks must be connected to one heald, so that either griffe could raise any of the healds. Two of the cords are shown in the sketch in the manner that they would have to be connected in case the machine had to raise those healds more than once, although in practice they were, perhaps, never used in this manner.

This leads to the double-action principle, in which the machine can raise any of the warp threads any number of times in succession and perform the work in half the time, consequently with half the wear and tear to the warp, &c. The system was patented in 1849 by A. Barlow, and shown in sketch, Fig. 307, where one set of hooks

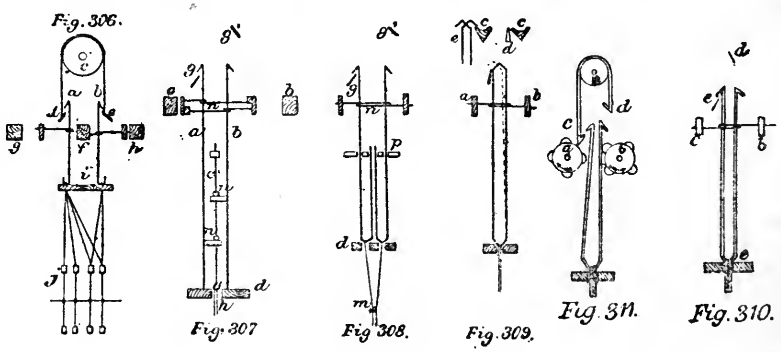


Fig. 306. Fig. 307. Fig. 308. Fig. 309. Fig. 311. Fig. 310.

only is represented. The neck cord attached to the heald is shown at *h*, suspended from the hook *c*, which has two nuts fixed upon it at *n n*. Either of the hooks *a b* can raise the hook *c*, for as either one of them is raised, the fork at *n* catches the nut on the wire *c*, and lifts the wire. After it has been raised and begins to descend the other hook may be made to rise and thereby catch the corresponding nut, and raise the wire again without allowing it to fall to its normal position. Thus the hook *c* can be kept up or down at pleasure, according to the perforations of the cards. The griffe *g* and *g′* are balanced in any suitable manner, so that one rises as the other falls. The cylinders also work alternately, and have the cards placed on them in proper order, as in Dean's machine.

This double-action Jacquard had too many wires, which made the apparatus, when three or four hundred sets were used, crowded with them. To remedy this defect, the modification shown in Fig. 308 was adopted, and by this means one set of needles and the central hooks were dispensed with, and a needle with a long eye used instead. The spring boxes also were not required, for the hooks acted as springs instead. To supply the place of the centre wire, the cords from the two hooks were tied together, and this operated on the warp in the same manner. A machine on this plan was shown in the Great Exhibition, 1851.

But there were still defects to be overcome, for the cords were apt to break by the sudden jerk during the change from one hook to the other, and the card cylinders were liable to get "across," or out of consecutive order. The first of these defects was remedied by using one hook only, as shown in Fig. 309, which was done in 1855, but not patented till 1870, when a contrivance for positively keeping the two cylinders in consecutive order, whether in going forwards or backwards, was effected. It was accomplished by means of a clip spring acting on one of the cylinder lanterns. There was another addition made to the machine, which is shown at *c c*, and consists in using a stationary griffe, upon which the hooks are pushed, and are allowed to remain suspended until neither end of the needle *a b* is pressed against, when the hook (which is double and has the hooks overlapping, as shown) descends.

Two other modifications of this principle are shown in Figs. 310 and 311. The first one was patented by Messrs. J. and M. Pearson, of Bradford, in 1868. The hook is formed double, and has two griffes, *d* and *e*. It acts in a similar way to that shown in Fig. 308, but has the advantage of only one neck cord, although it requires a slight dwell upon the cylinders during the passage of the griffes, or the hooks would be liable to catch on the opposite griffe bars; this is avoided by making the hooks as shown in 309. It has also another disadvantage, namely, the hooks by being pushed clear of the opposite griffe bars causes them to rub slightly the eyes of the needles.

In Fig. 311 a shedding motion on the same principle, of German invention, is shown. The double griffes *c d* are suspended from the pulley *e*, as in Dean's machine. Two cylinders, *a b*, are used, which are turned by wheels geared into each other, so that they cannot, in advancing, get out of consecutive order. Pegs, according to the desired pattern, are fixed in the cylinders, and they work by pressing against the hooks, and not by means of a needle. This modification of the double-action principle is, perhaps, the most simple of any.

In Crossley's double-action (1859), with one cylinder, each needle governs two hooks, and there are two griffes, which rise and fall alternately. The neck cords of each pair of hooks are connected to one neck cord, as in Fig. 308; but the hooks are placed facing one way, and not back to back. In these machines the cylinder acts upon each set of hooks alternately, although *beating against one set of needles only*, consequently an easy motion is obtained by the rising and falling motion of the hooks, as in the double-action Jacquard, but a very rapid motion is necessarily given to the cylinder. This motion appears to have been adopted to get rid of the difficulty attending the use of two sets of cards, or rather one set divided, as in the double-action Jacquard. It has the objectionable contrivance of double neck cords and a very rapid motion of the cylinder, but in all other respects the action upon the harness and warp is exceedingly easy and steady. Jacquards of this description have in some cases each griffe worked by a separate lever attached to the tappet shaft, and the card cylinder is driven by a lever connected to the crank shaft.

Messrs. Hattersley and Smith obtained a patent in 1867 for an ingenious shedding motion, in which the double action principle is adopted, and one cylinder is made to carry a set of double cards in lieu of using two cylinders, and two separate sets of cards. Fig. 312 represents the machine without the frame being shown. *A* are the front crank levers, which are hinged on a shaft or rod A^1, supported on the frame. One arm of each lever is attached by a cord to one of the healds, the other arm being attached to a rocking bar, to each of which are hooks or catches D^1 and D^1. These catches drop and catch on the knives or lifting bars *E* and E^1, when not held out of contact therewith by the rods or pins *F*, resting upon weighted levers *G*, which levers are lifted by pegs G^1, projecting from the peg lags G^2. The knives *E*, are supported by and capable of sliding in grooves formed in the frame of the machine and operated by rods E^2 and E^3, connected by a three-armed lever H, and hinged to the frame. An oscillatory motion is given thereto by a rod I, connected to a crank fixed on the lower shaft of the loom. It must be understood that each hook or catch has its separate rod F, and lever G, with its own line of pegs or peg holes in the lags G^2. The

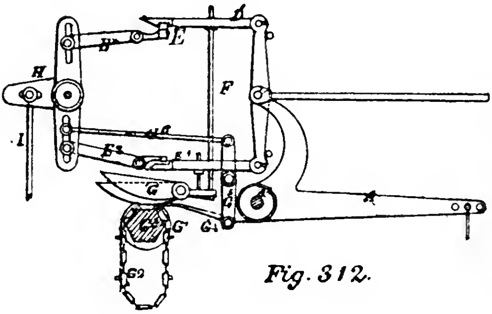


Fig. 312.

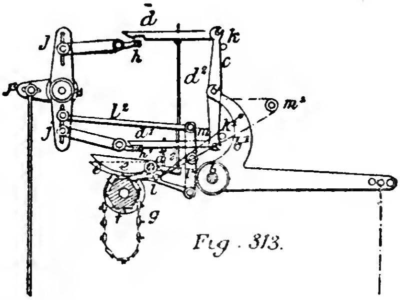


Fig. 313.

cylinder G^3, carrying the peg lags is turned by a pawl or catch G^4, a lever G^5, which is hinged to the frame, and a rod G^6, connected to the lever H. By this aparatus any of the healds can be arranged to be lifted and pulled down, when liberated, by springs in the usual way, or by the use of an additional set of bell-crank levers with bottom levers (placed under the healds to draw them down instead of springs), whereby the usual springs can be dispensed with. Cards or other actuating means may be used instead of pegs. Messrs. Hattersley show two of these machines at the Paris Exhibition (1878).

Several modifications of Messrs. Hattersley and Smith's shedding motion have been patented, the most recent (1877) being one by Mr. J. Eccles, of Preston, which is shown in Fig. 313, which is for the simple purpose of throwing the machine out of action at any desired intervals, so as to allow of plain weaving being produced when the cylinder was out of action, and thus produce borders on handkerchiefs and other similar articles. This is effected by employing the front jack lever b^1 to lift the pawl l from the teeth of the ratchet when the lag barrel f is to remain stationary; the front jack lever b^1 in this case being used only for this purpose, and not to actuate the front heald, which is actuated by a second jack lever; and the upright arm of the jack lever b^1 is connected by a cord m with the pawl l; and the endless lags g, are pegged to actuate the healds to produce the required cross stripe; and one lag is pegged to produce plain weaving; and when this last-named lag comes under the feelers *c*, the pawl *l* is lifted from the ratchet, so that the barrel *f* will remain stationary. Another modification was patented by P. S. Vitrant, of Paris, in 1876.

There are a great number of shedding motions variously termed Dobbies, Index machines, &c., which are operated upon by pegs, cards, metal plates, lags, rollers, and other equivalents, which are all employed for one purpose, namely, to throw in or out of action a series of hooks or bars. But they all depend upon one or other of the principles before described. It may be mentioned that in every case the healds after being raised may be drawn down by springs, weights, or counteracting levers as in hand looms; and various ways of attaching the machines to the looms may be adopted as most convenient. They are sometimes placed at one end of the loom, but more generally upon the top, in a similar manner to mounting the ordinary Jacquard machines.

Perhaps the best method of working the Jacquard machine in connexion with the power loom is that shown in Figs. 314, 315. Two light beams supported by short columns resting upon the looms are carried over each row of looms, and the Jacquards are supported upon them. The lever of the Jacquard *n*, Fig. 315, is connected to the crank shaft of the loom by the rod *d*, to which motion is given by the crank *a*. The card cylinder is actuated by a separate motion, by means of which the cards do not strike the needle points until they are free from the griffe bars. The cylinder can also be thrown out of action without stopping the loom, and the cards can be readily turned back when the loom is stopped. This is effected by means of a rocking shaft *z*, Fig. 315, supported on standards fixed on the top rail of the loom. At the end of the shaft a lever with a segmental arm is loosely fitted, which receives motion from a rod connected to the eccentric *b*. Adjoining the segmental arm, a handle *g*, shown in Fig. 314, is fixed fast upon the rocking shaft. This handle is made in two parts, with a spring to keep the parts open as shown. One of the parts has a projecting piece, upon which is placed a "nib," which the spring handle presses into a notch in the segmental arm. Two arms and two rods, *e*, *e*, are also attached to the rocking shaft, and connect the batten of the card cylinder thereto, as seen at *c*, Fig. 314.

Now the griffe lever is so timed that the griffe bars have passed below the hooks before the rocking shaft brings the card cylinder against the needles, and in case the cylinder should be required to stop or turn back, the split handle must be pressed together, by which means the "nib" is withdrawn from the notch and the rocking shaft becomes stationary. But by moving the handle the cylinder can be worked independently, so that by lifting the catches by means of the cord, the cards may be turned back at pleasure.

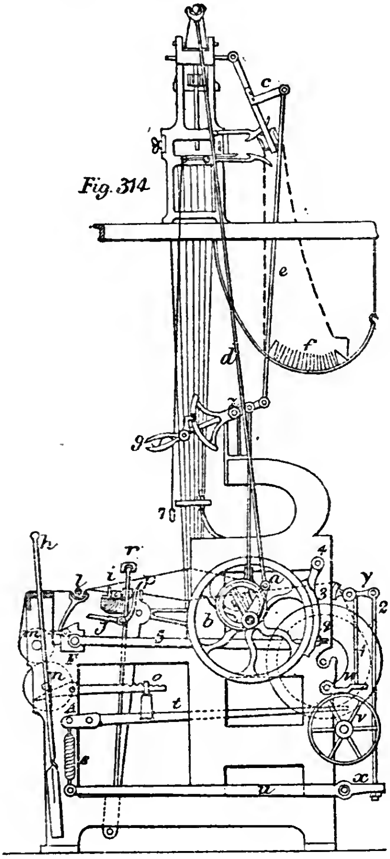


Fig. 314.

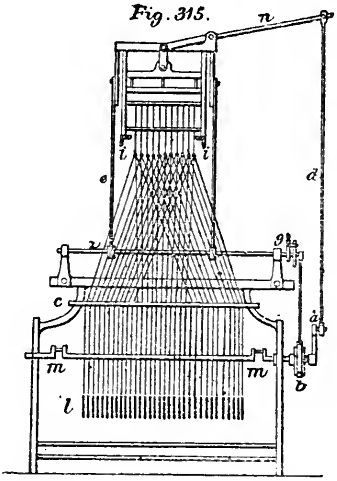


Fig. 315.

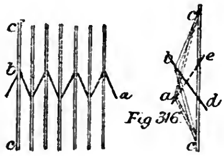


Fig. 316.

To work the card cylinder independently of the griffe motion, by attaching a separate rod to the cylinder batten, was first introduced by Mr. James Bullough in 1842, but the application of the split handle and disconnecting lever was patented by Messrs. Waller and Butterfield, of Bradford, in 1855, and it has there come into very general use.

The effect of this contrivance is that it saves the cards from the injury they are liable to receive by striking the needles before the hooks are clear of the griffe bars; and the cards can also be turned back without moving the loom, which was not previously the case, although Mr. Gilroy had many years before applied a pulley and cord to the end of the cylinder for that purpose, but it does not appear to have ever come into general use.

Jacquard machines are frequently used in power looms with shaft harness or headles, as in damask weaving. In this case the griffe is raised by a suitable crank or cam, and held up by another cam whilst the headles are working the ground. The principle upon which damask weaving depends having been already described, it will be readily understood that the Jacquard machine and shaft harness may be as effectually applied to the power loom as to the hand loom.

Various contrivances have been introduced for the purpose of making plain sheds, by dispensing with ordinary healds. One of the most ingenious plans for this purpose was patented in 1870 by Messrs. Holding and Eccles, of Manchester. The principle will be understood by referring to Fig. 316, which represents a plan and section of the warp and healds. The warp threads are shown at *c c*. The healds are composed of wires, arranged similar to the letter W, as shown, and the warp threads rest in the angles.

Now it will be evident that if the side *b* of the heald be raised, it will also raise the warp threads resting upon that side; and in like manner if the side *a* be raised, the alternate threads will be raised. This is shown in section where the side *e* has been raised to *b*, and the reverse movement is shown in dotted lines where the side *d* is raised to *a*. Consequently by simply raising each side of the zig-zag wires alternately, tabby or plain shedding will be effected.

The advantages of such a contrivance would be to dispense with threading the warp through the eyes of the healds, for they would simply require to be laid in their proper space or angle. On the other hand such a contrivance could only be applied to low numbered or coarse warps, for the wires would be too crowded for fine warps.

Thin pulleys have also been used for similar purposes, and various arrangements of them have been made to form gauze selvages, instead of using the common gauze leash: but it does not appear that any advantage has been gained by these means.

CHAPTER XXVII.

DROP AND CIRCULAR BOXES—DIGGLE'S CHAIN—WHITESMITH'S BOX MOTION—LEEMING'S—LONG'S.

In order to enable the weaver to use in the fly-shuttle loom two or more shuttles containing different kinds of weft, the drop box was invented by Robert Kay, in 1760. This contrivance was found to be of such great use that on the introduction of the power loom the application of a drop-box to it was at once suggested. Dr. Cartwright was perhaps the first to attempt its application, and it is mentioned in his patent obtained in 1792. It seems, however, not to have been carried out successfully until many years afterwards, for in 1830 Mr. Duncan states, in an article written in the Edinburgh Encyclopædia, that it appeared extraordinary that no plan for that purpose had yet been adopted, and he therefore suggested one. His contrivance consisted of five shuttle boxes placed upon the outside segment of a cylinder, and an arm connected thereto being brought into contact with a series of studs or projections placed upon a ratchet wheel, which, being turned by the loom, caused any required box to be placed under or in line with the picker. Hand looms with boxes on this principle were then in use, except that the boxes were placed on the inside of the periphery of the segment, and they were moved by hand, according to the shuttle required.

In 1843, Mr. Luke Smith applied a cylindrical or circular box containing chambers for three shuttles. This box was perhaps the first circular box, and was revolved, as required, by means of catches put into operation by suitable studs fixed upon an endless band, made to revolve over a cylinder, and kept in tension by a hanging pulley and weight. The picking stick was carried upwards through the lathe, or shuttle race, and the end of it drove the shuttle out of the undermost box, and not the uppermost, as now generally adopted in this kind of loom.

Since that time circular boxes have been brought to a considerable degree of perfection by the Yorkshire loom makers, but in Lancashire, where they were first introduced, the drop-box system seems to be preferred. In both systems the boxes may be governed by similar means, as will be hereafter shown.

In 1845, Mr. S. Diggle, of Bury, obtained a patent for a chain, composed of a series of plates or cams, which have since been extensively used and known as "Diggle's chain." By means of this contrivance, an ordinary drop-box can be raised to any desired level.

Fig. 317 represents the chain composed of various plates, *c*, *c*, *a*, which is supported on a barrel or cylinder, placed at the end of the loom. A lever *c*, having a roller attached, rests upon the uppermost plate, and is therefore raised according to the size of the plate.

Fig. 317.

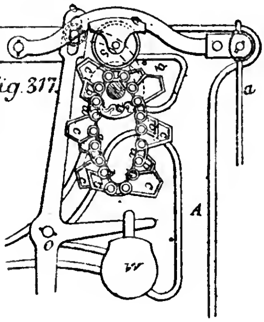
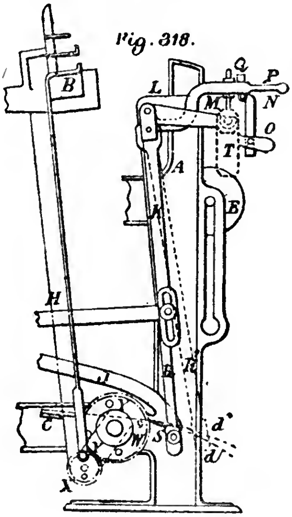


Fig. 318.



At the end of the lever a rod *a* is attached, at the lower end of which the drop-box is fixed. A lever *o*, having a weight *W*, attached, to keep it in position as shown, is moved at each pick of the loom, or in any other order; and being provided with a catch at the upper end causes the barrel upon which the chain rests to revolve, and thereby bring the various plates underneath the pulley, and raise the box according to the various heights of the chain plates.

Numerous modifications of this system have been made, to make it applicable to other purposes besides drop-boxes.

A drop-box motion extensively used in Glasgow, is shown in

Fig. 318. It is the invention of Mr. Isaac Whitesmith, of that city, and is found to answer its purpose well.

The shuttle-box *B* is supported on the spear rod, the lower end of which is fixed on a pin in the pinion *X*. As the pinion is turned from the bottom to the top dead centre it raises the box, and an easy motion is thereby obtained. The pinion *X* is turned by the wheel *W*, which is double the diameter of *X*. Four pins *Y* are fixed into the wheel *W*, by which it is turned a quarter revolution whenever the catch *J* comes into contact with one of them.

Now the action of the machine depends upon throwing the catch into or out of contact with the pins, and this is done as follows:—The pattern cylinder and chain of cards is shown at *T*, fixed at the short end of the bell-crank lever *K*, which receives motion from a cam on the tappet shaft through the lever *H*. At each revolution, therefore, of the tappet shaft, the cylinder rises and comes into contact with a pin *M*, fixed in the short end of another bell-crank lever *R*. The catch *J* is supported at *S* by the lever *R*, as shown, and thereby kept out of contact with the pins *Y*.

Thus it will be evident that when the cylinder rises it will not affect the pin *M*, if there is a hole in the card, but if there is no hole, the pin will be raised. By this means the lower end of the lever *R* will be thrown outwards, as shown in dotted lines at R^1, and the catch will then fall and turn the wheel *W*, so long as there is no perforation in the cards. The spring plate *d*, fixed to the frame of the loom at *C*, acts as a guide and pressure spring to the roller s' and lever *R*, as shown by the dotted lines, where the lever R^1 has raised the spring *d* to d^1. The apparatus is attached to the framing of the loom *A* by the bracket *L*. The cloth beam is shown at *E*.

In the above instance only two boxes can be used; but by using two or more catches, and fixing the pinion upon an eccentric, a number of boxes can be worked. The rod being always carried from one dead centre to another, and the effect being the same whether two or more shuttle boxes are used, causes the action to be exceedingly easy and devoid of all sudden and jerking motion. The only objection that appears to be raised to this plan is that the plates or cards require to be perforated according to the relative position of the boxes at each change. This, at first sight, naturally appears a little perplexing, but the weaver very quickly overcomes the difficulty.

A box motion, adapted both for circular boxes or drop boxes, is shown in Fig. 319, which was patented by Messrs. Leeming and Whyte, of Bradford, in 1876.

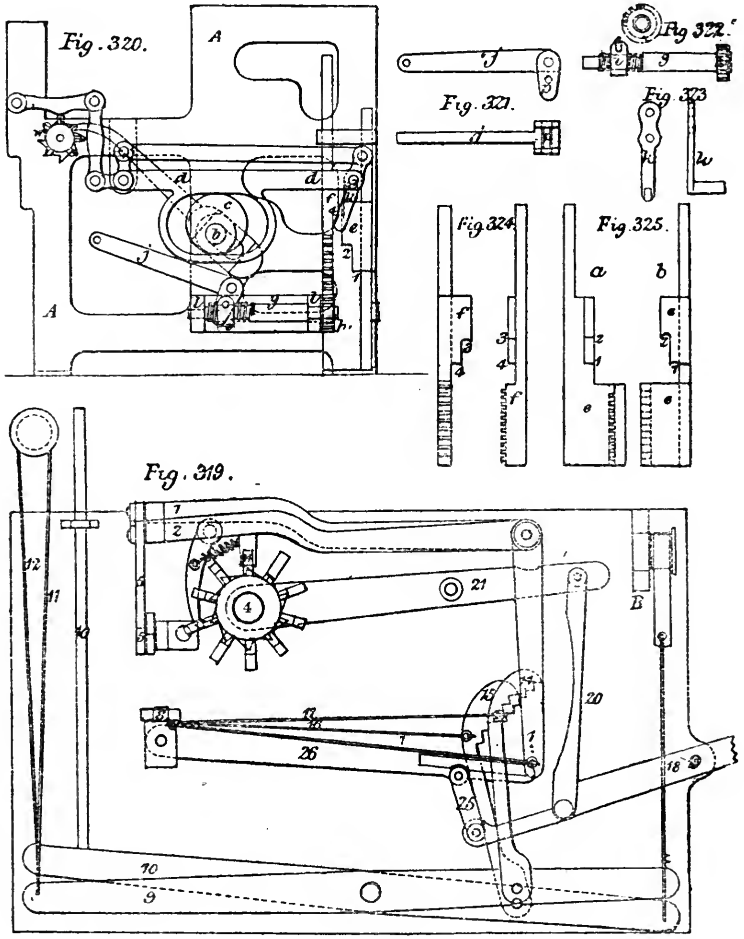
Figs. 1 and 2 are levers working on a stud, and under them is placed a card or pattern cylinder; the levers 1 and 2 may be provided with a number of pendant prongs, according to the number of shuttle cells, to act in conjunction with the holes or blanks in the cards (or pins of unequal lengths, as shown in the drawing). The cylinder or barrel has a rising and falling motion. The levers 1 and 2 are connected at their ends by links and lever 5, so that if one be raised by the pattern barrel, the other will be lowered. The lever 1 is a bell crank, and from its lower arm is a rod 7, connecting the swivel piece 8 therewith; 9 and 10 are two levers, each having at their free ends a rack rod and rack, 11 and 12, gearing with the rotary or circular shuttle box, as shown at the top. For drop boxes the vertical rod 10′ at the end of the lever 10 is required for actuating the box. On fulcrum pins attached to the levers 9, 10 are two upright catch pieces, 14, 15, each having a number of notches equal to the number of shuttle cells and shuttles, and these pieces are connected by rods 16, 17 to the swivel piece 8.

The action of the machine is as follows:—A cam or crank gives regular motion to the lever 18. On the upward movement of the lever arm 18, the link 20 will, by raising the lever 21, force downwards the pattern barrel, whereon the catch will turn the barrel with its card or pin under the pendant parts 24 of the levers 1, 2; meanwhile the lever 18 will have, by its upward movement and link 25, forced upward the lever 26 and the end have caught one of the notches on one or other of the catch pieces 14, 15; and as the latter are connected with the levers 9, 10, and shuttle boxes, they will thereby be moved into proper position.

Now, when the link 20 is drawn by the lever 18 downwards, the pattern barrel 4 will be forced upwards, and the pin or blank of the card, whichever may be used, will act on 24, and force one of the levers 1, 2, upwards; the arm 1 will be moved inwards, the rod 7 will turn the swivel 8, and the rods 16, 17 will change the position of the notched pieces 14, 15, so that on the lever 26 again ascending, its ends will engage with some other of the notches, and move the levers 9, 10 and the boxes as required.

Mr. James Long, of Philadelphia, has patented (1877) a drop-box motion, which he claims to be capable of rapid and positive action.

Figs. 320 to 325 represent the various parts of the invention, in which *A*, Fig. 320, shows the side of the loom; *b*, tappet shaft; *c*, the eccentric cam for operating the lever *d*, at the right end of which is hung on a pin the lifter *k*; *e* and *f* are the sliding racks, with spur teeth on the lower ends, and provided with projections, 1, 2, 3, and 4, two on each rack; this number is required to operate



three shuttle boxes. To operate four boxes, three projections are required on each rack, also a greater number of teeth or length of rack. *g* is a shaft set in a frame *l*, fixed to the side of the loom, on which the pinion *h* is fixed, and on the opposite end is a screw thread, upon which is fitted a nut *i*, in the top of which is cut a slot *s*, into which fits a pin *p* fixed in the heel of the lever *j*. To the left-hand end of *j* is connected a lifting rod supporting the shuttle boxes. In the ratchet wheel *w* are five pins, one being longer than the others. The pin wheel is operated by a pawl moved by a cam on the shaft *b*, and the action of the pins is conveyed to the lifter *k* by the connexions as shown.

The movements of the boxes are controlled by movable pins of different lengths. A long pin will bring the bottom box in line with the shuttle race; a short one, the middle box; and a blank or empty hole, the top box.

The operation is as follows. The shaft *b* and cam *c* give a lifting movement to the lever *d*, and this in turn to the lifter *k*. In Fig. 320, a long pin is shown in action, and the lifter *k* engaged in notch 4 on the rack *f*, and consequently the bottom shuttle box is elevated. The next movement of the pin will present a short pin, and the lifter *k* will engage in notch 2 on rack *e*; this will raise rack *e*, and since this is geared into the pinion *h*, it will revolve the latter, and the rack *f*, being geared on the opposite side of the pinion *h*, will be drawn down when *e* rises, and in the same manner *e* will be drawn down when *f* rises.

The raising of the rack *f* revolves the screw *g*, and screws the nut *i* to the right, depresses the end of the lever *j*, which in turn will put the middle shuttle box in position. The next move will present a blank or an empty hole in the pin wheel and the lifter *k* will engage in the notch 1 on the rack *e*, raising it still higher, and moving the pinion *h* will move the nut *i* still further to the right, and operating through the lever *i*, as before, will drop the top box into position.

Thus the invention consists in the combination of two sliding racks operating a pinion wheel fixed on a shaft, on which a screw thread is cut, carrying a nut connected with the heel of a lever, to which is connected the lifting rod of the boxes. The pattern may be made with pegs of different lengths fixed in a cylinder or on a chain of lags.

Fig. 321 shows two views of the lever *j*. Fig. 322 shows two views of the shaft *g*, on which is the nut *i* and pinion *h*. Fig. 323, two views of the lifter *k*. Fig. 324 shows two views of the sliding rack *f*; and Fig. 325, two views of the vertical sliding rack *e*.

The drop-box system has been frequently applied for the purpose of changing the shuttle when the weft thread breaks or becomes exhausted, by which means the loom need not be stopped for the purpose of supplying a fresh shuttle. It does not, however, seem to have come into general use.

Change boxes have been constructed in numerous ways, but the principal ones may be mentioned. The common drop box; circular box; swing box to move in a portion of a circle; sliding boxes placed horizontally to the framing of the loom and not to the batten or lathe, and moved into position as required; drop boxes attached to the framing of the loom; boxes placed in the middle of the batten, so as to weave two pieces in a broad loom.

To the above may be added numerous plans for working two or more pieces of cloth, requiring two or more shuttles simultaneously —one above or behind the other, both in horizontal and vertical looms; but they have never and perhaps never will be, found to answer the purpose intended, except in ribbon or narrow looms.

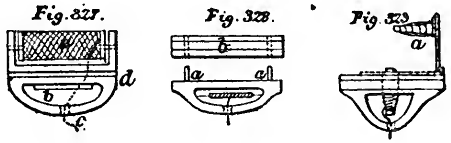
Circular boxes are usually made with six chambers, but some are constructed with double that number. In drop-box looms a still greater quantity of shuttles have been used, and it is not easy to see what advantage the circular box has over it in any respect.

In both circular and drop boxes the picker is used precisely on the same principle as applied to the hand loom, as described at page 92, although two spindles are sometimes used to steady the picker in lieu of the nib, as in the common picker. Springs and swells are inserted to hold the shuttle when in the box when requisite, as in fast-going looms. The weft stop and other motions, are also applied as in plain looms, and in fact the drop or circular box loom may be used as a plain loom when not otherwise required.

CHAPTER XXVIII.

RIBBON SHUTTLES—WHEEL MOTION—ELASTIC WEB WEAVING—REDDAWAY'S TUBE OR HOSE LOOM—THREE SHUTTLE SWIVEL.

Various descriptions of shuttles have been adopted for narrow looms worked by power, besides the common form already described for hand looms, each one having some special object in view. The shuttle shown in Fig. 327 has the bobbin placed at the back, and not



in the bow as is usually the case. By this means a much larger bobbin can be used. The thread passes from the bobbin *a*, through a slot extending the whole length of the bobbin, and thence between two plates *b*, which are slightly pressed together by a wire spring—the bottom plate being fast and the top one loose. By means of these plates any degree of tension can be put upon the thread. The front of the shuttle has an eye *c*, formed in the usual way, through which the thread passes. This shuttle is an American invention, and called the Thorndike Company's Patent Shuttle. But the use of a large bobbin in the position shown is not new, for Mr. Dean, elastic web manufacturer, of Derby, tried a shuttle with a bobbin of that description many years ago, but it was found to be defective from being too heavy, and placed in an inconvenient position at the back of the planks. Mr. Dean, however, did not use friction plates.

Fig. 328 shows the common form of ribbon shuttle as used when several tiers are employed, as in the Coventry fancy ribbon looms. The front of the shuttle is attached to the back *b* by means of dowels or pegs, *a*, *a*, so that fresh quills or bobbins can be conveniently replaced, equivalent to supplying a fresh shuttle, and each shuttle may have two of these loose bows, and thus save time in working, for they can be readily changed.

Another form of shuttle is shown at Fig. 329, in which the bobbin is placed in a contrary direction to the usual plan. This is done to save space, and thereby allow a greater number of shuttles to be used, as desirable in swivels for tissue weaving. The bobbin spindle is fixed upon a flap hinged to the back of the shuttle, and by opening the flap, as shown, the bobbin may be easily replaced. This contrivance was patented in 1845 by W. Henson, but since that time other patents have been taken out for a similar contrivance. Shuttles have also been made with the bobbin placed vertically, and in many instances two or more spindles for two or more bobbins or quills are inserted, but the same effect may be generally produced by winding the weft threads upon one bobbin only; for double threads are frequently used in that manner in silk weaving.

In weaving figured ribbons the Jacquard machine is employed, and used exactly in the same way as in the common hand loom; but ribbon looms are now more generally worked by power than by hand. It is requisite, however, that shuttles containing different coloured weft should be used, and to change them as required is a more difficult matter than the ordinary drop-box system. In the ribbon loom the shuttles are placed between the planks of the batten, consequently the whole of the batten must be raised in order to bring the various tiers into operation. A batten containing five or six tiers, or from 50 to 100 shuttles is of considerable weight; and as single picks of weft from any one tier of the shuttles are often required, means must be provided for supplying them.

In the first place, the batten must be raised to any desired level, and when so raised the line or tier of shuttles placed opposite the shed only must be used. The raising of the batten may be performed in various ways, as in the case of the ordinary drop box; but one plan may be mentioned in which inclined planes are used, upon which, as the batten recedes, the required tier of shuttles are brought to the requisite level. To accomplish this the under part of the batten has a broad roller fixed at each end, and beneath these rollers a number of wooden bars or levers are placed which have their fulcrum at the front part of the loom, but the opposite ends are free, and can be raised. The bars at each end act in unison, in order to raise the batten in a horizontal position. Now each tier of shuttles has its appointed pair of bars or inclined planes, and as the shed is being opened by the Jacquard it selects the pair of bars to be used upon the batten to be raised. Each of the bars is provided with a prop or support, to enable it to carry the weight of the batten and hold it firmly in position. These props are taken away when the batten advances to beat up the weft, or may be left in position if the same line of shuttles are required to be used more than for one pick. Thus, by erecting by the aid of the Jacquard a series of inclined planes, the various tiers of shuttles may be raised as desired. In other cases the batten is raised by means of strong hooks and a griffe. These hooks, according to the tier of shuttles to be raised, are put into position by the Jacquard machine at the top of the loom acting upon a corresponding number of needles and hooks. But these few hooks have a separate griffe, which is made to act suddenly, and long before the Jacquard griffe is raised. Therefore time is gained, and the hooks and griffe for raising the batten have completed their task by the time the shed is opened for the passage of the shuttles.

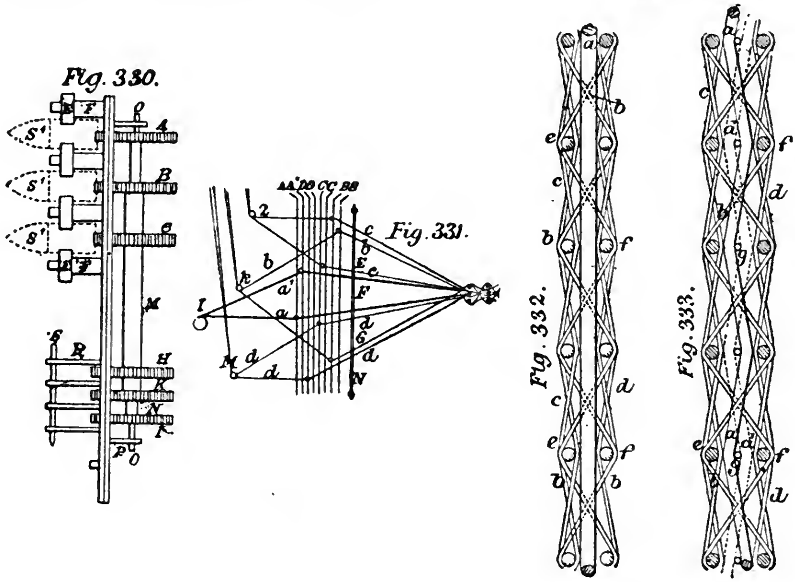
When the required tier of shuttles is selected, it is necessary to throw that tier only, and means must be provided to put it into gear with the driving power. There are several ways of doing this, but the one shown in section in Fig. 330, patented by Mr. J. Beesley in 1861, will suffice. In the figure *A B C* are pinions working, independently, the shuttles S^1 S^1 S^1. These shuttles run upon the races or planks *E E*, which are fixed upon bosses *F F*. At *H K N* are pinions corresponding to the pinions *A B C*, which are fastened upon tubular shafts made to revolve upon the central spindle *O*. The pinions *H K N* are worked by racks placed, but not shown, between the plates *R*, and are held in their places by the pin *S*. Upon taking the pin out, any of the racks can be removed if required.

Now it will be evident that by moving any of the racks the corresponding pinions *H K N* will be turned, and the pinions *A B C* also, which being geared into racks fixed into the back of the shuttles, cause them to be passed through the shed, as previously described. See page 227.

Motion is given to the racks by a machine of curious construction called a "marionnette," probably from the complexity of its motions. It is placed at one end of the batten, and contains levers which are made to rise and fall simultaneously, similar to the double-action Jacquard principle, and in so doing draw with them the racks, before mentioned, in either direction as may be necessary.

The system of working in ribbon looms two or three tiers of shuttles *simultaneously*, in two or three sheds of the same fabric, usually elastic webbing, is one that appears to be of considerable importance and becoming of extensive use. One example of this kind is shown in Fig. 264, and already described; but a plan in which three shuttles are used is represented in Fig. 331. The system also affords one of the best examples of double-cloth weaving, in which various warps are used, as shown in section in Figs. 332 and 333.

The arrangement shown in the above-named figures was patented by Messrs. France and Bradsworth in 1875, for the manufacture of



elastic webbing. Fig. 331 shows a section of one piece in which *H* is the reed; *I*, the india-rubber beam from which the threads a a^1 pass through the leashes A A^1; 2, k, M are rollers under which the warps b c d pass before entering the leashes *D D*, *C C*, *B B*, and forming the three sheds *E F G* for the passage of the three shuttles. The shuttles are driven by the ordinary peg motion, as shown in Figs. 174 to 176; but each tier of shuttles is provided with a separate pair of slide bars and pegs, which are put into action as required.

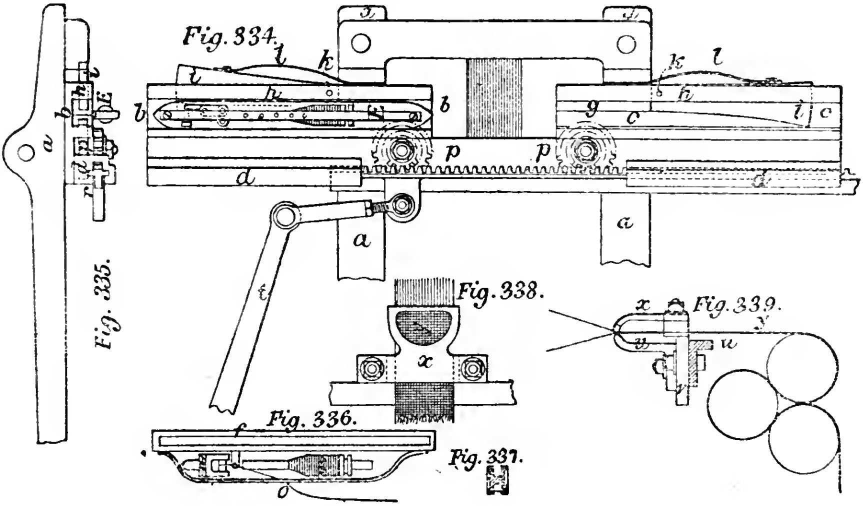
The operation of weaving will be best understood by referring to Fig. 333, in which a a^1 are the india-rubber warp threads and f g the weft threads. The face warp threads are shown at c, and the warp threads at the back at *d*. The face weft threads are shown at *e* and the back ones at *f*. In the example shown in Fig. 332 there are two shuttles only employed, and the shedding is arranged to show two distinct faces to the cloth. The warp threads of the face being shown at *c c* and the weft threads at *e e*; whilst *b b* are the binder threads which bind the two faces of the cloth together and secure the india-rubber warp threads *a* in between them. In Fig. 333 the binder threads are also shown by the letter *b*.

Excellent specimens of ribbon looms for weaving figured ribbons are to be seen in various places exhibited by Mr. Stevens, of Coventry, and fine examples from various countries of such looms are shown in the Paris Exhibition (1878) worked by power, and in one instance by the "bar."

The application of power to drive a ribbon loom is simply to apply fast and loose pulleys, or a clutch coupling, to the crank-shaft instead of working it by the "bar," as described in Chapter xix. The harness from the Jacquard is repeated, each ribbon being provided with a separate set of leashes attached to the hooks of the Jacquard, and of course all the ribbons are woven with the same pattern. Should any shuttle become exhausted, or the weft broken, then, in case it has not been observed in time, the weaving proceeds until the cards arrive at the place left off at by the shuttle, when the weft is again put in action. Weft stop motions are not applied to ribbon looms.

Although narrow looms are generally constructed with the whole of the shuttles placed in one batten, still several attempts have been made to adopt separate battens for each shuttle, so that when any one of the shuttles or warps require attention the whole of the loom need not be stopped from working as at present. Mr. Peter Fairbairn appears to have been the first to try this system, for in a patent dated 1838, No. 7699, he states:—"The last feature of improvement is associating a series of these narrow looms in one general frame side by side, in which the side frame of one loom is made the side frame of the next loom adjoining it, the whole being driven by one shaft extending through the series, but each loom being independent of its neighbour, and actuated by its own particular mechanism and driving strap." A loom with separate battens on this principle is shown at work in the French department of the Paris Exhibition, 1878.

A very compact narrow loom for weaving hose for the conveyance of water was patented in 1876 by Mr. F. Reddaway, of Manchester, and is shown in Figs. 334 to 339. The same letters refer to the same parts in each figure. *a, a* are the upper ends of the slay or batten swords; *b, c,* the shuttle races; and *d, d,* the rack slide. The



shuttle consists of a metal carriage *f,* and is made to slide in the races as shown in section in Fig. 337. The shuttle boxes are provided with swells *i, i,* hinged at *k, k,* and held down by springs *l, l.*

The shuttle is seen in the race at *E,* Fig. 334, and on plan at Fig. 336, where *m* represents the weft bobbin, and *o* the eye of the shuttle. A rack is fixed to the under surface of the shuttle which gears into the larger part of the pinions *p, p,* fixed at each side of the warp. The smaller part of the pinions (double pinion) are geared into the rack *r,* working in the groove *d,* which receives motion from the lever and link *t, s.* By this means the shuttle may be driven through the shed at a rapid speed. The lever *t,* has motion given to it as in ordinary picking looms.

Fig. 338 and 339 show a peculiar kind of nipper temple adapted to the work, also the take-up rollers. The woven fabric *y* passes through the nippers *u, x,* which can be adjusted as desired, and can be made rigid or with a slight spring, and the upper part *x* may be hinged on the lower part.

An ingenious modification of the "circle" swivel, by which three descriptions of weft can be used, was patented in 1865, by Messrs.

Clayton, Raper, and Goulding, of Bradford, and is shown in Figs. 340 and 341.

In the circles used in hand looms as described in Chapter xvi., only

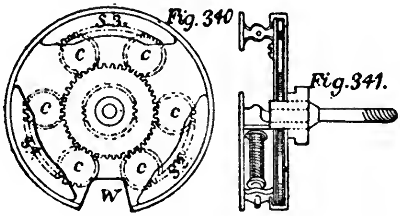


Fig. 340

Fig. 341.

one shuttle or bobbin was used in each circle, but in the present system three bobbins are mounted on the movable plate.

Motion is given to the shuttles by the small wheels *c c*, which gear into a rack in each shuttle, and these wheels are driven by a large wheel placed upon the same shaft as the small driving wheel.

The driving wheel receives motion from a rack as in the hand loom circles, and if it be moved the full distance it will cause all the three shuttles *S* 1, 2, 3 to pass the gap *W*, into which the top of the shed rises.

It will be evident that by properly adjusting the rack motion, any one of the three shuttles may be used, or any two of them, or even all three.

It is not necessary to show details, as they have already been fully described, and the application of circles and swivels to power looms is the same as in hand looms, with this exception, that in power looms a double shed can be made if desired so that the swivels and the ground shuttle can be used at the same time. See Fig. 300.

In the Conservatoire des Arts, Paris, a circle containing twelve small shuttles is preserved. It is about eight inches in diameter. It does not state for what purpose it was used, nor is the date given when it was made, but it appears to be of considerable age, and was probably intended for weaving a single width of ribbon, fringe, or braid. It is simply a circular grooved plate with an opening as at *W*, Fig. 340, and the shuttles fit into the groove, but no provision is made for moving them.

Mr. John Heathcoat, the inventor of bobbin-net machine, patented in 1835 a method of weaving fabrics standing edgewise, ranged side by side, their faces being parallel to each other, and to the ends of the machine. By this means a great number of tapes or other narrow goods could be woven in one loom.

Some looms for a like purpose are arranged with the shuttles placed in the batten in two or three lines or tiers, not directly over each other, but in step-like position, so that each warp and fabric can be seen side by side, as in the ordinary way.

CHAPTER XXIX.

THE NEEDLE OR SHUTTLELESS LOOM—APPLICATION OF THE PRINCIPLE TO SWIVELS—TO DOUBLE CLOTH BELT WEAVING.

In the shuttleless or needle loom the weft thread is carried through the shed by means of a needle which, upon its reaching the opposite side of the fabric, is caught by a pin and held there until the next insertion of the needle, when the pin again, after binding or removing the last loop, catches the weft thread. A loom on this principle was patented by Mr. John Smith in 1844.

This kind of weaving, therefore, requires the insertion of an additional thread at one of the selvages to hold the weft thread; but in the case of weaving fringes by this method the loose, or double end, forming the fringe does not require it. It will, however, be evident that the weft thread must be inserted double whether the selvage is bound fast or not.

In 1846 Mr. W. Unsworth applied two sets of weft carriers and points in lieu of shuttles, (patent No. 11,148,) but the weft bobbins were inconveniently placed at the back of the harness.

In the Exhibition of 1851, Messrs. J. and T. Reid, of Derby, exhibited a finely finished fringe loom on this principle, and it has since been applied by Mr. Ramsden to swivel weaving in lieu of swivels or circles.

In Fig. 342 the application of the needle shuttle to both swivel and fringe weaving is shown. The weft bobbins *c*, *c* are placed on a rail at the back of the needles *a*, *a*, *a*, and the thread is passed through an eye fixed in a rail, and thence through the eyes in the needle. Motion is given to the needles by means of a rack *b*, working the pinions to which the needles are fixed. As they carry the thread through the shed, as shown in dotted lines, a point or pin *e* takes into the loop of the weft, and holds it until it is bound into the cloth at the next stroke of the reed. These pins when weaving fringe may be made to ascend from below the selvage, but when applied to swivel weaving they are best applied from above, in the manner shown by Mr. Ramsden.

Fig. 343 shows the action of the pins. They are provided with

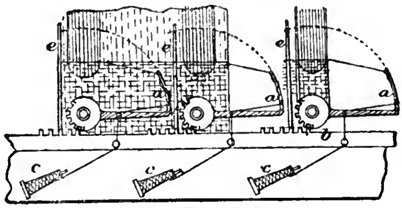
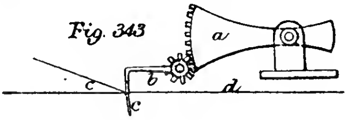


Fig. 342.

Fig. 343



a pinion *b*, which is moved by a rack lever *a*, fixed to a frame carried above the surface of the cloth *d*. The pin in this case is bent at *c*, where it enters the shed.

A needle loom of ingenious construction has recently (1877) been patented by Mr. G. H. Smith, of Manchester, for weaving driving belts and other fabrics, in which two, three, or four thicknesses of cloth are combined together to produce great strength.

In the annexed drawings four thicknesses of cloth are shown, employing four needles. Each needle is supplied with weft from a separate bobbin. The extreme selvage is formed by a shuttle intercepting the weft threads, and therefore holding them at the selvage. Four sheds are opened for the shuttles and five warp beams are required. To reduce the number of healds or leashes two eyes are made in each leash which, of course, govern the threads of two sheds.

Fig. 344 is a side view of the loom, and Fig. 345 a front view. The crank shaft is shown at *a*; *b*, the tappet shaft; *c*, the batten swords; and d^1, one of the warp beams, the other not being necessary to show. At one end of the shaft *b* is fixed a bevel wheel b^1, geared into a pinion e^1 on the side shaft *e*. The swords *c* and the batten are cast together, and support the reed c^1 as usual. To the

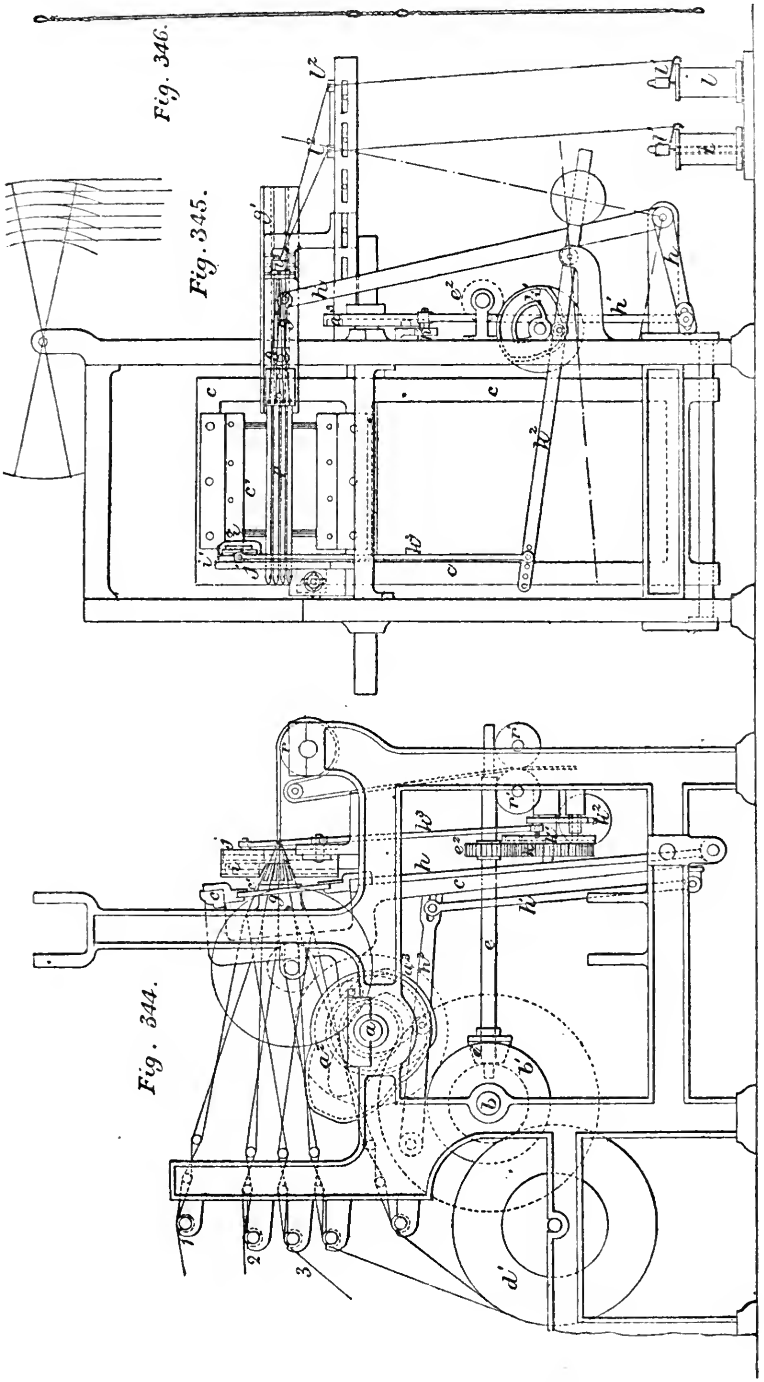


Fig. 346.

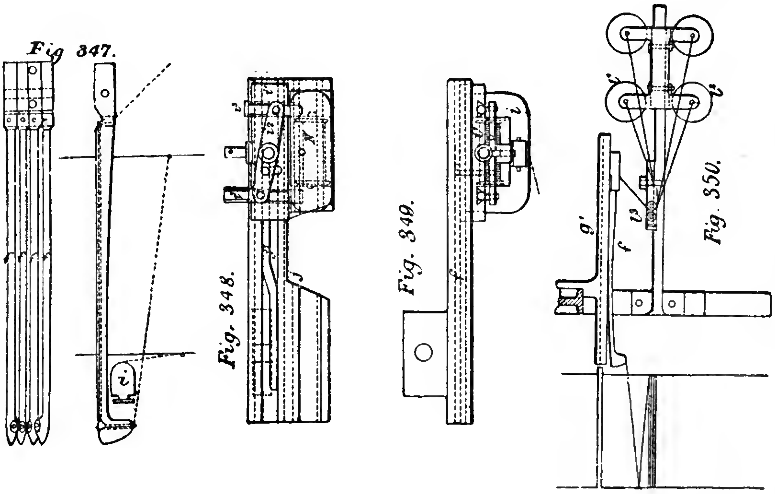
Fig. 345.

Fig. 344.

swords are cast projections which fit in grooves of the tappet a^2, and are made to cause the batten to dwell during the passage of the needles.

The shedding motion is of the ordinary kind, but as above stated, to reduce the number of healds two eyes are formed in each, as shown in Fig. 346, and they are made of wire twisted. The weft is carried to and fro by means of the needles *f*, shown in Fig. 347. They are fixed together with the eyes facing the cloth beam, as seen also in Fig. 344, and they are all secured to the slide *g*, working in the guide rail g^1, which is fastened to the loom side, as represented in Fig. 345.

The slide *g* is connected by the link g^2 to the longer arm of the elbow lever *h*, the shorter arm of which is connected by the link h'



to the lever arm h^2, which is by the link moved up and down by the tappet a^3 on the crank shaft *a*.

By this means, at every revolution of the crank, the needles *f* move to and fro, and the batten is made to dwell during their movement by means of the cam a^3.

At the opposite side of the loom is the small shuttle *i*, and the slide *g*, shown detached in Figs. 348 and 349; and the weft s taken from the bobbin in a similar way to a ribbon shuttle, excepting that the motion is vertical, as shown at *j*, Fig. 345. This movement is made by the shaft *e*, which has a pinion e^2, geared into the wheel *k*, cast on the tappet k^1, which imparts a vibrating motion to the lever k^2, the longer arm of which is connected to the shuttle carrier

i^1, by the link k^3. The shuttle carrier i^1 also slides up and down the guide j, and to it is hinged the lever i^2, in the ends of which are slots moving on pins projecting from the shot bolts i^3, which slide to and fro in the shuttle carrier i^1; these shot bolts fit in holes in the small shuttle i. In the lever i^2 is a stud which takes into the groove j^1 in the guide j. When the shuttle i is up, as shown in the drawing, the upper shot bolt fits into the upper hole of the shuttle, and when down the stud is guided by the groove j^1 to withdraw the upper shot bolt from the upper hole in the shuttle, and to push the lower shot bolt into the lower hole.

The bobbins l contain the weft, and are placed in any convenient position on the floor. Each bobbin fits on a hollow spindle and has a weight flyer l^1, which revolves as the weft is unwound. Each weft thread passes through an eye in the guide bar l^2, Fig. 350, and from thence between the upright rollers l^3, which are pressed together by springs, the position of the rollers being adjustable so as to make the tension equal on both selvages. Each weft thread is then passed through the small hole f^1 in the shank of each needle f, and thence along a groove at the back of the needle and through the eye of the needle. By this arrangement each weft thread is kept at its proper tension by the friction of the rollers l^3, they being placed in such a position that equal tension is brought to bear upon the wefts in their to-and-fro motion in the sheds, whereby a good selvage is made.

CHAPTER XXX.

TEMPLES—WARP STOP-MOTION—HEALD MAKING—PROCESS OF "TWISTING-IN," AND MACHINES FOR SAME—HAIR LOOMS.

In weaving various kinds of fabrics it is found that some have a tendency to contract in width, which is in consequence of the warp threads being too weak to withstand the pull of the weft thread, and this occurs more particularly in thin and scanty warps shot with heavy weft. To counteract this effect a stretcher or temple is used, and for hand-loom purposes the one shown in Fig. 34 answers the purpose. It will be evident that the temple must be moved as the work proceeds, which is not of great importance in hand-loom weaving, but in power-loom weaving it is necessary that it should be done more frequently in consequence of the greater speed of the loom. Therefore, to make the temple self-acting, so as to require no replacing, was at the very commencement of power-loom weaving a matter of some importance.

In this case, as in many others, Dr. Cartwright was the first who attempted to accomplish it by self-acting means, and he applied to his loom (1786) temples closed by a spring and opened by the motion of the treadles, thereby acting as intermittent nippers. In 1805 Thomas Johnson (the same who was engaged by Mr. Radcliffe) and James Kay obtained a patent for rotary temples formed like bevelled wheels, with pins in the edges to hold the cloth distended as it passed between them.

In 1836 disks with pins inserted were used by Mr. Parkinson, round the edge of which (one being placed at each selvage) the cloth travelled, and was, therefore, stretched to some extent. The disks were next made conical, and afterwards they were used in pairs, or two cones fitted together in each temple. Ultimately a number of small cones placed in a curved position were used, round the sides of which the selvages travelled.

In 1841 the roller temple was introduced by Messrs. Kenworthy and Bullough, which consists of a small roller reaching across the cloth and fitted to work in a case or trough, which is shown in end view at *l*, Fig. 314. The roller is either covered with sand or grooved in both directions, so as to give it a rough or file-like surface. The cloth passes under it, as shown, and by resting on the edges of the trough, causes it to bind against the roller, and thereby keeping the cloth from contracting, which is prevented by the amount of friction that would be required to be overcome. The trough and roller are fixed upon supports that have sufficient spring to give way in case the roller should be struck by the lathe. This temple is a very perfect one for calico weaving, and in great use, and is a modification of a roller patented by Mr. J. C. Daniel, in 1824.

Another description of roller temple was patented by Mr. J. Railton in 1842, and consisted of one or more rollers screwed with right and left-handed threads, and then fluted so as to make the threads into sharp points. If the cloth was passed under and over a pair of these rollers, the action of the right and left-handed screws was directed so as to draw the cloth towards each selvage, and thus produce the desired effect.

A modification of this principle is at present used in temples composed of a number of small disks, and Fig. 351 shows one of this kind patented by Mr. J. Hardaker of Leeds. These temples are used in pairs—one at each selvage, similar to disk and nipper temples, and are fixed on brackets with proper means for adjustments. The temple is composed of a number of small conical washers or disks, in the edges of which pin points are fixed as shown at Fig. 352. Each of these disks is carried upon a small bracket *b b*, provided with a projection *d*, or axis upon which the

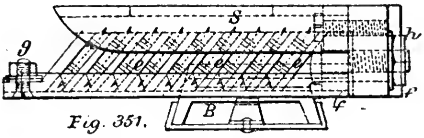


Fig. 351.

Fig. 352.

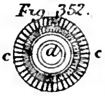
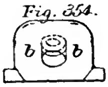


Fig. 353.

Fig. 354.



disk can revolve in a slanting position, as shown in Figs. 353 and 354. In Fig. 351, a temple is shown complete, fitted with a cap, and bound together by screws, *h*, *g*.

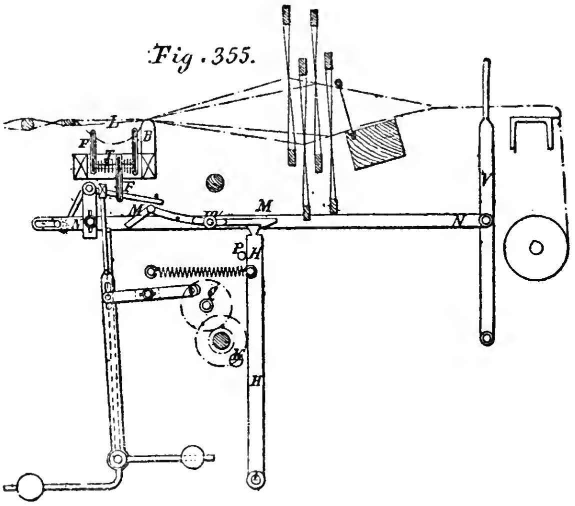
Now if the selvage be inserted under the cap, the pins in the disks will penetrate the cloth, and as the cloth travels over the tops of the disks it will be distended in consequence of the inclined position of the disks. The caps, which are also used in other temples, operate as guides in a similar way to the trough in the roller temple.

To stop the loom when any of the warp threads break was one of the tasks that Dr. Cartwright endeavoured to overcome, as described in Chapter xx. Several attempts have since been made to accomplish this, but, however satisfactory such a contrivance might be made, it would be of questionable advantage in weaving, and an incumbrance to an ordinary loom. Such motions are necessary for warping machines, and they may be applied to looms, but they are generally used only in warping machines. An example is shown in Fig. 355, which represents the plan recently patented, 1876, by Mr. L. Frey, for stopping the loom when a warp thread breaks.

The warp before reaching the headle, passes over a support or bar *B*, behind which are a number of guide bars *T*. Each thread is passed through looped or forked pieces *F*, which are kept raised by the thread, but fall when the thread breaks, as shown at *T*. Below the guide bars an arm receives a to-and-fro motion by means of a crank *Q*, which motion is interrupted when a loop falls below the guide bars, in consequence of the arm coming in contact therewith. At each end of the movement of the arm it acts either directly or indirectly upon the catch *M*, hinged at *m* to the bar *N*, thereby raising it so as to bring it out of reach of a lever *H*, pivotted at *I*, and held by a spring against a stop *P*, and receiving a slight movement by means of the tappet *K*.

Now if the movement of the arm be arrested by a fallen loop it

Fig. 355.



will fail to raise the catch *M*, and consequently this will be acted upon by the lever *H*, which will thereby push the bar *N* so as to actuate the detent *V* or throwing-off motion of the loom. The connexion of the crank *Q* to the arm *G*, is such that it will readily give way without fracture, so as to allow of the continued motion of the crank when the arm is arrested.

Messrs. Mather and Rossetter's warping machine, patented many years before, is on this principle, and in Mr. Singleton's machine the staples or forks are loose and allowed to drop between two rollers placed beneath. In passing between the rollers they cause them to be separated a sufficient distance to put in action a detent or stop motion is usually applied to looms. See page 237.

Healds were formerly made by hand by means of a reel, &c., and many are still formed so. Jacquard machine and other similar harnesses are also made or built entirely by hand. But ordinary healds, whether the eyes are formed by the thread or if mails are threaded upon them instead, are now generally made by machines adapted for the purpose. If mails are used they are threaded upon the thread before it enters the machine, and by means of levers the leashes on each side of the mail are drawn out and bound together at any required gauge or distance apart.

Healds constructed of twisted wire have long been used, and thin metal plates, &c., have also been tried. When made of thread, instead of looping to form eyes, in some cases they are plaited so as to leave unplaited the portion meant for the eyes.

Heald-making machines are often of very complicated and ingenious construction, but healds can be made in the common hand or power loom by using whip threads, as in fancy weaving, as the following recent invention will show.

Messrs. Cross and Brownhill, of Manchester, obtained a patent in 1877 for making healds by a process of weaving instead of knitting them by hand or by heald-making machines, and for that purpose an ordinary hand or power loom may be used.

The process is shown in Figs. 356 to 361.

Fig. 356 is an end view of the loom the patentees use.

Fig. 357 is a plan of weaving a single-width heald.

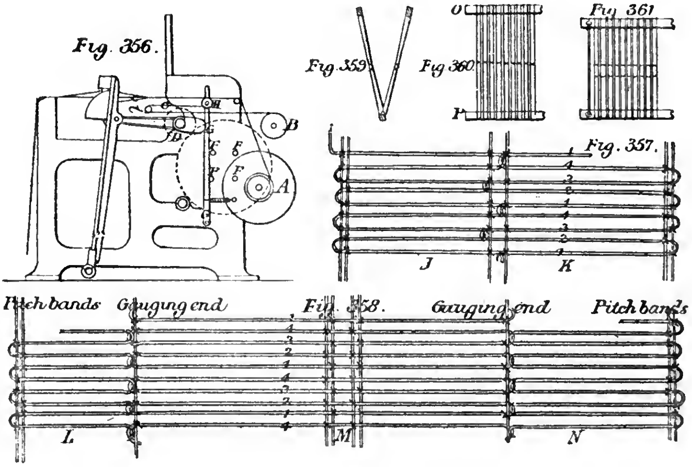
Fig. 358 is a plan of weaving a double-width heald.

Fig. 359 is a view of the double heald when folded with the heald staves attached.

Fig. 360 is a view of a single-loop heald; and

Fig. 361 is a view of the same when the staves are brought closer together.

In Fig. 356, *A* is the warp beam, containing the warp band or pitch band; *B* is the bobbin behind the loom, containing the whip strand, having tension placed upon it by weights or springs. *e t* shows the whip strand as it passes from its source to the heald and reed. *D* is a pinion wheel fixed on the crank shaft, which drives the shaft and wheel, upon which are placed two or four disks, or 'jiggers,' marked *F, F, F, F*. *G* is a lever fixed at one end in a stud in the locm side, and at the loose end is attached a smooth pulley or eye, *H*, for the whip strand to pass over easily. There is another smooth pulley or eye fixed in the ratch behind the hindmost heald. *J, K,* Fig. 357, shows the weaver's tie-up, four picks to the round. The cords shown in the middle of the fabric, Fig. 357, and the sides in Fig. 358 are simply for the purpose of gauging the lengths of the loops, and are drawn out after the fabric is woven. The warp threads marked thus × show that the warp strand must be uppermost over the weft strand. *L, M, N,* in Fig. 358, show a view of the double-width fabric, which may be afterwards folded up, as shown in Fig. 359, for the purpose of putting in the heald shafts and forming two loops, thus giving the requisite eye for the weaver's warp to pass through. *O, P,* Fig. 360, show the position of the heald shafts. In cases where straight loops or clasp healds are used, and where space for the weaver's chain or warp is required,



these two heald shafts should be brought closer together, so as to ease the warp and form a perfect eye for the warp. When the loom is at work, the ends of the pitch band and the gauging ends proceeding from the warp beam are lifted and depressed by a tappet or dobby, and the loops are formed thereby.

Now, the operation of weaving the healds is simply by using one or two whip threads in conjunction with a weft thread. Thus in Fig. 357 the threads 1, 2, 3, 4, &c., shown at *K*, are the weft threads, and the whip thread is shown at *J*. Both threads, of course, are of the same description. The shuttle is driven across the whole width of the loom, and at the left-hand selvage it passes round the whip thread. The whip thread having but a slight tension upon it, in comparison with the weft thread, it is drawn aside, and, in fact, would be drawn *completely through the shed were it not stopped by one of the gauging threads intercepting it.* Consequently the whip thread forms part of the leash up to the point it has been arrested, and the weft forms the remainder. In other words, the part *J* is formed by the whip, and the part *K* by the weft. The gauging threads, as the name implies, are merely used for stopping the weft thread at the point requisite, and are drawn out when the work is done. Sometimes gauging threads are made stationary, and as the work is woven it slides off the threads. See Fig. 212*b*.

In Fig. 358 two whip threads are employed, one at each side, as shown at *L* and *N*, whilst the middle part *M*, is formed by the weft. The shuttle in this case also is driven completely through the shed, and at each selvage it crosses the whip thread and draws it forward until arrested by the gauging threads, as before described.

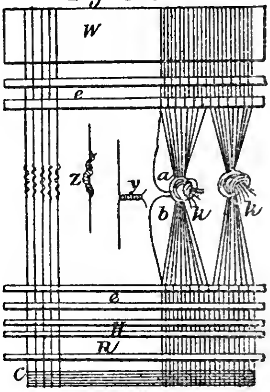
On this principle ornamental cloths are woven, called Indian *Kutars*, and it may be readily conceived that by using a number of gauging threads, governed by a "dobby" or Jacquard, that differently coloured whip threads may be drawn in from the selvages, so as to form various descriptions of borders. If the body of the fabric, Fig. 358, were filled in with warp threads and the shedding properly arranged, it would be in every respect a "Kutar" cloth. In that case the whip threads would necessarily be double, but the weft could be woven either single or double.

When a warp has been woven, a short length of it is left in the loom, in order to connect a new warp to it. If this were not the case the new warp would require to have each of the threads "entered" or threaded through the healds and the reed also, and it would entail a considerable amount of labour. The two ends of the old and new warps are therefore "twisted" together—each thread of the new to a corresponding thread of the old warp. By this means the operation is performed in a very short time, and is done as follows:—

In Fig. 362 let *C* represent the cloth; *R*, the reed; *H*, the headles; and *e*, the lease rods of the old warp. The new warp is placed on the beam *W*, and has the lease rods *e* also inserted. The two warps are then tied together in suitable groups, as shown at *k k*.

Now, in consequence of the "cross" keeping the threads of both the warps in consecutive order,the "twister-in" has no difficulty in finding the proper threads to twist together; and by placing his thumb and finger between the threads, as at *a* and *b*, he breaks them off to be twisted, and at once twists them together without losing hold. The twist is a double one, the first part being as shown at *y*, and the end so twisted is then twisted on the new warp thread, as shown at *z*. When the whole of the threads are twisted together, they are carefully "drawn" forwards until the twisted ends pass the reed, when the operation is completed. A little gum or flour paste is used between the fingers to stick the threads together, and the process is performed with remarkable quickness.

Fig. 362



As this work requires to be frequently done in connexion with power-loom weaving, it is not to be wondered at that attempts should be made to perform twisting-in by mechanical means, although it might appear that the advantage to be gained thereby would be questionable, seeing that a good deal of the labour attending it is taken up in placing the beams in position. But two machines have been patented (1872) for the purpose, one by Messrs. Shackleton and Binns, of Halifax, and the other by Messrs. Gillebrand and Walmsley, of Over Darwen and Blackburn. In both machines the threads are not twisted, but tied together by knots, and in one of them (G. and W.'s) provision is made to stop the machine in case a thread is absent.

In looms for weaving horse-hair and other substances of short lengths, special contrivances are required. Mr. S. Laycock, Sheffield, uses in his hair loom (1869) a Lyall's carriage shuttle. At each end of the batten is a trough containing the horse-hair, or other materials, which project slightly beyond the inner end of the trough, or nearest the cloth, and are held together by a spring. "Selectors" are usually made with a point pressing against a finger lever, and draw the hair away from the bunch. The shuttles have nippers actuated by cams, and at the proper moment they seize the hair provided by the selector. In case the hair has not been selected by the needle point nippers, *the shedding motion only is stopped* by the weft stop acting upon the "dobby," and the loom proceeds until a hair has been secured. The stop motion merely lifts the hook, and prevents the dobby cylinder from turning; thus the same card is repeated, and the action makes no progress. In this loom the selector obtains the hair ready for the shuttle to seize, although in other looms the shuttle itself is provided at the ends with needle nippers which open and close, when driven amongst the horse-hairs placed in the trough.

In 1873, Mr. W. Glover, of Prestwich, patented a very singular horse-hair loom, in which the cloth is placed with one selvage uppermost. By this means, when the shed is opened a shuttle can be *dropped through the shed.* Thus, by using a band passing over and under suitable pulleys placed above and below the warp, and provided with a number of shuttle pockets, the shuttles can be fed by hand as they travel upwards. After they have fallen through the shed, and delivered, by suitable trigger motions, the horse-hair, they are made to fall into empty pockets, and thus constantly proceed on their journey. Mr. Glover uses shuttles with nippers, and they can be either fed by hand as they ascend, or by pushing the nipper end of the shuttle amongst a bunch of hairs placed with their ends in two boxes lined with wire card. The loom is worked by the weaver by means of a double crank, in a manner similar to working a bycicle.

CHAPTER XXXI.

PREPARING JACQUARD CARDS—RE-CUTTING MACHINES—FINE EXAMPLE OF DESIGNING—BEAUMONT'S TREATISE ON THE TEXTURE OF LINEN CLOTH—VARIOUS TABLES AND CALCULATIONS REQUIRED BY WEAVERS.

To produce designs and transfer the same to cards for use in the Jacquard machine, necessarily requires a considerable amount of skill in the art of drawing; and a thorough knowledge of how to apply the same to the loom, and the effect likely to be produced on the fabric to be woven. But these matters depend upon the ability and trained experience of the designer. At the present time manufacturers, when they do not keep designers in their employ, suggest the kind of pattern or design they require, and get the work done by professional designers, who also supply the cards ready for use, which are usually charged for at so much per hundred, according to the size or number of needles in the machine they are cut for. When the manufacturer has obtained a set, he can then re-cut any number of other sets from the same, so as to put as many looms to work on that pattern as he may want.

In cases where small designs only are required, such as can be woven by means of shedding motions and small Jacquards, a sample pattern of cloth is usually imitated or modified as may be desired, and then transferred to the cards, pegs, tappets, or other means by which the pattern is woven. New methods of intersecting the threads for producing double cloths, as in carpet weaving, for saving materials, or producing some particular effect or advantage, are frequently secured by patent, several instances of the kind having been already alluded to.

To be able to apply any given pattern to the loom was formerly considered as being one of the "Mysteries" of weaving, for the weaver was expected to tie-up or arrange his loom to produce satins, twills, spots, and small figures. He was accordingly provided with various diagrams or plans, showing him how to do so, and if he was a careful man he would have a number of the most prevailing patterns drawn in his "Book of Ties," which was the name given to memorandum books for that purpose.

A century ago there were in this country no printed works on weaving, therefore, it may be interesting to describe a fair specimen of a weaver's pocket-book of that period, for it is questionable whether many of them remain in existence at the present time.

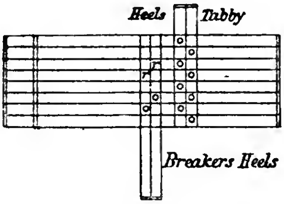
A book of this kind is now before us; it is an ordinary long-shaped pocket-book, and contains about eighty different "ties" or patterns, clearly drawn. Each pattern has its particular name, such as "Bird's-eye or diamond handkerchief;" "Twelve lam diaper;" "Barcelona twill;" "Florentine;" "Long-cut velvet;" "Shamrock gauze;" "Rocktabby;" "Velveret;" "Wild-worm-warp-way," and other curious names, for weavers centuries ago were perfectly aware of the effect of a new name. Thus Dr. Fuller in his "Worthies," says, "Expect not I should reckon up their several names, because daily increasing, and many of them are binominous, as which when they begin to tire in sale, they are quickened with a new name. In my childhood there was one called 'Stand-far-off' (the emblem of hypocricie) which seemed pretty at a competent distance, but discovereth its coarseness when nearer to the eye. Also 'Perpetuano,' so called from the lasting thereof, though but counterfeit of the cloth of the Israelites, which endured in the wilderness forty years. 'Satinisco,' 'Bombacino,' 'Italiano,' &c. A favourite must have a handsome name, which his prince may easily call on all occasions, so a pretty pleasing name complying with the buyer's fancy, much befriendeth a stuffe in the sale thereof."

Names of cloths are frequently derived from the places they were made at, such as damask, from Damascus, &c. According to an Act of Parliament, 5 Edward VI., relating to woollen cloth, it appears that twenty-three districts in England gave names to woollen cloths, and five to cotton, at that time.

The book before mentioned appears to have belonged to an Irish weaver, and is subscribed "Richard Walsh, his book of Ties, 1786." At that time it was customary for journeymen weavers to travel through the country to obtain experience before settling down, and it appears that Walsh left Dublin, then noted for its manufactures, and went to Manchester, Coventry, Oakington, and thence to London.

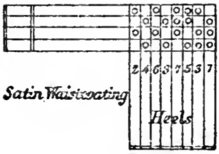
It commences with the following general rules or instructions, which are equally valuable at the present day, as they were when written. The spelling is retained.

"In the tieing up your mode let your breaking treadles be to your left foot. Your kane roll not higher than your breast roll. Your harniss tied up near the bottom of the eye of the lish, one shed not larger than another. Your batrons hung pretty well over your head. Beware of hang shoots. A horse-hair bow in your shuttle would be a great means to prevent them. Beware of tight shoots, tight threads and shades. Let your breaking treadles be two inches lower than your tabby. Let it be wrought slack and spurted slightly to make it cover well. Let the breaker's heels be under your foot rail, and the tabby heels under the porry thus:"



The use of the breaker treadles, &c., are explained in Chapters vi. and xxxvi. The letters *rr* in the sketch mean "riser" headles.

The following example of a tie-up for weaving satin waistcoating is



taken from the book, the figures showing the order of working the treadles.

However, poor Walsh when in London appears to have met with very bad times, and was so much reduced as to have to dispose of his best clothes, which form a contrast to a weaver's dress of the present day. They are described in his book as follows:—"Blue coat, florentine waistcoat, velveteen breeches, striped silk and cotton waistcoat, and a pair of silk and cotton stockings." He expresses his sorrow at ever having left his native place, Dublin, and concludes with "A devout Prayer."

In 1801, a small work, perhaps the first one ever printed in England, actually relating to the practice of weaving, was published at Manchester, under the title of "A Guide to Universal Manufacture; or the Web Analyzed," by John Butterworth. A second edition was published in 1825.

The object of the work is to show how to copy designs from sample, and the instructions given are as follows:—

"Taking up your patch, unravel the shoots or pickovers till you have gained about ¼ or ⅛ of an inch at least of the warp, this will enable you the better to discover the floats when you separate the shoots with your needle. Then proceed separating a shoot and carefully observe by means of your microscope which ends it floats *under* and which *over*, for the float being regular, you may easily discern how many ends are required to make up the draught.

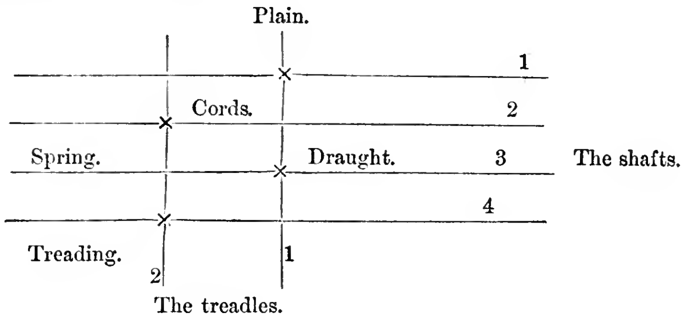
"Next with the point of your separating needle dipped in ink make a dot or mark at that end which you judge to be the first end in your draught, and another dot or mark at the end which you make or suppose to be the last. Observe, however, always to begin to put down your floats at that shoot which passes under or floats under the ends which you fix upon for the first in your draught—because the treading part in goods with plain backs should begin with a plain shed, and in Genoa backs with a Genoa shed; but this observation is needless to those who are weavers themselves. In order to illustrate the method of forming a draught from the patch, take this first example of plain goods:—

"I observe by the microscope when I draw out a shoot in this kind of goods, that the said shoot or pickover floats under the first and third ends of those four ends which (I dotted out as before directed) form the length of the draught; therefore I put down or analyze this pickover thus:— $\frac{3\ \ 1}{4\ \ 2}$. Then I draw or separate the next shoot, and find it floats under the second and fourth ends, and over the first and third, therefore I analyze this pickover $\frac{4\ \ 2}{3\ \ 1}$.

"I then separate the next shoot with my needle, and I find it is the same in respect of the floating as the first shoot, so I conclude there are but two shoots or pickovers in this kind of goods, and when analyzed they stand thus:—

2nd pickover.	1st pickover.	Floats.
4 2	3 1	Under.
3 1	4 2	Over.

"Now, as there are but two pickover shoots, I conclude immediately it must be wove with two treadles and four shafts, because four ends form the draught—so I write down the draught, and by observing the general rule laid down at the beginning, I find the first and third ends must be raised by spring cords: I represent these spring cords, therefore, on the shafts by crosses thus × × . Likewise in the second shoot the second and fourth are to be raised, and the first and third pulled down by means of long cords; as likewise the second and fourth in the first pickover; therefore I lay down the draught as here shown.



"But the generality of weavers couple the first and third healds or shafts, and so are enabled to weave it with only two lams."

An elaborate treatise on the same subject has recently been published in the United States, under the title of "The Theory and Practice of Designing Fancy Cotton and Woollen Cloths from Sample." By F. T. Ashton, of West Pittsfield, Mass.: 1874.

The following extract explains the principle treated upon, and as practised at the present time.

"When a draft is required, examine the cloth to see if there is any nap on the back of it; if there is, it should be burned off by means of a lighted match, care being taken not to burn the thread. If the sample should be a cotton pattern, a magnifying glass must be used. Next remove as many of the filling threads as will leave about one-eight of an inch of fringe. If there are any double and twist threads in the warp or filling, always commence with them. Remove as many of the warp threads as of the filling. When raising the threads be careful not to split those of the warp. Now having the sample prepared, take it in the left hand between the fore-finger and thumb, holding it so that the second finger may secure the threads as they are picked out.

"Commence at the right hand side of the sample; note down on the designing paper all the threads on the filling, and call them so many threads *on*; and all the threads under the filling, call them so many threads *off*. Leave as many blank checks as there are threads under the filling. Continue to work thus, until the pattern repeats itself in both warp and filling, and the draft is complete.

"Sometimes, however, there are repeats in samples: these can be found by taking out two threads more than the pattern so called; and if both repeat, then the pattern is correct; but if only one repeats, trace the draft until both warp and filling repeat.

"The next thing is to reduce the draft. At this point, do not forget that it is the filling that has been picked out; therefore after the draft is complete turn it round one square from right to left, and let the reduction begin at those lines representing the warp. This will be better understood by a reference to diagram 1st and 2nd. This is a fine stripe and is got out of twelve bars or threads in the warp, and four in the filling; the warp is eight of black and four of white, the filling is pick and pick, black and white. The draft is reduced to its lowest term, four harnesses: the first eight threads are reduced to two harnesses, the ninth is called three; the tenth four; the eleventh, three; and the twelfth, four.

"Sometimes harnesses are brought forward, and again they are carried back. Strict care must be taken that the threads are drawn into the headles as indicated in each harness, otherwise the work will be a failure.

"The next thing is to make the chain draft for the loom. To do this, bring down the line of dots called one, just as they are, then that called two, then three, then four, and the chain is formed to weave the pattern.

Diagram 1.

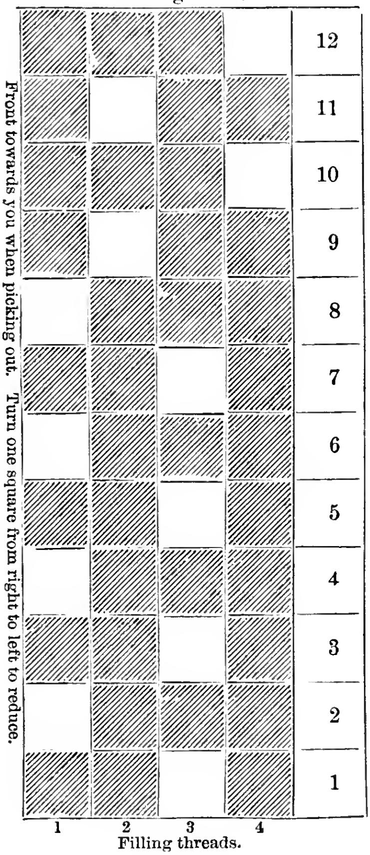
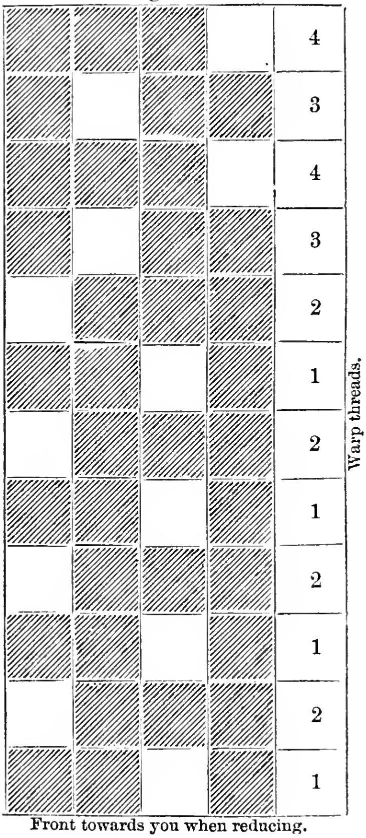


Diagram 2.



"The reader must understand in studying these drafts that no attention has been given to that part of the cloth known as the selvage or listing, as every designer consults his own taste in these things."

When the Jacquard machine began to be adopted, it became necessary to provide some ready means whereby the design could be transferred from the design paper to the cards. If machines of not more than 300 needles are used, such as are employed in the stuff manufacture, the punches in the steel perforated plates, between which the blank cards are placed, are usually arranged by hand without the assistance of a reading-in machine. But for machines with a greater number of needles and greater lengths of design it becomes necessary to adopt some other means.

Various machines have been introduced for arranging the punches, principally by means of keys placed in a key-board similar to the manuals of an organ. Electro-magnets have also been applied to operate on the punches. But the plan most generally used in the silk manufacture is a machine called a "Reginier." When Mr. Stephen Wilson introduced the Jacquard machine into England, he shortly afterwards (1821) obtained a patent for a machine on this principle which he claims as his invention.

The plan adopted by Mr. Wilson is shown in Fig. 363, which is copied from his specification and is the system still used. It is based upon exactly the same plan as designing from sample; for the pattern or design is first woven and afterwards unravelled, as will presently be seen.

A series of endless cords *a a* are passed over drums or cylinders *b c f*, Fig. 363, having rings and weights attached to give tension to them, as shown *o h*. The weighted cords pass through a guide board to keep them in position, as shown at *p*.

A cross or lease is made at *d*, to keep the cords in order, and at this place the design paper is fixed in front of the "reader-in." For each line of the design paper a short length of stiff cord is threaded through the endless cords *a*, at the place *e*, which is about level with the hands of the reader-in. As the intersecting of the cords proceeds the work is drawn downwards until it passes beneath the drum *f*.

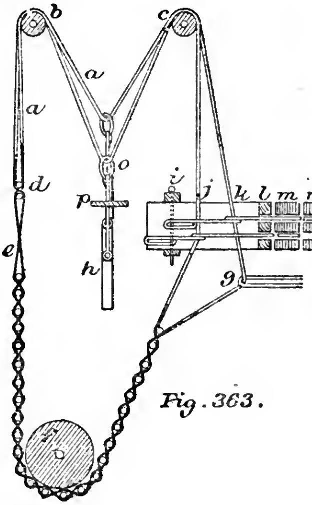


Fig. 363.

At *i j k l* a box containing needles, similar to the needles in a Jacquard machine, is placed, although in this case only two needles are shown. At *n* the steel plates between which the blank cards are to be punched are placed; and at *m* is a punch receiver, to hold the punches, so that those which are required can be pushed forward into the plates *n*.

Now the operation is first to "read in" the pattern at *e*, and as it is proceeded with it is drawn under the cylinder. The cords that have been intersected at *e*, are then drawn forwards, as shown at *g*, and a stick inserted, so as to enable the operator to project the needles and force those punches that are required, out of the plate m into the plates n, the whole of the punches having been first inserted in the plates m. A blank card is then introduced between the pair of plates n, and placed either under a fly stamping-press or passed between rollers, when the card is perforated in accordance with the pattern.

It will be evident that two persons can be engaged at the machine at one time—one to read-in or insert the cords, and the other to draw them out and attend to the punching. Or the reader-in may be assisted by one to insert the lease cords whilst he calls out the places, as by saying "pass four take one, pass six take three," &c., &c. By this means patterns may be transferred with great rapidity, and in so doing any mistake being made is to a certain extent observable in time to rectify, which would not be the case in some other systems.

After the pattern has been completed, the cards, having been numbered first, are strung together in the manner already described, and in case other sets are required of the same pattern, they are produced by means of a "repeating" machine. These machines are constructed on various principles, the oldest being a modification of the apparatus above described, in which the cards to be repeated are placed upon the cylinder of a Jacquard machine attached to the apparatus, and the punches are selected by their means. A blank card is then punched, or any number desired, when all the punches are replaced and a fresh selection made.

Machines have been introduced more recently, by means of which the operation is much simplified, and far more effectual. Messrs. Nuttall's machine, constructed by Messrs. Weild and Co., of Manchester, is a fair example. In this machine the cards to be perforated are placed between the plates at *A*, Fig. 364. The punches, two only of which are shown at *D D*, fall by their own weight downwards. At *B* are the ends of a number of needles indirectly connected to a Jacquard cylinder, upon which is placed the cards to be re-cut, but not necessary to show here. At the end of each needle a flat plate is attached, as shown in plan at *C*, and these plates can be pushed over the heads of each of the punches, as seen in the step-like arrangement in the section.

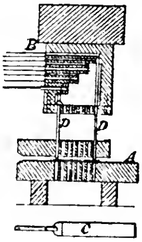


Fig. 364.

The card to be re-cut is made to push forward the needles at *B*, so as to place the plates over the heads of the punches that are to be brought into action, and a blank card is then placed between the plates at *A*. Now upon raising these plates by a treadle or a cam, either by hand or power, it follows that the punches will be raised also, excepting those which are prevented from rising through having the blocking plates *c* placed above them, and by this means the card is perforated. Thus a set of cards may be rapidly re-cut without transferring the steel plates at each operation to a separate punching press, as in the old method.

The following account of perhaps the largest set of cards ever employed in the Jacquard loom may be of interest. They were designed and cut to weave a fine damask table-cloth, known as the "Crimean Hero Table-cloth," which was produced at Dunfermline about twenty years ago.

"The designing and executing of the work occupied about eight months, and occasioned an outlay of nearly 600*l*. The cloth was inspected and greatly admired by the Queen and Prince Albert, also by the Emperor and Empress of the French, and orders were given for the imperial as well as royal tables.

"The cloth is composed of the finest linen warp, and white silk weft, six and a half yards in length and three in breadth; but when woven for sale it would consist of linen only. The pattern consists of a beautifully elaborate leafy scroll-work for border, in which at proper intervals are inserted twenty-four faithful portraits. In one border are her Majesty Queen Victoria in the centre, and on either side the Prince Consort and the Duke of Cambridge. In the other end border are the Emperor Napoleon in the centre, and on either side the Empress Eugenie and Prince Napoleon. In the centre of one of the side borders is placed the King of Sardinia, and on either side Bosquet, Brown, F. Nightingale, La Marmora, St. Arnaud, Cardigan, Raglan, and Bruat. In the other side border, the Sultan in the centre, with Omer Pasha, Williams, Canrobert, Evans, Campbell, Pelissier, Lyons, and Simpson on either side. Each portrait of the sovereigns is surmounted with their respective armorial bearings, placed towards the middle of the cloth; and alternately with these are trophies containing the names of the chief battles with their dates, and in the centre of the cloth there are magnificent trophies illustrative of the fall of Sebastopol, with the motto *Deus proteget justitiam*, and the date 8th September, 1855—the ground around all of these being interspersed with the stars and orders of the different sovereigns, &c. &c.

"An idea may be formed of the extent of the design when it is mentioned that there were 50,000 cards and seven 600 cord Jacquard machines employed in forming the pattern on each loom.

"These machines required to be kept in operation at the same instant, and the whole was put in motion by a single movement of the foot.

"The web was 1600 threes in the reed, equal to 4800 threads per yard, or a total number of 14,400 in the breadth of the cloth."

It was manufactured at the Bothwell Factory, by Messrs. Dewar, and designed by Mr. Balfour.

Although the fitness of cloth of various kinds to withstand the maximum of wear, does not appear at the present time to be considered of such importance as it was formerly, it will be requisite to show that it far more depends upon the method of weaving than is generally supposed. All plain woven materials are expected to withstand more or less wear and not to be woven so hard as to cut, on the one extreme, or to be flimsy and weak on the other. The best materials may be spoiled by the inattention of the manufacturer to observe a proper combination of the weft and warp. As this subject was investigated in a scientific manner by a competent man, duly authorized for the purpose, and at a time when the quality of cloth was perhaps more appreciated than at present, it will be better to follow his report, and give his conlusions in his own words. By doing so the principles of plain weaving will be more thoroughly and satisfactorily shown.

At the commencement of the last century great interest was taken in the linen manufacture of Ireland, which country at that time particularly excelled in that branch of manufactures. Spinning was then performed by hand only, consequently it was not possible to obtain any great quantity of yarn or thread of a definite size or thickness. Now it will be evident that with various sizes of yarn, equality in the cloth could not be expected, and it required great experience on the part of the manufacturer to regulate the warp and weft, to produce the best result from unequal materials. At the present time the thread can be produced of the exact size required, and the difficulty is now overcome, but the quality of the cloth still depends upon certain relative proportions of warp and weft.

It was owing to this uncertainty in regulating the weaving that the quality of the cloth was liable to be seriously affected, simply from want of an exact knowledge of the proportion required. Those manufacturers who succeeded best, could, with the same quality of materials produce far better cloth, simply because of their superior knowledge of these proportions. Other manufacturers suffered in consequence of their ignorance—for however well they might be able to weave, they could not produce cloth of a satisfactory kind without knowing the proper proportions.

At that time there was a Board for the Improvement of the Linen Manufacture, and Mr. Joseph Beaumont, a London merchant, was authorized to proceed to Ireland, and ascertain the principle upon which the weaving of linen cloth depended, so that he might be able to reduce the subject to a simple mathematical formula, and thus relieve the linen manufacture from further uncertainty. The result of Mr. Beaumont's investigations were published by order of the House of Commons in 1712, and a second edition was published in 1754. The work is entitled "Mathematical Sleaing Tables, or the Great and only Mystery of Weaving Linen Cloth explained."

The following extracts from this scarce and excellent work will be read with interest, especially as the rules laid down respecting the principles upon which sound cloth depends being still the same, it will be gratifying to know the result of Mr. Beaumont's inquiries.

"The scheme," observes Mr. Beaumont, "I have drawn in the following papers for the improvement of the linen manufacture in one of its most important articles (the true weaving of cloth) cost me much pains, time, and expense before I discovered it to four or five friends skilled in the mathematicks or weaving trade."

"I was assured by Mr. Crommelin and his brothers, that they could never fix upon a certain rule further than private observations drawn from practice, in about twelve sorts of cloth, which cost Mr. C. about four years thought," &c.

"My business was to have a piece of cloth which the best weavers would allow, by comparing it with other pieces, to be wrought to an exact perfection. I then numbered the threads in the breadth of that piece, weighed the cloth, and having fixed on this foot allowed by Mr. Crommelin, and some others of the most skilful artists, I thought there might be a way found out by mathematical proportions to give certain rules for making all sorts of cloth to the same exactness with that piece from whence I took my first foundation, upon which I calculated the tables now printed."

These were certified to be correct, as follows:—

"Being informed that Mr. Crommelin, who has advanced the linen manufacture to the perfection 'tis now come to, proceeds upon this as a certain rule—that a standard hank of yarn, weighing four ounces, must and ought to be woven in a reed of thirteen hundred and a half, to make a true exact square cloth, yard wide. Taking this for granted, I certify that Mr. Joseph Beaumont hath demonstrably calculated the diameters of all yarn, the weight and length being known, whereby is adjusted the reed to the yarn, as appears by his mathematical table which I have examined.

"*June 8th*, 1710. CHARLES CONNOR."

Mr. Beaumont proceeds with these observations:—

"If there be too few threads in the warp or breadth it will be a fleazy, weak, unserviceable cloth, and if there be too many it will be stubborn and fret in the weaving, and look coarser than really it is."

"It is great odds against the weaver that he miscarries (without the use of tables) the consequence of which is either he must make bad cloth, or else be at great loss of time and pains to fix and mount another set of yarns and reeds, which must cause great waste of yarn."

Many objections were made to the tables by the weavers, which were answered; one was:—

"Take a pound of flax that grew in a rich soil, and spin it to a certain length; then take a pound of flax that grew in a poor and hungry soil, spin it to the same length, the rich flax shall look finer than the poor flax, yet weigh the same."

"This objection was urged with great confidence as matter of fact, though the objectors could not prove it by any single experiment they had made; and since the many experiments I have made incline me to believe the contrary, I hope I may with equal modesty and more reason deny what they affirm.

"The objectors know nothing of the specifick gravity of vegetables, though they borrow the objections from thence, for they would say a vegetable would increase in the specific gravity, if it be removed to a richer soil, which is false, for that never changes or alters, though the soil be changed several times, &c.

"Granting an inconsiderable difference of specific gravity may arise from different soils, yet considering the many purging operations flax and yarn go through before it is brought to the loom, that difference will be still lessened, &c. And since it is well known that the fourth part of the weight of all yarn is purged and dried up in the bleaching before it is warped, to which I might add as much in the flax before it is spun, I may conclude that the solid parts only remain unaltered and of the one universal natural specifick gravity proper to that plant."

"There are but four ways that I know to judge of good linen cloth; first the colour, secondly to see that the weft or cross threads be but very little finer than the warp or long threads; thirdly that the threads look square and no longer one way than another, and lastly the weight of the cloth according to the set or reed it was woven in."

"I will assure the buyer if he cannot discern the threads to look one way longer than the other, nor the weft to be finer than the warp, that the weight according to the tables will never deceive him, but he will find the cloth to be right good and truly made, and will answer all other ways of trial that may be thought of.

"All yarn by Act of Parliament is to be reeled into hanks or dozens, each hank to contain 3600 yards and no more.

"It is found by many experiments that such a hank weighing four ounces must be wrought in a thirteen hundred and a half reed, that is to say two thousand seven hundred of those threads must be in a cloth, yard broad, made of that yarn.

"All reeds that are used according to the tables are to be one tenth part wider than you design your cloth—that is to say you must allow 40 inches of chain or warp for every yard of cloth because the tenth part will shrink up in the weaving and whitening.

"Take this for a constant rule, that two dozen and a half of true counted yarn will make warp and weft 20 yards long for one hundred in the reed at any pitch whatever.

"The weaver must not be over thirsty in saving his yarn, because he will infallibly find upon experience that where he saves one pennyworth of yarn in a yard of cloth his cloth will be three pence a yard the worse. A sleazy cloth is not only worse on the account of its sleaziness, but appears always coarser in proportion—and will yield a worse price in the market, &c., &c.

"I have been more particular in this matter because I know ninety-nine weavers in a hundred are of quite a contrary opinion, and believe the thinner and lighter a cloth is wove, the finer it will look.

"The weaver must be sure to take care his weft be never above half a hundred, or one set finer than his warp, for he will find by a just computation that he saves nothing by it.

"If the warp be too light, and thinking to mend it by driving in more weft, he will be mistaken, for it will look like cat's-teeth all across the cloth.

"Again, if the warp be too heavy, or he be too lazy to drive in equal weft, then the cat's-teeth will be all along the length of the cloth.

"In both ways the cloth is spoiled and not worth half the money it might be sold for was it truly wrought, because the short thread will not wear, and cut the long, and, therefore, will not last half the time it would do was it made a true and square cloth."

The application of tables and calculations for assisting the weaver has since Mr. Beaumont's time been carried to a great extent. In one work on weaving nearly a hundred pages are devoted to the subject and the author makes ample use of logarithms, thereby rendering the subject still more perplexing to the weaver.

It occurred to Mr. Bennet Woodcroft (late Head of the Patent Office) that the rules laid down by Mr. Beaumont might be carried out and practically shown by means of a machine, if made capable of the required adjustments. Mr. Woodcroft therefore constructed a model for that purpose, and we believe he succeeded in carrying out the plan satisfactorily, although he has not made it public.

In a "Letter from Sir Richard Cox to Thomas Prior, Esq.," printed in Dublin, 1749, an interesting account is given of the establishment of the linen manufacture in the parish of Fanlobbus, in which the towns of Kinsale and Bandonbridge are situated. Sir Richard's grandfather established an English Colony at the last-named places in Queen Anne's reign, and it was for the general benefit of the neighbourhood that his attempt to introduce the linen manufacture was undertaken.

After finding that flax could be grown, he at once commenced business, and to quicken matters he published a list of premiums, to continue for seven years, for those who should produce the greatest quantities of flax, spin the most, weave the most, and sell and buy the most cloth, &c., the prizes ranging from 50*l.* to 1*s.*

The master weaver's house was rent free as part of his premium, and in front of it was placed a board, on which was painted in gold capital letters:—

"DATUR DIGNIORI."

"This house is rent-free for the superior industry of the possessor."

This board was called the Table of Honour, and every year when the premiums were given for weaving, the board was removed, "and carried with all solemnity, attended by music and colours flying, and all other marks of respect, and placed by the whole body of the town over the weaver's door; there to remain till the next year, to signify his merit to every passenger," &c.

A good deal of difficulty appears to have arisen respecting the rate of wages and other matters of a similar character, but this was got over by the election of a board of master weavers, who decided all matters in dispute. The quantity of cloth woven in 1746 was 11,174 yards, valued at 676*l.* 16*s.* 2*d.*, and in 1748, 19,181 yards, valued at 1278*l.* 4*s.* 8*d.*, showing a considerable improvement.

In the first year, May, 1747, John Wallis got the premium, 5*l.*, having woven 2360 yards, valued at 145*l.* 18*s.* 8*d.*

In 1748 William Curry obtained it by weaving 3,830 yards, valued at 181*l.* 9*s.* 1½*d.* In May, 1749, William Curry again obtained the premium by weaving 6290 yards, valued at 342*l.* 2*s.* 3½*d.*

In May, 1747, there were in the town (Bandonbridge) 87 houses and 557 inhabitants. In 1749 there were 117 houses and 807 inhabitants.

In former times it was customary to couple the term "mystery" to certain trades, thus the weaver would rejoice in the name of his calling as the "Art and Mystery of Weaving." That the mysterious part of the craft was not wanting will be seen in the way their calculations were made; for the basis upon which they are constructed seems to have been purposely framed to perplex the uninitiated.

Mr. Beaumont, already referred to, alludes to this subject, but after the time he wrote a small treatise was published in Dublin, in the year 1757, called "An Inquiry into the State and Progress of the Linen Manufacture of Ireland," in which the following observations are made:—"And the principal obstacles that appear to me at present to impede the progress of the Linen Manufacture in most branches are the want of a sufficient quantity of flax of our own growth, *and making the pretended mystery of a weaver a less penetrable secret.*" That there was some ground for this complaint the following table of measurement for linen yarn will show:—

120 threads	=	1 cut	=	300	yards.
2 cuts	=	1 heer	=	600	,,
3 heers	=	1 slip	=	1,800	,,
2 slips	=	1 hank	=	3,600	,,
2 hanks	=	1 hesp	=	7,200	,,
2 hesps	=	1 spyndle	=	14,400	,,

The reed for weaving the same is measured in an equally complex manner, for the unit of length is 37 inches, and according to the number of hundreds of dents, or splits, it contains, so is the reed called. For instance, a "fourteen-hundred reed" means that 37 inches of a reed of that number, no matter what length, contains 1400 dents, or about 38 per inch. It must not be called a 38 dent reed, for that would perhaps be too simple. Still the plan of counting a reed according to the number of dents per inch is now adopted in many places, as in the "Stockport count."

In the silk trade another plan is adopted. If a weaver is asked what is the fineness of his work, he may say "a twelve-hundred eight-threads." That specifies the number of threads, but not the number per inch. He must therefore explain the length of the reed, and if it be 24 inches long, then a "twelve-hundred-eight-threads" means 1200 dents with 8 threads in each dent, or in other words his work contains 400 threads per inch. But if his reed be only 16 inches wide, then his work will contain 600 threads per inch, and still be a "twelve-hundred-eight-threads." In this system there is some show of reason for its adoption. In the first place both the warper and the weaver are told the full number of threads the work contains, and the number of threads to be entered in each split of the reed. The manufacturer can then decide as to the width of the reed and consequently the quality of the work.

As a guide to the manufacturer in any of the textile arts, it is necessary that some fixed data should be given, so that the relative weight and length of the threads used can be ascertained, for upon the fineness of the yarn the cost and quality of the cloth greatly depends.

Therefore all calculations requisite for ascertaining the cost of a fabric depends in the first instance upon the length and weight of the material used, and for that purpose arbitrary numbers are given to yarns according to the length contained in one pound or other given weight.

When only a small sample is available, and the value or cost price of the materials of which it is composed is known, a ready approximation of its value may be obtained by weighing a square inch of the cloth. For instance, if a square inch weighs 13 grains, a square yard of the same cloth will weigh 38½ ounces. The following table shows the proportionate weight from 1 grain per inch to 16 grains, and the corresponding weight of cloth 36 × 36 inches.

Grains.		Ounces.	Grains.		Ounces.	Grains.		Ounces.	Grains.		Ounces.
1	=	$2\frac{19}{20}$	5	=	$14\frac{16}{20}$	9	=	$26\frac{13}{20}$	13	=	$38\frac{10}{20}$
2	=	$5\frac{18}{20}$	6	=	$17\frac{15}{20}$	10	=	$29\frac{13}{20}$	14	=	$41\frac{9}{20}$
3	=	$8\frac{18}{20}$	7	=	$20\frac{15}{20}$	11	=	$32\frac{12}{20}$	15	=	$44\frac{9}{20}$
4	=	$11\frac{17}{20}$	8	=	$23\frac{14}{20}$	12	=	$35\frac{11}{20}$	16	=	$47\frac{8}{20}$

Cotton yarns are numbered according to their fineness, which is estimated at the number of hanks that go to a lb. A hank contains 840 yards, therefore a No. 40 yarn would contain $840 \times 40 = 33{,}600$ yards to a lb.

COTTON TABLE.

1 Circumference of reel	= $1\frac{1}{2}$ yards	=	1 thread	
80 Threads	= 1 skein	=	120 yards	
7 Skeins	= 1 hank	=	840	,,
18 Hanks	= 1 spyndle	=	15,120	,,

JUTE TABLE.

90 Inches	= 1 thread	=	$2\frac{1}{2}$ yards	
120 Threads	= 1 cut	=	300	,,
2 Cuts	= 1 heer	=	600	,,
6 Heers	= 1 hasp	=	3,600	,,
4 Hasps	= 1 spyndle	=	60,000	,,

Raw silk is estimated in fineness by measuring its hanks, containing 1000 yards, and naming it by the number of Deniers it weighs; and woollen yarns are weighed in lengths or "runs" of 1600 yards.

It will be evident that the calculations actually necessary for weaving purposes would be of a very simple nature if divested of useless complications.

The following is from Mr. White's work on the subject.

"The calculations connected with weaving are chiefly such as are connected with the cost of the goods or the quantity of yarn as necessary to make them without any reference to the cost.

"In estimating the cost of any description of cloth the quantity of yarn necessary to make it must be known as well as the price of it, and the price of the weaving. The quantity of yarn as necessary for any given piece of cloth is dependent on the length of the piece, the number of porters or beers in its length, and the number of shots in the glass. The calculations for cotton, linen, and woollen cloth, &c., are based on the length of the spyndle. Thus the cotton spyndle is 15,120 yards, and the linen 14,400. The length of the cotton spyndle is therefore to that of the linen as 21 to 20.

"Now as the piece or web in Scotland is measured in hand-loom work by the ell (which is five-fourths, or 45 inches) one round of the reel in calculations for linen warps will make exactly a splitful an ell long, a cut 6 porters, a heer 12, a hank 72, a hesp 144, and a spyndle 288. Hence the rule to find the number of spindles in a given length of linen warp is to multiply the ells by the porters and divide by 288.

"For example, how many spindles will it require to make a web 100 ells long, with 70 porters?

$$100 \times 70 = 7000 \div 288 = 24 \text{ spyndles, 1 hank, } 2\tfrac{2}{3} \text{ cuts.}$$

"If the yarn is given, to find the ells it will make with a given number of porters—multiply 288 by the spyndles, and divide by the porters.

"If the warp is to be calculated by the yard, 36 inches, instead of the ell, the number 360 must be substituted for 288, because 36 are to 45 as 288 to 360.

"And thus the last example if wrought accordingly will be as follows:—

$$100 \text{ ells} = 125 \text{ yards} \times 70 = 8750 \div 360 = 24 \text{ spyndles, 1 hank, } 2\tfrac{2}{3} \text{ cuts.}$$

"The rule for the calculation of cotton warps is the same as for linen, only that the divisor is different in consequence of the difference in the length of the spyndle. The cotton spyndle makes 302·4 porters an ell long, and the hank 16 porters and 16 splits, and, therefore, the divisor for cotton warps is 302·4. The fraction, however, may be thrown away as unnecessarily accurate for practice, and the more so if the remainder is divided by 20 for hanks instead of 16·8, which makes an allowance for it."

The annexed table shows the comparative sizes of the Scotch and English reeds. The Scotch reed is 37 inches wide, and the first column gives the total number of hundred dents it contains, and the second column the number of dents in the same per inch. The third column shows the number of beers in the Manchester and Bolton reed of $24\frac{1}{4}$ inches. The beer is 20 dents or splits. The fourth column is the Stockport count, showing the number of threads per inch, there being two to each split. Therefore the numbers in the fourth column give actually *double* the amount of dents that each inch of the reed contains. It will be noticed that the numbers given are the nearest numbers exclusive of small fractions.

Hundreds.	Splits in an Inch.	Manchester and Bolton.	Stockport.	Hundreds.	Splits in an Inch.	Manchester and Bolton.	Stockport.
5°°	13	16½	26	18°°	49	59	98
6°°	16	20	32	19°°	51	62½	102
7°°	19	23	38	20°°	54	65½	108
8°°	22	26	44	21°°	57	69	114
9°°	24	29½	48	22°°	60	72	120
10°°	27	33	54	23°°	62	75½	124
11°°	30	36	60	24°°	65	79	130
12°°	32	39½	64	25°°	68	82	136
13°°	35	42½	70	26°°	71	85½	142
14°°	38	46	76	27°°	74	89	148
15°°	41	49	82	28°°	76	92	152
16°°	43	52½	86	29°°	79	95	158
17°°	46	56	92	30°°	82	98½	164

A peculiar kind of reed may be here mentioned by means of which articles varying in width, as in weaving elastic stockings, can be woven in the common hand loom. The reed is made wedge-shaped, the upper part being much wider than the lower. It is also several times deeper than the common reed. Thus the bottom may be 4″ wide, the top 8″, and the depth 15″. It is fixed in a sliding frame, so that it may be gradually raised or lowered to any desired level to give the width required. By altering its position as the work proceeds, the shape of the article is regulated. It will be evident that proper selvages can be woven, and neat and strong seams be made in irregularly shaped articles.

CHAPTER XXXII.

THE LEVERS LACE FRAME, WITH DOUBLE-ACTION JACQUARD APPARATUS.

In the machinery department of the Exhibition, the manufacture of lace, although forming one of the special subjects of this year's (1874) display, is represented by one machine only, which has been contributed and worked by the Nottingham Chamber of Commerce.

The machine is known as a Levers machine, from the name of its inventor, and is provided with a double-action Jacquard apparatus for working the design or figure upon the lace. It is at present employed in weaving guipure, or narrow lace, of which sixty pieces, of about 2½ inches wide each, or a total width of 152 inches, are being woven at once. Of this width it is capable of weaving about one yard per hour, or a total length of sixty yards of narrow lace. The machine can be arranged to weave any desired width of lace, and even shawls may be produced by it. This is effected, not by the alteration of any of its mechanism, but in the production of the figure by the designer. For instance, the sixty pieces that are now being made are simply a repetition of the same figure, and by inserting a thread, called the "lacing thread," at the selvages or divisions of each figure, the whole of the pieces are connected together and form one piece only. By this means the entire piece when woven can be removed from the machine, and, after being dressed, the lacing threads are cut or drawn out, whereby the narrow pieces become separated, and are packed or wound upon cards, as may be desired. The lacing thread is not, therefore, inserted by any special contrivance, but is introduced by the designer making a special provision for it in the formation of his design, which will be hereafter described.

It will be evident that such a machine is capable of producing all the ordinary varieties of machine-made lace; and, as far as one machine can do, it fairly represents the present state of the lace manufacture of Nottingham.

The total length of the machine is thirty feet, and the height nine feet. It contains 2907 shuttles, or as they are technically called, "bobbins and carriages," and upwards of a hundred warp beams. The speed it is worked at varies from 110 to 120 picks per minute, which means that the shuttles are passed through the machine that number of times in each minute.

From its great size and the multiplicity of its parts, it forms one of the finest examples of mechanical skill ever concentrated in one machine. In it are accumulated the result of the labour of a hundred ingenious men, the history of whose fortunes and misfortunes is of strange interest. Many of them never reaped the benefit of their inventions, but passed their lives in misery and neglect, terminated in some instances by suicide. Others, more fortunate, reaped the full advantage of their skill, and arrived at opulence.

The history of the machine itself, and the various forms and modifications it has undergone before being brought to its present perfection, affords as remarkable an instance of gradual mechanical development as can be found. It does not represent the genius of one or a few men, but rather the experience derived from a thousand different inventions.

Lace has always been admired and used as a most refined and beautiful article of dress. When made by hand it is also by far the most costly of textile fabrics. At the same time, the implements used in its production are of the simplest kind, though in the variety, extent, or richness of design no limit could be fixed that could not be surpassed by their means. Considering, however, the cost of production, it need not be wondered at that men have often been desirous to supplant the tedious process of hand-work by substituting machines for that purpose. The high price which hand-made lace fetched offered an ever-increasing temptation to the ingenious mechanic to attempt its production by other means, and at last it was accomplished. Not that machinery can ever surpass or equal the finest description of hand-made lace, but it can produce very good imitations of it, which have often been substituted for it, and in some cases are superior to it.

There are two descriptions of lace, namely, point and pillow. Point lace is made with the needle, and is a much more ancient art than the making of pillow lace. Point, or needle-made lace is said to have been invented by the Italians at a very early period, and during the 16th and 17th centuries became of very general use in this country, as may be observed in the huge frills, collars, and ruffs worn in the time of Queen Elizabeth, Charles I., and Charles II.

On the other hand, pillow lace is of more recent date, and the history of its invention is known, for Beckmann, with evident satisfaction, says, "I will venture to assert that the knitting of lace is a German invention, first known about the middle of the 16th century; and I shall consider as true, until it be fully contradicted, the account given us, that this art was found out before the year 1561 at St. Annaberg, by Barbara, wife of Christopher Uttmann. This woman died in 1575, in the sixty-first year of her age." The statement does not appear to have ever been disproved, and it is recorded upon her tomb.

Uttmann was a master miner, and his wife, observing that the girls made caps for the miners, taught them to make them on this new plan. She afterwards set up a workshop at Annaberg for the making of lace of different patterns; and it is this description of lace, or pillow lace, with which we are now concerned. There are several varieties of it, such as Brussels, Alençon, Lisle, Honiton, &c., which differ according to the meshes, twistings, thick or thin threads, and other details, but not in the principle of the operation.

The production of pillow lace is effected simply by twisting together a number of threads in the order and combination necessary to produce the desired pattern. To do this, the design is first drawn upon a piece of parchment, and holes are made in the outline of the design for the insertion of pins. Round these pins the threads are twisted, so as to form meshes. Thick and thin threads can be combined, or three or more together. As the lace is made the pins are moved. In the process of knitting the operation is different, in order to form the fabric. Knitting, in its simple form, is effected by using one thread only, upon which a series of loops are made, and they are connected together by intersecting each other, as is well understood in the common process of knitting. Knitting and lacemaking are therefore widely different in their modes of production; but as nearly all the first attempts for the making of lace were tried upon modifications of the stocking-frame, they will be noticed in the description of that machine.

In the production of figured lace it is requisite that the threads should be arranged in such a manner that they can be twisted round each other any number of times, and in any quantity and arrangement. In bobbin net it is also requisite that the threads should be twisted round each other, and follow the arrangement necessary for the production of meshes of uniform size and order. Previous to Mr. Heathcoat's invention, the meshes were produced by loops or knotting, and not by twisting the threads round each other, as in the production of pillow lace or bobbin net. He was the first who arranged the threads one part in a warp and the other part upon bobbins. The bobbins were fixed in carriages, or thin shuttles, which were made to slide in grooves in a comb-bar. The comb-bar being divided for the warp to pass between, the shuttles, as they passed from one side of the comb-bar to the other, necessarily passed through or between the threads of the warp. Now, if the warp threads, being placed in regular order, were kept in that position, and the shuttles also were kept moving backwards and forwards through the warp or between the threads, then no work would be the result. But after passing the shuttle through the warp, as before stated, if a lateral movement were given to the comb-bar, so as to advance it one or more grooves to the right or left of its former position, then on the return of the shuttles through the warp to the other portion of the comb-bar, they would be deposited in different grooves from those they started from. Again, if this motion were repeated in certain order, the threads of the bobbins could not only be made to twist round the warp threads, but they would travel from thread to thread, and the threads of the fabric they had woven would present a diagonal appearance. This motion of the comb-bar is technically called "shogging," and by its means the diagonal arrangement, or "traverse," is given to the threads. By this plan a firmly-made fabric is produced, for if there were no traverse, then on the breakage of any of the threads the work would run or untwist. Mr. Heathcoat having thus solved the problem of forming regular meshes by twisting threads round each other, and then passing from thread to thread and repeating the operation in regular order, accomplished all that was required for the production of bobbin net. The advantages were so great that in all directions a fresh impetus was given for further improvement. Amongst the various inventions thus brought into existence was the invention of the machine known as Levers' machine, the specimen now exhibited being on that principle.

Mr. John Levers was originally a machine maker, or frame smith, of Sutton in Ashfield, but he removed to Nottingham, where he extended his business. The success of Mr. Heathcoat's invention had already given rise to a new one, which, as in many other instances, was simply reversing the process of working the machine. In Heathcoat's machine the bobbin and carriages travelled or traversed, and the warp remained stationary. But it occurred to Mr. John Brown, of New Radford, that by traversing the warp thread, instead of the bobbin thread, a better result might be obtained. This contrivance he patented in 1811. The result was that many of the artisans of Nottingham, seeing the success of Brown's traverse warp, and that he had not been interfered with by Mr. Heathcoat, had an idea that similar efforts might be carried on without incurring the penalties of legal obstruction. With this idea it is supposed that Levers also devoted his mechanical genius and skill to the subject. Mr. Felkin, in his "History of the Hosiery and Lace Manufactures," to which this account is much indebted, gives an interesting account of Levers' invention, from which the following particulars are taken:—

"In carrying out the invention Levers worked in a garret at the top of a building situated in a yard on the northern side of the Derby Road, Nottingham, and so quietly and secretly as not to be seen by any one, even of his own family. The carriage and bobbins, things which presented so much difficulty to Mr. Heathcoat, with some of the inside parts, had been made as thin as was requisite by a relative, Benjamin Thompson, an extraordinarily clever workman in metals. He was never permitted to see the machine in progress, but was the first, except its constructor, to witness its completion. Levers had no son, but two brothers and a nephew, John. All worked afterwards with him, and the nephew always stated that they saw the frame for the first time when it was ready to work. They found it to be eighteen inches in width, waiting for materials, and prepared to start, which it did without difficulty. The entire isolation of the inventor during this period was a remarkable fact. Levers had expended his available means in the lengthened experiments and necessary expenditure incurred during the years 1812-13.

"The house of John Stevenson and Skipworth, carrying on a lace business in Nottingham, was induced to furnish the funds required for producing more machines, upon what terms is now not known. Several were built, one of which was retained by Levers for experimenting upon. The others were worked in a shop, on their owners' premises, in St. James's Street. It is probable that the then exist-ing patent rights on the one hand, and the profits daily realized by Levers and his patrons on the other, were the reasons why no patent was obtained to secure what was new in his method; for it seems to have been the prevailing notion among the mechanicians of the time that a patent must be taken out for all the machine, and not, as might have been, for any parts or combinations only which were really new.

"In 1814 John Farmer, with another hand, worked one of these machines, fifty-four inches wide, each taking five-hour shifts, the machine working twenty hours a day. The production was four pieces of ten racks each weekly. The wages were 5*s.* per rack, *i. e.*, 5*l.* for each workman a week. Some of the bobbins, and all the carriages in the machines, were stamped out by B. Thompson, who employed a very similar process to that described in Mr. Heathcoat's specifications, to get the sides of the bobbins flat and true. Two half circles of very thin brass were placed within each bobbin, fitting exactly the inside; they were put on an arbour, passing through the centres, and were screwed together very tight, and heated until the arbour showed a bluish tint, from which, on gradually cooling, the inside half-circle plates were removed. The bobbins came out perfectly flat, and capable of turning without friction or accident in the carriages. This in Levers' machines, where often thirty carriages and bobbins must work together edgewise within the space of an inch in width, is evidently a matter of the first importance.

"Levers left Stevenson and Co., but for what reason the connexion was broken is not known. In 1817 he worked in a shop in the higher part of St. James's Street, and it was at this time that he altered the arrangement of his frames. They were at first made to work in a horizontal position, but he now made them to work in a vertical one, as at present in use. In 1821 Levers went to France, and set up his machines at Rouen, and there died. Levers is said to have been a friendly, kind-hearted man, and a great politician. He was fond of company, music, and song, and was bandmaster of the local militia. He sometimes worked day and night if a mechanical idea or contrivance struck him, and would then quit all labour for days of enjoyment with chosen boon companions. He was frequently heard to say that the machine he had constructed was only in its infancy, because of the great facilities it afforded for alterations and improvement."

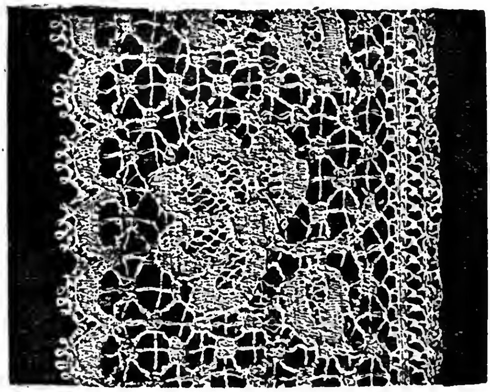
His opinion has certainly been verified, for since the successful application of Jacquard apparatus to it, the power it possesses for the production of figured lace is almost without limit. To adapt the Jacquard machinery to lace machinery proved a long and tedious task, and many years were passed before it was successfully accomplished. The difficulty arose from the circumstance that a widely different requirement was exacted from the Jacquard when applied to the lace machine from that used in the common hand loom, for which it was originally intended. When used in the hand loom, the operation of the cards upon the needles is simply to throw those hooks out of contact with the griffe which are not required to be raised. Thus only those threads of the warp are raised for the passage of the shuttle that are necessary for the formation of the design or pattern. It matters little whether the hooks are raised two or three inches in height, so long as the shed is high enough for the shuttle; in the lace frame this is quite another matter. Not only do the perforations in the cards select the particular threads to be moved, but they also regulate the exact distances they are required to move. These distances are so small, that the most exact working of the parts is absolutely requisite to insure the formation of the pattern.

In the frame shown there are, as before stated, nineteen shuttles working freely in the space of one inch. Now, to produce the figure it is requisite to be able to draw any of the warp threads in such a position that the shuttle, as arranged by the designer, shall pass at the side of any particular thread, and the position must be very correct to accomplish this. Sometimes the thread is drawn only one space, in other cases they are drawn twenty spaces and upwards. These spaces being only 1-19th of an inch from centre to centre, and in some machines only 1-30th of an inch, it follows that to stop exactly at the proper place the mechanical arrangement for that purpose must not only be true, but made upon a principle that will stand the wear and tear of rapid and hard usage. It was also necessary that the Jacquard should be able to work at a speed not only equal to that of the lace frame, but to do its work easily at whatever speed was required. These conditions are admirably supplied in the Jacquard apparatus connected to the lace frame, the principle of which will be hereafter described.

The importance of the Jacquard in conjunction with the lace frame cannot be overrated, and it is questionable whether the modification now shown is not the most valuable and ingenious part of the machine.

Lace-making consists in twisting any desired number of threads round each other in such a manner as to form meshes, or, according to the famous definition given by Dr. Johnson, it is "Anything reticulated or decussated at equal distances, with interstices between the intersections." The threads may be twisted either two, three, or more together, or thick and thin threads may be so combined. For the formation of any desired pattern, or figure, it is requisite that any one, or more, of the threads may be twisted round any one, or more, of the adjoining threads. It is not necessary that the threads should be able to pass completely from

Fig. 1.



side to side of the lace and then be made to twist round the most distant threads, but so long as they can be moved a moderate distance, with perfect freedom, to be twisted together with one or more of the neghbouring threads, that is all that is required, so far, for making ordinary lace.

Before the invention of the bobbin and carriage, by Mr. Heathcoat, a very similar process was, to a slight extent, effected in the common hand loom in the weaving of gauzes and whip nets. In weaving gauzes the adjoining threads of the warp were twisted half round each other, and, by repeating the process backwards and forwards, a gauze mesh, or intersection, was formed. In this case the weft thread held the twisted warp threads in their proper position. But the process was very limited in extent, and it required a great amount of tedious labour even for the production of small designs. One shuttle only was requisite for gauze weaving, the warp threads alone being moved to form the twist.

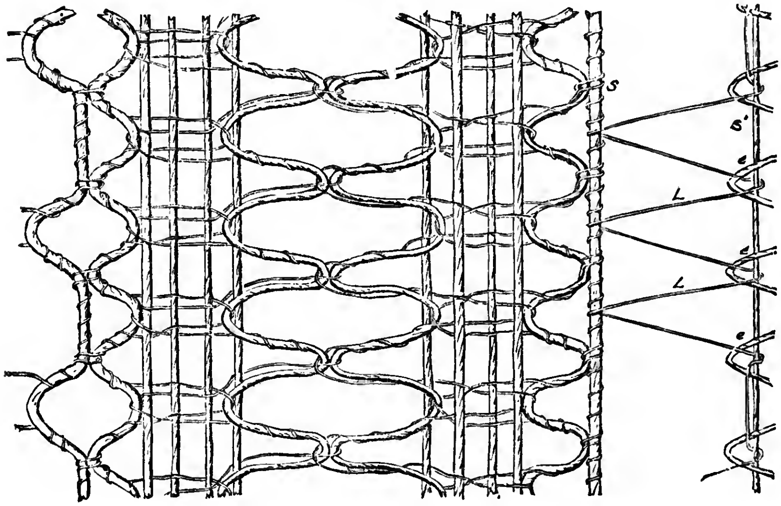
Fig. 1 represents a portion of the guipure or narrow lace made in the Exhibition, and is of the same size as the lace. As before mentioned, sixty of these pieces are made at once, forming a total width of 152 inches. It will be noticed that the figure merely represents a sufficient length to give the whole of the pattern, so that a fair idea of the lace may be formed. In the production of the sixty pieces the pattern is merely repeated sixty times in the arrangement of the frame or loom, all the sixty pieces being governed by one apparatus. They are woven in a vertical position, or, as shown, in the position of the figure. In the production of each of the sixty pieces, forty-eight bobbins and carriages, or shuttles, and 100 beam or warp-threads are required, or a total number of 148 threads for each piece.

Fig. 2 represents a portion of the right hand or plain border of the lace, as it would appear when magnified, and shows about half an inch in length of the actual selvage of the lace, which may be seen by comparing the looped meshes of the two figures. In Fig. 2 the extreme thread of the lace is shown at *s*, and the thread *L, L* is the temporary, or lacing thread, which connects the selvage to the opposite selvage of the adjoining piece of lace; in short, the loops *e, e, e* are the loops which appear at the edge of the curved border of the lace, as may be observed in the left hand selvage in Fig. 1. The lacing thread is connected to a thread placed vertically, *s′*, as shown in the back of the loops in Fig. 2, consequently, the whole of the sixty pieces are held together in this manner. These threads are not removed until the whole width of the lace has been made perfect and dressed; when they are "drawn" or cut, and the pieces of lace become separated. In Fig. 2 the looped or curved selvage appears straight, the loops being in a right line above each other; but in Fig. 1 the same loops are no longer in a right line, but form the curved line as shown. This arises from the circumstance that Fig. 2 shows the border as the lace would appear in the process of weaving, when the necessary tension was operating upon the threads. When the lace is removed from the loom the tension no longer exists, and the twisted threads assume the form intended by the designer of the pattern or figure.

If the threads in Fig. 2 be examined, they will appear to consist of three descriptions, viz. 1st, vertical threads, which retain one position only; 2nd, threads which form half-loops or zigzags; and 3rd, threads which are twisted round the others, in order to bind them together. The latter threads are those that have been inserted by the shuttles or bobbins and carriages.

Now, although it would seem that three different kinds of threads composed the design shown in Fig. 2, still there are really but two descriptions, viz., the warp and the weft. The warp threads are shown much thicker in proportion to the weft threads than actually used in the production of the lace, but this has been done in order to represent the manner in which the threads are twisted more dis-

FIG: 2.



tinctly. It will be found that the threads running in a looped or zigzag direction are merely vertical threads that have been drawn from side to side according to the arrangement intended by the designer. This is effected by varying the degree of tension upon the threads, and to accomplish this for the production of complicated designs, or figures, requires consummate skill and labour on the part of the designer. His design must not only show the work to be performed by each of the threads in all their various twistings, but the different degrees of tension must also be shown. When the design is made, it is then transferred to the "drafting" paper, which gives the extent of motion of each of the warp threads laterally. From this draft the Jacquard cards are perforated to correspond. To produce the pattern or design, $1\frac{1}{2}''$ long, shown in Fig. 1, requires 160 Jacquard cards, each 30 inches long by $2\frac{1}{8}$ inches wide. Before these cards could be punched for the production of the small figures or flowers, with the borders annexed, the design and draft have to be completed, and the amount of labour necessary, even for so small a figure, can scarcely be realized. But to give some idea of it, a copy is given in Figs. 3 and 4 of a portion of the actual design and draft that were used for the formation of

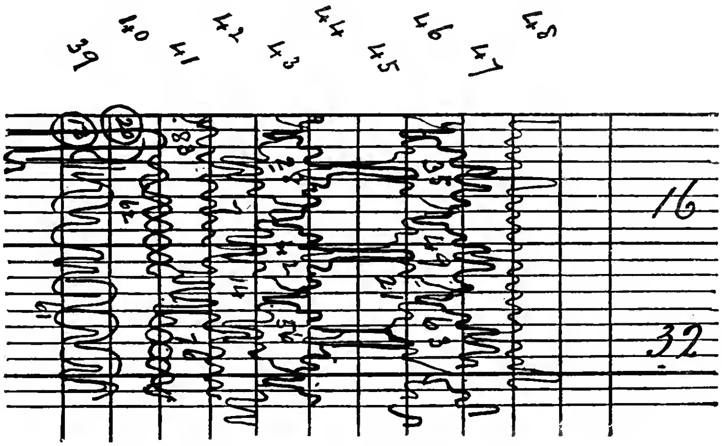


FIG. 3.

the lace shown in Fig. 1. Thus in both the figures, 3 and 4, only 1-50th of the design and draft are represented. In other words the whole of the two figures, 3 and 4, shown, merely represent one quarter of an inch square, of the lace in Fig. 1. Consequently for the production of lace of more extensive and elaborate designs it may be easily understood how great is the amount of skill and labour required.

In Fig. 3, thick and thin lines are shown in a zigzag direction. In the actual design two different colours are used instead, in order to prevent confusion, and to enable the designer to trace the threads more clearly when transferring them to the drafting, Fig. 4, than it would be possible to do if they were drawn in one colour only.

Therefore, to produce figured lace in the loom the movement of each thread must be considered. It is not necessary that the design should be drawn so as to show each twist as distinctly as represented in Fig. 2, for the same effect is produced by the designer in the much more ready manner shown in Fig. 3, which corresponds to Fig. 2. He not only, by this means, shows the warp and bobbin threads, but by the use of numbers and coloured inks he gives every information necessary for transferring the design to the Jacquard cards, and the degree of tension on the threads necessary to produce the desired effect. Thus, the exact distance that each warp thread must be drawn for the proper interception of the shuttles, and the relative degree of tension of the various threads, must all be determined and carefully noted in order to produce the figure.

To assist the designer various contrivances have been introduced from time to time. Messrs. Richardson and Slack, of Nottingham, have recently patented an apparatus in which photography and stencil plates are used. They provide two frames, in which threads or wires can be arranged, so that one frame may represent the warp threads and the other the weft or bobbin threads. These can be regulated by suitable means to any required guage. The outline or design is then placed in front of the photographic apparatus, also the two frames containing the wires. They are adjusted according to the effect or purpose desired, and the draft is then photographed.

The stencil plates are afterwards used to fill in the ground meshes, which may be of one or more descriptions. By this means designs may be enlarged, and the necessary lines to any required guage may be introduced, and the ground and other details may be filled in afterwards.

This system is also adapted to designs for other fabrics.

From the above it will be evident that upon the ability of the designer far more depends than in the designing of other fabrics, and the admirable way in which the machine is contrived to meet the requirements of the designer, alone gives ample proof of the genius of the inventor.

Each of the threads forming the lace, whether weft or warp, has a separate shuttle or warp beam, and the various shuttles and beams have more or less friction applied to them in order to produce more or less tension upon the threads as they are woven. In the shuttles or bobbins and carriages, the friction is caused by a small spring, which not only presses upon the bobbin to cause the friction, but at the same time holds the bobbin in the carriage. These springs are varied, either by using stronger springs or bending them so as to exert greater pressure to several degrees of strength. Fig. 5 represents a bobbin and carriage, also a section of the same, and the letters refer to the same parts in each. The bobbin *B* is composed of two thin disks of brass, $2\frac{1}{8}$ inches diameter, or twice the scale shown in the figure. The weft thread is wound between the disks, and it passes from thence through the eye *t*, at the top of the carriage. The carriage *a a* is made of steel plate, a hole being cut through it of about the size of the bobbin, excepting at the lower part, where a thin flange shown by the dotted line at *c*, is made to

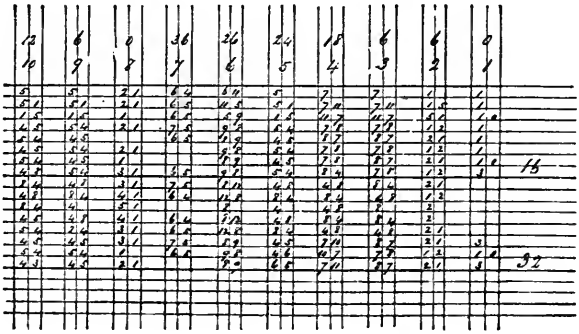


FIG. 4.

fit between the disks of the bobbin, and thus hold it in position. The small spring *s* has a nib, *n*, upon the end of it, the thin portion of which also is inserted between the disks, whilst the broader or upper part presses upon the edges of the bobbin and holds it down upon the flange *c*, as before described. The spring *s* is rivetted into the carriage at *u*, and it will be evident that according to the degree of pressure put upon the bobbin by the spring, so will be the amount of friction and tension upon the thread when unwound. The bobbins will each hold about 120 yards of thread, which is wound upon them when removed from the carriages and placed upon a spindle passing through the hole *d*. The lower portion of the carriage *b* is made much thinner, as will be seen in the section. It is this part of the carriage that slides between the comb plates, as will be hereafter described. The section of the bobbin and carriage is shown much thicker than they are actually made, for in the machine nineteen of the carriages work freely, with room between them for the passage of the warp threads, in the space of one inch, and in some instances as many as thirty to each inch in width of the lace made. In making the lace, as before described, forty-eight bobbins and carriages are used for each of the sixty pieces. This number is not absolutely correct, for although forty-eight spaces for forty-eight shuttles are used, one of the shuttles has been omitted from each of the sixty pieces, these shuttles not being required at the extra width of the space occupied by the lacing thread, as shown at *L*, *L*, Fig. 2.

The warp threads, of which there are 100 to each of the sixty pieces of lace, are placed upon 100 separate warp beams. The corresponding threads in each of the sixty pieces being used or woven in equal lengths, and requiring the same tension upon them, it fol-

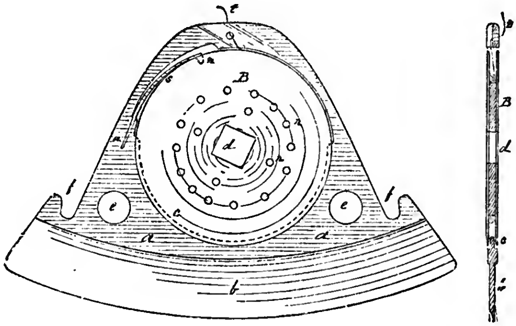


FIG. 5.

lows that one set of beams may contain the threads for the whole sixty pieces as freely as for one piece of lace. Therefore 100 beams are equivalent to having a separate beam for each separate thread in the whole of the sixty pieces.

The friction to cause the tension upon the warp beams is effected in a similar manner to the ordinary loom, viz., by winding a cord round the end of the beam and attaching a spring or weight to it. The tension is regulated by the strength of the spring and the number of turns that the cord is wound round the beam, or the small pulley fixed on the beam for that purpose. This will be better understood by referring to Figs. 10 and 12, in which the warp beams are shown at *w*, *w*. They have a small pulley fixed on one end, and round this pulley the friction cord is passed as many times as may be necessary. Thus, at *p*, Fig. 12, the cord is shown with one end attached to a stud, or peg, fixed to the frame in which the beams are placed, and after it has been wound round the pulley *o*, once or several times, the other end of the cord is attached to the spiral spring *s*. The warp beams are made of tin, and are about $1\frac{1}{2}$ inches in diameter, with small gudgeons at the ends.

It will be evident that various degrees of tension can be placed upon any of the 147 threads which compose the lace, and it now remains to see the important uses to which this simple matter is applied, and the effect it produces.

Fig. 6 represents five threads hanging from a rod *h*. The thread *a* has but a slight weight or tension applied to it, whilst the threads *b, b, b, b* have a much heavier one. The bobbins *e*, round which the latter threads are wound, are supposed to oscillate in the direction of the dotted lines shown at *o*, *o'*, the points from which they move being at the level of *d*. If these four threads are made to move, or oscillate altogether, they really represent the motion of the shuttles and weft threads of the lace machine, whilst the thread *a* would represent one of the warp threads. So long as the threads oscillate without any movement of the thread *a*, no effect will be produced, and the threads will remain intact, but if during the oscillation the thread *a* be drawn laterally across the path of the bobbins *e*, then on withdrawing or advancing the thread, it will be found, on continuing the various lateral movements of the thread *a*, that it will become twisted round the threads *b, b* accordingly. In this manner the various threads round which the thread *a* has been twisted, simply correspond to the distance that it has been moved at each oscillation of the threads *b, b*.

There is a comb or fork shown at *c*. The action of this is to beat together the twisted threads in a similar manner to the use of the reed in the common hand loom. But in lace-making the comb must be withdrawn completely clear of the threads after each oscillation, in order to allow of the lateral motion of the warp threads, which the comb would otherwise prevent.

It may now be seen that, owing to the extra tension upon the threads *b, b, b, b*, the thread *a*, after each twisting, is held in the position it was drawn to, for it has not sufficient strain or tension upon it to draw the threads *b, b, b, b* aside. Consequently, the effect produced is similar to the looped threads before alluded to, and shown in Fig. 2.

On the other hand, if the thread *a* had a greater tension upon it than any of the threads *b, b, b, b,* then the latter threads would be drawn aside in a reverse manner. This will be evident on referring to Fig. 7, where the tension upon the threads is reversed to those shown in Fig. 6. In this instance the threads *b, b, b, b* are, after each oscillation, drawn completely aside, and in this manner the action of drawing the fine, or weft threads, shown in Fig. 2, in the various positions there represented, and particularly so in the case of the lacing thread *L L,* is effected.

FIG: 6

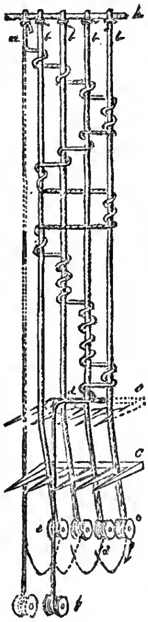
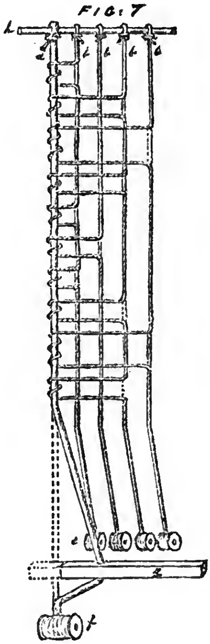


FIG: 7



It may be seen now that the various strains or degrees of tension that the threads are subjected to, perform a most important part in the manufacture of lace. The weft threads themselves have but a simple oscillatory motion, the shuttles simply sliding backwards and forwards from front to back of the machine. The warp threads, on the contrary, are moved to a greater or less extent laterally, and it is in the exactness with which these motions are made, upon which the proper formation of the lace depends.

It is in this portion of the machine that the greatest ingenuity has been shown, for the Jacquard apparatus, together with this peculiar adaptation of it is, perhaps, unsurpassed by any other mechanical invention.

In the production of the lace, as before described, 100 warp or beam threads have been used, and each of these threads must be so arranged that any one, or several of them, may be moved laterally as far as required. They may be required to move only past one of the oscillating or weft threads, or past ten or twenty. The spaces through which they move being in the present machine only 1-19th of an inch for each thread they pass, some idea of the exactness of the motion may therefore be formed. When thirty shuttles or bobbins to the inch are used instead of nineteen, then the difficulty becomes far greater still. The way in which this has been effected gives nothing like uncertainty, but performs the operation with the greatest precision and rapidity.

The processes to be accomplished by the lace machine consist as follows :—

1. In giving the weft or bobbin threads an oscillatory motion.
2. In giving each of the beam or warp threads a lateral motion to any required distance, so that they may be intersected by the shuttles and weft threads at the place desired.
3. In varying the degrees of tension upon the various threads.
4. To beat or comb together the twisted threads as they are formed.

The purpose of each of the above operations having been shown, the method adopted for carrying them into effect will be readily traced in the action of the machine itself, which will now be described.

A general view of the machine is represented in Fig. 8, (see *frontispiece,*) where it will be seen to consist of two separate machines, rather than one only. The larger portion is the lace machine or frame, and the smaller machine is the Jacquard apparatus.

The lace frame consists of a massive iron framework, well fitted together and fixed as firmly as possible, in order to prevent vibration. Both machines are driven by the same shaft *A*, by means of a strap and pulleys at *I*, near to which is also fixed on the same shaft a heavy balance or fly-wheel, to give steadiness to the motion of the machine. Near the top, and at the back of the lace frame, is a revolving shaft *C*, which is driven by a connecting shaft and wheels, fixed at the end of the frame next the driving pulleys. Upon this shaft *C* are placed various cams, and it is consequently named the cam-shaft. Below this shaft there is a vibratory or rocking shaft *D*, which is worked by means of the cranks on the shaft *A* and connecting rod attached to crank levers, as shown at *D*.

The Jacquard machine is connected, and worked by means of the wheels shown at *B*.

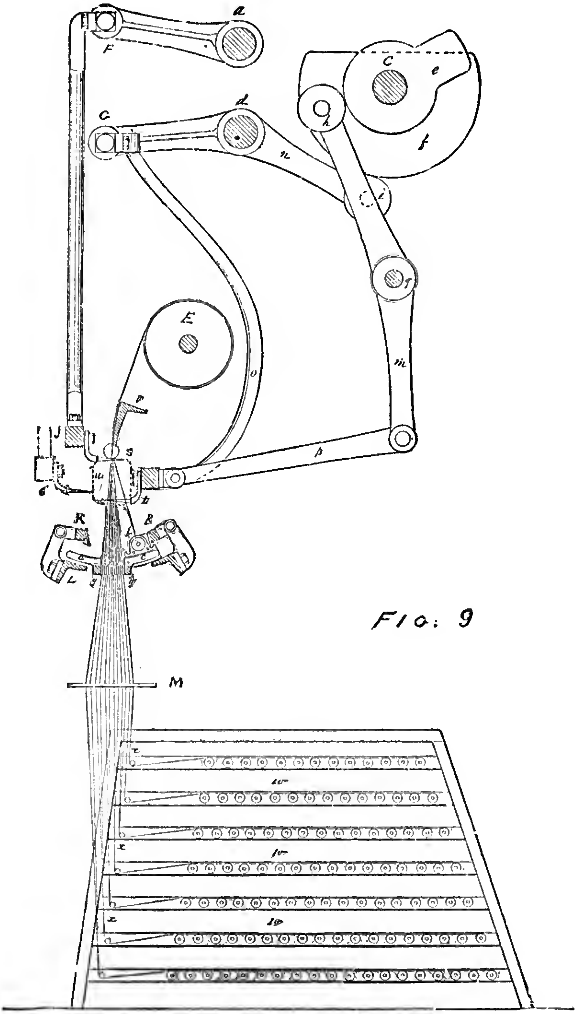


FIG: 9

Fig. 9 is a section of the lace frame, showing the most important parts. The warp beams are shown at *w*, *w*, from which the threads are passed through eyes fixed on the bars *x*, *x*, and from thence they are carried vertically through the perforated plate *M*, and the slide bars *y*, *y*, and are finally attached to the lace-beam *E*, upon which the lace is wound as it is made. At *b* will be seen one of the bobbins and carriages, with the weft thread leading to the point *s*, which is the centre of the arc, or point from which the oscillatory motion of the shuttles or carriages moves. As before described, the carriages slide between the comb or guide plates *c*, *c*, and as they pass from one comb-bar to the opposite one, they necessarily pass through the warp threads *y*, *y*. At *L* will be observed an angle bar. There is also a corresponding bar on the opposite side, and upon them the shuttles which protrude through the comb rest. The bars are called "landing bars," for when the shuttles are pushed through the warp they "land" upon the opposite landing bar, and are then drawn completely through to the other side. In the moving of nearly 3000 shuttles, as in this instance, considerable friction would arise if they were made to slide through the comb without the aid of the landing bar. Attached to each landing bar is a catch bar *k*, *k*. In Fig. 5, representing the carriage, there are two slots *f*, *f*. These slots are for the strip or blade of the catch bar *k*, *k* to fall into, and by that means the whole of the carriages are drawn across. On returning to the opposite side, the catch bar pushes the carriages until they are within reach of the opposite catch, when it drops into the grooves, at the same time the pushing bar is withdrawn. In this manner, by means of the catches and the landing bars, the carriages are moved from side to side of the comb bars.

In the carriages will also be noticed two holes *e*, *e*, Fig. 5. When they are removed from the frame for the purpose of being refilled with thread, a strong wire is inserted in these holes, by which means the lace-maker can remove several hundred carriages at once, which would otherwise take considerably more time to perform.

In the diagrams, Figs. 10 and 11, the carriages may be seen at *b*, *b*, also the comb plates *c*, *c*. The weft threads are shown at *a*, *a*.

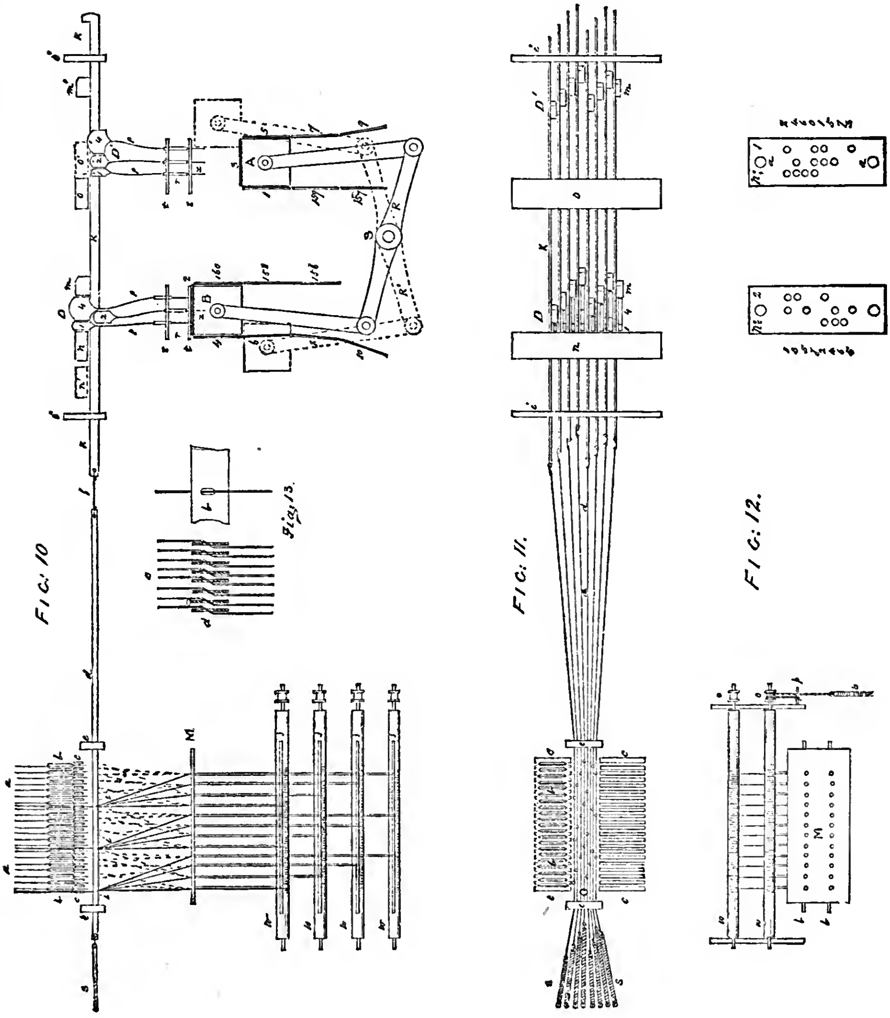
The motion of the carriages from side to side of the comb bars, and the varied pressure put upon different bobbins by the springs, constitute all that is required from them. The oscillating motion is given to the landing and catch bars by means of connexions to the rocking-shaft *D*, Fig. 8.

The arrangement and movements of the warp or beam threads is a very different matter, for each of them can be moved separately. This will be best understood by referring to the diagrams, Figs. 10, 11, and 12, which, instead of showing the whole of 147 threads, as used in the weaving of the lace described, show only 45, which will be quite sufficient to describe the operation of the Jacquard apparatus.

Fig. 10 is a longitudinal section of the machine; Fig. 11, a plan of the same; and Fig. 12 is a sectional plan taken at the level of *M*, Fig. 10.

There are only eight warp beams represented, viz., four tiers in height and two in width, as shown at *w*, *w*, Figs. 10 and 12. The threads are passed under the bars *j* and *b*, and thence through the holes in the plate *M*.

Now it is at this point where a most important and ingenious arrangement occurs, which, when understood, will at once explain the design and draft shown in Figs. 3 and 4. It will be noticed in Fig. 10 that there are 24 threads which pass from the beams through the plate *M*. These threads are not continued upwards in the same order, but are simply divided into three sets or rows of eight each, and they are threaded through the eyes of the slide bars, which lead to the Jacquard apparatus as shown. In Fig. 10 the three sets of eight are seen to converge at *i*, *i*, *i*, where they pass through the eyes of the slide bars. This will be seen on a larger scale in Fig. 13, which represents in section the eight bars with the threads *c* passing through the eyes at *d* and *b*. As there are only eight slide bars and twenty-four threads shown in the diagram, it follows that each bar guides three threads. Consequently, if any of the bars are drawn forward, they draw with them the three threads to an equal distance. For instance, the normal condition of the bars would place the threads in three rows, as shown at *i i i*, Fig. 10, but if the bars be drawn to certain distances, then the threads may be placed in the position as shown in the dotted lines, Fig. 10. Thus, any set of the three threads can be drawn to whatever intermediate space that may be required. In Figs. 11 and 12 the spaces through which the threads, shown by the dotted lines in Fig. 10, have been drawn, can be seen. In Fig. 11, the first eight threads would be in their normal position at *O*, but as the bars have been drawn to various distances, the holes shown upon them show the distances they have been drawn from their normal position, or straight line. This will be more clearly observed by noticing the extent to which the spiral springs *s*, *s* have been drawn, also the various distances at which the opposite ends of the bars protrude at *i* in the same figure. In Fig. 12, the plan of the Jacquard card, marked No. 2, shows that the nearest bar has been moved five spaces, or past five of the shuttles, and the last bar has only been moved one space. It is upon this principle that the 100 slide bars in the machine are used for making the sixty pieces of



lace. In Figs. 10 and 11 only eight bars are used, and they would produce three pieces, or repetitions of the same pattern. But there is this difference in the two cases, that in Fig. 10 the 8 threads are concentrated in one line only, whilst in using the 100 threads in the large machine they have been concentrated in 7 sets or lines. These points or lines of concentration are called "stops," and it is from them that the designer measures the distances that the threads must be moved.

Figs. 3 and 4 may now be understood. In Fig. 3 the numbers 39 to 48 refer to the number of the shuttles, and 16 and 32 are the numbers of the oscillations or cards to be used. It will be remembered that Figs. 3 and 4 only represent 1-50th of the actual design and draft, consequently only 10 of the shuttles are numbered, also 32 out of the 160 cards, in like manner.

As before explained, one of the shuttles was dispensed with, only 47 being used. The one marked 45 in Fig. 3 was the one that was omitted.

The numbers filled in the body of the design refer to the particular beams which supply those threads, and the tension is also marked accordingly. In Fig. 4 the top row of figures represent the "stops" above mentioned, and the second row the consecutive numbers of the warp threads, of which there are 100, but only ten are there shown. The numbers 16 and 32 represent the cards, or 32 out of the 160 required for the pattern as in Fig. 3.

The figures are arranged in two columns. Under each of the consecutive numbers at the top which corresponds to the numbers of the warp threads, and under No. 6, representing the 6th thread of the warp, appear the numbers 6, 11, 11, 5, 5, 9, &c., which refer to the number of spaces that the thread must be moved through, in a similar manner as shown in the case of Fig. 12. In the left hand column the odd numbers of the cards are represented, and the even number on the right. Thus the eight lines, or spaces between them, show the 16 cards, as numbered in the right hand margin. Where no figure occurs in the columns, it is understood that the last number must be repeated. This plan of double columns has the great advantage of showing at a glance the two sides of the cloth, so that the designer can use the threads to the best advantage and effect.

The application of the Jacquard apparatus to the lace machine is quite upon another principle to that applied to hand-loom weaving. In that system of weaving the cards are perforated directly according to the corresponding warp threads that have to be raised, each warp thread having its appointed hook and needle, and a position upon the cord. But in the lace frame, each thread having to be moved to various and certain distances, a very ingenious method has been invented, which accomplishes what is wanted in a most effectual manner. It is done by using a series of wedges of different thickness. These wedges are inserted between a sliding bar and a stud fixed upon each of the slides which move the warp threads. Now if a wedge, representing in thickness the distance through which the slide is required to move, be placed between the bar above mentioned and the stud on the slide, then it will push the slide a corresponding distance. If two wedges are used, then a greater distance can be passed through.

At *D* and *D′*, Fig. 10, three wedges are shown, of three different thicknesses, viz., 1, 2, and 4. If all three wedges be inserted, the bar will be moved equal to 7 spaces. In the figure only two are inserted, viz., the first and third, which represent 5 spaces. In this manner any number of spaces from 1 to 7 can be accomplished by the three wedges shown. If another wedge equal to 8 spaces be added, then any number up to 15 spaces can be drawn. In the lace machine there are five wedges used, viz., of 1, 2, 4, 8, 8, spaces. With these from 1 to 23 spaces can be used.

In Fig. 8, the slide bars *b*, are shown leading from the Jacquard to the lace frame. There are 100 of these bars, and so thin are they that they all work freely in the space of 1¼ inches, besides leaving ample room for the warp threads to pass between them. They are made of fine steel and have guide holes made in them for the threads as shown at *d* and *b*, Fig. 13. One end of each bar is attached to a spring, as shown at *s*, Fig. 11, and the other end is attached to the slides of the Jacquard machine, shown at *c*, Fig. 1, and *k*, Figs. 10 and 11. In Fig. 10 the attachment is shown at *f*. The Jacquard slide bars *k*, in the same figure, are made to move freely in the guides *i*, *i*. At the extreme end of the bar, a nib or projection is left on the bar to form a stop, against which the spring at the other end tends to draw the bar *k* against the guide *i*. On the upper edge of the bars two studs or plates are fixed, *m* and *m′*, Figs. 10 and 11.

There are two bars shown at *n* and *o*, in the above figures, which are made to slide simultaneously in opposite directions to each other; consequently, one of them is always advancing towards the stops on the slides *k*. The dotted lines *n′ o′* in Fig. 10, show the extent of their motion. The bar *o* is shown drawn in its normal position, and the wedges *D*, below it can be raised in front of it.

If any of the wedges are raised, then, when the slide moves, it blocks them between the slide *o* and the stud *m'* in a similar way to the position of the wedges 1 and 4 shown at *D*, which are blocked between the bar *n* and the stud *m*. In this case the slide bar *K* is moved five spaces. Whilst the wedges *D* are in work there is ample time for the wedges *D'* to be inserted, for they work upon the same bars, although upon different studs. By this means no time is lost in the movement, and the advantage of the double action is at once self-evident. The cards being divided into two sets, viz., the odd numbers to work on one cylinder and the even numbers on the other, as shown at T^1 and T^2, Fig. 8, and *A* and *B*, Fig. 12, enables them to be used at double the ordinary speed, with all the advantages of steady, uniform, and balanced motion. The Jacquard cylinders are worked in the usual way, and are turned by a catch, except the cylinder *f*, Fig. 8, which is turned by means of the rack and pinion as shown. The wedges are fixed on the ends of thin, flat springs, as shown at *p*, *p*, Fig. 10, and the lower end is made round, so as to pass through the holes in the card where required. Between the spring and the round part there is a strong flat piece *r*, which is made for the purpose of working without turning in the guide plates *t*, *t*.

The cylinders *A* and *B*, Fig. 10, are connected to the rocking shaft *S* by the balance lever *B*, by which means they are alternately raised and lowered, for the purpose of turning and changing the cards, 160 of which are used in the formation of the lace as before stated. Now the cylinders in their upward movements raise the wedges *D* and D^1, unless there are holes in the cards. Where there are holes, of course the round end of the needle passes through the card and the wedges are not raised. At Fig. 12, two cards are shown, the one marked No. 2, is the same as shown raised on the cylinder *B*, and the wedges are inserted as at *D*, Fig. 11. The distances to which the slides can be moved are shown by the figures 1, 3, 5, 7, 2, 4, 6, 5, at the side of the card, which figures indicate the wedges required to be raised by the card. For instance, opposite to 1 there are two holes, but the first space is blank, consequently No. 1 wedge would be raised. Opposite to 5 there are two blank spaces, consequently they would raise No. 1 and No. 4 wedges, as shown at *D*, Fig. 10.

It has now to be observed that the cylinders and wedges altogether move laterally in conjunction with the slide bars *n* and *o*, Fig. 10. If this were not the case the wedges could not be kept in position. The dotted lines show the reverse motion of the cylinders, when following the movement of the slides n' and o'.

In Fig. 8 the slides are shown fixed on the side bars *s, s.* These bars are moved by means of cams fixed on the shaft moved by the wheel *B,* one of the pulleys worked by the cam being shown at the back of the wheel *B.* There are two pairs of these bars, one pair at each side of the Jacquard machine, and the slide bars *w, w,* are fixed upon the top of them, as shown. The spiral springs return the slides to their proper position after each revolution of the cams.

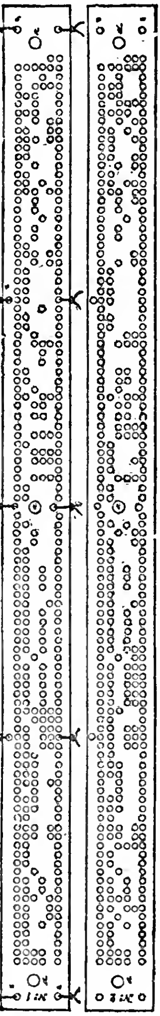


FIG. 14.

Fig. 14 represents two of the cards actually used in the machine, viz., Nos. 1 and 2. They are 30 inches long by $2\frac{1}{8}$ wide. There are 100 rows of holes in each, corresponding to the needles of the Jacquard, besides the needles which work the selvages at the extreme sides of the sixty pieces of lace.

It is in this manner that the Jacquard operates upon the warp threads and effects in the most exact manner all that is desired by the designer.

When the warp threads have been moved according to the arrangement of the cards, the meshes or twisted threads have to be beaten or combed together. This is done by means of two "point bars" placed at opposite sides of the lace, whose operation is similar to that shown at *c, c,* Fig. 6, and in Fig. 9, at *t, t.* The dotted lines *u* shows the path of the points as they descend, for it is only on their ascent that they pass through the lace and thereby comb the threads together. The point bars consist of a row of fine steel points of about fifty or sixty to the inch, and of course they extend the whole width of the lace. They are inserted into the lace and raised, and then removed clear of the lace and lowered by means of a combination of levers and two cams fixed on the cam shaft *C.* These cams operating upon the levers *n* and *m,* and turning upon their fulcrums *d* and *q,* accomplish the motion as above described. In the sketch, only the levers and cams connected with the back point bar is shown; the front bar being moved in a similar manner, it is unnecessary to show it.

Although the most important movements of the machine are those above described, still there are several others that require notice. The lace beam *E*, Fig. 9, is turned by means of the worm and wheel shown at *o*, Fig. 8. The worm is driven by means of a catch, which is moved by a cam and lever in connexion with the shaft *C*. There are three ratchet wheels of different pitch, or distances of the teeth, so that more or less motion can be given to the beam *E* under various circumstances. Temples are also used at each end of the lace beam, as in the common hand loom, for the purpose of keeping the lace stretched. The warp threads *A*, after passing through the perforated board *M*, are not carried up to the slide bars vertically, but are made to lean considerably on one side. This is for the purpose of keeping the thread pressed constantly on one side or edge of the holes in the bars—otherwise, unless the hole was exceedingly fine, there would be too much movement of the thread, and the spaces could not be moved through in an exact manner.

The front catch bar *K*, Fig. 9, is also shown at *J*, Fig. 8. It is provided with handles, so that the weaver can raise it clear from the carriages when he requires to remove them, or to repair any broken threads. The front point bar, in a similar manner, is raised by means of the lever *P*.

The machine is thrown in or out of motion by means of the lever *H*, which is connected to the fork or strap-guide at the pulleys on the driving shaft *A*.

The ends of the warp beams are shown below *D*. At the point *a* is shown the centre of the arc through which the landing bars move; and it is of the greatest importance, in fixing the machine, that the line from end of the frame from these points should be perfectly true.

The large springs *n*, *n* relieve the machine of the weight of the oscillating bars, and give them more freedom and ease in their rapid motion. The rocking shafts *a*, *d*, Fig. 9, are shown also *F*, *G*, Fig. 8, and are for the purpose of raising the point bars, as may be observed in the figures.

Before the application of the Jacquard machine to the lace frame, the organ barrel motion was adopted, but Mr. S. Draper, of Nottingham, having seen a Jacquard machine at work in the Adelaide

Gallery, London, at once attempted to apply it to the lace frame. This was in 1834 and 1835. He took out several patents and the first scarf made on the Jacquard principle is now in the Kensington Museum. In 1841 Mr. H. Deverill obtained a patent for an improved application of the Jacquard to the frame in which two griffe bars and one cylinder were used, and this is said to have been the first successful use of the Jacquard to lace making. A great improvement was made in 1842, by Wm. Catford, who used two cylinders, operating alternately upon one set of levers. In 1858, Mr. G. Pigott made further improvements by using wedges instead of studs of different lengths, and the machine before described is an improved modification of his invention. The object of having two cylinders and griffe bars is to obtain an easy and steady motion, and, in fact, nearly double the speed can be attained than is possible by a single action machine.

By means of Jacquard apparatus, not only can any desired arrangement for guiding the warp threads be made, but the bobbins and carriages can be governed by its means also. Separate pushers can be used to each bobbin; and by combining the "shogging" motion, as used in the bobbin-net machine, various effects can be produced. Even the warp threads have in some cases been dispensed with, and the bobbin threads, only, used for the making of lace.

For the manufacture of wide fabrics, such as curtains, a Jacquard apparatus is fixed on the top of the lace frame in a similar manner to an ordinary Jacquard loom, and the cords are carried down to the warp threads below the carriages and bobbins, but in place of having the slide bars, as before described, each hook of the Jacquard merely draws by means of jacks or guides, the warp thread one space only instead of from one to twenty, or upwards. By this means a very wide pattern can be woven, for a Jacquard, containing 600 needles, may be made to produce a figure several feet wide or several wide pieces or curtains can be made. But by this arrangement the figures have a flat appearance, for they are devoid of the principle of drawing the threads to various distances laterally. It will be evident that numerous modifications can be made in this excellent machine without deviating from the principle of its action.

CHAPTER XXXIII.

THE TRAVERSE BOBBIN-NET MACHINE—THE PRINCIPLE OF ITS ACTION—JOHN HEATHCOAT.

In 1808, Mr. John Heathcoat obtained a patent for a bobbin-net machine, being the first successful attempt to produce by machinery an imitation of pillow lace. The machine was provided with bobbins, placed in the form of a segment of a circle, and the threads from them were concentrated towards the centre of the circle. This arrangement was limited to the production of lace of only a few inches in width.

It occurred, however, to Mr. Heathcoat, shortly after he had satisfied himself of the accomplishment of the task, that, the bobbins should be placed in a straight line, when lace of far greater width could be made. He therefore at once turned his attention to the new plan, and in 1809 he obtained his second patent.

During a period of fifty years previously, numerous attempts had been made to accomplish the making of lace on the stocking frame, as will be hereafter alluded to; but that machine was not adapted to the purpose, and it is to the genius of Mr. Heathcoat that the traverse bobbin-net frame is due. He found out, after carefully watching the process of making lace on the pillow, that the operations required for making bobbin-net, consisted in placing one series of threads in a vertical position, around each of which a second series were twisted, and at the same time to traverse after each twist towards the right hand, whilst another series of threads after each twist traversed to the left. He, therefore, like William Lee, set himself the work of carrying out mechanically the various notions as actually performed in the process of making the lace by hand.

Lace made without this traversing motion would, in case a thread was broken, "run" or become undone. Consequently, the traverse has the effect of binding the parts firmly together, for on the breaking of a thread the "running" would be stopped by the repeated twistings in a diagonal direction.

The machine was completed at Loughborough, hence it was long known as the "Old Loughborough" Bobbin-net machine.

The complexity of the process was proverbial, so much so that Dr. Ure said of it that "bobbin-net surpasses every other branch of industry by the complex ingenuity of its machinery. A bobbin-net frame is as much beyond the most curious chronometer as that is beyond a roasting-jack."

In his work on the "Cotton Manufacture" the Doctor makes use of many pages, including eighteen diagrams, to show the principle only of the machine; but mistakes crept in which were corrected by several additional pages and diagrams, supplied by Messrs. Boden and Morley, lace manufacturers of Derby. The machine is doubtless of an intricate nature, but it is in this respect behind the Levers' frame.

As before stated, the action of the bobbin-net frame consists in arranging a series of threads in a vertical position, and twisting two other series round them, which after each twist has been made traverse to the *right* and *left*. Now this traversing to the right and left may be said to be wrongly expressed and misleading. Let it be said that the bobbins, with the traversing threads, travel or traverse to the right along one side of the cloth, and on reaching the selvage they turn round it and travel back again on the other side of the cloth, at the same time performing the work of twisting as they proceed, then the difficulty of understanding their motion will diminish. They appear to be travelling to the right and left, but really they are *making a continuous circuit*, or traversing first along the face and then along the back of the cloth, and twist round each of the vertical threads as they pass.

This operation will be readily understood by means of the diagram Fig. 15. It is not necessary to follow each motion of the bobbins step by step, by using a number of diagrams and a lengthy explanation, for it is believed that the various motions of the machine will be rendered self-evident when the simple principle upon which they act is represented.

In Fig. 15 the meshes of the net are shown as they appear when in the loom, when the tension on the vertical or warp threads gives them a harsh angular appearance; but when the cloth is taken from the loom they become of a true hexagonal form.

The machine consists of two comb bars *R* and *S* placed facing each other, and the upper surface upon which the bobbins and carriages slide are segmental in form. This form is to cause the threads, when the bobbins travel, to be always at the same distances from the point of intersection with the warp threads, for they move similarly to the oscillation of a pendulum.

Let *A, B, A, B* represent a series of warp threads passing through two guide bars *C, D,* through eyes placed alternately in each bar. By this means the warp threads may be moved laterally, half in one direction and half in another, or in any order that may be desired.

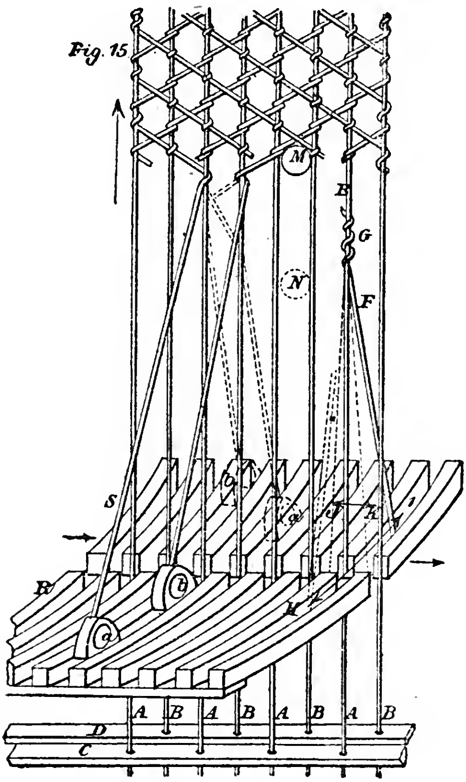
The bobbins and carriages are constructed in the same way as in the Levers Lace Frame, for Levers adopted Mr. Heathcoat's plan of making them. Therefore, let *a* and *b* represent two only of such bobbins and carriages placed in one groove of the comb *R*. These bobbins and carriages can be made to slide across the open space to the opposite comb *S*, as in the Levers machine. In the Levers machine there is only one row or *tier*, but in this machine there are two rows or tiers.

It is at this point where the two machines differ. The two comb bars *R* and *S* are not firmly fixed, but they are capable of being moved longitudinally as indicated by the arrows. Therefore, by this means if the bobbin *b* were pushed across to the opposite comb *S* then that comb could be moved to the *left*, and the bobbin would reach the place shown at *b*. In the meantime if the comb *R* be moved to the *right*, then the bobbin and carriage *a* would arrive at the point *a* on the comb *S*, as shown in both cases in dotted lines. In that position the two bobbins are no longer in the same line or groove but, by the "shogging" motion of the combs, as the longitudinal motion is technically called, they become divided. By this means if two lines of bobbins be placed upon the comb *R*, the whole of them may be made to pass from one comb to the other, and by means of the "shogging" motion being properly arranged, one line of the bobbins may be made to travel in one direction, whilst the other line travels in the opposite direction.

On the other hand, if the comb bars be kept stationary, and the bobbins be made to pass from one bar to the other, as at *H* to *I*, then if the warp thread *E* be drawn, by means of one of the guide bars *C, D,* across the path of the bobbin alternately, as from *J* to *K*, a twist round the warp thread *E* would be effected by the thread *F*, as shown at *G*, and it would continue to do so; but by the alternate action or "shogging" of the combs and the bars *C, D*, the twistings to form the meshes may be carried forward from thread to thread and the formation of the lace be accomplished.

The action of the bobbin-net machine therefore consists simply in the use of two lines of bobbins being made to travel from one comb to the other so as to break joint, as it may be termed, when they pass from one bar to the other. At the same time the guide bars *C D* move the warp threads. Thus the bobbins travel *round*

Fig. 15.



the cloth from edge to edge, as the diagonal threads in the diagram show, first along one side and then back along the other side; and by this traversing motion, threads from the bobbins being intercepted by the warp threads, as indicated in the sketch, the necessary motions are performed for the making of bobbin-net.

The return motion, when the bobbins reach the selvages of the cloth, is made by means of what may be termed a *switch* motion, for after the bobbin has twisted round the end warp thread it is thrown into the other line or tier of bobbins, and pursues its course until it again arrives at the same place.

It may be scarcely necessary to add that when one tier of bobbins has passed from one comb to the other a slight halt in their motion is made, to allow time for shogging the combs and moving the vertical threads before the other tier of bobbins are passed.

Vertical pin bars or combs, for beating or pressing together the meshes, are required, as in the use of the reed in the common loom, and as described in the Levers frame. One pin only is shown in section at *M*, where it has travelled to from *N*, carrying or combing together the mesh.

Since the expiration of Mr. Heathcoat's patent, in 1823, numerous modifications of the machine have been made, and one of the first and most useful may be mentioned as being still in common use.

In some machines spotted net is made, in which an ingenious contrivance is used. The spot is made by traversing the thread a number of times across the space occupied by a single mesh; and during the time this is being worked all the other twisting motions are suspended. But the thread so passing to form a spot would draw the warp threads together unless a special contrivance were used, for the strain, as indicated in Fig. 7, would be too great for the vertical or warp threads to withstand. This effect, however, is counteracted, for before the bobbin is allowed to pass, a flat wire (one to each spotting bobbin) is made to press against the bobbin thread sufficient to slacken off a small quantity; by so doing no strain is put on the thread, as would be the case if the thread had to be drawn off in the usual way.

The shogging is done by suitable cams placed at the ends of the comb bars; but when a greater number of movements are required, as in making spots, a chain of tappets or cams, like a Diggles chain (see Fig. 317), is used.

John Heathcoat was born at Duffield, near Derby, August 7th, 1783. He was the son of a small farmer who had the misfortune to become blind, in consequence of which affliction he removed with his family to Long Whatton, near Loughborough, about the year 1790. At this place he embarked some money in the purchase of warp machinery, which he let on hire to the smaller manufacturers in the neighbourhood, and it was from this circumstance that his son John became connected with the Hosiery manufacture. After leaving school he was apprenticed to a Mr. W. Shepherd, a Hosiery manufacturer and frame smith at Long Whatton, and was employed in making and fixing Hosiery machines. At the age of twenty-one he married the daughter of Mr. W. Caldwell, of Hathern, and removed to Nottingham, where he entered the employment of an excellent machine-maker named Elliott. He afterwards removed to Hathern, to join Mr. Caldwell and his son, who were also in the machine trade, when they all became engaged in making and carrying out a new invention. It was at this time that Mr. Heathcoat resolved in future upon devoting his energies to invention. On the completion of the machine alluded to, a patent was taken out for it in 1804, in the names of Caldwell and Heathcoat, "for a new apparatus to be attached to warp frames, whereby all kinds of thread lace may be made," but it was found afterwards that the invention had already been anticipated.

He now turned his attention to the long-sought problem of making pillow lace, which he completely mastered in 1809. Many attempts were made to show that he was not entitled to all the credit of the invention, but that certain important steps had previously been made by others which had led to the successful result.

The most important of these claims was in respect to the invention of the thin bobbin and carriage which was claimed for Robert Brown, a very ingenious man, who had constructed a fishing net machine. In this contrivance he had made use of thin bobbins, but the twisting of the threads as required in making bobbin-net is not at all mentioned in Brown's specification.

Mr. Felkin had ample means to arrive at the truth of this matter, and gives the sole credit of the invention to Mr. Heathcoat. He says, "that no model or actual machine, or combination of these or any other parts of Heathcoat's machine can be shown to have been previously put together, upon which bobbin-net *twisted and traversed from side to side* could be or ever had been made."

In order to carry out the making of the machines, and the manufacture of lace, Mr. Heathcoat took into partnership a gentleman named Lacy, who supplied the necessary capital. A factory was established at Loughborough, and the business proved highly successful, but Mr. Lacy, after realizing some 50,000*l.* therefrom, lost it all in mechanical experiments.

In 1816 the factory was burned down by a gang of Luddites, and machines valued at 10,000*l.* were destroyed. The Luddites took their name from one Ned Ludd, and they had for years been in the habit of destroying machines whenever differences occurred between the masters and their work-people. Several of them were hanged, and ultimately the league broke up.

To avoid further interference, Mr. Heathcoat determined to leave the district altogether, and having, during a visit to Devonshire, noticed a woollen factory at Tiverton that appeared suitable for his purposes, he transferred his work-people thither.

He took out several other patents, one amongst them being for a steam plough.

The business at Tiverton became thoroughly established, and after amassing a large fortune, he died in January, 1861.

As in the stocking frame and the Jacquard loom, numerous modifications have been made in the bobbin-net machine, but the essential principle upon which the twisting of the threads depends still remains unaffected by them.

CHAPTER XXXIV.

THE STOCKING LOOM—KNITTING BY HAND—WILLIAM LEE—INVENTION OF THE STOCKING LOOM—JAMES LEE—DESCRIPTION OF THE LOOM AND PROCESS OF KNITTING—JEDIDIAH STRUTT—BUTTERWORTH—FROST—CRANE'S WARP LACE MACHINE—DAWSON'S WHEELS—SIR M. I. BRUNEL'S CIRCULAR FRAME—BOSWELL'S FISHING-NET MACHINE—PATERSON'S.

When the crude state which every branch of the mechanical arts was in previous to the 16th century is taken into consideration, it may be claimed for William Lee's invention of the stocking loom that it was one of the most extraordinary examples of mechanical ingenuity that has ever been achieved.

In every other process of weaving various threads are made either to intersect or to twist round each other, in order to bind or connect them together to form the web; but in stocking weaving, in its simple form, only one thread is used, and it is by this alone that a series of loops are made, in such a manner as to intersect each other, and thereby form the looped fabric which is the distinguishing feature of this system of weaving.

The invention of the stocking loom was not, as is generally the case, the result of the efforts of many inventors, but was the product of the genius and perseverance of one man.

As to the invention of the art of knitting by hand considerable uncertainty exists. It is not only a question of who the inventor was, but even the country in which it was first practised is not known. In Henry VII.'s reign knitted woollen caps were in common wear, and several Acts of Parliament were passed in that and the succeeding reigns relating to knitted articles. Previous to this time hose were made of cloth sewn to the proper shape, and Henry VIII. wore them of that kind, "except there came from Spain by great chance a pair of silk stockings." It is thought from this circumstance, and the fact that Sir Thomas Gresham presented the young

King Edward VI. with a pair of silk stockings, which probably came from the same country, that the art originated in Spain, or that the Spaniards may have learnt it from the Moors. Then there is the popular statement given by Stow, to the effect "that in 1564 one William Riley, apprentice to Master Thomas Burdett, having seen in the shop of an Italian merchant a pair of knit *worsted* stockings from Mantua, borrowed them and made a pair exactly like them, and these are said to have been the first stockings of woollen yarn knit in England." But it is said that worsted stockings were at that time made in England, and that they were probably silk stockings—coming from Mantua—that young Riley imitated, and which were worn by the Earl of Pembroke. To this may be added the well-known story of Queen Elizabeth, who was presented in the third year of her reign with a pair of black silk stockings by Mrs. Montague, the Queen's silkwoman, whose assistants had become "so dexterous in knitting that from thenceforth Elizabeth never wore cloth hose any more."

Beckmann refers to many other circumstances relating to the early history of the subject, from which it would appear that towards the end of the reign of Elizabeth knitting had become a most important branch of industry, and from its nature it was admirably adapted for domestic employment. It was not only practised as a common household requirement, but numbers of persons were engaged and employed by masters who carried on the business on an extensive scale.

To this period may be traced the rise of the manufacturing arts in England. Weaving and spinning had been introduced, and were widely practised, but machines of an automatic nature may be said to have been unknown. The various manufactures depended upon the handicraft skill of the workman, for he had little assistance from any mechanical contrivance. A change, however, was about to take place, the effect of which is in full force at the present day. This was caused, it need scarcely be said, by the invention of the stocking-frame by William Lee. The great peculiarity of this invention is that it is probably the first of any kind for the purposes of manufacture that may be classed as an automatic machine.

Respecting the life of William Lee many conflicting accounts are given. It appears that he was born at Woodborough in Nottinghamshire, but as the Parish Register only commences in 1547, it does not contain an account of his baptism. "He is said to have been heir to a good estate, and was matriculated as a Sizar of Christ's College in May, 1579. He subsequently removed to St. John's College, and as a member of that house proceeded B.A., 1582-3. It is believed he commenced M.A. 1586, but on this point there appears to be some ambiguity in the records of the University. In 1589, at which time it is stated he was Curate of Calverton, about five miles from Nottingham, he invented the Stocking Frame." This statement was given to Mr. Felkin by Mr. Cooper, the late town clerk of Cambridge.

Concerning this period of his life many romantic tales are told—his secret marriage and expulsion from the University—his depending upon his wife's earnings by knitting for a livelihood—his watching intently the process, and ultimately, after innumerable other incidents, inventing the machine to relieve his wife from further labour and bring wealth and prosperity as well as the patronage of their Sovereign Lady the Queen! Unfortunately the few facts that are known make sad havoc with these happy legends, for there is no proof that he was ever married, and after years of patient toil, instead of wealth and patronage being his lot, he was driven to a foreign country, where he died in obscurity and poverty!

In 1833, Dr. Ure, assisted by Mr. Felkin and other gentlemen of Nottingham, made a thorough inquiry respecting the history of the Lee family, and all information that could be obtained about Lee and his invention. Unfortunately nothing of importance was added to what was already known; but the Doctor gave his opinion that the following is the more probable statement of the case.

"It being an ancient tradition around Woodborough, his birthplace, that Lee in youth was enamoured of a mistress of the knitting craft who had become rich by employing young women at this highly prized and lucrative industry. By studying fondly the dexterous movements of the lady's hands, he became himself an adept, and had imagined a scheme of artificial fingers for knitting many loops at once. Whether this feminine accomplishment excited jealousy or detracted from his manly attractions is not said; but his suit was received with coldness, and then rejected with scorn. Revenge prompted him to realize the idea which love first inspired, and to give days and nights to the work. This ere long he brought to such perfection as that it has since remained without essential improvement, the most remarkable stride in modern invention. He thus taught his mistress that the love of a man of genius is not to be slighted with impunity."

Be that as it may, it is admitted that having become curate of the church of his native village of Calverton, it was there that the invention was carried into effect. Nottingham, at that time, as at present, was famous for the skill of its artisans, and with their help and the assistance of his brother, he applied himself for about three years to the task, and in doing so, had expended not only a large portion of his patrimonial means, but had even suffered privation from the cause. At last the machine was completed, in the year 1589, and was worked for about two years, but finding a prejudice against it, he removed it to London, where it was set up in a house in Bunhill Fields, St. Luke's, where he met with varying success. In order to secure the profit arising from his loom, he endeavoured to obtain a patent from the Queen (Elizabeth) who had heard of the new invention through her kinsman, Lord Hunsdon, and she consented to see the machine. For that purpose she went to Lee's lodgings in Bunhill Fields, accompanied by Lord Hunsdon and his son, and there saw it worked by Lee or his brother. She expressed her sense of the ingenuity of the invention, but was evidently disappointed when she found it was knitting coarse worsted and not silk hose. Lord Hunsdon, however, had faith in the enterprise, and not only assisted Lee, but endeavoured to obtain a patent for the invention. After repeated applications Elizabeth refused to grant a patent, and in reply to Lord Hunsdon, said "My Lord, I have too much love for my poor people who obtain their bread by the employment of knitting, to give my money to forward an invention that will tend to their ruin, by depriving them of employment, and thus make them beggars. Had Mr. Lee made a machine that would have made silk stockings, I should, I think, have been somewhat justified in granting him a patent for that monopoly, which would have affected only a small number of my subjects; but to enjoy the exclusive privilege of making stockings for the whole of my subjects is too important to be granted to any individual."

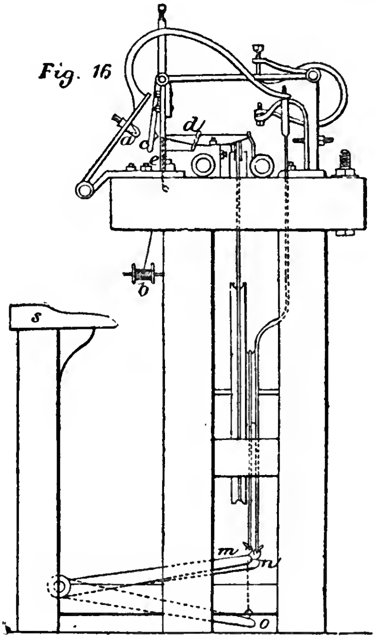
It was evident that the Queen was disappointed with the first products of Lee's invention, but he did not lose the hint concerning the silk stockings. At last, in 1598, he succeeded in making a machine by which he made a pair, and he presented them to the Queen. But it added nothing to his advantage, and he obtained no patent. Other misfortunes fell upon him. Lord Hunsdon died, upon whom he had hitherto depended. He was neglected and fell into a deep melancholy. Some time afterwards he was invited over to France, by the minister of Henry IV., and he went, taking with him his machines. Before he could make arrangements for establishing his new business the king was assassinated. Lee thereby lost all hope, and died in Paris in 1610. During his illness, Mr. James Lee, a brother of William, who was at that time at Rouen, where it was intended to carry on the manufacture, went to Paris, but he found on his arrival that his brother was dead and buried. On his return to Rouen he, with seven of the workmen who had gone with them from England, returned to London, taking with them the machines they had brought. These machines were set up in Old-Street Square, and became the foundation of the London Hosiery Manufacture. Thus, the business narrowly escaped being introduced into France, but was fortunately brought back in time to prevent it. The machines were sold, and Mr. James Lee went to Nottingham, for the purpose of making more. He found out one of his brother's old apprentices, named Aston, who was at the time in business as a miller. They joined in partnership, and began making new frames in 1620. It appeared that Aston had made an important improvement in the machine by dispensing with a set of "sinkers," and this was perhaps the first and probably the best improvement that the machine in its simple form has ever received.

In 1621, the Venetian ambassador in London engaged one of James Lee's apprentices to go to Venice and establish the business there, and James Lee was paid 500*l*. for releasing his apprentice, and providing a machine for him to take with him. But the enterprise failed altogether, for although the Venetian smiths were excellent workmen, they were not equal at that time to the task of making or repairing a stocking frame.

From this period the business rapidly extended, and in 1657 the Company of Stocking Weavers, or "Frame Work Knitters," obtained their charter. London, Godalming, and Nottinghamshire were the chief seats of the trade. For a long time disputes were of frequent occurrence, owing to the custom of taking great numbers of apprentices and learners, which gave rise to competition of a very severe and impoverishing nature. Various attempts were made to improve the condition of the trade, and to prevent it being carried abroad, but with little or no effect. Some slight improvements had been made in the construction of the machine, from the time of Aston's, but it was not before the middle of the next century that various additions were made to the frame by means of which considerable changes were made in the fabrics produced.

An ordinary stocking loom is shown in Fig. 16, which represents an end view of the machine. The working parts are supported on a framework of wood, opposite to which is placed a seat *S*, for the workman. The thread is supplied to the needles, or hooks *e*, from the bobbin *b*. The handles of the frame are shown at *c*; the presser bar to close the hooks at *a*, which is pressed by means of the treadle

Fig. 16



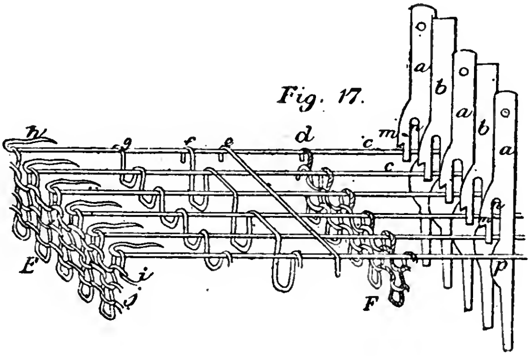
n. The treadles *m* and *o*, are for "drawing the jacks," and are attached to a cord passing round the smaller of the two pulleys fixed upon a shaft in front of the weaver, as seen in the sketch. The cord used for drawing the jacks passes round the larger pulley, so that the treadles can draw the required length of cord.

The action of the machine will be readily understood by referring to the diagram Fig. 17. In this sketch the needles, or hooks, are drawn considerably longer than used in the machine, in order to give space to show each separate operation required for the formation of a row of loops. Only six hooks are shown, and between each will be seen the thin curved plates or "sinkers" *a*, *b*.

Each of these sinkers has an "arch" or hook *n*, and a projection *p*, also a "nib" shaped like a saw cut formed upon it. Every alternate sinker *b*, *b*, is fixed to a bar, and they can be depressed between the needles *c*, *c*. All the sinkers can be depressed together or be drawn forwards towards the hooks *h*. The sinkers, marked *a*, *a*, are each separately fixed to the end of a lever or "jack," consequently they are called the jack sinkers, and they can be depressed separately.

Let it be supposed that a portion of work has been woven, as shown at *d* and *F*, and it is required to add another row or line of loops to it: Then the first operation of the weaver will be to draw the thread over the hooks as at *e*. But when this is done the sinkers *a*, *b*, *a*, *b*, are shifted so that the cloth *d*, *F* is placed beneath the arches *n*, *n*, and not in the position shown in the sketch, which is

Fig. 17.



drawn so merely to prevent confusion. Therefore the thread *e*, really passes under the nibs *m*.

The action of the machine is as follows:—After the thread is laid as shown at *e*, the jack sinkers *a*, *a* are depressed—say an inch deep. By that means the thread will be forced down between the needles as shown at *f*. Then by again raising the jack sinkers and afterwards depressing *all the sinkers together*, *a*, *b*, *a*, *b*, the thread will be sunk as shown at *g*, but of course to only half the depth of the sinkings at *f*. Then by advancing the sinkers *a*, *b*, *a*, *b*, the thread *g* is pushed under the hooks *h*, and the presser bar *a*, Fig. 16, is now pressed down upon them, which has the effect of closing the opening at the point of the hooks. It will now be evident that by advancing the fabric *d*, *F*, by means of the curved part *p* of the sinkers *a*, *b*, it can be *pushed over the ends of the hooks* and thereby passed over the loops *g*. Thus *the loops* g *will form the top row of loops,* and by means of the arch or hook on the sinkers the work *E* can be drawn back to the position *F*, and the process be repeated. It may be mentioned that the points of the hooks are pressed into a hollow or groove made in the needles, so as to allow the web to slide freely over them.

It will be noticed that in sinking the thread as at *f*, the sinkers *b*, *b* must be sunk only one at a time, otherwise the thread could not be depressed as shown. To do this the cord from the larger pulley draws backwards and forwards a sliding wedge or "slur," which raises the opposite ends of the jacks as it passes beneath and consequently depresses the sinkers at the other end. By this means the thread is sunk between the needles in consecutive order from side to side of the machine. This operation was done by William Lee by means of a separate set of sinkers, but by attaching each alternate sinker to a series of levers, the special set, as provided by Lee, was dispensed with. This was the improvement made by Aston, who joined James Lee in the business in 1620.

It is the action of the "slur" upon the jacks and sinkers that causes the peculiar grating noise so well known in connexion with stocking weaving.

The thread is used without breakage in a continuous length, and is passed by hand from side to side of the machine. But it will be evident, as in ordinary weaving, that the thread may be changed for one of a different colour or texture, or various threads may be used alternately, and thereby vary the appearance of the work. The width can also be varied according to the distance the thread is carried over the needles, and thus the shape of the stocking web is made before being sewn or looped together. The tops and heels of stockings as well as wristbands are made by transferring the web to another machine adapted for it, for looped work can be easily transferred and joined to other work by simply forcing the web upon the hooks and proceeding with the loops as above described.

It may be easily seen that by means of a pin any of the loops may be removed from its hook and transferred to the adjoining hook or to one further off still, and yet at the formation of the next series or row of loops all would be bound together. By means of a pin or point, called a "tickler" needle, fixed in a small handle, numerous variations can be made in this way and patterns be formed.

Various numbers and different arrangements of tickler points may be fixed into a movable bar placed opposite the hooks, and by their means numerous effects can be produced, such as ribs, twills, &c. Thus in Fig. 18 a bar containing the same number of tickler needles as hooks has been used. It has been inserted under every loop and by raising (as shown at *d*, *d* and *i*, Fig. 22), and then "shogging" or moving the loop sideways to the left hand; and placing the loops so raised on the adjoining hook, has produced the effect shown at *a*, *a*, Fig. 18, where it will be seen that each loop now covers two hooks, and not one only as shown at *a*, *a*, Fig. 19, before the ticklers were used. Fig. 20 shows the hooks *a*, about half full size, with a section of the slide bar *l*, containing the tickler needles *r*, in the act of moving a loop, and at the same time enclosing a separate thread, shown in section at *i*, also seen in front view at *i*, *i*, Fig. 19.

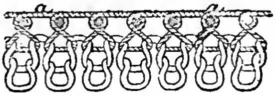
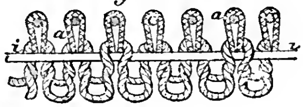


Fig. 18.

Fig. 19.



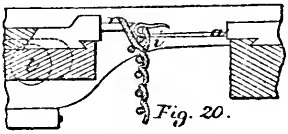


Fig. 20.

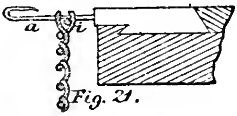


Fig. 21.

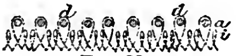


Fig. 22.

In this case the thread so enclosed may be an elastic or other cord, and thereby produce an elastic or a stronger material. Fig. 21 shows in section the cord after it has been inserted at *i* on the hook *a*.

Not only can tickler points be used, but different arrangements of hooks can be inserted, and the loops transferred in a similar manner. Thus a ribbed or striped appearance can be produced; for it will be observed in knitted work that the back of the web is different in appearance to the front. Therefore by reversing the loops from one, two, or more hooks, in any order desired, a series of narrow or wide ribs can be made, as in ribbed stockings.

This plan was the first important modification of the stocking frame, and was made in 1758, when Mr. Jedidiah Strutt added to the frame an apparatus by means of which ribbed goods could be made. The contrivance was called the "Derby rib machine." The advantages derived from this invention were so great that the attention of many ingenious men was directed to it, with a view to still further improvements. Numerous inventions were the result, and they met with more or less success. One of the most important of them was that patented by Morris and Betts in 1764, "For making by a machine fixed to a stocking frame eyelet holes or net work, having an additional row of frame tickler needles."

This invention, although patented by Morris and Betts, was the work of one Butterworth, a stocking weaver at Mansfield, who having devised the plan had to reveal it to Betts, a smith, for the purpose of getting the working parts made; Butterworth was unable to find money for the patent, so Betts obtained it from one Shaw, and in conjunction with T. and J. Morris took out a patent in their joint names. When the three were in London, Betts sold the entire interest in the patent to Morris, so that not only Butterworth was robbed of his invention but Shaw also of his money to pay for the patent.

The history of many inventions during this period of the progress of the manufacturing arts is unfortunately disgraced with conduct of this kind, and even such men as Arkwright did not hesitate to use the inventions of others and claim them as their own. Not only were inventions pirated or infringed in the most shameless manner, but in some cases the inventors were deliberately ruined in various ways, so that they were unable to defend their claims. In one instance, it is related, that in order to obtain possession of a new invention a press-gang was actually sent from London to seize the inventor, and he only escaped through the timely information given him by a magistrate's clerk who knew of the proceeding.

In 1769 the first figured lace-web was made by Mr. Robert Frost on a frame arranged by Thomas Taylor of Nottingham. This led to further improvements and a Mr. Broadhurst of Nottingham improved Frost's machine by reversing its action. In 1771, Marsh and Horton took out a patent for knitted or knotted hosiery, which was further improved upon by Horton in 1776. He aimed at and succeeded in knotting every loop of the web, thus making an elastic and sound fabric that would not run when the thread was broken.

A most important and curious modification of the stocking frame was made in 1775, by a Mr. Crane of Edmonton, which has since given rise to numerous improvements and adaptations for the production of both useful and fancy articles. The invention consisted in the application of a warp to the stocking frame. Each warp thread was threaded through an eye made in the end of a guide pin, and there were as many warp threads and guide pins as hooks in the stocking frame. There was also a contrivance to plait or loop each separate warp thread, in a similar manner to chain-stitch, or the way children plait a single string. But this operation of itself would merely plait each string, and the result would be so many separate plaited threads.

Now, by the movement of the guides to the right or left, the loops on each string were joined or connected with the loops on the adjoining threads, and by various movements a great variety of work could be produced, although the web has not the advantage of being elastic.

In the various modifications of the stocking frame, for the purpose of producing figured work, numerous plans were adopted, either by moving by hand or arranging in various ways tickler needles for the purpose, and notching the presser bars to act upon certain hooks, &c. But it occurred in 1790 to a framework knitter, William Dawson, of Leicester, that the edge of a wheel might be notched in such a manner that when rolled over the parts controlling the figure it would act upon them accordingly, and produce a similar effect as the use of pegs in a barrel organ. These wheels are admirably adapted for circular machines, and are still known as "Dawson's wheels." This talented man produced "a machine for making all kinds of hosiery," which was patented in 1791, and on the expiration of the patent he applied for an extension of it, but being refused he destroyed himself.

The numerous modifications of the stocking frame that were made during the latter part of the last century and the beginning of the present, led to the invention of the bobbin-net machine by Mr. Heathcoat, and the Levers Lace Frame described in Chapters xxxii. and xxxiii.

In the year 1816 Mr. Brunel (afterwards Sir M. I. Brunel) obtained a patent for a circular knitting machine, which he termed "The Tricoteur." The machine consisted in placing the needles on the external rim of a frame or ring, which is suspended and fixed to a spindle, so that as the fabric is knitted in the form of a tube it can be removed from below the machine. The needles and other working parts of the machine operate in exactly the same manner as in the ordinary knitting-frame, excepting that the thread is supplied by one or more feeders revolving round the frame; and a small wheel which travels with the thread operates upon the needles as it revolves round the fixed wheel to which the needles are attached.

The machine could be made of any diameter, even large enough for "the largest carpets," and several sets of wheels, with a bobbin to supply the thread, &c., as before mentioned, may be applied to work at one and the same time, so that an expeditious and uninterrupted working could be carried on. The instrument could be put in motion, says Mr. Brunel, "by hand or by machinery connected with it;" and at the present time the principle of applying a circular action to the knitting-frame is in very extensive use, from its being so well adapted to be worked by power.

In Lee's first machine it is said that there were only twelve needles or hooks, occupying a space of eight to an inch. Now they are made to contain as many as thirty and upwards per inch, and of various sizes.

By hand-knitting about 100 loops may be formed in a minute by a skilful knitter; but Lee succeeded in producing 1500 loops in that time. Circular machines have been made to produce nearly 300,000 loops per minute, or equal to 1200 square yards of webbing per week.

Sir M. I. Brunel was born at Haqueville, Normandy, in 1769. He entered the French navy, but during the Revolution he, being a Royalist, emigrated to the United States. In 1799 he came to England, where he constructed the well-known Block-making machinery at Portsmouth, for which the Government awarded him 16,000*l.* Numerous other inventions were carried out by him, including nail-making machinery, veneer cutting, shoemaking machines, &c. Amongst the various engineering works upon which he was engaged mention of the Thames Tunnel is sufficient to show his great ability and versatile genius. He died in 1849, aged eighty.

Stocking knitting, similar to that done on the common frame, is now extensively worked by power. The machines are constructed so as to comprise about six ordinary frames in one; consequently, one workman can produce an equivalent amount of work. During the introduction of these machines a difficulty was found in supplying the thread to the hooks at an even tension, which is an important matter. This was at last overcome by passing the thread through two eyes, and suspending a small wire ring, of any required weight, on the thread between the eyes. By this means *the slack was always taken up*, and an equal tension given at all times to the thread, and at once did away with a great amount of complicated and expensive contrivances. See also the doubling-frame, page 392.

In the account of the introduction of the Jacquard machine, page

145, mention is made of Jacquard's attempt to produce a net-making machine, in order to compete for a premium offered by a society in England. It appears that the Society of Arts (no doubt the Society Jacquard alluded to) awarded a premium of fifty guineas, in 1795, to a Mr. J. W. Boswell for the invention of a machine for that purpose, in which loops were made in a similar manner to those made by the stocking frame, and a binding thread was, by means of a wire hook, drawn through them and a true knot was formed. It does not appear that any use was made of this invention by Mr. Boswell; but a similar system was introduced in Scotland and extensively used, as will be seen from the following account given by Mr. Brenmer.

James Paterson, a cooper at Musselburgh, being connected with fishing and conversant with the making of nets, patented a machine in 1820, and established a factory for making nets in Musselburgh. He had been in the army for many years, but leaving it after Waterloo he devoted his time to carrying out the idea he had long entertained of being able to make nets by machinery, and in which he ultimately succeeded.

In 1839 Mr. Paterson had eighteen looms at work; and about that time his manager, Mr. Low, succeeded in making an improvement by producing the knot similar to that formed in hand-made nets.

In 1849 Messrs. J. and W. Stuart acquired Mr. Paterson's works and patent-right, and they have further improved the machine so as to make nets with much smaller meshes.

Each loom requires the space of three or four common power-looms, but resembles the ordinary knitting frame, some portions being identical in shape and name, having hooks, needles, and sinkers, one each being required for the making of every knot. They are from six to eight feet long by six high. There are about 600 looms in Scotland. Cotton twine is used for machine-made nets, and is found to last for nine or ten years, or nearly twice as durable as hemp-made nets.

The mode of working the loom is as follows:—"The operative moves a lever which draws the last completed row of meshes off the sinkers, and transfers them to the hooks. Another lever is moved and the meshes are caught by the levers. The effect of these changes, and the movement of the other parts of the machine, is to twist the lower part of each mesh into a loose knot. The foot of the operative touches another lever and a steel wire is thrust across the machine through all the knots. There is a hook at the end of this wire—or shuttle as it is called—into which the end of a piece of twine is fixed. The wire is then withdrawn, and as it goes takes the twine along with it.

"Now the sinkers play their part. They consist of thin slips of brass, having a hook or notch formed on the upper end, and are situated between the needles. When the twine has been drawn across through the loops of the meshes the sinkers are released in succession, and as they descend each draws down the cross thread into a loop sufficient to form two sides of a mesh, the other two being formed by the same parts of the previous row. One or two movements more remove the knots off the needles and draw them firmly, thus completing the operation.

"In forming each row of meshes the worker has to press upon half a dozen levers in succession, and pass from one end of the machine to the other."

CHAPTER XXXV.

SUBSTANCES USED FOR WEAVING—COTTON—FLAX—WOOL—HAIR—JUTE—SILK—PROCESS OF SPINNING—SILK CULTURE—SHODDY—SELECTING DIFFERENT FIBRES FROM WASTE FABRICS—DRESSING MACHINE—WILLIAM RADCLIFFE—SIZING MACHINES, ETC.

The most important substance at present used for the purpose of weaving is cotton. It is not only used separately, but is often combined with flax, wool, silk, and other fibres. Sometimes they are mixed and spun together into a thread, but in ordinary cases they are spun separately—the cotton being used for warp and other materials used for weft. Formerly, to almost within a century ago, cotton was used only as weft, the warp being of linen.

The cotton plant is a native of India, where its manufacture into articles of clothing was carried on long before any allusion to it occurs in history. It was, also, cultivated and used to a great extent by the Egyptians and other ancient nations. England is said to have been the last nation in Europe to adopt its use, although it was applied here for making candlewicks before the year 1298.

In consequence of the extraordinary advancement made in cotton machinery the demand for cotton wool has been proportionately extended, and various countries are extensively employed in its growth. At the present time the Southern States of America not only produce it in the largest quantities, but the best in quality.

The value of the unmanufactured and manufactured cotton imported and exported from the United Kingdom probably exceeds all other textile materials and manufactures combined, as may be seen by referring to the Tables in the Appendix. Its importance as an article of general use and adapted for clothing purposes far exceeds all other known substances.

The vast extent of the cotton manufacture now carried on in various countries, and the quantity of cotton wool used therein, are shown in following tables as given by Messrs. Ellison and Co., in their "Annual Review," the best authority on such matters of the cotton trade, for the season 1876—1877, respecting the total amount of cotton consumed and the number of spindles employed. The amount per spindle depends upon the thickness of the yarn spun.

	No. of spindles.	lbs. per spindle.	Total lbs.
Great Britain .	. 39,500,000	33	1,303,500,000
Continent .	. 19,500,000	53	1,033,500,000
Total Europe .	. 59,000,000	40	2,337,000,000
United States .	. 10,000,000	63	630,000,000
Grand Total .	. 69,000,000	43	2,967,000,000

Cotton Mills of India.

1,231,000 spindles; 10 to 11,000 looms; 75lbs. per spindle.

	Spindles.	lbs.	Cotton consumed. Bales, 390lbs.
1861 . .	338,000	25,350,000	65,000
1877 . .	1,231,000	92,325,000	237,000

Messrs. Ellison and Co. estimate the probable import of cotton into Europe 1877—1878 as follows:—

American	1,314,000,000
East Indian	472,500,000
Egyptian	270,450,000
Brazillian	65,600,000
Sundry Mediterranean . .	35,000,000
Peru, West Indies, &c. . .	18,450,000
Total lbs. . . .	2,176,000,000

The average consumption of cotton and the number of spindles employed on the Continent at the same period is estimated at:—

	Spindles.	lbs. per spindle.	Total lbs
Russia and Poland .	2,500,000	65	162,500,000
Sweden and Norway	310,000	80	24,864,000
Germany . .	4,700,000	55	258,500,000
Austria . . .	1,558,000	67	104,386,000
Switzerland . .	1,850,000	25	48,250,000
Holland . . .	230,000	60	13,800,000
Belgium . . .	800,000	60	48,000,000
France . . .	5,000,000	48	240,000,000
Spain . . .	1,775,000	48	85,200,000
Italy . . .	880,000	67	58,960,000
Total . .	19,603,000	53.2	1,044,460,000

The approximate value of cotton factories is generally estimated at 1*l.* per spindle; thus a factory containing 80,000 spindles would represent in round numbers 80,000*l.*

One acre of ground will produce 100 lbs. of cotton, and this amount when spun into yarn can be woven by one power-loom weaver in about a fortnight.

Cotton yarn is made up into hanks of 840 yards each, and the designation or No. of the yarn is named from the number of these hanks that go to make up a pound.

At the beginning of the present century No. 150 was considered to be the utmost degree of fineness that cotton could be spun into, and one pound of it would extend a distance of seventy-one miles.

The finest yarn ever spun in the East does not exceed No. 400, but in England as fine as No. 600 is spun for useful purposes; and at the Great Exhibition, 1851, Messrs. Houldsworth exhibited an experimental specimen of the extraordinary fineness of No. 2150. A single pound of this yarn would reach 1026 miles; but for practical purposes it would be useless. Mr. Houldsworth has ascertained that in No. 2000 there are only four fibres of cotton that compose the thread, which is perhaps the utmost limit of their power to cohere together. No higher than No. 800 could be made into a hank.

No. 540 single and 670 double are the finest that have ever been woven, the former producing the most beautiful muslin ever made.

In the reports of the jury on the linen manufacture (Class 14), Great Exhibition, 1851, it is stated that—

"The specimens from Ireland are also very creditable; that spun by Jane Magill, eighty-four years of age, being the finest (760 leas), and that by Ann Harvey (about 600 leas) being the most perfect in quality and spinning." They were awarded 10*l.* each.

A "lea," or cut, contains 300 yards, and ten leas, or 3000 yards, equals one hank. 760 leas would amount to nearly 130 miles per lb.

The old process of spinning the thread from cotton by the distaff and spindle, was first to pick and clean it from dirt and impurities. It was then brushed or carded with coarse wire brushes. The carding was done by hand-cards about twelve inches long and five inches wide, the carder holding one in each hand. The cotton, after being picked and cleaned, was spread upon one of these cards and brushed, scraped, or combed with the other, until the fibres of the cotton were all disposed in one direction. If was then taken off in soft fleecy rolls about twelve inches long and three-quarters of an inch in diameter. These rolls, called cardings, were converted into a coarse thread or roving by twisting one end to the spindle of a hand-wheel, something similar to that shown in Fig. 35, by turning the wheel, which moved the spindle, with the right hand, and at the same time drawing out the carding horizontally with the left. The motion thus communicated to the carding twisted it spirally; when twisted it was wound upon the spindle; another carding was attached to it, drawn out and twisted: thus was formed a continued coarse thread or roving, the spindle performing two operations, namely, spinning or twisting the thread and winding it up afterwards. The rovings were then taken to the spinner to be converted into weft. The hand-wheel was again used for this purpose, and the rovings were drawn out into fine yarn nearly in the same manner as the cardings were made into rovings.

These two processes were necessary, because the cardings could not otherwise be drawn out fine enough into a level and even thread fit for the loom by one operation only.

By the introduction of cotton machinery during the last century the above-named processes had been closely imitated by automatic means. The carding is done by rotary motion, and the drawing out of the fibres is accomplished by means of rollers, as will be hereafter shown. Within the last thirty years a combing machine has been introduced into the cotton manufacture, by means of which longer fibres can be worked, which could not be done by carding, and much finer yarn thereby produced. This invention was made by M. Heilmann, of Mulhouse, in 1846, but he died in 1848, before reaping any advantage from it.

Wool, hair, and flax are, also, materials of the highest importance in the textile manufactures, and within the last fifty years a new material, jute, has been introduced from India and most extensively used. The preparation and spinning of these substances are analogous to the processes adopted in the cotton manufacture, and, in fact, are in many respects modifications of them.

The peculiar property of felting, which makes wool so valuable, arises from the circumstance that each single hair is covered with scales attached at their bases only to the cylindrical part of the hair, and each scale pointing towards the point or tip of the hair. If the hair be bent and examined by the aid of a microscope, the scales will be seen to be detached from the body of the hair except at the base. Now, if two of these hairs be placed reverse ways together—the point of one being at the base of the other—the scales will be found to interlock if the the hairs are drawn in opposite directions, with the scales facing and touching each other.

In all countries except Egypt wool was greatly esteemed. The property of felting more important in short staple wool, and in the merino species the scales number three or four thousand per inch of fibre, but in long and coarse wool about two thousand scales per inch are found.

If a quantity of wool be spread in a layer, and wetted and beaten with a flat piece of wood, the fibres will interlock into each other and form a felted cloth, and by this means boots, coats, hats, &c., can be made; but the oldest remains of woollen clothing have been woven and not felted.

The annual consumption of wool is more than 350,000,000 pounds.

Wool has been spun by hand into remarkably fine yarn, and a Miss Ives, of Spalding, is said to have produced 168,000 yards, or 95½ miles of yarn from a pound of wool, or more than four times finer than ordinary superfine yarn.

Long-staple wools are for cloths called *worsted* goods, and short-staple wools are for woollen goods.

Gold and silver wire, horse-hair, willow shavings, asbestos, and even glass are also used for weaving purposes. The last-named substance was introduced about thirty years ago, but was, notwithstanding its brilliant appearance when woven as damask wall-hangings, soon discarded on account of small broken pieces of fibre flying off and entering the lungs and causing great irritation.

The most beautiful of all materials used for weaving purposes is silk, and it displays to the best advantage the art of the weaver. Its preparatory processes are also the most simple required by any of the textile substances, and as it is desirable to show the process of spinning, upon which in a great measure the beauty and quality of all cloth depends, the throwing of silk is, as in the case of weaving, therefore selected. Automatic spinning machinery was applied to silk long before it was invented for cotton, the former substance being, in consequence of the great length of its filaments, more adapted for the purpose, and the carding and combing processes, excepting for *waste* silk, are not required.

Mention is made of the silk manufacture in England so early as the year 1363, in an Act of Parliament passed in the reign of Edward III., but it was then of very slight importance. In France it was not introduced for more than a century later; but during the 16th century the mulberry-tree was extensively cultivated there, and the manufacture of silk was encouraged to such an extent that titles of nobility were conferred upon some manufacturers who had persevered and had been successful in the business. James I. of England observed that the French were deriving great benefit from this comparatively new manufacture, so he determined to encourage the trade in England. For this purpose he sent letters to all parts of the country recommending the people to cultivate the mulberry-tree, and it became fashionable to do so. Thus it is related of Shakespeare, Milton, and others having planted trees of that description. The king, also, by a like proceeding requested his subjects in the American colonies to cultivate the mulberry-tree instead of that "detested weed" tobacco. He encouraged Mr. Burlamach, a London merchant, to introduce throwsters, weavers, and dyers from the continent, and in 1629 they became of such importance that the throwsters formed themselves into a company under the name of "The Master, Wardens, Assistants, and Commonalty of Silk Throwers." In 1661 they are said to have increased to such an extent in London that 40,000 men, women, and children were employed in the business. But this statement, although mentioned in the preamble of an Act of Parliament, is probably very far from being correct.

Although the cultivation of the mulberry-tree was encouraged, it does not appear, from that time to the present, that the production of silk has ever been in England attended with any degree of success. The raw silk, therefore, upon which the manufacture depends, is procured from countries more favourable for its production, and large quantities are imported from Italy, India, China, and Japan. Before silk throwing became well understood in England the silk imported, at that time from Italy, came already thrown or spun. At first the English throwster could only spin "tram," or the most simple process of spinning as required for weft. The "organzine" used for the warp was for a long time afterwards imported ready thrown.

In 1702 a gentleman named Crotchet thought he saw a good opening for profitable speculation ; he, therefore, erected a small silk mill at Derby, but he did not succeed, and he became insolvent. Some time afterwards Mr. John Lombe, who was a good draughtsman, went to Italy to obtain the secret of the process, and he succeeded in doing so by corrupting the workpeople at one of the Italian mills. His plans were discovered and he had great difficulty in making his escape.

On arriving in England he fixed upon Derby where to commence the business, and rented from the Corporation of that town a small island formed by the river Derwent, where he built a new mill adjoining the one lately used by Mr. Crotchet. During the building of the mill he obtained the use of the Town Hall, in which he carried on the process under protection of a patent obtained in 1717, with such great success that it is said the new mill was gradually built and filled with machinery from the profits derived from the work done in the Town Hall![1]

In three or four years after he had obtained his patent John Lombe died, when the proprietorship devolved on his brother William, and subsequently to his cousin Thomas, who afterwards became Sir Thomas Lombe, and who obtained 14,000*l.* from the Government in lieu of an extension of the patent. Hutton says that the Lombes had amassed 80,000*l.* before the expiratian of the patent.

One of the conditions the Government exacted for the payment to Sir Thomas was, that he should deposit in the Tower of London—perhaps the only available public place at that time—a complete set of models for the benefit of the public, showing the process used by him. These models, some thirty or forty years ago, were destroyed by order of the then Governor of the Tower! Three or four pieces remain, however, and are to be seen in the Patent Office Museum. They consist of a spindle belonging to the throwing mill, a reel, and a portion of a "sledging-bench," or the rail *p*, Fig 7, page 391.

There is a tradition that John Lombe was followed by a woman from Italy, and that his death was attributed to poison administered by her in revenge for his obtaining, surreptitiously, the secret of the Italian process of throwing.

The Derby silk mill was long afterwards considered a great wonder, although in reality the process was exceedingly simple, for it was in the combination of numerous spindles into each machine that really formed the value of the new introduction. A second mill was shortly afterwards built at Stockport, and from that time Congleton, Macclesfield, and Leek followed the example.

Silk is the production of the silkworm, or bombyx, which is a species of caterpillar, and feeds upon the leaves of the mulberry-tree. During its existence it undergoes three changes, viz. :—the caterpillar, the chrysalis, and the moth. The moth lays from 250 to 400 eggs, and so minute are they that 40,000 of them weigh only one ounce. The eggs are usually hatched by artificial means, to suit the best season for the mulberry-leaf. After the worm is hatched it arrives at its full growth in three or four weeks' time, when it weighs about one-sixth of an ounce, consequently it has increased in bulk about 9000 times in that short period of time.

During its growth it throws off its skin three or four times, according to the species, to allow for its increase in size. When full grown it selects a place amongst the leaves or small branches in which to spin, and in the space of three or four days it completely encases itself in a cell composed of silk filament, which is called the cocoon. The filament consists of two threads of silk, which proceed from two small apertures situated under the jaw of the silkworm, and they are gummed together during the process of spinning or making the cocoon. In this process the silkworm moves with an oscillatory motion, at the same time fastening the thread at every turn to the sides of the cocoon. When

[1] Hutton's History of Derby.

the cocoon is completed and the worm encased, it changes from a caterpillar form to that of a chrysalis, and in that state it remains from fifteen to thirty days, after which time it changes into a moth, when it *pushes* its way through the layers of filament forming the sides of the cocoon and escapes into the open air. In this last state of its existence it lives but three or four days, during which time the female moth lays its eggs and dies.

About two per cent. of the finest cocoons are reserved for the purpose of maturing the moth and obtaining the necessary quantity of eggs, and the remainder are subjected to a sufficient heat to kill the enclosed chrysalis, thereby preventing damage to the cocoon through forcing its way out.

One cocoon will produce from 600 to 1300 yards of silk weighing eight and a-half grains, and 1090 cocoons will yield one pound of silk. Also, twelve to twenty pounds of mulberry leaves produce one pound of cocoons, and 100 cocoons weigh one pound. The whole process of rearing silkworms requires great attention and a variety of artificial means.

Mr. B. F. Cobb,[2] secretary to the Silk Supply Association, in his treatise on silk, draws the following very important and suggestive conclusions relative to the advantages that might be obtained by a more general cultivation of the mulberry-tree:—

"There are in the world ten times as many acres of land available for mulberry cultivation as there are for cotton. An acre of suitable land will grow 500 trees. From each of these when three years old 20 lbs. of leaves can be gathered; from 20 lbs. of leaves 1 lb. of cocoons can be produced.

"The Agricultural Bureau of the United States gives the highest yield of clean cotton per acre to be in Louisiana at 300 lbs., all other states being less. Thus the comparative money values from an acre are—

300 lbs. of cotton	at 1*s.*	equal	15*l.*
500 lbs. of cocoons	,, 1*s.* 6*d.*	,,	37*l.* 10*s.*

Thus showing that a knowledge of sericulture, if more widely spread, would be able to compete in quantity and value with vegetable and all other fibres."

Mr. Cobb also states, that "The value of the cocoons grown in the whole world in 1870 was said to be as follows: France, 4,334,000*l.*; Italy, 11,260,000*l.*; Spain and other European countries, 984,000*l.*; giving a total for Europe of 16,588,000*l.*; China, 17,000,000*l.*; India, 4,800,000*l.*; Japan, 3,200,000*l.*; Persia, 920,000*l.*; other Asiatic states, 2,192,000*l.*; giving a total for Asia of 28,112,000*l.*; Africa, 68,000*l.*; America, 20,000*l.*; making a general total of 44,788,000*l.*"

[2] Published by Stansford.

In Fig. 1 a cocoon is shown with the course of the filament at a, as worked layer after layer by the silkworm as it oscillates its head and attaches the fibre to the sides of the cocoon, until it becomes a compact hollow shell of silk in which the worm is enclosed. At b a portion of the filament is shown magnified, in which the layers of filament are more clearly seen.

The first process in the manufacture of silk is to unwind the fibres from the cocoons. For this purpose a trough of water is used, provided with a stove to keep it sufficiently warm so as to soften the gum on the fibres of silk. The threads from five or six cocoons are wound together to form one thread of silk. In Fig. 3 and Fig. 4 the winding apparatus is shown in elevation and on plan, and the letters refer in both Figures to the same parts. R is a reel revolved rapidly by the cord c and P. The trough is shown at T in which the cocoons are placed. The fibres from five or six cocoons are collected at d and carried over a glass rod a, thence through the eye fixed on the rail s, and finally through the eye of the movable guide g to the reel. Two sets of cocoons are used, and at x the two sets of fibres are twisted several times round each other and divided again as shown. It would seem that this twisting would prevent the threads being carried forward, especially during rapid motion, but it does not do so, for they roll over and are carried on almost as freely as though they were kept separate. The twisting has the effect of consolidating the fibres together, and as the gum immediately

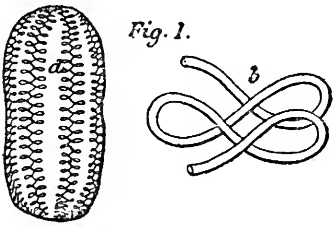


Fig. 1.

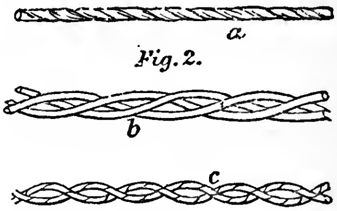


Fig. 2.

becomes hard they form one solid thread. Thus two skeins or hanks are wound upon the reel at once. The twisting, also, has the effect of throwing off any foreign matter that may attach itself to the fibres.

Should any of the cocoons become completely unwound or the filament break, all that is required is to throw with the fingers a fresh filament against those that are being wound so as to strike them before they reach the bar a. The new thread immediately adheres in consequence of the gum, and is carried forward with the others. A number of spare cocoons lie ready at the corner of the trough with their ends hanging over the sides, as shown at e, Fig. 4. To find the end of the filament a small wisp is used, and by merely touching the cocoon with it the filament adheres to it with ease.

One of the bars of the reel is made to slacken so as to allow the silk to be taken off, when the hank is tied in a knot or slip. Bengal silk is tied into small slips about twelve inches long as shown at m, and Italian slips as at n. In this state they are packed in bales and are received by the silk throwster.

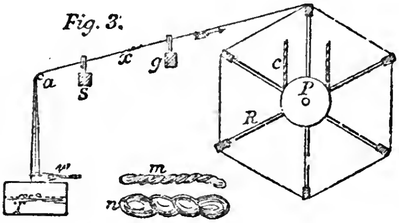
In Fig. 2 a thread of silk is shown twisted at a. It appears as a single thread only, but when the dyer boils off the gum it is found to consist of ten or twelve filaments, namely, if wound from five cocoons it would contain five double, or ten filaments. Therefore, unless these fine threads were twisted before the gum was discharged they would be too fine and flossy to do so afterwards. This kind of thread is called "singles," or single twist, and is generally used for fine warps. When two such twisted threads are spun together, as shown at c, they are still required for warp, but of course they are stronger In this state it is called "organzine," meaning extra spun. For weft the threads, whether two, three, or more, are simply put together and twisted as at *b*, and the three threads would contain altogether thirty or more separate filaments held together merely by a slight twist. This kind is called "tram," which means soft, spongy, or tender thread, and is used for weft.

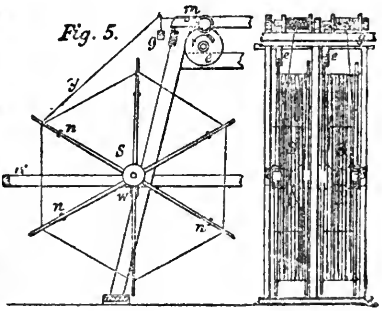
To spin the silk suitable for weaving, the following operations are required for Organzine as shown at *c*, Fig. 2:—1. winding; 2. cleaning; 3. spinning; 4. doubling; 5. spinning; 6. reeling. The first spinning (single thread) having about fifteen turns, and the second (two or more threads) about eight turns per inch in length.

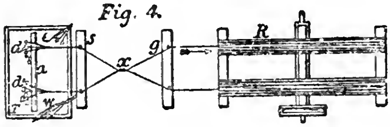
For weft, as shown at *b*, the operations are similar, excepting that No. 3 is omitted, and No. 5 has only about four turns per inch.

In spinning singles, as shown at *a*, the operations are Nos. 1, 2, 3, and 6. In some instances singles are twisted as many as sixty turns per inch as required for weaving fine silk sieves.

Winding is performed by means of a frame containing a number of reels called swifts, upon which the hanks of raw silk are spread. They are made (see *S*, Fig. 5) about three feet in diameter, with a block of wood forming a knave into







which six pairs of thin round sticks, made of lancewood, are inserted. The silk rests upon thin cords tied in loops, which connect each pair of sticks. To make them firm a stretching piece or bridge, of wood, is wedged below the cord as shown at *n n*. The cords and bridges can be easily moved to suit the size of the hank to be unwound or to balance the reel. To prevent the swifts moving too readily a weight, *w*, is hung to the blocks to give friction, so as to throw a slight tension on the thread *y*, in order to wind it more firmly on the bobbin. The bobbins are fixed upon spindles provided with heads or small rollers, and are turned by means of friction wheels *e*. At *m* is a slot into which the spindle can rest when taken out of contact with the friction pulley or wheel.

Now the operative finds "an end" in the slip or hank, and by slightly wetting it, in the mouth, it is caused to adhere to the bobbin. After doing so it is turned round the ring which forms the eye made of wire and inserted in the guide bar *g*, which causes it to be wound regularly upon the bobbin. When the thread breaks or is exhausted a fresh end is found in the slip, and tied with a common knot to the end on the bobbin—thus the bobbin contains one continuous thread. Although it is only a common knot that is used, the mode of making it is peculiar, and by long practice it is done in an exceedingly rapid manner in all the process in silk throwing.

The guide bar is moved so as to wind the thread upon the bobbin in an even and orderly manner, and to do so various differential motions are used for the purpose. A common crank would cause ridges at the sides of the bobbin to be formed, and the threads would be likely to be laid time after time in one place—the disadvantage being that when the thread broke it would be difficult to find it again, and would thereby cause much waste of silk and loss of time. The motions used for guide bars of all sorts are preferably obtained from heart-shaped cams, elliptical wheels, sun and planet motions, or combinations of these motions.

Swift engines or frames generally contain about thirty or forty swifts on each *side*, or double that number for the complete frame. Only one swift, *S*, Fig. 5, is shown, in elevation, but a front view of two is also shown. Children under the guidance of women attend to the winding, and it was to this class of work that Hutton, the historian of Birmingham, was put when a child, and was so ill-treated and lamed for life by the overlooker. The height of the frame is about four feet from the floor, consequently young children had to stand upon small stools—but they tied stools to Hutton's feet! Formerly children were paid according to their height. A factory-book, that belonged to a factory in Congleton about a century ago, contains "A Standard to take Children by," which is a scale of wages regulated in proportion to the height of the child!

From the swifts the bobbins are taken to the cleaners, which process is merely to pass the thread through a slot formed by two blades of steel screwed together so as to regulate their distance apart. The advantage of cleaning is that it ensures the thread being more perfectly wound, and any large knots, "slubs," or other imperfections which will not pass the slot or guage are removed. As in all other silk machines a number of separate sets are fixed in one frame. Fig. 6 shows one set only. The bobbin *a* is unwound, and the thread *n* is passed over the rod *m* and through the guage or cleaner *c*, which is fixed in the guide rail *g*. The thread is wound upon the bobbin *b*, which is turned by the friction-wheel *S* in the usual way. At *d* a front view of the cleaner is shown to a little larger scale.

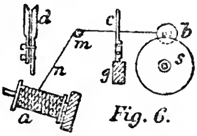


Fig. 6.

In making organzine the next operation is to spin each thread separately. The process of spinning either single or double threads is the same, with the exception that when the single thread is spun for organzine it is twisted in the contrary direction to that when the doubled threads are spun. Each spinning-mill or frame contains several hundred spindles, and they are placed in several tiers one over the other so as to economize space. The spindles are driven by cords passing over a cylinder (one to each tier) and round the small pulley fixed upon the spindle. Before the introduction of cylinders the spindles were arranged in convex curves, and a strap was made to press against them, and by its friction the whole of the spindles in its path were turned without any pulley being placed on the spindle. It was the curious arrangement of the spindles so that great numbers could be used, that was one of the secrets upon which spinning machinery depended. It is only necessary here to show the action of one spindle. Fig. 7 represents one running in a brass bearing *r* and step *d*. On the upper part of the spindle the bobbin containing the thread to be spun is firmly fixed on the conical part of the spindle. Above the bobbin is the "fly," which is a small cylinder of wood fitting loosely on the spindle, and kept from flying off when the spindle revolves by the button or top *g*. Fixed to the cylinder is a wire with an eye at each end, bent round a groove made in the cylinder and curved as shown. The bobbins upon which the thread is received are screwed together upon shafts, but only one is shown at *K*.

Now the thread, whether single or double, is carried from the bobbin *e* and passed through the eye *h'*, thence through the eye *h*, and through the guide eye *i*, and finally to the bobbin. If the bobbin *K* be turned round it will draw the thread off the bobbin *e* without any twist, excepting one for each turn of the flyer; but if the spindle be turned in a proper direction it will twist the thread, and according to the speed with which the bobbin *K* moves or the number of turns, so will be the proportionate amount of twists. The fly travels not only as fast as the spindle, but as much faster in proportion as the thread is unwound.

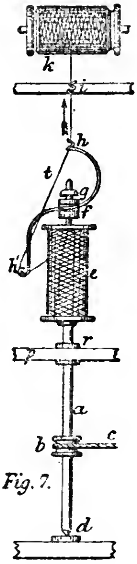


Fig. 7.

Spinning may be, and is frequently, performed without the aid of the fly, for its use is really to keep the thread in its place and deliver it clearly off the bobbin. Still it has another advantage. If the flyer be made heavier or weighted it will consolidate or put more tension on the spun thread. When the thread breaks, the spindle is held by the hand and the threads are tied whilst in motion. In cotton spinning several contrivances to supersede the fly are used, but the effect in all cases is the same and for the same purpose.

In cotton spinning the fly acts upon the reverse principle, namely, it is screwed fast upon the spindle and the bobbin itself is loose. Fig. 9 represents a spindle and fly, in which it will be seen that the thread is wound upon the bobbin on the spindle and not drawn off it. The fly is made with double sides, so as to balance it. In this case the bobbin rests upon the guide rail *S*, and as the rail is moved up and down so the thread is distributed upon the bobbin. Should the thread break, the spindle still travels, but the bobbin remains stationary, therefore it is the pulling of the thread by the fly that draws the bobbin after it, and according to the speed with which the thread *t* is delivered so will be the speed of the bobbin *e*, for it is, as above stated, the drag of the bobbin that winds up the thread.

In the same figure the famous drawing rollers are shown, which were invented by Paul in 1738 and claimed by Arkwright, who patented them in 1775; but his patent was afterwards disputed and upon trial it was annulled. The principle upon which they work is, that the two pairs of rollers *m* and *n* grip the fleecy cotton thread, and as the rollers *n* travel faster than the rollers *m*, so in proportion they draw out and extend the thread with similar effect as in spinning by hand. But there was an important difficulty to be contended with, namely, that after the fleecy yarn had left the rollers, the spindle, in the action of spinning and winding up the yarn, necessarily caused some degree of strain upon it, which, if very fine, it could not withstand. Now Compton overcame this difficulty by his invention of the mule, which still more nearly imitated the method of spinning by hand, for he adopted the simple and important principle of drawing the thread away from the rollers as it was delivered, without strain being put upon it. This was done by causing the spindles to travel backwards and forwards, at the same time spinning and then winding up the thread with the least possible strain. The mule spins the finest threads, but not the strongest.

Before the invention of the doubling frame by Mr. Crawford, who patented it in 1770, the process was done by simply holding between the fingers and thumb of the left hand the threads from two or more bobbins, and winding them altogether upon a bobbin fixed upon the spindle of a common hand wheel, such as is shown at Fig. 35. It is evident that one person could only wind or double threads upon one bobbin at once; but by Mr. Crawford's plan a large number could be arranged in a frame, and one person could attend to from ten to twenty sets.

Fig. 3 is a diagram showing one set of bobbins on Mr. Crawford's principle. The friction pulley *a* is one of a number placed at several inches apart on a shaft *b*. A bobbin is screwed or otherwise fixed upon a spindle which is turned by means of the pulley *a*, the head or small pulley *c* resting upon the friction pulley *a*. Part of the head *c* is of larger diameter, and ratchet teeth are cut into it as shown at *d*. There is a balance lever *p* with its fulcrum at *i*, which when raised as at *p'* comes into contact with the ratchet wheel and stops its motion. At *g* are three (or more as required) small levers having their fulcrums at *k*.

Now, if two or more threads are required to be wound together or "doubled," they are put in a frame as at *e e e*, which shows the ends of three bobbins. The threads from them are carried upwards and over two glass or wire rods *z z*, between which each thread is passed through the eye of one of the small wire levers *g*, there being a separate lever for each thread. The three threads are then carried forward to the guide eye *m*, where they converge, and proceed forward to the bobbin on the spindle, where they are all wound together as one thread. Should any one of the threads break, or any of the bobbins *e e e* become exhausted, the corresponding lever *g* will fall (for it is supported by the thread), and by falling upon the tumbler lever *p* at once stops the bobbin at *d* by raising the opposite end of the lever.

By the use of the Doubler a person can attend, as above stated, a number of sets, and as the threads break the bobbins remain stationary until they are repaired.

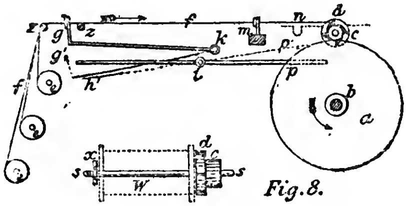


Fig. 8.

This principle of using tumbler levers has been modified in numerous ways, and the weft stop-motions in looms and warping machines are based upon it. In Mr. Crawford's time the friction pulley *a* had V shaped teeth cut in it, and the spindle head had similar teeth also—in fact, forming together a wheel and pinion. They were also used in the winding "engines" or frames (as in the No. 2 process), and owing to the shape of the teeth were called "star-wheels," which name they still retain although they have long since been converted into friction-wheels. Therefore, in Mr. Crawford's contrivance, the spindle head had to be raised out of gear with the star-wheel in order to arrest its motion.

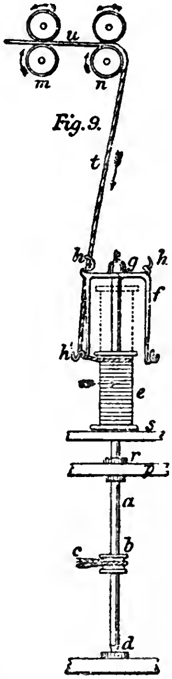
Whilst the threads are being attended to the bobbin and spindle are taken clear away from the friction-wheel and placed in the notches *n*.

An enlarged sketch of the spindle is shown at *W*, upon which the bobbin is represented in dotted lines. In this sketch *c* is the spindle head or friction pulley; *d* is the ratchet wheel, and *x* is a nut to secure the bobbin upon the spindle. The two ends *s s* work in slots in the framework of the machine.

The last process in throwing is to reel the silk off the bobbins and make it into hanks ready for the dyer. As each hank ought to contain an equal length, they are sorted in sizes according to their weight, and numbered to several degrees of fineness. The hanks being packed in neatly formed bundles are then ready for the dyer.

Many attempts have been made to combine two or more processes in throwing into one only. Thus, winding and cleaning, and even doubling and spinning have frequently been tried, under the impression that the spinning would be more satisfactorily done; but the result does not appear to have ever been successful. It is evident that a greater number of processes gives a greater assurance that the thread will be more perfect, and thereby save the weaver a vast amount of labour which ought to be avoided, especially as the threads can be more easily repaired before they are put in the loom.

There are differences in opinion respecting the combination of doubling and spinning at one operation, and in silk throwing it has not been effected in a satisfactory manner. Mr. Cobb states that "When two threads are wound together in a parallel manner on a bobbin, and one is, as is generally the case, finer in size than the other, the number of coils being the same, the finer thread occupying less space will certainly be shorter than the coarser thread, from which it follows that in unwinding and twisting the doubled thread there will be more tension or strain upon the finer and shorter than upon the coarser and longer thread. This evil becomes more manifest in the loom, where considerable strain is applied to the threads; for unless they possess the due resisting power of combination they will have no more strength than single threads, a defect well known to all weavers.



"The cotton doubler overcomes this difficulty to a great extent by doubling and twisting simultaneously, whereby the finer thread has a tendency to wrap itself round the coarser thread, which is invariably the shorter of the two, and can, therefore, the better sustain any excessive strain to which the double thread may be subjected. The cording of threads doubled and twisted together in one operation, is more perfect than when the process is accomplished in two operations."

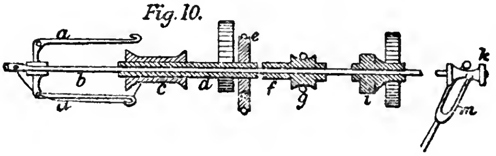
It may be mentioned that in some kinds of silk the gum is so strong that the slips, particularly at the place that has pressed upon the reel when wound from the cocoon, require to be "washed" or, properly speaking, soaked in warm soap and water. By this means the gum is softened and the slips can be unwound.

Spinning is best performed in damp or cool rooms, which from moistening the gum on the silk prevents, in a great measure, its wiry and curly nature. In hot, dry climates this was a great obstacle, and Mr. Lombe alludes to this fact in his patent. He says, "We shall be able to work this fine organzine silk in England at all seasons of the yeare, and even be able to perform the work by daylight, whereas the Italians work it all day long by lamp-light in dark, close, hott rooms without windows." In like manner various substances require to be spun and woven in a damp or wet state.

In a work recently published by Professor Grothe, of Berlin, it is said that the invention of the fly, as shown in Fig. 9, is due to the great painter Leonardo da Vinci, so well known as the painter of "The Last Supper," but of which picture only copies exist. Leonardo was born at Vinci, near Florence, in 1452, and died in 1516 at Fontainebleau. The papers left by this remarkable man have been examined by Dr. Grothe, and they were found to contain many extraordinary inventions, and amongst them is a flying machine, steam gun, boring mill, skew bevil wheels, planing machine, file-cutting machine, cloth-shearing machine, washing machine, chains, pumps, draw bench, and what the Doctor supposes to be a forecast of the Jacquard apparatus. It is also said that he anticipated Galileo, Kepler, and other great men, in several of their discoveries.

Fig. 10 is a copy of the sketch of the fly which Dr. Grothe found

Fig. 10.



among Leonardo's papers. The Doctor states that the earliest description of this invention appeared in a work called "La Machine," by Branca, published in Rome in 1629, or upwards of a century after Leonardo's death. And as the name of the inventor of this valuable contrivance has, as yet, not been otherwise named, the Doctor's conclusions may, in all probability, be correct in reference to Leonardo.

The spindle and fly shown are intended for hand spinning. In the sketch *a, a* represents the flyer; *b*, the spindle; *c*, the spool; *d*, the hollow shaft for driving it; *e*, the pulley by which motion is given to the shaft carrying the spool; *g* represents the pulley for actuating the flyer, which is moved up and down by the fork *m*, for the purpose of distributing the yarn evenly on the spool; *i*, is a bearing for the flyer shaft.

Previous to dyeing silk, the natural gum is "boiled off," and this reduces its weight from about sixteen to twelve ounces. In dyeing it, the weight of the dye stuffs slightly recover the lost weight; but, unfortunately, advantage is taken of this operation by the use of heavy dye stuffs, and in many cases the fibre is almost painted with with them. In "A Practical View of the Silk Trade," by Mr. J. Prout, Macclesfield, 1829, when, referring to this subject, the author says, "The shute is dyed in the gum, and the dyer, instead of returning twelve ounces of silk, returns from sixteen to twenty ounces; the article, when finished, resembling paper for its stiffness, and when made into dresses, frequently cuts at the seams from the hardness of the shute as compared with the warp, while the public are imposed upon by having drugs instead of silk." But what would Mr. Prout say to the practice at the present time, when "the weight is increased for broad silks and ribbons to double the weight, and for fringes four times the weight is often given"? In the Exhibition, 1873, silks were shown which had been weighted to *six times their original weight,* produced by iron, gambia, &c.!

Not only does the weaver suffer from this practice, which appears to be carried to a great extent on the Continent, being scarcely able to weave the material owing to its brittleness, or, as they say, its "rottenness;" but many trades have suffered greatly from its use. The elastic boot-spring trade of Derby appears to have declined greatly thereby, for the manufacturers there have been unable to compete with others who use heavy-weighted silks, and the use of side-springs has been affected considerably by it. In the "Leather Trades Circular and Review," 1877, Mr. J. Dean, a manufacturer of Derby, states that heavy dyes have had much to do with the falling off in the use of elastics. Certain it is that silk dresses, formerly so highly prized, do not at the present time hold much favour with the wearer, and thus the most beautiful textile manufacture is ruined by this wretched means.

Before the gum has been boiled off the silk it is said to be *hard* silk, but when boiled off it becomes *soft* silk—terms very expressive of the actual condition of the fibres. Silk is woven in both these states, but more generally when the gum has been discharged.

In the process of throwing, the various degrees of fineness are ascertained by weighing skeins of a given length separately. In France a skein measures 520 yards, and is weighed in deniers, one denier being equal to ·825 of an English grain. The English method is to weigh skeins of 1000 yards in deniers or in drams.

For the protection of traders in raw silks, there are establishments for ascertaining the actual weight of silk when divested of moisture and substances used in throwing, &c.

In the manufacture of crape the application of heavy or thick dyes or dressing is used, in order to produce its well-known crimpled appearance.

Crape may be woven with any description of twill. The peculiarity of its texture arises from the method of dressing after it is woven, and each manufacturer affects some peculiar process which is kept secret. It is woven with silk in its raw or natural state, or without the gum with which the filaments are covered being dissolved and washed off, or in the state above named as "hard silk." The warp is spun or twisted far greater than in ordinary cases;

and when the threads are made thicker with size or gum, they have a tendency to frizzle, curl, or "créper"—hence the name. Therefore the process consists in extra spinning, sizing, and stoving, and not in any peculiarity in weaving, although imitations of crape called crape-cloths, by weaving a twill to resemble crape, or pressing between crimped rollers, are frequently made.

In 1872 the manufacturers of Lyons, Mr. Cobb states, occupied 120,000 looms, of which 30,000 were in the city, and 90,000 in the neighbouring departments.

These 120,000 looms consume annually 2,200,000 kilogrammes of silk, and produce goods valued at 460 millions of francs, of which 350 millions are exported, and 110 millions consumed in the country.

The most important of these manufactures comprise—

	Millions Francs.
Foulards	50
Crapes	8
Tulles, plain and coloured	14
Velvets, silk and mixtures	30
Satins	25
Taffetas and "Failles," black	165
Ditto, coloured	120
Other plain thin goods	10
Brocades, for dress	8
Ditto, for furniture	10
Sundry mixed tissus	20

For the material of this enormous production France is indebted—

To China, Japan, and Bengal for	40 per cent.
To Italy for	22 „
To Broussa, Persia, and the Levant	8 „
Raised in France	30 „

Waste silk, such as is produced in the throwing process, and from cocoons that are either defective, or too fine to be unwound, has long been spun in a similar manner to cotton wool. To accomplish this the fibres were cut up into short lengths, so that they could be carded. As far back as 1671, a patent was obtained by a Mr. E. Blood, for "A new manufacture being a rich silk shagg, comodious for garmente made of silke waste hetherto of little or no use." And this was probably the first attempt to spin it in a similar manner to wool and cotton. An even and fine thread could scarcely be produced by means of carding, although silk so spun has been in extensive use. But within the last few years Mr. Lister, of Bradford, has succeeded, after an immense expenditure, in adapting combing machinery to this purpose, and the result is of very great importance. In the event of cocoons being more extensively grown and worked up in this manner, instead of the tedious and costly process of winding and throwing, a comparatively new and extensive manufacture will arise.

Rag wool, or shoddy, is now a manufacture of considerable importance. In this business woollen rags are torn up and re-converted into yarn; thereby saving from waste a large amount of valuable material. In 1874 there were 1437 power looms employed in the business, which is carried on at Batley and the surrounding district. It is said to have been first introduced by Mr. Benjamin Law, at Batley, in the year 1813, and machines were erected there, at Howley Mill.

Mr. S. Jubb, in his "History of the Shoddy Trade," states that 25,000 persons were engaged in the business, and the value of the cloth produced at the date he wrote, 1860, amounted to between five and six millions annually. The Government account, 1874, gives the number of persons employed in the mills as 3431, but probably Mr. Jubb includes the whole population dependent upon the trade. Numerous fabrics are made of shoddy, amongst which may be mentioned Druggets, Irish Frieze cloth, Witneys, Pilots, Tweeds, Petershams, Union and Prison cloths, Sealskins, Army goods, Coloured Blankets, and Canadian cloths.

In order to select the fibres of wool from cotton and other vegetable substances, as required for the re-conversion of the wool or hair contained in rags and worn-out fabrics, various methods are adopted. Animal fibre being of much greater value than vegetable, recourse is had to chemical solvents, such as are capable of destroying the less costly material, yet do not affect the more valuable. Thus Mr. J. Stuart, in a patent obtained in 1869, No. 410, says, "In 100 gallons of hot water I dissolve 100 lbs. of the sulphate of alumina of commerce; I then add 50 lbs. of chloride of sodium. When this last-named ingredient is added a re-action takes place. Sulphate of soda is formed, also chloride of aluminium. With this solution I now saturate the material to be treated, which is then placed upon hurdles to drain, after which it is placed in a drying-room, and by means of a steady temperature of 200 deg. F. when the chloride of alumina decomposes, and as the volatile products pass off they act upon the vegetable fibre and rot it, but leave the animal fibre uninjured. The material is then scribbled and the vegetable matter separates in the form of dust."

With respect to silk, nitric acid turns it yellow, and hydrochloric acid is a solvent of it, while it leaves cotton and wool, which have been combined with it, unacted upon for a lengthened period. By this means Mr. B. F. Cobb states that "To detect cotton, hemp, flax, and jute in mixture with wool and silk, boil the sample in an aqueous solution of soda containing ten per cent. of hydrate of soda; wool and silk dissolve, while the vegetable fibres remain unacted upon. The whole is thrown upon a cotton filter, and the undissolved matter is then washed with hot water, and afterwards acidulated with five per cent. of hydrochloric acid, to which, if the residue is black, or dark coloured, a few drops of chlorine water are added. Meantime the original alkaline filtrate can be tested for wool with the acetate of lead. If a white precipitate is formed, which dissolves on stirring, silk alone is present. A black precipitate indicates wool. The nitro-proxide of sodium gives a violet colour, if wool is present. If the tissue is deeply coloured, it may be cut up and steeped for fifteen or twenty minutes in a mixture of two measures of concentrated sulphuric and one of fuming nitric acid. Wool, silk, and colouring matters are destroyed, while the cellulose is converted into gun cotton."

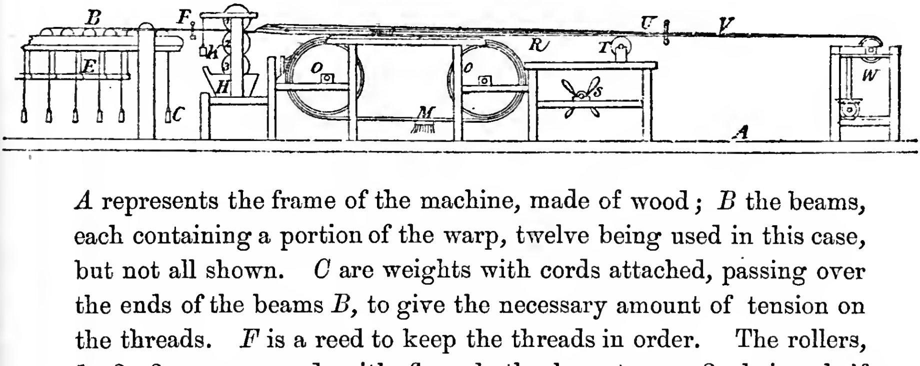
All threads that are composed of short fibres spun together have a more or less rough surface which arises from the ends of the fibres not cohering with the surface of the thread. This is more particularly the case with threads composed of cotton, the fibres of which material vary in length from three quarters of an inch to an inch and a half. The coarse threads are spun from the shortest, and the finest from the longest fibres—simply because the longer the fibre the greater is its power to cohere with others.

Yarn composed of two or more threads spun separately, and afterwards spun all together, naturally has a greater power of cohesion than a thread composed of one strand only. Therefore single twist yarn in particular needs some assistance in order to bind and consolidate the short fibres together, or the thread would scarcely be able to undergo the strain and friction of the process of weaving.

For this purpose the warp is brushed over with some glutinous material, such as paste made of flour, and the operation is known as "dressing."

In Dr. Cartwright's time the warp was dressed in the power loom in the same way as practised by the hand loom weaver, and as only a short length could be done at once it either necessitated a frequent stoppage of the loom for the weaver to attend to it, or otherwise it would require the assistance of another hand to keep on dressing as the weaving progressed. In fact in the early stage of power loom weaving this course was generally adopted. The warp was woven while still wet, for if allowed to dry it would be difficult to break its stickiness.

Now it was perceived by William Radcliffe that this operation of dressing should be effected before the warp was put into the loom, when a great saving of the time and labour of the weaver would be effected. He, therefore, set to himself the task of inventing a machine for performing that operation, and he succeeded in producing the first dressing machine, as represented in the following figure copied from his specification, dated March, 1803, of which the following is a description:—



A represents the frame of the machine, made of wood; *B* the beams, each containing a portion of the warp, twelve being used in this case, but not all shown. *C* are weights with cords attached, passing over the ends of the beams *B*, to give the necessary amount of tension on the threads. *F* is a reed to keep the threads in order. The rollers, 1, 2, 3, are covered with flannel, the lowest one 3, being half immersed in the "Sow," or paste contained in the tub *H*, and supplies the rollers 1, 2 with paste as they revolve. *K* is a weight and lever to press the rollers together. After passing the rollers the warp is opened by rods and dressed by the brushes *M* as they revolve on a strap, passing over the drums *o, o*. *R* are lease rods. *S* is a winnow or fan to dry the warp as it passes over it; *T*, a roller of wood to support the warp in its passage; *U*, a reed to keep the warp distended at a proper width; *V*, lease rods to take the cross, and which are taken away with the warp beam when filled, and other rods inserted; *W*, the warp beam on which the warp is wound. Motion is applied to various parts of the machine by suitable straps and gearing.

The action of the machine consists in uniting the threads contained on twelve rollers, so as to form one warp, and at the same time applying the paste and brushing and drying the threads as they pass to the warp beam in a condition ready for weaving. Thus, if the twelve beams have received 150 threads each, 3600 yards long, at the warping machine, when united they would form a warp containing 1800 threads, and consequently fill twelve beams with 1800 threads 300 yards long.

Mr. Radcliffe wrote a book professedly on the subject of power-loom weaving, but in reality it contains very little concerning it, the bulk of the work being a strange display of one-sided political notions. From his intimate knowledge of the first attempts to introduce the power loom, no one could have been better able to have described them; and as his book was not published till 1828, he must have had opportunities of seeing many things that would have been of interest to know at the present time.

The title of Mr. Radcliffe's work is "Origin of the New System of Manufacture commonly called Power-loom Weaving, and the purposes for which this system was invented and brought into use, fully explained in a narrative containing a candid statement of the strenuous, persevering, and uncompromising endeavours of William Radcliffe. Stockport, 1828."

From it we learn that the author was well descended; his great-great-grandfather, George Radcliffe, Esq., of Mellor Hall, owned nearly all the township of Mellor, and was slain at Stockport in 1644 in a contest with the Roundheads.

Mr. Radcliffe was born in 1761, and brought up as a weaver. At that time cotton yarn was exported, for the looms could not work it up so fast as it was spun, and this to Mr. Radcliffe appeared to be a sin.

The merchants and manufacturers held meetings to get the exportation prohibited, and Radcliffe promised to use his best endeavours to discover means to work up the yarn in his own country, and not to enrich the "foreigners" with it.

His first step was to employ some looms, and divide as much as possible the different processes, similar to the plan adopted by Arkwright, and which in his case led to such great success. Instead of dressing the warp in the loom as was hitherto done, he had it dressed by a separate process, which relieved the weaver of the trouble. Here he discovered that if the sizing or brushing the paste on the warp was done in a contrary direction to the weaving, the slay would not fray the threads, and the warp could be woven dry, and thus avoid the practice of weaving in damp cellars or rooms.

He obtained the services of a young man named Thomas Johnson, who proved himself to be a clever mechanic, and Mr. Radcliffe patented his inventions in Johnson's name, in order that "foreigners" should not find out his plans by seeing his name in a specification, and thereby put them off the track. With the assistance of Johnson and several other mechanics, he not only followed up the perfecting of the dressing frame, but constructed a loom that was long known as the "Dandy Loom." (See page 245.) Before completing these various inventions, many of the contrivances failed or were imperfect, and on one occasion all his men left work, and adjourned to the tavern to discuss the state of things. They concluded that all was lost, and the outlay of 70*l.* per week, which had long been incurred, was gone. They therefore deputed one of their number to tell Mr. Radcliffe their opinion. To this Mr. Radcliffe asked "where the difficulties were, and which was the most serious one?" "If I overcome the worst one," he observed, "will you overcome the rest?" To this offer they agreed, and very shortly afterwards the work was satisfactorily completed. No doubt these men were of great importance to Radcliffe.

Thomas Johnson above mentioned was named Mr. Radcliffe's "conjuror;" Daniel Wild was foreman of mechanics; Samuel Wild, foreman of weavers; and Edward Partington, foreman over all. Mr. Baines states that Johnson received by deed the sum of 50*l.* in consideration of his services.

In 1808, when Dr. Cartwright appealed to Parliament for a remuneration for the expense he had incurred in bringing out the power-loom, witnesses were called and examined before a Committee on the subject. Mr. Joseph Taylor, having been Dr. Cartwright's engineer, proved that the Doctor was the inventor, and Mr. Radcliffe referred to the advantages that might accrue to the cotton trade from the general adoption of Dr. Cartwright's loom. The committee were satisfied with the evidence of these two witnesses, and a grant of 10,000*l.* was allowed to the Doctor.

In a similar case Mr. Radcliffe was not so fortunate, for he himself petitioned Parliament for some recompense for the loss he had sustained in promoting the cotton manufacture, but he met with no reward.

While carrying out the "Dandy" loom, Mr. Horrocks (see page 241) came to see it, and Radcliffe strongly asserts that he carried away his idea of the take-up motion contrived by Thomas Johnson, and claimed it as his own.

Mr. Johnson was also inventor of the first circular or revolving temples.

Mr. Radcliffe ultimately became unfortunate in business. He lived to be eighty-one years old, and was buried in Mellor churchyard in 1842.

The process of "*sizing*" is an extension of the principle of dressing. In sizing, the yarn is not merely coated with paste to allay the loose fibres, but the thread is thoroughly saturated with it. Numerous machines have been introduced since Mr. Radcliffe's time for this purpose, and one in particular has been long in use, called the "Slasher," made by Messrs. Harrison and Sons, of Blackburn.

At the first glance sizing seems to be a matter requiring no very great nicety in its process, for so long as the yarn is well soaked with size, and quickly dried, it may, perhaps, appear all that is necessary. This, however, is not the case, for there are several important conditions that must be observed, but more especially as regards the sizing of fine yarns.

In the first place the yarn must be properly saturated and not merely coated with size, otherwise the surface of the yarn will be rough and the size peel off. To avoid this defect the yarn must be kept immersed a sufficient time, and the heat must be kept up to boiling point, or the air in the yarn will not be expelled so that its place can be taken up with size. The machine should be so arranged that all unnecessary strain arising from the contraction of the yarn during the process, or from its being drawn through the machine should be avoided. It is also found that drying the yarn on the surface of heated cylinders is not so desirable as the system of drying by hot air.

Many of the machines hitherto used for this purpose are evidently not intended to admit of any great degree of adjustment, to enable light and fine materials requiring careful treatment to be as satisfactorily done as those of a coarser description. This object, however, has recently been accomplished by Messrs. Baerlien and Co., of Manchester, who have succeeded in producing a powerful machine which is capable of executing every description of work for which such machines are required.

CHAPTER XXXVI.

SUMMARY AND GENERAL REMARKS.

The process of weaving may be divided into seven distinct classes, under one or more of which every kind of woven cloth can be produced. They are as follows:—

1. Plaiting.
2. Plain Weaving.
3. Figured Weaving.
4. Cross Weaving, or Gauze.
5. Pile, or Velvet Weaving.
6. Knitting, or Looped Work.
7. Lace.

The order in which they are arranged above not only proceeds from the most simple to the most elaborate systems, but it corresponds with the age and progress of the art.

Plaiting appears to have been the process first practised, for short fibres, such as grass, rushes, &c., can be used without the aid of spinning by this means. The earliest remains of any woven fabric yet found have been plaited work, as discovered in the Swiss Lake Dwellings belonging to the Stone Age.

Plain Weaving, even of the most simple kind, can scarcely be practised without the aid of spinning. It is therefore probable that spinning, for the production of cords, ropes, fishing-tackle, &c., may have preceded plain weaving, and evidence that this was the case is again found in the remains of the Lake Dwellings. As to the age or country in which either spinning or plain weaving was first practised, it is unknown.

Figured Weaving is practised either as a handicraft process or the weaver is assisted by the aid of machines. The process of ornamental weaving, as used at the present time in India, is perhaps the same as it has been practised there from the most remote times. It consists in interlacing differently coloured threads of various substances and thicknesses; and this is done by inserting them in the warp as in plain weaving. By this means the effect is produced by the different colours and materials, rather than by the ornamental decussations of the threads, in which the skill of the weaver is shown.

When assisted by mechanical contrivances the art at once assumes a new feature, for by this means, with only one or two colours or varieties of thread, endless effects can be produced on the surface of the cloth.

Whilst India seems to have always depended on their simple looms and handicraft processes, China appears to have shown more reliance on their mechanical ability; and there is reason to believe that not only the draw loom but diaper weaving emanated from that country.

When the silk manufacture was brought into Western Asia from China doubtless the draw loom was introduced also. In this way it was established at Damascus, and the rich silken cloths produced were named therefrom. Neither the ancient Egyptians, nor the Greeks and Romans, appear to have had any looms of a similar nature to the draw loom, for their skill rather depended upon the manufacture of fine linens, and did not resemble the ornamental works of India or China.

It is very probable that the draw loom and diaper weaving were introduced into Europe in the early part of the present era, for diaper weaving was known in England in the 11th century, although the draw loom was not used before the middle of the 16th century.

The *draw-loom* system of weaving consists in the use of two harnesses, which have each a separate control over the warp threads. One portion is required for drawing up the threads in large numbers so as to form the outline of the figure, whilst the other part of the harness is for weaving the separate threads in detail.

In the Chinese draw looms, still used by them, the draw boy, or weaver's assistant, stands on the top of the loom and draws up the clusters of threads in consecutive order (which have been previously arranged to form the pattern), whilst the weaver works the treadles to form the smaller intersections.

This plan was practised in Europe until 1604, when M. Simblot, in

France, connected a separate series of cords called the "*simple*" (probably a corruption of his name), so that the draw boy could draw the cords when standing at the side of the loom instead of at the top.

The next improvement was to dispense, when possible, with the draw boy's services, and for that purpose Joseph Mason, in 1687, obtained a patent for a "*draw-boy engine.*" Since Mason's time this class of machine has undergone numerous modifications, and was in general use until the Jacquard machine, or "new French draw loom," supplanted it about forty years ago. The Jacquard was so named because it could be used in every way similar to the draw loom.

Diaper weaving consists in using two or more sets of treadles, each set being attached to the same headles, but in a different order. By this means if one set of the treadles were used, striped cloth of two different twills, satin or other ground, could be produced. By using the other set of treadles another series of stripes could be woven. Now, by simply alternating the stripes a square or check may be woven, and this method is the system known as diaper weaving.

When treadles only were used and several sets were required, they became not only inconvenient to use but were therefore limited in number. A contrivance was consequently adopted, about a century ago, to use one set of treadles only, and to bring the different changes into operation by other means. This effect was produced by means of slack cords. Let a number of bells be attached to one bell-pull in such a manner that all the cords or wires are slack, and upon drawing the handle none of the bells will be rung. Now, if by means of of a cord, or other contrivance, any of the connecting wires be drawn aside it will be equivalent to making tight the slackness of the wire, and then the particular bell whose cord has been so acted upon can be rung by drawing the bell-pull. Thus a series of cords can be arranged in the same manner as completely as one cord.

It will be evident that for the production of large patterns or designs, great complication in the tying-up of the harness of the loom was unavoidable; and it is probable that attempts had been made to remedy it, and at last it was successfully accomplished.

In 1725 M. Bonchon, a Frenchman, tried an experiment to throw in or out of gear the "simple" cords of the draw loom by means of a paper band operating upon needles, the pattern being arranged by having holes punched in the paper. Here was the foundation of the Jacquard principle, which nearly a century later was brought into operation. In 1745 Vaucanson improved upon Bonchon's contrivance, and arranged a machine with perforated paper on the top of the loom, in the position occupied by the draw boy in the old looms. A cylinder or prism and cards had already, in 1728, been tried by M. Falcon, but from some cause or other the plan was not brought into practice until taken up by Jacquard about the commencement of the present century. Since that time it has proved to be one of the most important contrivances ever introduced, and is now applied to all kinds of textile figure-producing machinery.

Since the introduction of the power loom and the lace frame, the Jacquard machine has undergone various modifications in order to make it more effectual and rapid in its action, as well as to apply it to purposes not originally thought of. Thus it is made to govern the action of the shuttle-boxes in figured weaving, and in the slide-bars of the lace frame, &c. As applied to the power loom it is singularly applicable, for had it not been for this contrivance figured weaving would have been almost impossible to effect, to any great extent, by other means.

But the nature of the motion of the ordinary Jacquard machine is of the worst and slowest kind used in weaving; therefore numerous attempts have been made to improve it and make it more rapid. This has been effected by using two griffes, so that the suspended wires and weights can rise and fall simultaneously, and thereby perform the work in about half the time.

In the Levers Lace Frame this class of Jacquard is of most ingenious construction. In some looms two cylinders are used, one to raise those headles that are required to be raised and the other to sink those that are to be sunk. But the system now being gradually carried out is to combine two griffes, or sets of lifting-bars, so that the rising and falling motion is made perfect and carried out in one action only.

Gauze and Velvet Weaving seem to have been first practised in the early part of the present era. The former is said to take its name from Gaza in Asia, whilst the latter is supposed to be named from Velutio, in Italy. But gauze weaving is probably of Chinese origin.

Gauze, or Cross Weaving, consists in crossing the warp threads as follows. Let the following numbers represent, in section, a series of warp threads, as in plain weaving, where every other thread is alternately raised for passing the shuttle, thus, 1 2 1 2 1 2. Then if a thread be dropped down between any of the threads 1 2, and after passing under the thread 2 let it be looped round the thread 1. Now, by drawing the looped thread upwards it will carry with it the warp thread 1, which will be drawn under the thread 2, and on the next passage of the shuttle it will be bound in the cloth *out of its normal position*, and in fact, it will be *crossed* under the thread 2. But when the loop is slackened again the thread will return to its normal position, when the plain, or other weaving, can be proceeded with. The looped threads may be used in any number or order, for they are merely an addition to the ordinary harness, and used for the purpose of drawing the warp threads under and across the paths of the other threads. See also *Kutar* weaving, page 311.

Velvet Weaving consists in the production of a brush-like surface to the cloth, called the pile. A separate warp-beam is used for the purpose of supplying the pile threads, for they are used in much greater lengths than the plain warp threads, with which they are combined. When the pile threads are raised by the harness, a wire is passed under them similar to a weft thread, and woven in as such. Now, if the wire be withdrawn a row of loops will be formed on the surface of the cloth. In this case, on repeating the operation, terry velvet similar to Brussels carpets would be produced; but if, by means of a sharp knife, the loops be cut before the wire is withdrawn—by passing the edge of the knife along a groove made in the wire—then the loops would be cut and form velvet.

Both gauze and velvet weaving can be woven in the power loom as in the weaving of curtains and carpets. When terry velvet is woven, the wires are inserted and drawn out by suitable motions; and when the pile is cut to form velvet, a sharp blade is attached to the end of the wire, which on being withdrawn cuts the loops. Or two pieces of cloth are woven face to face and the pile threads passing from one to the other are cut asunder during the process of weaving and thereby form two pieces of velvet.

The Process of Knitting by hand was known in England at the end of the 15th century, although it is not known to what country it belongs nor when first used. In 1589 William Lee invented a machine for performing the work in a much more rapid manner than could be done by hand. The principle of Lee's invention is still used. In 1816 the celebrated engineer Brunel gave a rotatory action to a modification of the machine. Knitting is a process by means of which a series of loops are made which intersect each other. By hand about 100 per minute can be formed; but machines have been made on the rotary system by which 300,000 loops per minute can be produced.

Lace is the last of the seven classes of weaving. It is not only the most recently invented system of weaving but by far the most complicated. There are two kinds of lace, viz., point and pillow. The former is produced by means of the needle, and is an ancient process. The latter is made by twisting a series of threads round each other, to form meshes, by means of numbers of small bobbins and a pillow upon which the fabric is formed. Pins are inserted in the pillow to form the pattern, and the threads are twisted round them. The pattern is drawn on parchment, which forms a guide for placing the pins in the cushion. This method of weaving was invented by Barbara Uttmann in 1561. Many attempts were made during the last century to produce lace by machinery similar to pillow lace, and in 1808 John Heathcoat succeeded in doing so. Since that time numerous modifications have been made in the process, and the Jacquard machine has been applied to produce figures on the lace.

The Levers Lace Frame, which is based upon the system adopted by Mr. Heathcoat, is composed of a series of contrivances that are so perfect and extensive in their application that it is worthy the careful study of every mechanician. It can, and has been, modified in numerous ways. Far greater numbers of slide-bars have been used than in the machine herein described, and various modifications of the carriages and combs have been used. But the principle is still the same, for whatever alterations or additions it may receive, the basis of its action can scarcely be deviated from.

Tapestry and *Braid-making* may be said to be branches of the art of weaving. Tapestry is really a fine art, although the process is simply one of weaving. There are two kinds of tapestry, one in which the surface of the cloth is similar to plain weaving, and the other having a pile or velvet surface. The first kind is employed for the production of pictures, and the second is for use as table-cloths, &c.

In both classes the design is produced by means of various coloured weft threads interlaced and knotted between or upon the warp threads, which may be composed of cotton, worsted, or silk. The warp is strained upon beams placed sometimes horizontally, as in the common loom; but more frequently the warp is held vertically. Another plan is to place the warp beams vertically. The instruments used by the artist in this work are of the most simple description, and a comb is used to beat the threads together after they have been arranged. The work produced is the most costly and effective of the textile manufactures. It is comparatively a modern art, for formerly tapestries were wrought by the needle on the surface of cloth, as in the Bayeux tapestry, and not interwoven in the body of the cloth as it has been customary to do during the last three centuries.

Braid-making is done by machines constructed with spindles carrying bobbins and made to travel in a serpentine course. In so doing the threads are plaited round each other or entwined together. By this means braid, stay and other laces, upholsterers' cord, covering to india-rubber threads, crinoline wire, whip handles, &c., are made. Webbing of various widths can be produced by this means, and tubes. Braiding machines are made of various sizes, some having but a few spindles, whilst others have nearly a hundred.

The power loom.—During the period when several of the above inventions were being carried out, the hand loom was undergoing various improvements, and motive power instead of manual labour was ultimately applied for performing the work of the weaver.

In 1678 a French officer, M. De Gennes, constructed a model for weaving cloth by power, but it was practically of no use. In 1745 Vaucanson produced a loom, now in the Conservatoire des Arts, Paris, which not only contains his improved Jacquard apparatus, but the whole loom is arranged to be worked by motive power. Twelve years previously John Kay, in this country, had invented the fly-shuttle, and it was perhaps not known to Vaucanson or he might have adopted it, instead of trying to carry the shuttle through the shed by means of levers, as was proposed by De Gennes. Had he done so the system of power-loom weaving would have advanced much earlier than it did. In Vaucanson's loom the friction-roller take-up motion is applied; but he failed through want of the fly-shuttle. He shortly afterwards (about 1760) succeeded in making the Dutch ribbon-loom self-acting, and this was probably the first loom capable of being driven by power.

Shortly before the commencement of the present century the power loom, for weaving broad goods, began to be used; but its successful introduction by Dr. Cartwright and others was a long and tedious task.

In order to weave by power there are many things necessary to be overcome which are not required in hand-loom weaving. For instance, a self-acting motion must be applied to stop the loom when the weft breaks, or the weft bobbin requires to be renewed. Also a take-up motion for winding up the cloth as it is woven must be provided, and a temple that does not require being moved, as in the case of hand-loom temples. These look simple matters of themselves, but they took, in time, upwards of half a century to bring to a satisfactory result.

The first steps towards the accomplishment of power-loom weaving were doubtless the inventions of the fly-shuttle and metallic reed by John Kay, the former being patented in 1733. But it was not till near the end of the century that any practical result was attained. In 1796 Mr. Robert Miller successfully applied the stop-rod motion, to stop the loom instantly when the shuttle stuck in the shed or was thrown out of the loom. This contrivance was not perfected till 1845, when Mr. John Sellers applied a brake to it.

Self-acting nipper temples were introduced by Dr. Cartwright in 1787; and in 1805 Thomas Johnson used revolving temples formed like bevel wheels. Temples have undergone numerous modifications on the roller principle since that time, and are now comparatively perfect. During the same period the fork and grid weft stop-motion has been brought to a high state of perfection. Contrivances for this purpose were attempted by Dr. Cartwright in 1786. In 1834 Messrs. Ramsbottom and Holt applied the fork and grid plan, which was greatly improved by Messrs. Kenworthy and Bullough in 1841, and a brake added by Mr. James Bullough in 1842.

The take-up motion for winding up the cloth as woven was first applied by Vaucanson to his loom in 1745, before mentioned, in which friction-rollers are used, being the same in principle as now adopted.

The letting-off motion to the warp-beam, as applied to the power-loom, was at first similar to the ordinary plan used in the hand loom; but as the alterations of the strain or tension should be regulated in the power loom by self-acting means, numerous inventions have been introduced for that purpose.

In the *process of weaving* whether performed in the hand loom or the power loom, the operation is the same and dependent upon exactly the same principles. Amongst power loom weavers much difference of opinion exists as to the treatment of the warp when in the loom, and the best way of producing a sound cloth, and having, at the same time, the best appearance or surface.

Upon the proper proportions of the warp and weft the strength and quality mainly depend; but with the same materials a very much better cloth may be produced, simply by a difference in the operation of weaving.

This effect can be best observed in the weaving of silk fabrics, for owing to their fineness of texture, and the care required in weaving them, any defect is more distinctly shown, and the cause of it is more anxiously traced than in the weaving of other substances.

Apart, therefore, from the question as to the proper proportion that should be made in the warp and weft, and other matters relating thereto, it will be found that the quality and the appearance of the cloth very much depend upon the weaver.

The evenness of the selvages is greatly affected by the manner in which the shuttle is used; but the appearance and quality of the web principally depend upon the shedding, and the amount of tension applied to the warp threads.

Some substances require different treatment in order to weave them, according to the strength and elasticity of the fibres, but more particularly with respect to the class of fabric to be woven. Thus it was thought that linen might be woven in a common cotton power loom, but owing to its rigid nature it necessitated the invention of a vibrator, to counteract the strain of the headles.

The action that is desirable in the process of shedding is to throw as little strain as possible on the warp threads; and although considerable tension is often required, an undue share is often given to some if not all parts of the warp. This defect generally arises from opening the shed too wide, or by raising or sinking some of the healds unequally, as well as from other causes.

In *weaving silk goods* of different kinds, a different treatment is absolutely required, so that no general rule can be made that would be applicable to every case. Thus glacé, sarsnet, or fine tabby silk, requires to be well weighted on the warp-beam, in order to produce a desirable "skin"-like surface on the cloth. On the other hand umbrella silk must be very lightly weighted, in order to look and wear well. Should it be overweighted the cloth would be hard and wiry, and would cut itself in wearing. The difference that may be effected both in the appearance and quality of silk of this class is so great, that even two or three pounds weight added to the beam will make it at once observable.

Ducapes, or corded silks, require a soft covering to the weft, therefore they must not be heavily weighted. Satins of the same texture require more weight than ducapes in order to produce a sharp, bright face.

In *weaving velvets* and other descriptions of pile fabrics in which two or more separate warps are combined, it is necessary that the warp forming the pile or surface of the cloth should have much less tension than the ground warp in order to make it cover well.

In *double cloth* weaving tubes or sacks may be made, or cloth of double the width of the loom may be woven. Also fabrics of considerable thickness and of different colours or textures on each surface may be produced by this means.

In order to vary the appearance of certain parts of the web a shuttle with thicker weft is sometimes used, to give it a ribbed appearance; but the same effect may be produced by passing the shuttle containing a fine thread through the same shed two or three times, but of course it must be bound in by shedding the selvages.

The blow of the reed, after the shuttle is thrown, must be given when the shed is closed and not before, or the weft will recover itself and a loose cloth will be the result. If the blow be given on the rising of the next shed, then there will be too much strain on the warp, and it will not only be liable to breakage, but a hard, dry, wiry effect will be produced.

In *weaving satins* and other fabrics requiring a number of headles, and only one or two are required to be raised at a time, then a rising shed with a standing bottom is to be preferred, as in the tying-up shown in Fig. 68, although in weaving linen in the power loom this plan is frequently reversed by drawing the headles downwards, although the principle is the same. But care must be taken not to raise the headle, or headles, too high, or too much strain will be thrown upon the raised threads, and the result will be that the weft threads will overlap or "ride" over each other, and the evil effect will be observable on both surfaces of the cloth.

When the work requires the headles to be raised in about equal numbers to those remaining down, then a rising and falling shed is preferable, as in Fig. 71. In this case the strain will be equal and easier, and less tension will be thrown upon the warp.

In all cases an easy balanced motion is to be preferred. The shed should never be opened deeper than barely sufficient for the shuttle, and all jerking and unsteady actions must be avoided.

It is too often the custom to put greater strain on heavy, rich warps than is beneficial, merely for the purpose of obtaining as clear a shed as possible without using a breaker treadle (see p. 106), which would prevent the sticking together of the threads in the sheds and the defects arising therefrom, such as floats and hang-shoots. A *float* is caused by the shuttle passing either above or below the thread or threads intended, consequently it is not intersected, as it ought to be, but floats loosely upon the surface of the cloth. A *hang-shoot* is caused by warp threads sticking together and preventing the weft being laid in a straight line, so that it is bent round the obstructing thread, and causes a kink or loop in the weft thread. A bow, made of two or three horse-hairs twisted together, is fixed to the front of the shuttle so as to project and form a flexible wedge of the shape of the letter U. By this means the sticking threads of the warp are divided, and the weft is in consequence laid evenly, and hang shoots are avoided.

Comber marks are great defects in silk weaving, and should be guarded against as much as possible. They are caused by an unequal tension on the warp threads. Thus the threads raised by the front leashes in the comber board will have a different degree of strain upon them than the threads raised by the leashes at the back of the board, so that the effect produced upon the cloth will present a rib-like appearance.

The threads from front to back of the comber board may be twenty-four in number, therefore the ribs will be of the width of twenty-four threads.

This defect arises from the faulty action of the shedding, which has been already referred to at p. 274, &c. Owing to the impossibility of arranging the leashes in one line, so that an equal strain can be put upon each of the threads, various contrivances are used to avoid the defect as much as possible (see Figs. 296 and 305).

Sometimes the harness has been tied up in an irregular manner, or some defect, such as the sagging of the bottom board of the Jacquard machine (which for hand loom purposes is often made too light) will cause an irregular face on the work; therefore great care is required to avoid anything that may tend to throw uneven tension on the warp.

In the silk loom the stretch of the warp between the harness and the warp beam (the "porry") is much longer than in power looms, and this shortness of stretch is probably one of the defects in power loom construction.

In some instances two or more sheds are used for the passage of two or more shuttles simultaneously. In this case, to prevent uneven tension on the warp threads, separate warp beams should be used, as shown in Fig. 331.

The position of the lease rods is by some weavers taken into consideration. In the silk loom, where the length of the stretch of the warp is considerable, little notice is taken of it; but in the power loom where the stretch is very short, the position is of more importance, although the shortness of space does not give much room for choice. It will be found, however, there will be more equality of strains on opening the sheds if the lease rod next the harness be made as small as possible, and not placed far from the back rod. In some instances two separate rods, one above and one below the warp, are placed in front of the lease rods nearest the harness, so as to form a narrow opening and not allow any headle to raise a shed with a different angle to another. In this case there will always be a more equal strain upon the warp threads than there would otherwise be.

As so much depends upon the proper weighting of the warp beam, so that any given tension can be put upon the warp, it follows that a self-action motion that will not vary, but will always keep the warp at one degree of tension, is a matter of very great importance. The difficulty that has to be overcome is to keep the strain always the same, as the warp becomes unwound from the beam, and several of the most recent contrivances for this purpose have been described in Chapter xxiii.

The shuttle should be of sufficient weight to enable it to draw with it the weft thread, and overcome the drag or strain caused by the unwinding of the weft. If it is too light the drag of the thread will draw it out of its course, and it will be liable to be thrown out of the warp and will miss the opposite box. In this case a plug of lead must be inserted at each end of the shuttle, to give it greater momentum.

When thick or heavy weft is used, or a large weft bobbin, then a proportionately heavy shuttle must be used, and a small roller inserted at each end of the shuttle for it to run upon. The rollers are made as wide as the shuttle will allow, for they are enclosed in the shuttle and only project slightly on the under side.

When quills or pipes are used for the weft to be wound upon, it is of little consequence as to the mode of winding the thread upon them, for the thread will be readily drawn off as the pipe revolves. But if a bobbin is used, so that the weft unwinds off the end without the bobbin revolving, then care must be used in filling the bobbin. The winding must be commenced at the base, and gradually wound in a tapering shape until filled to the point of the bobbin, otherwise the thread would not leave the bobbin freely, and would be liable to stick and break. When bobbins are filled by machines, the guides are arranged to wind the thread in this manner.

The French method of using the fly-shuttle in the hand loom is very different to that practised in England. Instead of using the picking stick, as shown in Fig 27, two pulleys are placed on the front of the cross bar of the batten, and a cord from each picker passes over one of the pulleys, so that the ends of the two cords terminate at a handle suspended over the middle of the reed. Each picker is kept drawn to the far end of the box by a spring cord. Now, by pulling down the handle both pickers are thrown forward, and whichever box the shuttle be in, it will be thrown also. A wooden flap is made to press against and retain the shuttle in the box, similar to the ordinary swell in the power loom, and the pickers are drawn back by springs in a similar way to that used in the drop-box system.

In the power loom the principle of throwing the shuttle is the same as in the ordinary fly-loom; but as it is done by automatic means, care must be taken to avoid any defects it may be liable to.

The picking motion must not be too strong or the swell springs too weak, or the shuttle will rebound and the stop-rod will fall and stop the loom. The check strap must be short enough to prevent the picker being forced against the end of the box, or it will rebound and cause the loom to "knock off" or stop. By picking too late, too weak, or two slow, bad selvages will be made. Wide looms require to pick sooner than narrow ones, to allow more time for the shuttle. Picking too strong will knock the cops off the shuttle-spindle, and when bobbins are used will often cause the tongue to break. A loose spindle, or if not set true, or a broken picker, or an uneven reed, will cause the shuttle to turn or to be thrown out of its course. Broken weft, fringed edges, &c., are often caused by some defect of the picker. The stop-rod may throw the loom off, owing to some defect or wear of the swells, or from a shuttle being too small.

The loom is liable to throw off, owing to the wear or other defect connected with the stop-rod, or the catch may be set too low. If the shuttle-box be too wide or the shuttle too small to force the swell back, it will also have the same effect.

If a larger shuttle than usual be used on account of its being able to carry more weft, and so, on the score of economy, save a more frequent change of bobbins, it may prove to be of much less advantage than at first sight would appear. A deeper shed would be required for it, and, consequently, greater strain thrown on the warp threads. This would give rise to more breakages of the threads; and as a weft thread can be replaced several times more quickly than a broken warp thread, the use of larger shuttles, to say nothing of any other disadvantage, would have a doubtful result.

The various defects above named offer no serious difficulty to the experienced weaver, for if he cannot entirely remove them, he, at all events, knows the cause of the evil and how to contend against it.

But there are other obstacles which are, unfortunately, completely out of the control of the weaver, and which cause him far more trouble, loss, and annoyance, than matters concerning the adjustments of the loom. He is too often supplied with threads that have not been properly spun. The fibres may have not been carefully cleaned or divested of the rough and thick portions. Thick and thin fibres are indiscriminately doubled and spun together, so that when the necessary strain is put upon the warp, the weaker strands will give way.

Heavy dyed silks.—Perhaps the greatest difficulty that operates against the silk weaver, and destroys the elasticity and strength of the fibres and makes them brittle, rough, and sticky, is the comparatively new and baneful practice of using heavy dyes (see page 394). Not only does the weaver suffer greatly thereby, but the work when produced is devoid of the beautiful appearance and strength of the properly manufactured substance.

Formerly the practice of overweighting was confined to coarser materials and fabrics, such as in the sizing of cotton cloths; but at the present time silk seems to suffer far more from such practices than any other material. Silk when properly dyed is actually *reduced* in bulk and weight; but when it is returned at from *twice to six times* its own weight, it is evident that the purchaser or wearer of such articles must suffer by them.

At the present time the American silk manufacturers claim that "the American article contains a smaller percentage of dye-stuffs than the foreign, and hence is purer." Still their use is admitted and may soon equal the amount used in other countries, as in Germany, France, and England.

Before the improved system of spinning was introduced by Arkwright and others, cotton yarn was used for weft only, but when it began to be used for warp also it was found to be unable to stand the strain and friction of weaving, without some further assistance to hold the short fibres together. This was effected by the application of a thin flour paste. Unfortunately the practice began to be taken advantage of and to be carried beyond its original purpose. No doubt it suggested a similar course to be adopted in the silk manufacture, which has led to the result above mentioned.

The process of sizing has for some time past attracted considerable attention, as being not only detrimental to the quality of the cloth, but very prejudicial to the interest of the purchaser, and likely to injure the reputation of the English cotton manufacture. It is an old practice, but it has gradually been carried to a questionable extent, as the following extract from a letter that appeared in the *Manchester Examiner* will show:—"Testing Yarn consists in wrapping the weft from the cloth in order to calculate the counts of weft used; but you cannot know the weight of size in a piece of cloth unless you have the counts and weight of the warp as well. The bulk of the plain cloth made to-day is out of all proportion. Take, for instance, a 7 lb. T cloth, 15 by 15, and, instead of being, as its name implies, equal in counts of yarn and picks, you will find it made from 16's warp and 40's weft, instead of 16's weft to equal the warp. Such cloth is very little worth to the wearer, as the warp, being so much stronger than the weft, breaks it before it is half worn. The bulk of the China drills are even worse, 16's warp and 36's to 40's weft; the merchants who buy the cloth must know the quantity of size in the cloth they buy, as it is easy to tell by washing a piece. I believe there never was a time when manufacturers used heavier sizing than at the present time. Only yesterday I was talking to a sizer who sizes for various manufacturers; he said 'Only let me have a good warp, and I will guarantee to put 20 lb. of size to every 20 lb. of yarn, and the warp shall be dry and in good workable condition, and very little will come off in the weaving.' He also said, 'I can even do more than that, if it is required, but I can do that easily.' Those who buy grey calicoes to wear are the real sufferers. I have no hesitation in saying that cloth made from yarn of equal counts will wear for more than double the time the heavy-sized cloth will wear. In fact, the bulk of the grey cloth manufactured to-day is absolutely spoiled in the making."

On the subject of *calendering* Mr. Beaumont, referred to at page 324 respecting his investigations on the strength of linen cloth, observes, that "it is of no benefit to cloth. I can tell no other reason that could have introduced this custom further than a feeling smooth to the hand, and making it appear much thicker than it will be after one washing or two, for then nobody is able to tell whether it were calendered or no, and the sleaziness appears without any disguise."

The power required to drive a common power loom has been for some time a question of considerable interest, for it is assumed by many that a great saving might be made in that respect. When the same class of goods is woven both in the hand loom and the power loom, then the difference of power required by the two looms appears extraordinary.

The gearing of a power loom may be made considerably lighter, and less power would be thereby necessary to work it; but by so doing another defect would arise. The power loom is a machine which is subjected to sudden shocks and strains, and if its parts were not able to withstand them a constant cause of accident would result. Thus, when the shuttle fails to reach its box or becomes trapped, the loom is brought to an instantaneous stoppage. Before the brake was applied to the stop-rod the damage done by this means was very great, and the loom still requires the necessary strength in all its parts to withstand it. Therefore it may be questionable whether much saving of power could be gained by reducing the weight and strength of the loom.

Perhaps the act of throwing the shuttle takes up at least one-half of the power required to drive the loom, for the ordinary shuttle is of considerable weight, and must be driven at a great speed to accomplish its work. It may be said that the shuttle is too heavy, weighing about twelve ounces with the bobbin and weft. But if it were made much lighter it would not have sufficient strength to withstand rough usage, or weight to force the swell back as required. It is a question which has thoroughly engaged the attention of power-loom makers, but at present there does not, in this respect, appear much hope for any great alteration to be made.

If it is granted that one-horse power is required to drive ten looms, then each loom would absorb power equal to the raising of 3300 lbs. one foot high per minute, or one-tenth of a horse power. The power required to drive the shuttle may be assumed to be equal to raising a similar weight fifteen feet high; then if the loom be driven at 200 picks per minute the power required will be $200 \times 15 \times \frac{3}{4}$ lbs. (the weight of the shuttle) $=$ 2500 lbs. raised one foot high per minute, or more than two-thirds of the power required by the loom.

But if the power be estimated as equal to raising the shuttle ten feet, then $200 \times 10 \times \frac{3}{4}$ lbs. $=$ 1500 lbs. one foot high per minute, or not quite half the power given to the loom.

The ordinary cam-picking motion has one disadvantage. The picker is not only too far from the driving motion, but the speed of the crank-shaft, when transferred to the tappet shaft, is reduced to one-half, consequently, the action of the picking-cams, by being reduced in speed, work at a disadvantage.

In substituting springs, or other equivalent means for cams, the advantage of an equal blow is obtained at whatever speed the loom may be driven at. The spring is simply wound up and let off suddenly in order to throw the shuttle. But it has been found that the power given to a spring to wind it up is nearly double to what it is capable of exerting in its re-action, therefore in such case there does not seem to be any advantage to be gained over the ordinary cam-picking motion.

The method of driving the shuttle by *pneumatic* means has still many advocates, for they believe that by supplying compressed air from one source to each loom, not only could a more regular picking motion be obtained, and a great saving in the wear and tear of pickers and other parts of the loom be avoided, but a great saving of power would also be effected.

The formation and general *construction* of the loom is also a matter of great importance. The inverted batten makes the loom more compact, but this contrivance was first adopted by Mr. Almond in his improved hand loom (see page 245). The early power looms were heavy and clumsy, but Messrs. Harrison, of Blackburn, made such great improvements therein that the looms they exhibited in the Great Exhibition, 1851, have perhaps never been surpassed. One of these looms is now in the Patent Office Museum, Kensington.

The calculations that are required by the manufacturer are merely such as are necessary to enable him to ascertain the length and weight of yarn required to produce a given amount of cloth, and is a matter of simple arithmetic. Rules and tables have been frequently given to assist in the computation, as in the case of ordinary ready reckoners, but they seem scarcely necessary to the intelligent manufacturer of the present time. If he wishes to produce more goods of the kind he usually produces, or if he desires to make any alteration in them, it is not a matter of much difficulty. Or if the manufacturer desires to produce, or is required to imitate some new fabric, the question is rather concerning the cost and quality of the materials; for as regards the quantity required, it can offer no great difficulty for him to arrive at.

It has been already shown that the unit of measurement adopted by weavers (page 328) tends rather to confuse matters than to simplify them. Mr. Beaumont, who was perhaps the first to systemize the subject, believed he had succeeded in doing so. It may be, therefore, curious to see the first rule he gives. He states that,—

"A four hundred reed (at yard wide) will require yarn of four cuts two loops in the pound; a standard hank, or one dozen, will weigh two pounds thirteen ounces three drams; ten dozen of that yarn will make twenty yards of that cloth.

	lb.	oz.	dr.
Half a yard warp	00	05	13
One yard "	00	11	11
Two yards "	01	07	06
Three yards "	02	03	01
Four yards "	02	14	12
Five yards "	03	10	07
Ten yards "	07	04	15
Twenty yards "	14	09	15
The whole webb	29	03	14

Half a hundred of that warp, or one hundred threads of that yarn, twenty yards on the warping bars, will weigh one pound thirteen ounces and three drams. Twenty-two shoots or threads of that yarn must be struck into one inch of that cloth."

For different reeds other instructions of a similar nature are given. The strange custom of counting the splits in the reed, and not the threads in the cloth, is still used. One split being equal to two threads —although two threads are by no means always used, for in silk weaving from one to twelve threads are placed in each split.

Mr. Beaumont also gives instructions to purchasers of linen cloth, so that they may obtain the best quality. From the table given it appears that cloth one yard square made in a—

	lb.	oz.	dr.
400 reed[1] should weigh	1	2	1
600 " "	0	12	5
800 " "	0	8	15
900 " "	0	8	0
1000 " "	0	7	4
1200 " "	0	6	1
1400 " "	0	5	4
1600 " "	0	4	9

[1] 400 reed equals 800 threads per yard.

	lb.	oz.	dr.
1800 reed should weigh	0	4	1
2000 „ „	0	3	10
2200 „ „	0	3	5
2400 „ „	0	3	0
2600 „ „	0	2	13
2800 „ „	0	2	9
3000 „ „	0	2	7

From the above list it appears that linen cloth one yard square should weigh, if woven in a 900 reed, eight ounces, consequently if woven in an 1800 it should weigh four ounces.

It will be evident that the number of threads in an 1800 reed will be double in number to those in a 900, consequently they must be only one-half the diameter, so as to occupy the same space when laid flat. But a thread of *half the diameter* of another weighs only *one quarter* the weight—according to the square of its diameter,—therefore if double the number are used in the same space, the cloth will weigh only half the weight, and this corresponds with the weights given in Mr. Beaumont's table.

Now as it has been found that the most approved plain cloth is that in which the warp and weft nearly correspond, it follows that the number of threads and the weight of various counts, if composed of the same substances, must necessarily bear, when properly woven, a definite proportion to each other. All, therefore, that is necessary for the formation of a rule to ascertain what weight or count any plain cloth should be, is simply to fix upon some unit of measurement, and in the table above given the 900 reed cloth being eight ounces, it affords an easy means of comparison with the other counts.

Threads composed of different substances vary greatly in size in proportion to their weight, and in this respect the difference between the weight of linen and cotton is very apparent. Yet, extraordinary as it may appear, Dr. Ure came to the conclusion that the *specific gravity* of cotton and linen were alike when the air was expelled from between the fibres of both substances. And he believed that all vegetable fibres had about the same specific gravity, viz. 1.50, or $1\frac{1}{2}$ times the weight of water.

The animal fibres, such as silk and wool, he found to have a specific gravity of about 1.30, or nearly $1\frac{1}{3}$ the weight of water, and he concluded that all animal fibres might be the same.

The strength of vegetable fibres differs considerably, some kinds of flax being twice as strong as others. If the average be taken, the strength of silk is about double that of flax, and probably other animal fibres would be similar in that respect.

The units of length and other counts connected with weaving not only differ, but in one instance the weight used is of doubtful value. Thus the *denier* weight is often described as being equal to two grains. Dr. Ure, in his "Philosophy of Manufactures," understood it to be equal to 0.693 of an English grain, but upon testing a denier weight he found it to be 0.833 grains. In the last edition of his "Dictionary" it is said to be $\frac{1}{24}$ of an ounce *Poids de Marc'*. The pound avoirdupois is to the pound Poids de Marc' as 10 is to 17 nearly. Mr. Simmonds, in the appendix to the "Philosophy of Manufactures," says that "the custom of the trade is to reckon 32 deniers to a dram, and that the standard of silk measure is about 400 yards; that lengths of a single filament of China cocoons will weigh 2 deniers, and of French or Italian $2\frac{1}{2}$." In some places 1000 yards are measured and weighed as a means of comparison. At Macclesfield 530 yards of silk are weighed, and 530 deniers equal one ounce. Mr. B. F. Cobb, secretary to the Silk Supply Association, gives the weight as 200 (? 20) deniers equal $16\frac{1}{2}$ grains. In addition to the above there are various other definitions on the subject, but these will be sufficient to show the uncertainty that exists through the want of some fixed unit that would apply to some, if not all descriptions of threads.

It is scarcely to be wondered at that men acquainted with the application of *electricity* to telegraphy and other purposes should have believed it equally serviceable in some of the operations of weaving. As might be expected, the Jacquard apparatus seemed to offer an excellent opportunity for the needles to be worked, not by the direct pressure of a card, but by the connexion of a series of electro-magnets. By this means it was believed that paper might be substituted for cards, and the magnets might operate upon the needles through the perforations in the paper, or by passing a current of electricity through the medium of a metallic conducting surface on a sheet of paper or cloth representing the design to be woven, and thereby act without the use of perforations. It was also thought that one apparatus would suffice to work a number of looms, provided they were weaving the same design. But doubtless this substitute for Jacquard cards would be far more complicated and costly, and would not be readily understood by the weavers; and so far as one apparatus being able to govern a number of looms, it evidently did not occur to the inventor that when one loom was stopped through the breaking of a weft or warp thread all the rest must be stopped accordingly. Still there may be some purposes connected with weaving to which electricity may be applied ultimately with success, as it is at present done in spinning machinery.

In 1853 Chevalier Bonelli obtained a patent for an apparatus to dispense with the use of tappets or perforated cards, "and employ electricity to operate on the warp threads. For which purpose a series of electro-magnets are employed, the armiture or keeper of each of which is fixed to a suitable wire or hook, by which means, when the armature or keeper is attracted to its magnet, the particular thread or threads in connexion will be acted on."

For a similar purpose M. Bolmida obtained a patent in 1856 "for plain or figured weaving with the aid of a Jacquard, the needles of which are actuated by a peculiar arrangement of electro-magnets. One portion consists of a mode of elevating the griffe of the Jacquard, which is effected by means of a horizontal vibrating arm working on a centre at one end, and actuated at its free end by a stud or pin in a revolving disc, the pin working in a slot formed in the end of the arm. To this arm the 'lifter' is connected by suitable rods and levers. In like manner a smaller Jacquard for working the headles is used, which is actuated by a pair of levers below and connected by rods and levers to the griffe. The hooks or vertical wires of the Jacquard and the horizontal needles are arranged in the ordinary manner, with this exception, that, in place of being pushed backwards, they are impelled forwards, those not intended to be acted upon being prevented from moving by stops presented by the electro-magnetic apparatus. It is preferred to produce the pattern by the use of a thin sheet of metal cemented on to a sheet of paper. On this metallic surface is traced the outline of the design, and the ground is then coated over with any non-conducting varnish, leaving the pattern alone uncovered." Each needle of the Jacquard is provided with a separate magnet, and "the current is made to pass through the whole of the magnets, by means of several coils which are connected at one end to the conducting plates, which are supported by a wooden cross-bar and are insulated one from another. On each of the conducting plates rests the point of a copper plate or tracer, the opposite end of which rests upon the pattern cylinder or surface. Between the cylinder is a similar but shorter plate resting at one end on a transverse copper bar, and at the other end on the pattern surface or cylinder. The transverse copper bar is connected by a wire with the negative pole of the battery. The copper plates or tracers, and the short intermediate plates, are insulated from each other by having their sides covered with paper or other suitable non-conducting material. It will thus be obvious that the current will be established only when the point of a tracer and the point of its intermediate plate rest on the conducting metallic surface of the pattern cylinder."

It has also been suggested to employ electro-magnetism for governing the changes of the drop-boxes of looms.

Provisional protection only was obtained in 1856 by Eugenio Vincenzi for working Jacquards and the reading of the patterns by means of an electric current.

It is probable that electricity may prove of service in this operation and for recutting cards. Type-setting by this means has been very successfully done, and cutting punches may be arranged in like manner. Vincenzi describes his invention to "consist in cutting out, by means of a metallic point, the outlines of each of the coloured spots of which the pattern is formed in a thin sheet of tin or other suitable metal fixed to a sheet of stout paper, paste or card-board, or other suitable material; thus isolating these outlines from each other. On the margin of the sheet of paper are traced as many lines as the pattern contains colours, and on the back of the sheet each of these lines is made to communicate with its corresponding colour by means of small strips of tin, pewter, or other metal, and thereby causes the electric current to communicate with its corresponding colours without touching the others. By placing, consequently, the comb of the electric apparatus on the entire surface of the pattern, those teeth only will come into effect that touch a described colour, whereas, by bringing the current in contact with other lines on the margin, other colours of the pattern come into action."

It has also been proposed to carry the shuttle through the shed by means of a magnet, thus: J. Meus, in a patent obtained in 1844, says, "I propose to employ for this purpose the power of a magnet acting upon an iron shuttle." In 1851 Mr. R. Whytock claimed also to cause a shuttle to "travel under the influence of a magnet," and in 1854 M. F. Durand obtained provisional protection for actuating shuttles by means of magnets attached to shafts placed under the shuttles, small plates of steel being fixed to the underside of the shuttles for the purpose.

Another mode of employing electricity to purposes relating to weaving has been already alluded to (see page 213), viz. to cut or rather burn the pile threads in double velvet weaving by means of a thin platina wire heated by an electric current.

The principles of the various branches of the art of weaving having been described, it need scarcely be added that in order to obtain full effect from the various mechanical contrivances that have been shown depends principally upon the ability of the designer. It is not only necessary that he should be a good draughtsman, but it is requisite that he should be thoroughly conversant with all the artifices that the weaver can apply, so that every advantage can be taken of the means he has at his command. This, however, rests entirely upon the knowledge, experience, and skill of the designer, and can only be acquired by actual practice. New descriptions of cloth, having some special advantage, either as regards its strength, usefulness, or ornamental purposes, are frequently being introduced. So great are the changes made, and of such great importance, that the texture or mode of decussation is often secured by patent, and we have shown several examples of the kind. This, however, is the work of the designer rather than of the weaver. He knows the nature of the materials he has to deal with, and to make the best use of them depends almost entirely upon his skill and judgment.

We will conclude our summary by quoting the following passage from Mr. Charley's excellent work on "Flax and its Products in Ireland:"—

"It is interesting to watch the various motions in the machinery of a power loom;—the roller quietly pulling on the cloth as it is made, the sleigh driving tight home the weft which the little shuttle slips in between the divided yarns of the warp; the headles raising the alternate sets of yarn to receive the next shot of weft; the striker, which represents the weaver's arm, at regular intervals propelling the shuttle by a blow across to the other side of the loom; a regular game of battledoor and shuttlecock. All these actions going on with each loom, and hundreds of looms in the same building, causing a din resembling the crash of battle. In this peaceful strife, however, no blood is shed, but food and raiment are earned by willing hands for themselves and the little hungry mouths at home."

APPENDIX.

The following Statistics relating to Factories in the United Kingdom, in which spinning and weaving are carried on, are taken from the most recent Parliamentary Reports on the subject, and may be found to be of considerable interest and importance.

It may be mentioned that the Lists do not include any persons except those engaged in Factories, consequently an allowance must be made on that account, for in some cases the business is carried on to a great extent at the workpeople's houses and other places not included in the Factory Return. Thus in the Hosiery and Lace trades probably four times the number given are employed, and in the Silk trade about twice. But in those trades which require motive power, such as the Cotton manufacture, the number of persons employed out of the Factories is considerably less in proportion.

General Summary of Factories, 1874.

	Number of Factories.	Number of Spinning Spindles.	Number of Doubling Spindles.	Number of Power Looms.	Number of Power Loom Weavers.	Number of Persons Employed. Males.	Females.	Total Males and Females.
England and Wales	6,379	42,293,772	4,812,127	572,460	231,692	328,494	454,528	783,022
Scotland . .	680	2,436,947	446,429	74,195	44,350	44,269	110,650	154,919
Ireland . . .	235	1,062,388	25,580	21,056	11,464	21,281	46,463	67,744
Total for the United Kingdom	7,294	45,793,107	5,284,136	667,711	287,506	394,044	611,641	1,005,685

Summary of Cotton Factories, 1874.

	Number of Factories.	Number of Spinning Spindles.	Number of Doubling Spindles.	Number of Power Looms.	Number of Power Loom Weavers.	Number of Persons Employed.		
						Males.	Females.	Total Males and Females.
England and Wales	2,542	36,034,232	4,024,883	431,389	148,341	180,607	259,729	440,336
Scotland . .	105	1,373,454	337,760	29,171	14,122	5,830	30,274	36,104
Ireland . . .	8	108,086	3,374	2,558	1,169	1,183	1,892	3,075
Grand Total of Cotton Factories	2,655	37,515,772	4,366,017	463,118	163,632	187,620	291,895	479,515

Summary of Woollen Factories, 1874.

	Number of Factories.	Number of Spinning Spindles.	Number of Doubling Spindles.	Number of Power Looms.	Number of Power Loom Weavers.	Number of Persons Employed.		
						Males.	Females.	Total Males and Females.
England and Wales	1,483	2,604,610	98,780	45,025	33,975	54,119	51,252	105,371
Scotland . .	257	529,011	56,904	11,758	7,516	11,816	15,912	27,728
Ireland . . .	60	31,948	2,628	307	240	782	724	1,506
Grand Total of Woollen Factories	1,800	3,165,569	158,312	57,090	41,761	66,717	67,888	134,605

Summary of Shoddy Factories, 1874.

	Number of Factories.	Number of Spinning Spindles.	Number of Doubling Spindles.	Number of Power Looms.	Number of Power Loom Weavers.	Number of Persons Employed.		
						Males.	Females.	Total Males and Females.
England and Wales	123	101,134	946	1,437	686	1,568	1,856	3,424
Scotland . .	2	...	...	...	...	3	4	7
Ireland . . .	...	...	...	...	...	...	...	...
Grand Total of Shoddy Factories	125	101,134	946	1,437	686	1,571	1,860	3,431

Summary of Worsted Factories, 1874.

	Number of Factories.	Number of Spinning Spindles.	Number of Doubling Spindles.	Number of Power Looms.	Number of Power Loom Weavers.	Number of Persons Employed.		
						Males.	Females.	Total Males and Females.
England and Wales	648	2,128,890	381,560	75,591	36,737	53,995	77,835	131,830
Scotland . .	43	53,330	17,846	6,156	3,200	3,052	7,203	10,255
Ireland . . .	1	572	252	...	...	3	9	12
Grand Total of Worsted Factories	692	2,182,792	399,658	81,747	39,937	57,050	85,047	142,097

Summary of Flax Factories, 1874.

	Number of Factories.	Number of Spinning Spindles.	Number of Doubling Spindles.	Number of Power Looms.	Number of Power Loom Weavers.	Number of Persons Employed.		
						Males.	Females.	Total Males and Females.
England and Wales	141	291,735	47,287	5,264	3,120	6,856	15,471	22,327
Scotland . .	159	275,119	15,432	18,529	12,279	12,752	33,064	45,816
Ireland . . .	149	906,946	18,616	17,827	9,730	18,323	41,993	60,316
Grand Total of Flax Factories	449	1,473,800	81,335	41,980	25,129	37,931	90,528	128,459

Summary of Hemp Factories, 1874.

	Number of Factories.	Number of Spinning Spindles.	Number of Doubling Spindles.	Number of Power Looms.	Number of Power Loom Weavers.	Number of Persons Employed.		
						Males.	Females.	Total Males and Females.
England and Wales	45	6,448	1,019	22	9	1,465	1,574	3,039
Scotland . .	12	9,744	3,861	...	...	581	1,250	1,831
Ireland . . .	4	1,098	372	...	...	221	120	341
Grand Total of Hemp Factories	61	17,290	5,252	22	9	2,267	2,944	5,211

Summary of Jute Factories, 1874.

	Number of Factories.	Number of Spinning Spindles.	Number of Doubling Spindles.	Number of Power Looms.	Number of Power Loom Weavers.	Number of Persons Employed.		
						Males.	Females.	Total Males and Females.
England and Wales	15	21,754	1,278	927	897	1,510	3,423	4,933
Scotland . .	84	185,419	7,658	8,325	7,058	9,543	21,350	30,893
Ireland . . .	11	13,738	338	347	308	479	1,615	2,094
Grand Total of Jute Factories	110	220,911	9,274	9,599	8,255	11,532	26,388	37,920

Summary of Hair Factories, 1874.

	Number of Factories.	Number of Spinning Spindles.	Number of Doubling Spindles.	Number of Power Looms.	Number of Power Loom Weavers.	Number of Persons Employed.		
						Males.	Females.	Total Males and Females.
England and Wales	21	46	8	53	5	464	322	786
Scotland . .	6	60	...	...	...	48	377	425
Ireland . . .	...	...	...	...	...	...	...	...
Grand Total of Hair Factories	27	106	8	53	5	512	699	1,211

Summary of Silk Factories, 1874.

	Number of Factories.	Number of Throwing Spindles.	Number of Doubling Spindles.	Number of Power Looms.	Number of Power Loom Weavers.	Number of Persons Employed.		
						Males.	Females.	Total Males and Females.
England and Wales	812	1,103,893	214,740	9,759	5,936	12,772	31,647	44,419
Scotland . .	4	10,810	6,968	226	127	109	631	740
Ireland . . .	2	...	...	17	17	290	110	400
Grand Total of Silk Factories	818	1,114,703	221,708	10,002	6,080	13,171	32,388	45,559

Summary of Elastic Factories, 1874.

	Number of Factories.	Number of Spinning Spindles.	Number of Doubling Spindles.	Number of Power Looms.	Number of Power Loom Weavers.	Number of Persons Employed.		
						Males.	Females.	Total Males and Females.
England and Wales	88	1,030	41,626	2,633	1,986	3,114	2,156	5,270
Scotland . .	2	...	...	30	26	35	19	54
Ireland . . .	...	...	...	...	...	...	...	...
Grand Total of Elastic Factories	90	1,030	41,626	2,663	2,012	3,149	2,175	5,324

Summary of Lace Factories, 1874.

Counties.	Registration Districts.	Number of Factories.	Number of Lace Machines.	Number of Persons Employed.		
				Males.	Females.	Total Males and Females.
England and Wales.						
Wilts, Dorset, Devon, and Somerset	South Western.	5	527	900	1,030	1,930
Leicester, Rutland, Lincoln, and Nottingham	North Midland.	273	2,609	5,270	2,045	7,315
Derby	...	33	326	775	353	1,128
Total of Lace Factories .	...	311	3,462	6,945	3,428	10,373

Summary of Hosiery, 1874.

	Number of Factories.	Number of Heads of Circular Frames.	Number of Feeders of this Number of Heads.	Number of Flat Frames.	Number of Inches on the same.	Number of Persons Employed.		
						Males.	Females.	Total Males and Females.
England and Wales	150	15,414	23,130	3,457	176,747	5,079	5,835	10,914
Scotland . .	6	90	180	293	7,264	500	566	1,066
Ireland . . .	...	...	...	...	...	...	...	...
Grand Total of Hosiery Factories	156	15,504	23,310	3,750	184,011	5,579	6,401	11,980

IMPORTS.

Total Quantities and Value of Articles relating to Textile Manufactures, imported in the Year 1876.

		£
Cordage and Twine . . . . . £	558,374	558,374
Cotton, raw . . . . . . cwts.	13,284,454	40,180,880
„ yarn . . . . lbs.	1,937,063	183,259
„ Manufactures of India and China pieces	117,685	53,498
„ „ of Europe . . £	1,757,261	1,757,261
Embroidery and Needlework . . . £	106,483	106,483
Flax and Tow (dressed and undressed) cwts.	1,405,838	3,539,501
Hair, cow, ox, bull, or elk . . cwts.	44,725	175,023
„ goats', or wool . . . . lbs.	5,988,473	729,535
„ horse . . . . . . cwts.	24,311	202,472
„ manufactures of . . . . . £	147,651	147,651
Hemp and Tow (dressed and undressed) cwts.	1,174,859	1,958,208
Jute . . . . cwts.	3,825,259	2,804,597
„ yarn . . . . lbs.	1,706,330	60,593
Lace . . . . £	509,323	509,323
Linen yarn . . . . lbs.	3,414,205	185,747
„ manufactures . . . . . £	240,827	240,827
Silk, raw . . . . lbs.	6,016,927	5,770,341
„ knubs or husks, and waste . cwts.	29,663	406,051
„ thrown . . . . lbs.	164,040	199,293
„ manufactures out of Europe . . £	260,331	260,331
„ „ in Europe . . £	11,555,409	11,555,409
Wool, sheep and lambs . . . . lbs	386,568,323	23,244,554
„ Alpaca, Vicuna, and Llama . . lbs.	3,487,436	393,255
Wollen manufactures . . . . . £	4,920,711	4,920,711
„ yarn . . . . . . lbs.	14,042,780	1,737,248

EXPORTS.

TOTAL QUANTITIES AND VALUE OF ARTICLES RELATING TO TEXTILE MANUFACTURES, THE PRODUCE OF THE UNITED KINGDOM, EXPORTED IN THE YEAR 1876.

			£
Bags and Sacks, empty	dozen	4,020,211	1,211,728
Cordage and Twine	cwts.	96,766	266,460
Cotton Yarn	lbs.	232,554,627	12,781,733
Cotton manufactures—			
Piece goods, white or plain	yds.	2,667,423,176	31,454,280
Printed or dyed	„	990,147,298	18,494,492
Of mixed materials (Cotton predominating)	„	11,833,900	429,401
Total piece goods	yds.	3,669,404,374	
Lace and Patent Net	£	1,016,051	1,016,051
Stockings and Socks	dozen pairs	1,105,666	364,054
Thread for sewing	lbs.	9,635,363	1,763,586
Hosiery and small wares	£	1,337,671	1,337,671
Haberdashery and Millinery	£	3,770,171	3,770,171
Linen and Jute Yarn—			
Linen Yarn	lbs.	22,278,259	1,449,513
Jute „	„	16,709,239	226,813
Linen manufactures—			
Piece goods, white or plain	yds.	146,666,075	4,365,072
Checked, printed or dyed	„	13,181,129	449,918
Sailcloth and sails	„	3,121,784	186,922
Total piece goods	yds.	162,968,988	
Linen Thread for sewing	lbs.	2,638,131	349,549
Unenumerated	£	269,175	269,175
Jute manufactures	yds.	120,813,966	1,558,256
Silk—			
Thrown, Twist, and Yarn	£	1,080,678	1,080,678
Broad piece goods	yds.	3,943,737	648,047
Other sorts	£	1,146,518	1,146,518
Wool—			
Sheep and lambs	lbs.	9,817,249	757,832
Woollen and Worsted Yarn	„	30,854,160	4,417,241
Cloths, Coatings, &c.	yds.	40,479,373	6,451,410
Worsted Stuffs	„	221,561,999	9,141,605
Blankets and Blanketing	„	6,157,539	606,499
Flannels	„	7,764,765	408,387
Carpets and Druggets	„	6,298,479	911,873
Of other sorts	£	1,083,704	1,083,704

FOREIGN AND COLONIAL PRODUCE EXPORTS.

Total Value of Articles relating to Textile Manufactures, of Foreign and Colonial Produce and Manufactures, exported in the Year 1876.

	£		£
Cotton—		Silk—	
Raw	4,534,464	Raw	2,801,240
Yarn	76,069	Knubs or husks and waste	54,264
Manufactures . .	228,929	Thrown	56,100
Flax—dressed and undressed	57,026	Of countries out of Europe	50,408
Hemp—ditto ditto .	205,220	Ditto in Europe . . .	252,646
Jute	704,904		

	£
Wool—sheep and lambs .	11,340,645
Woollen manufactures—	
Cloth and stuffs . .	182,229
Unenumerated . .	123,429

INDEX AND GLOSSARY.

LONDON:
GILBERT AND RIVINGTON, PRINTERS,
ST. JOHN'S SQUARE.