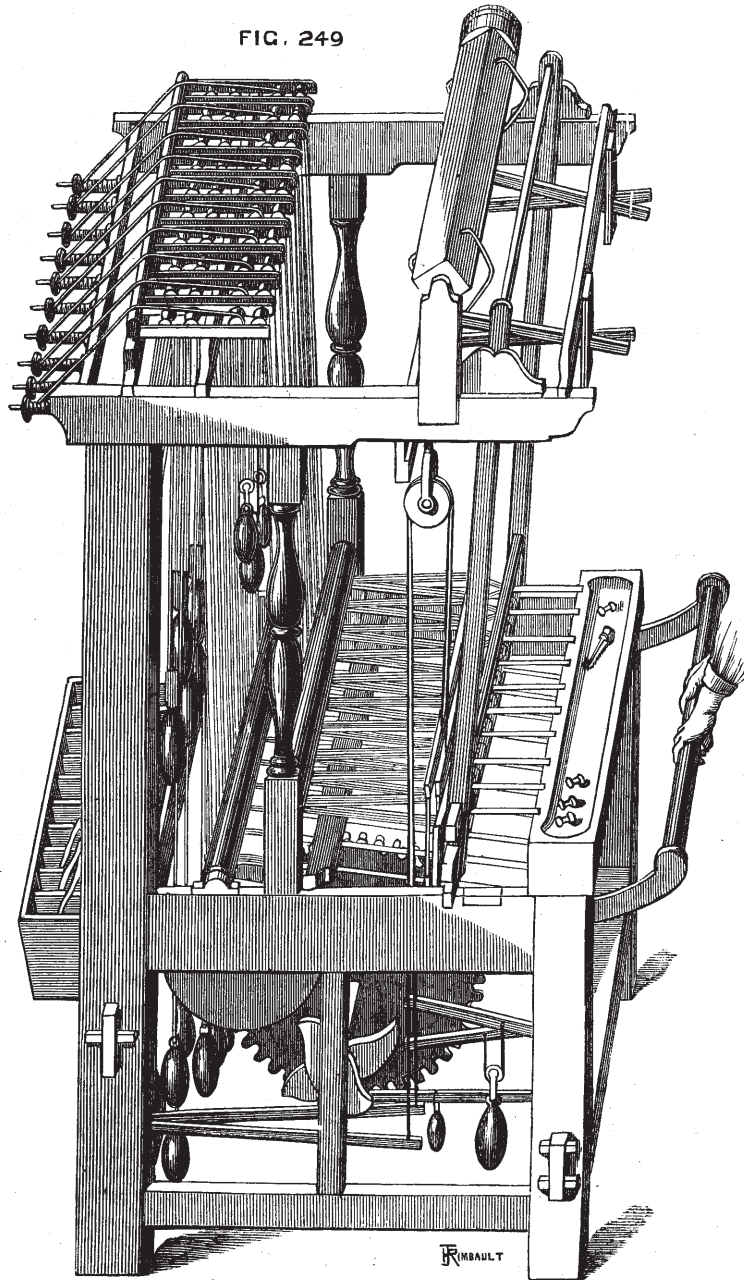


FIG. 249



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.

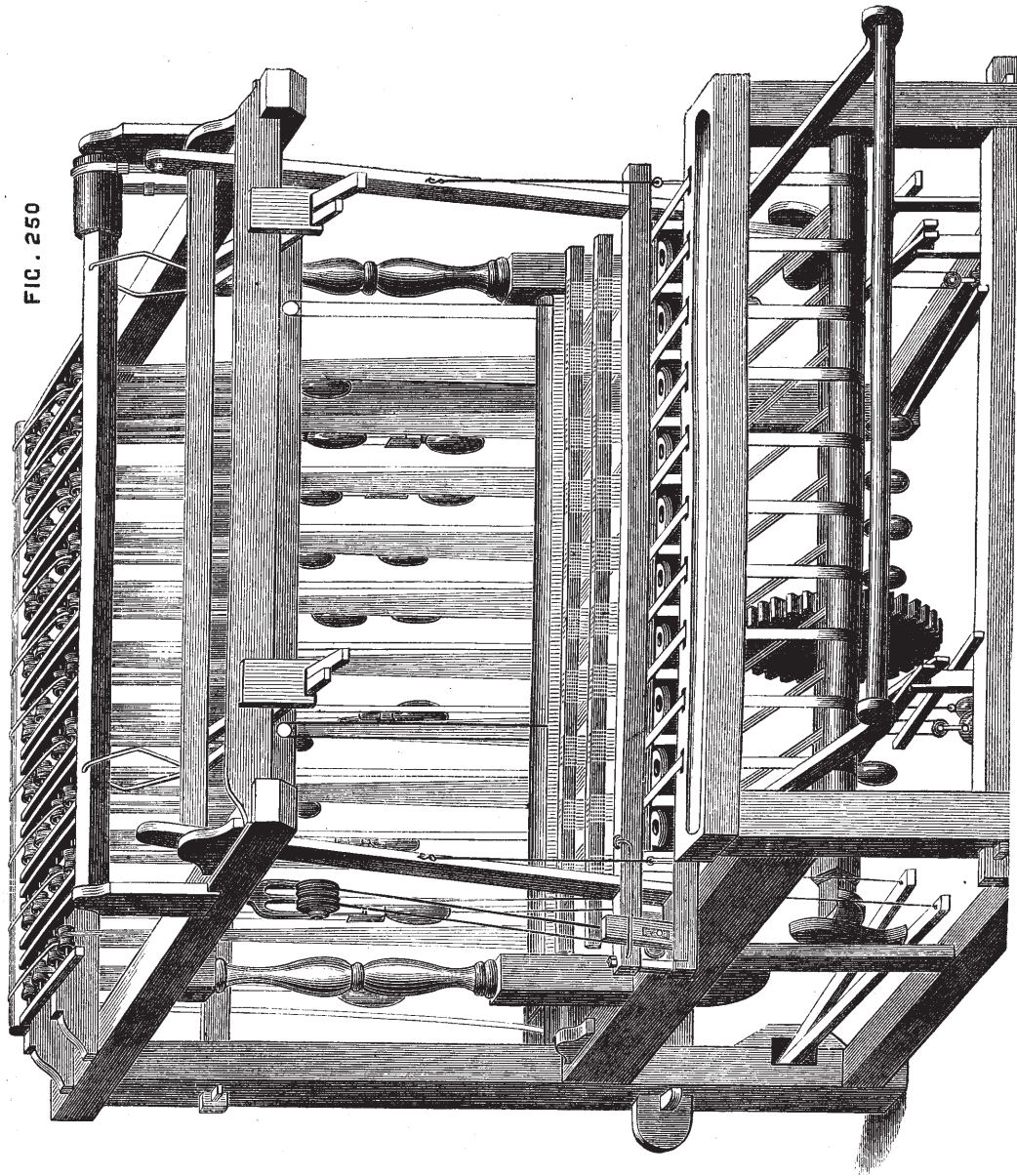
“It is some confirmation of Boxhorn’s account that the States General as early as the 11th of August, 1623, if they did not totally prohibit the use of the ribbon loom, as commonly asserted, at any rate greatly circumscribed it. The proclamation for that purpose may be found in the *Groot Placaet Boeck*, 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 fol-

lowed 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



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.

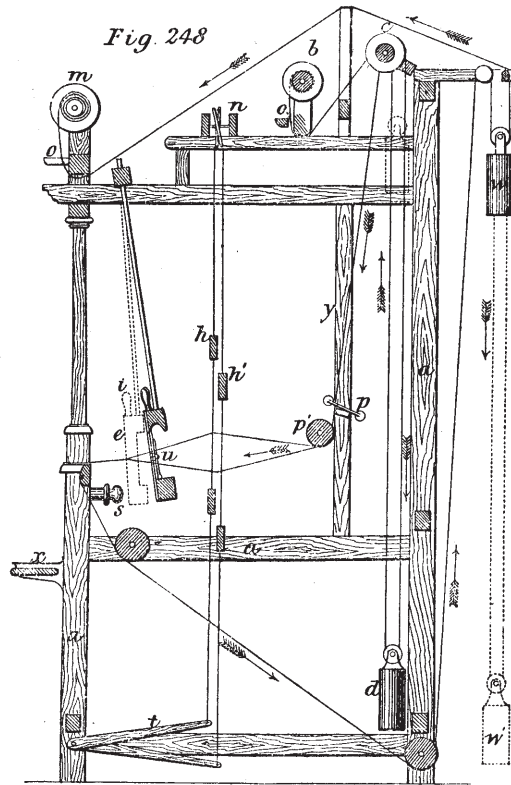
Mr. Baines, in his "*History of the Cotton Manufacture*," states that "about the middle of the eighteenth century a swivel loom was invented by M. Vaucanson, and in 1765, a weaving factory, probably filled with those looms, was erected by Mr. Gartside at Manchester, but no advantage was realized, as 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



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 e , thence under a cylinder or beam at p' , and through the headles h' 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.

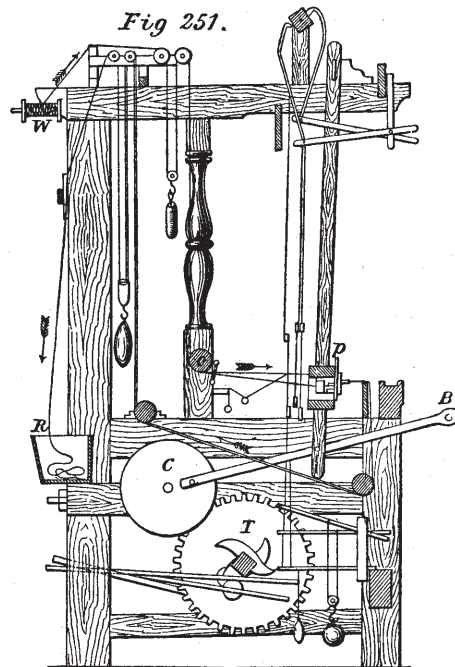
When the weights have arrived at their full extent of motion, they are replaced in their former position by slackening out more warp and winding up the woven ribbon. Small wedges or other contrivances are used at $o o$ to hold both the warp and cloth firmly during the process of weaving.

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

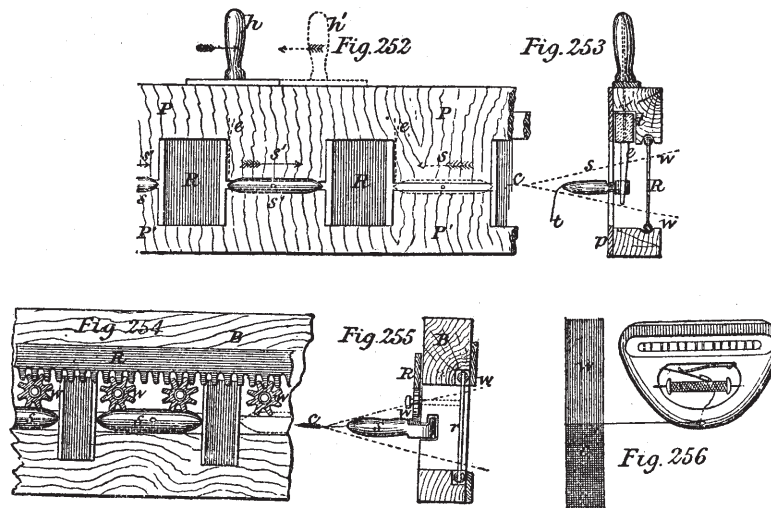


the reed *R* to the cloth *c*. The shuttles *s s* slide in the openings formed by the planks *P P* and *P' P'*, and are thrown across the openings by means of the driver *d*, which is a bar of wood in which pegs *e e e* are fixed to strike the shuttles from side to side. The driver is moved by means 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.

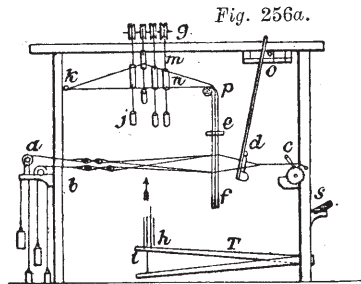
Fig. 256 shows a plan of a shuttle as originally used in the rack and wheel motion, which is still the most important method used at the present time in ribbon looms, although modified in certain ways.



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. 256a 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.



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 *h* 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.

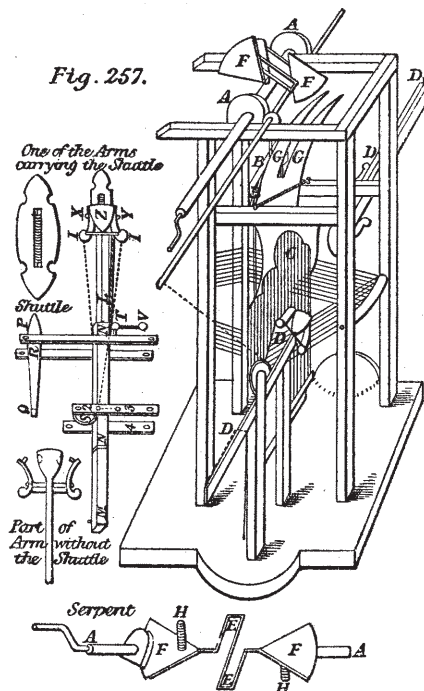


Fig. 257 is a copy of the drawing, which is inserted here on account of its being the first known attempt at power weaving, and not from any practical value it possesses. The crankshaft is called a "serpent," and the shuttle is inserted in a lever, and carried half-way through the shed, where it is received 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.

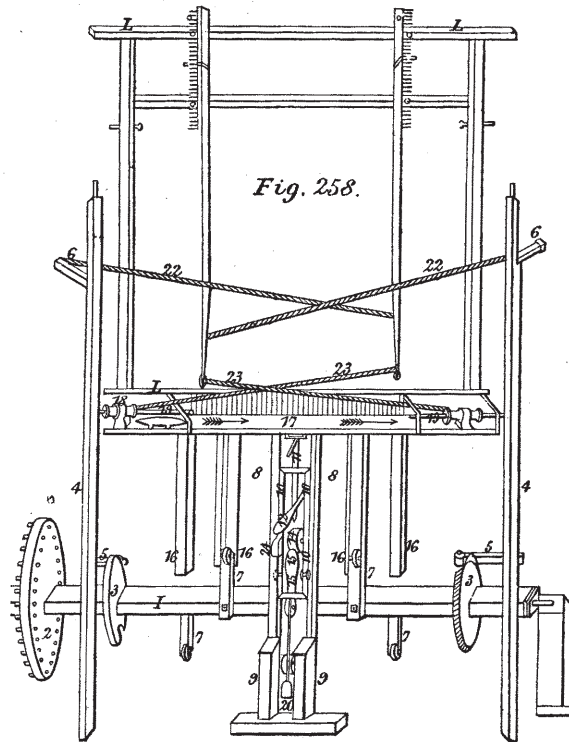
The shuttle was intended to be driven in the same way as in De Gennes's loom above shown, viz. by being carried through the shed by means of levers provided with sockets to hold the shuttle. Now John Kay's fly-shuttle had been patented at least twelve years before Vaucanson's loom was made, and had become 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. I, I, 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 flit 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



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 grooves 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.”

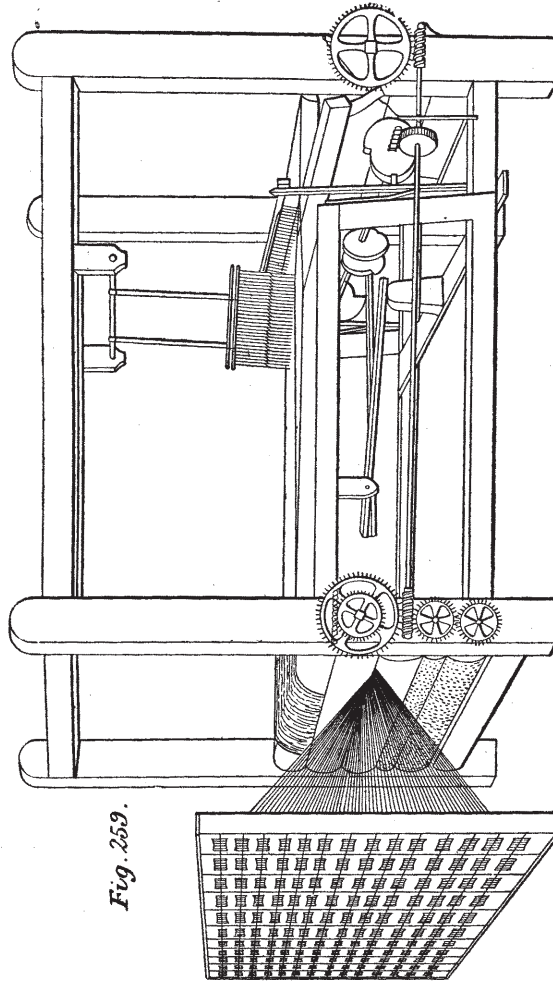
His first attempt at mechanical invention occurred in 1784, which he so graphically describes in his letter above cited.

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-



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 *ee*, *ff* 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 *gg*. 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 *hh*. 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 *mm*; 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 *mm*, 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 *mm* 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 cylinder 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 *rr*, 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. *NN* the wheels which force back the laths. *OO* the springs which throw it to. *PP* are the wheels which force up the rods *SS*. 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 *PP*, the springs *UU* strike and the shuttle is thrown. Note, the wheels *PP* 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. *QQ* are the pickers gliding in grooves, and having springs. *VV* 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. *RR*, are the wheels or tappits that work the treadles that draw down the yields or harness, and open the shed; see Fig. 1. *S* are the temples closed by the springs *ww*; *T* are the temples opened by the treadles *xx*, which are pressed down by the cogs *YY* upon the wheels *PP*. Note, when the temples are open, the space from the points *zz* 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 *zz* 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

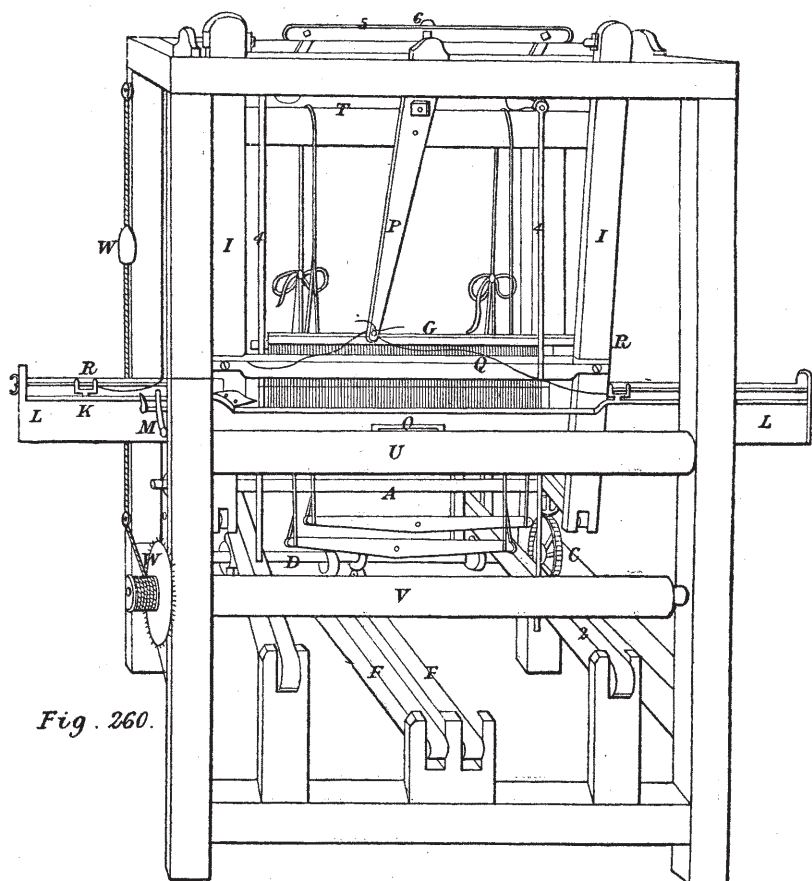


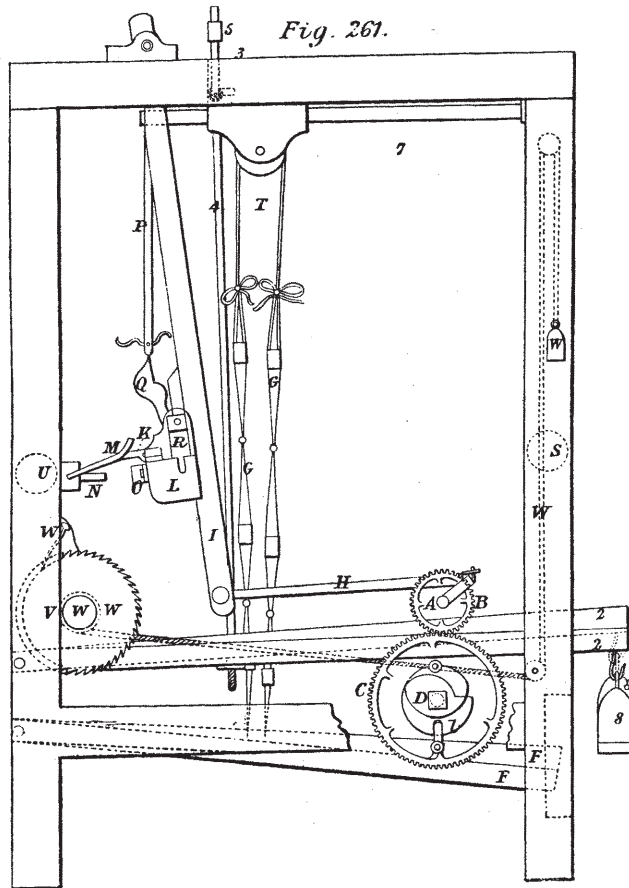
Fig. 260.

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,



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 *RR*. 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
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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 :—

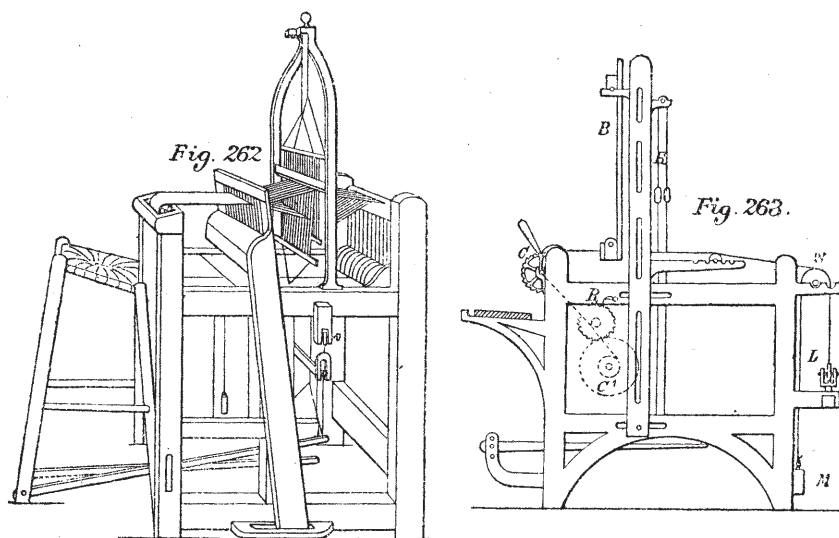
England	600,000
Scotland	78,000
Ireland	22,000
India	11,000
United States	175,000
France	82,000
Germany	80,000
Russia and Poland	41,000
Switzerland	32,000
Spain	30,000
Austria	28,000
Italy	14,000
Belgium	13,000
Sweden and Norway	5,000
Holland	4,000
Total	1,215,000

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.

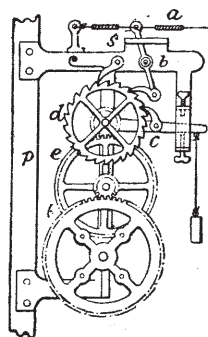
The advantages that the power loom possesses over the hand loom is in its greater productiveness, and the complete saving of manual labour, for while the irksome and laborious part of the work is being done by power, the weaver is occupied in attending to the replenishment of the shuttles, and keeping 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.



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'*, 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 handloom 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.

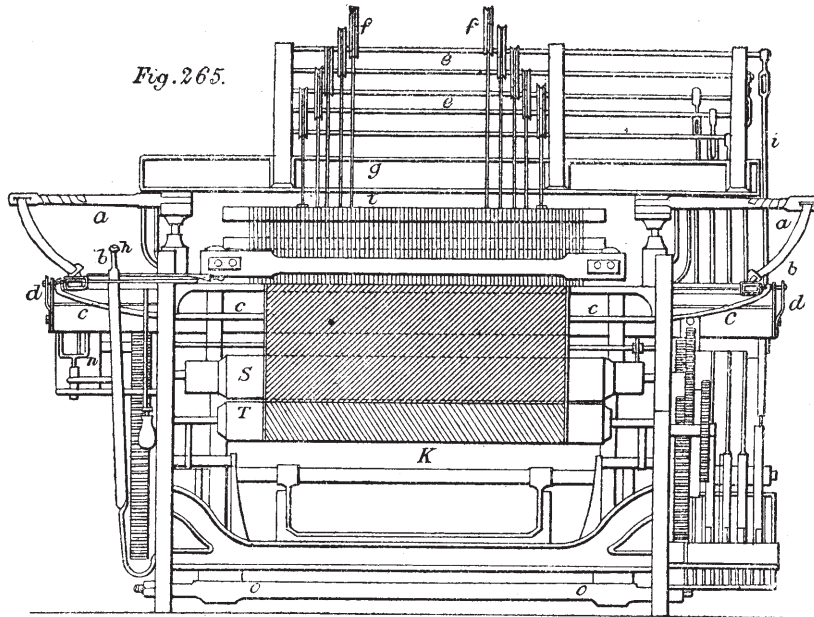
THE COMMON POWER LOOM—TAPPET MOTIONS—BOWMAN'S—ROBERTS'S
—WOODCROFT'S—SCHOENHERR'S—HATTERSLEY AND PICKLES'.

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



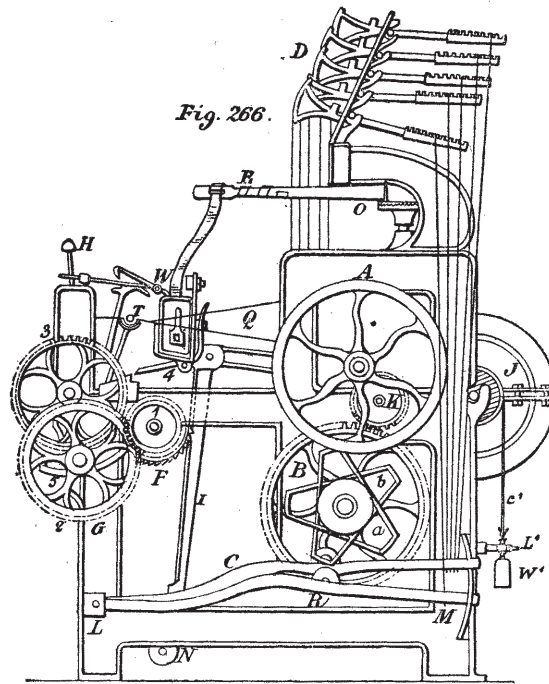
fly-shuttle. A strap *c c* extends across the shuttle race, as shown, and is kept in position by means of staples. The ends of the strap are looped on the picker spindles at the back of each picker, so that when the shuttle is driven to the opposite box, it forces back the picker and the strap also, 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.



The headles i , Fig. 265, are each attached to a pair of levers ff , fixed upon rocking shafts ee , 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 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*, 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.

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

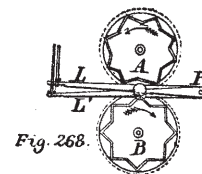


Fig. 268.

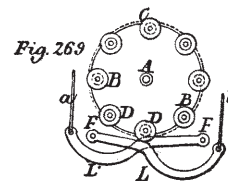


Fig. 269.

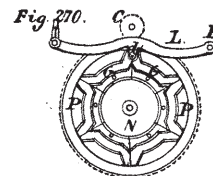
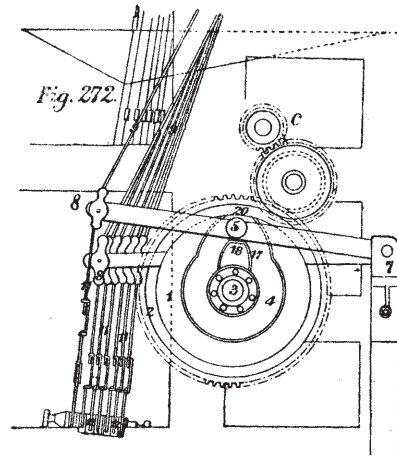
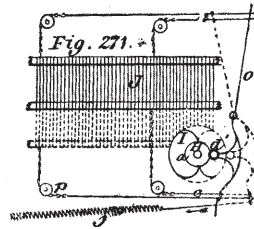


Fig. 270.

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 pulleys are fixed as shown.

The peculiarity of this motion consists in the formation of the pulleys—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'* will rise and the lever *L* will fall, because the larger or outside pulley depresses the lever *L*, and consequently raises the lever *L'*. Therefore upon fixing the pulleys against the plate depends which treadle is to be raised, for by placing the larger side the lever *L'* would be depressed and the lever *L* raised, one of the



ords *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 *H*. The roller *a'* 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 neces-

sity 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.

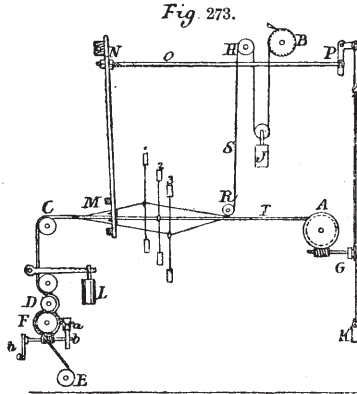
The warp beam should also be supplied with means to allow the warp to be delivered at either a given rate of speed or with a constant and even tension upon it. To deliver it at an even rate so as to exactly correspond with the take-up motion would be a hopeless task, although it has been frequently attempted. 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.



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 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.

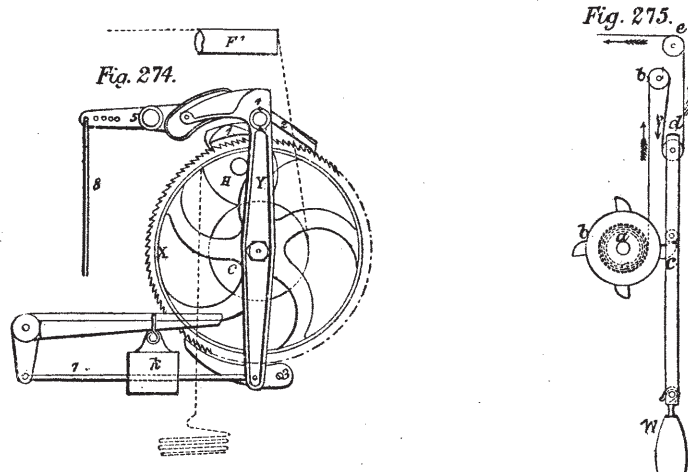
This arrangement takes up the cloth with perfect regularity and is well adapted for its purpose.

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*ⁿ 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



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.

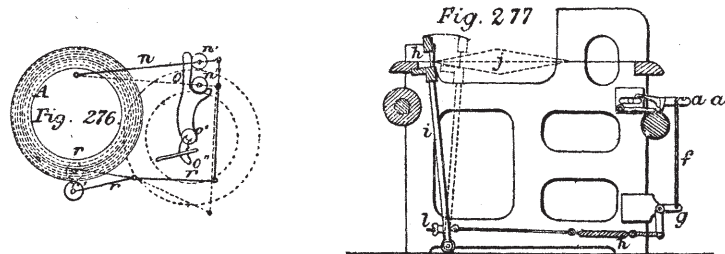
The warp is contained on the bobbin *a*, Fig. 275, and passes over and under the pulleys *b*, *d*, *e*. The pulley *d* is placed between two

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.

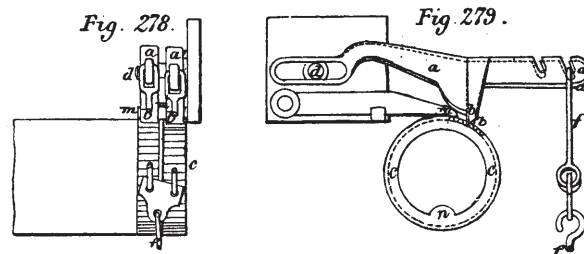
Now it will be evident that as the warp beam decreases in diameter the pressure pulley on the lever n will fall from n' to n'' , and in consequence the even tension on the lever n will be regulated so as to throw upon the brake connexion between o' and o'' an even pressure. The effect produced by this 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



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 gauge 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.

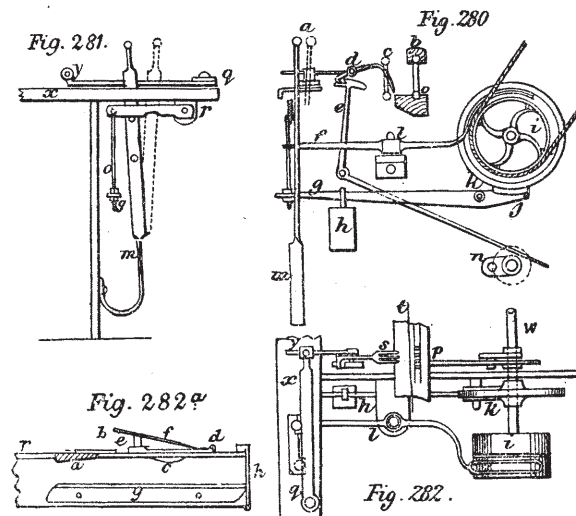


Fig. 280 is a section; Fig. 281 a front view; and Fig. 282 a plan.

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 *e* 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*.

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.

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

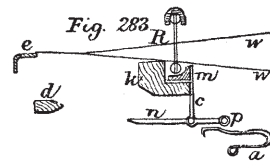


Fig. 284

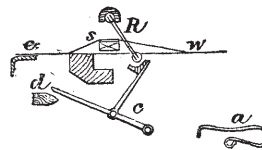
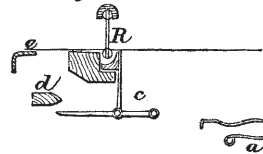


Fig. 285.

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.

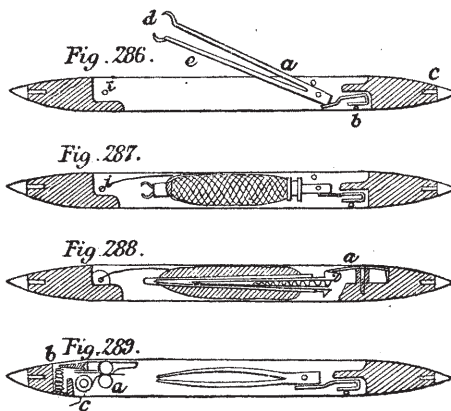
THE common power loom shuttle differs from the hand loom fly shuttle but very little except in size. A good specimen of one is shown in section at Fig. 286. It measures $12\frac{1}{2}$ " long, $1\frac{1}{2}$ " wide, and $1\frac{1}{8}$ " deep, and weighs exclusive of the bobbin $9\frac{1}{4}$ ounces. 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



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.

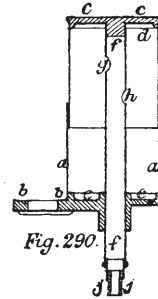
A shuttle for weaving wire or other substance requiring an equal tension, as shown in Fig. 289, was patented by Mr. R. C. Rayson, Manchester, 1875.

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.



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.

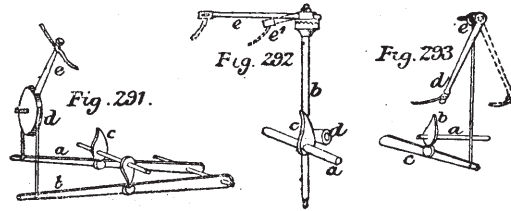
The various means for propelling the shuttle are as follows:—

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.

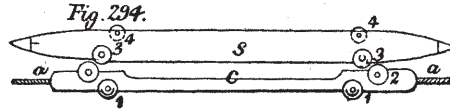
The application of compressed air for driving looms or parts of the loom, such as the shuttles, does not seem to have met with success, although considerable ingenuity has been displayed, and numerous attempts have been made to carry it into effect. When applied to the shuttle, a cylinder with piston 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.



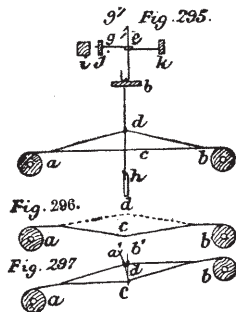
As the carriage is drawn along, the warp passes between the rollers 2 and 3, and does not prevent the movement of the shuttle; but to make the action more certain rollers, 4, 4, are fixed on the upper part of the shuttle, so that a plate fixed on the underside of the reed cap prevents the shuttle from 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,



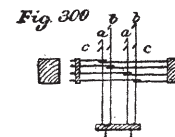
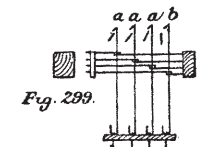
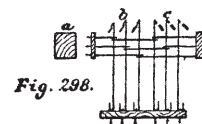
which is a diagram showing its action upon the warp. The cloth and warp beams are shown at *a* and *b*; the cylinder and needle board at *i* and *j*; the spring box at *k*, and the raised griffe bar at *g*¹. The shed is opened by lifting the hook, which raises the warp thread from *c* to *d*; and in 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

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.

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.



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.

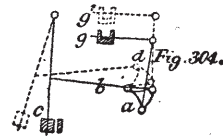
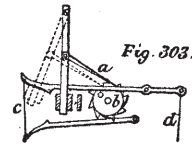
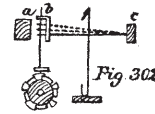
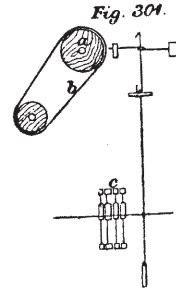
Martin's machine (1850) was a good specimen of a paper applied Jacquard, and machines are now (1878) shown in the Paris Exhibition worked with paper.

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.

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.

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

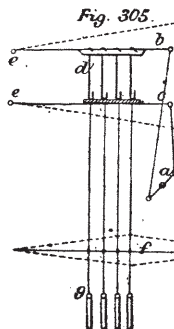


on a similar plan, but the system has not hitherto been found to answer satisfactorily.

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.

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.

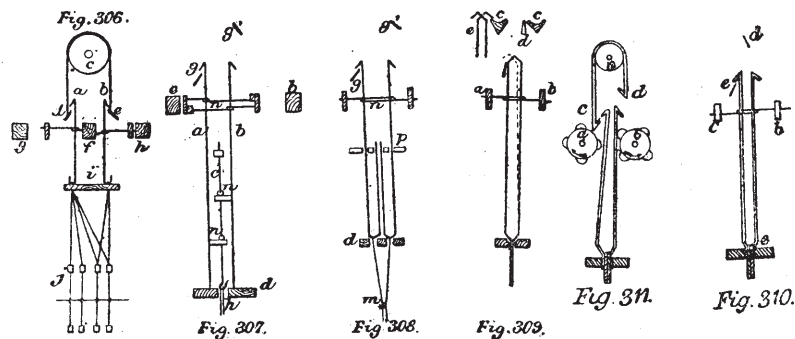
After the various double treadle draw-boy machines were introduced, the barrel machine, an old contrivance, underwent an alteration in the same direction, for in 1818 Benjamin Taylor obtained a patent for an improved barrel loom by employing two barrels, one on each side of the loom, the harness having 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 doobby, 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



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 corre-

sponding 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.

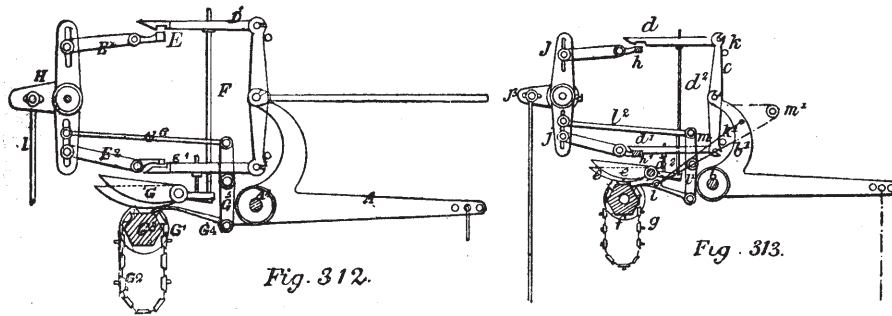
Two other modifications of this principle are shown in Figs. 310 and 311. The first one was patented by Messrs. J. and M. Pearson, of Bradford, in 1868. The hook is formed double, and has two griffes, *a* and *b*. It acts in a similar way to that shown in Fig. 308, but has the advantage of only one neck 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 *c*, 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'*, 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 pég 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



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 apparatus 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

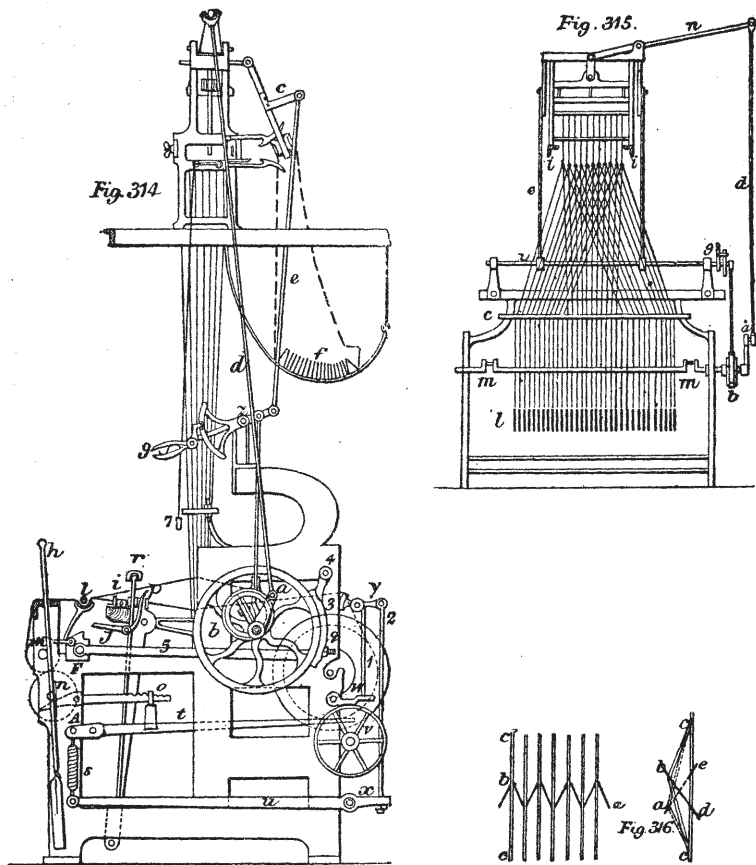
healds to produce the required cross stripe; and one lag is pegged to produce plain weaving; and when this last-named lag comes under the feelers *c*, the pawl *l* is lifted from the ratchet, so that the barrel *f* will remain stationary. Another modification was patented by P. S. Vitrant, of Paris, 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.



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.

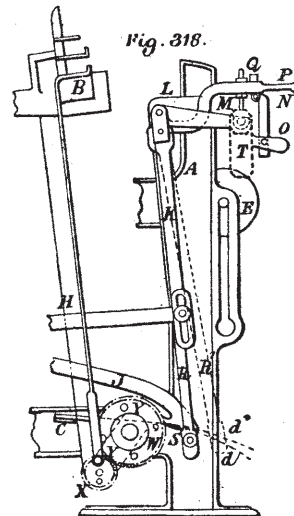
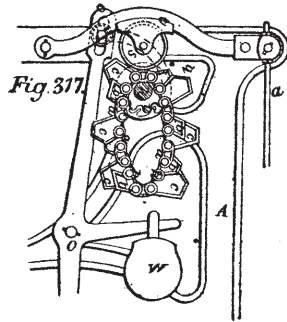
IN order to enable the weaver to use in the fly-shuttle loom two or more shuttles containing different kinds of weft, the drop box was invented by Robert Kay, in 1760. This contrivance was found to be of such great use that on the introduction of the power loom the application of a drop-box to it was 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.



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'*, 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'* has raised the spring *d* to *d'*. 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.

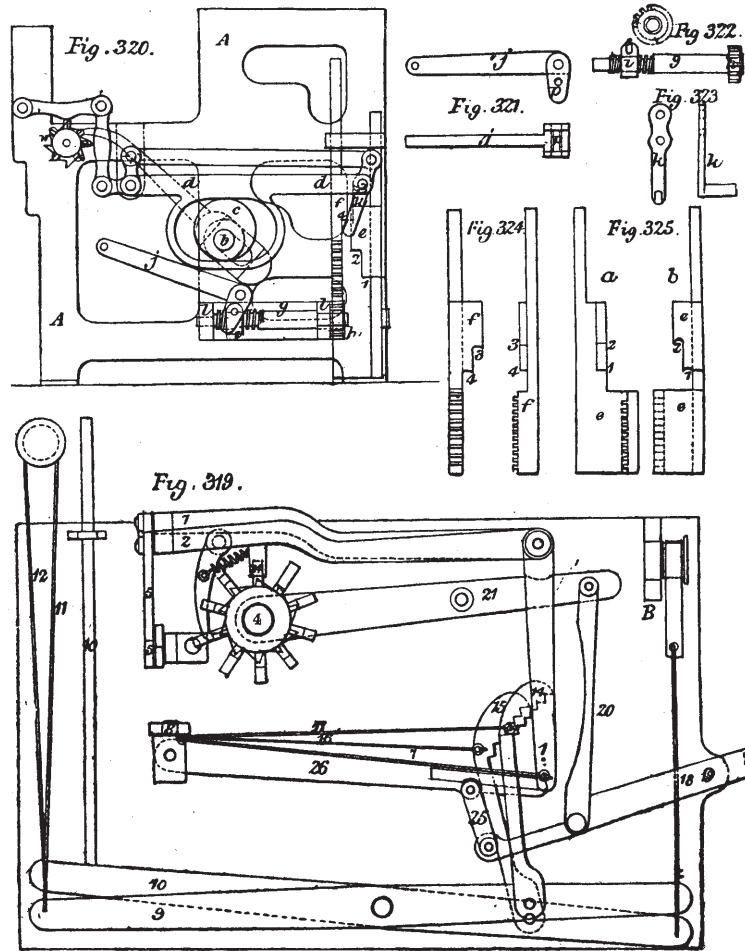
Figs. 1 and 2 are levers working on a stud, and under them is placed a card or pattern cylinder; the levers 1 and 2 may be provided with a number of pendant prongs, according to the number shuttle cells, to act in conjunction with the holes or blanks in the cards (or pins of unequal lengths, as shown 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.

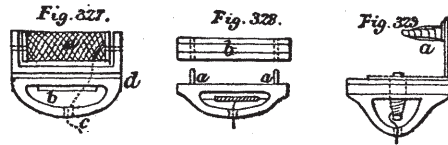
Circular boxes are usually made with six chambers, but some are constructed with double that number. In drop-box looms a still greater quantity of shuttles have been used, and it is not easy to see what advantage the circular box has over it in any respect.

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.

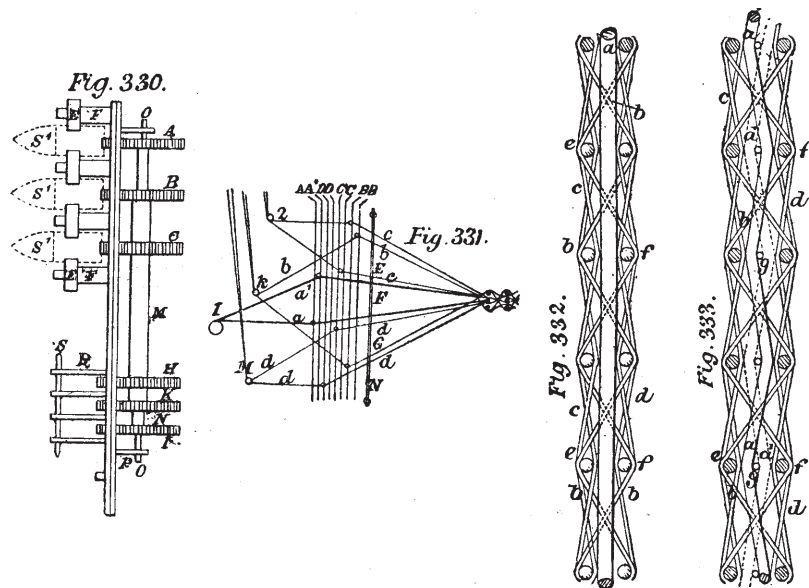
When the required tier of shuttles is selected, it is necessary to throw that tier only, and means must be provided to put it into gear with the driving power. There are several ways of doing this, but the one shown in section in Fig. 330, patented by Mr. J. Beesley in 1861, will suffice. In the figure *A B C* are pinions working, independently, the shuttles *S¹ S¹ S¹*. 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'* pass through the leashes *A A'*; *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'* 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*.

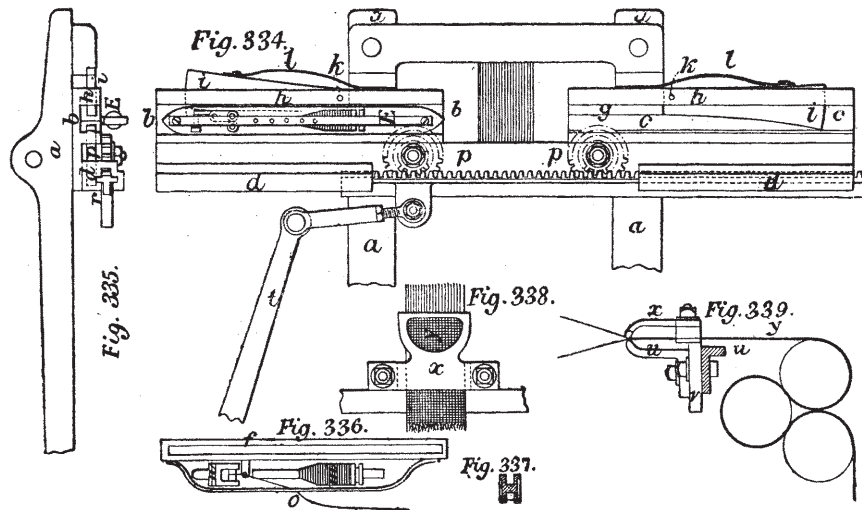
Excellent specimens of ribbon looms for weaving figured ribbons are to be seen in various places exhibited by Mr. Stevens, of Coventry, and fine examples from various countries of such looms are shown in the Paris Exhibition (1878) worked by power, and in one instance by the "bar."

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*.

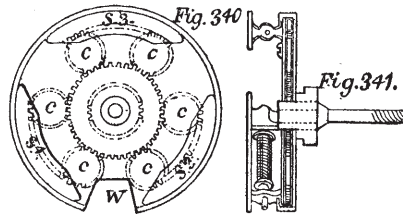
The shuttle is seen in the race at *E*, Fig. 334, and on plan at Fig. 336, where *m* represents the weft bobbin, and *o* the eye of the shuttle. A rack is fixed to the under surface of the shuttle which gears into the larger part of the pinions *p, p*, fixed at each side of the warp. The smaller part 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



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 selvaqe 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

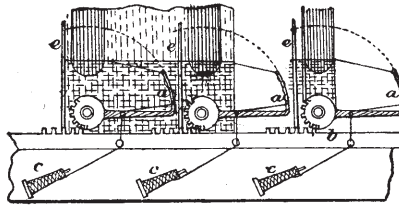


Fig. 342.

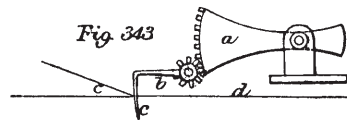


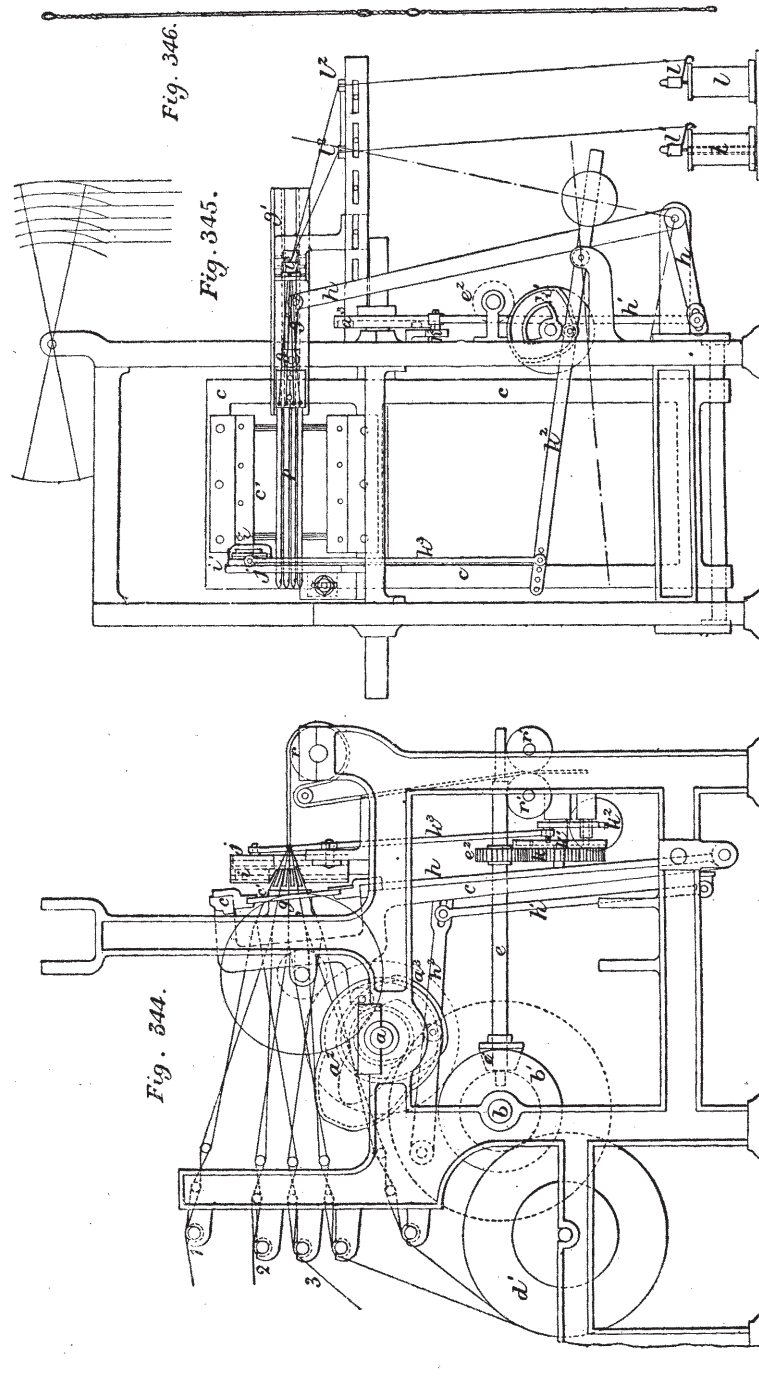
Fig. 343

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.

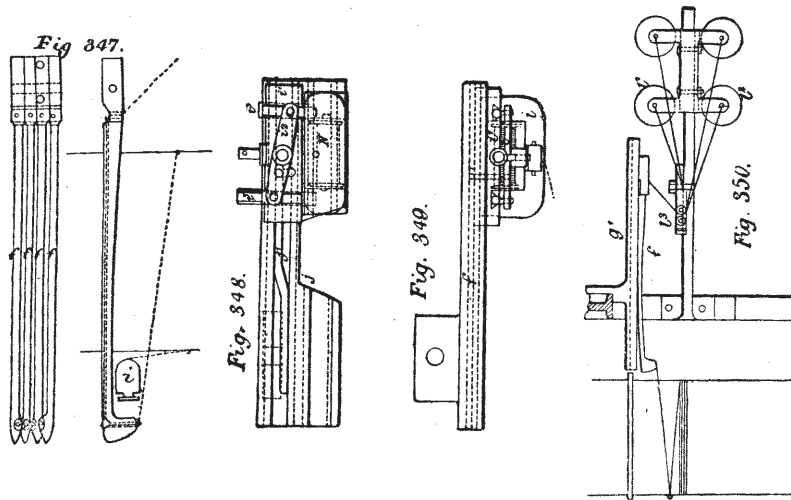
Fig. 344 is a side view of the loom, and Fig. 345 a front view. The crank shaft is shown at *a*; *b*, the tappet shaft; *c*, the batten swords; and *d*¹, one of the warp beams, the other not being necessary to show. At one end of the shaft *b* is fixed a bevel wheel *b*¹, geared into a pinion *e*¹ on the side shaft *e*. The swords *c* and the batten are cast together, and support the reed *c*¹ as usual. To the



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 k



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 h^1 , which imparts a vibrating motion to the lever h^2 , the longer arm of which is connected to the shuttle carrier

i^1 , by the link l^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.

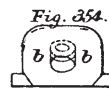
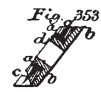
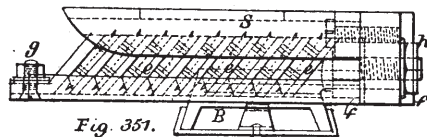
In 1836 disks with pins inserted were used by Mr. Parkinson, round the edge of which (one being placed at each selvage) the cloth travelled, and was, therefore, stretched to some extent. The disks were next made conical, and afterwards they were used in pairs, or two cones fitted together in each temple. 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



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*.

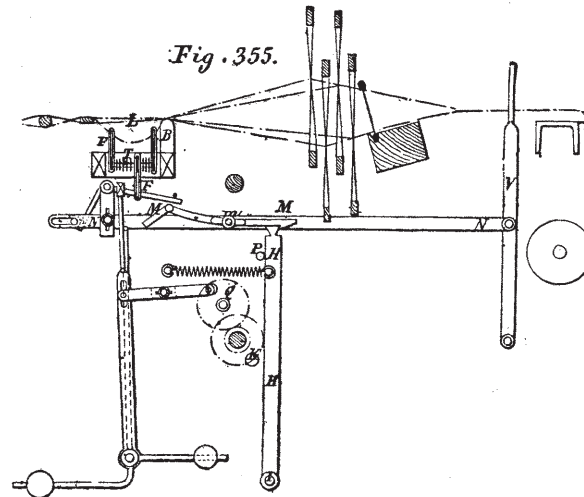
Now if the selvage be inserted under the cap, the pins in the disks will penetrate the cloth, and as the cloth travels over the tops of the disks it will be distended in consequence of the inclined position of the disks. The caps, which are also used in other temples, operate as guides in a similar way 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



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 as 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.

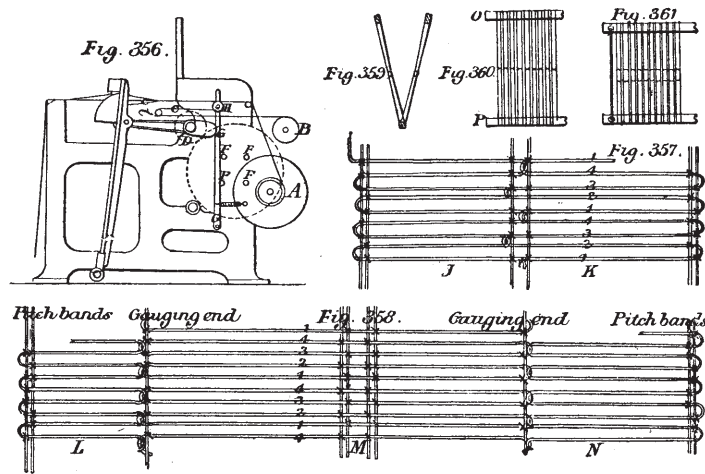
Fig. 359 is a view of the double heald when folded with the heald staves attached.

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 loom 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 hind-

most 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 \times 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 dobbie, 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.

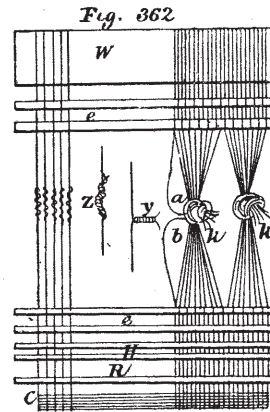
On this principle ornamental cloths are woven, called Indian *Kutars*, and it may be readily conceived that by using a number of gauging threads, governed by a “dobby” or Jacquard, that differently coloured whip threads may be drawn in from the selvages, so as to form various descriptions of borders. 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.



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 Danvers 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 dobbie 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 bicycle.

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;" "Ververet;" "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-

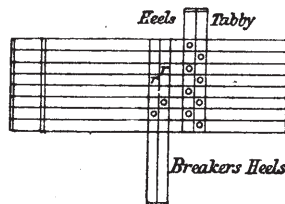
far-off' (the emblem of hypocrisie) which seemed pretty at a competent distance, but discovereth its coarseness when nearer to the eye. Also 'Perpetuano,' so called from the lasting thereof, though but counterfeit of the cloth of the Israelites, which endured in the wilderness forty years. 'Satinisco,' '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 stufte 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.

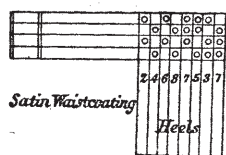
It commences with the following general rules or instructions, which are equally valuable at the present day, as they were when written. The spelling is retained.

"In the tying 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 $\frac{1}{4}$ or $\frac{1}{8}$ 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:—

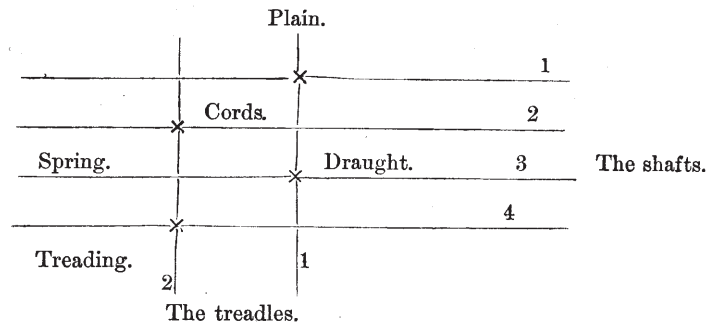
"I observe by the microscope when I draw out a shoot in this kind of goods, that the said shoot or pickover floats under the first and third ends of those four ends which (I dotted out as before directed) form the length of the draught; therefore I put down or

analyze this pickover thus:— $\frac{3}{4} \frac{1}{2}$. 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 $\frac{4}{3} \frac{2}{1}$.

“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 $\times \times$. 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-eighth 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.

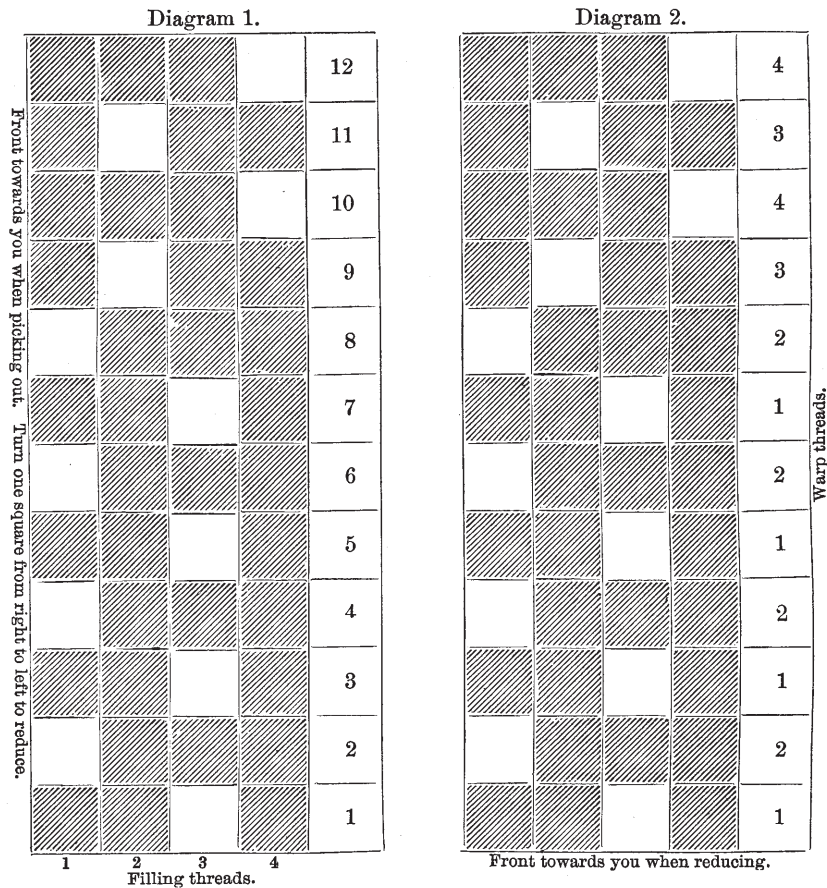
“Commence at the right hand side of the sample; note down on the designing paper all the threads on the filling, and call them so many threads *on*; and all the threads under the filling, call them so many threads *off*. Leave as many blank checks as there are threads under the filling. Continue to work 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.



“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*.

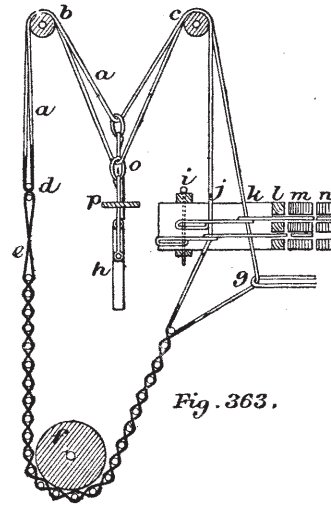


Fig. 363.

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 cards, 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 conclusions 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 Sleaving 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:—

“DATUH 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 67*l.* 16*s.* 2*d.*, and in 1748, 19,181 yards, valued at 127*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 14*l.* 18*s.* 8*d.*

In 1748 William Curry obtained it by weaving 3,830 yards, valued at 18*l.* 9*s.* 1½*d.* In May, 1749, William Curry again obtained the premium by weaving 6290 yards, valued at 34*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 $38\frac{1}{2}$ 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	= $2\frac{1}{2}\frac{9}{0}$	5	= $14\frac{1}{2}\frac{6}{0}$	9	= $26\frac{1}{2}\frac{3}{0}$	13	= $38\frac{1}{2}\frac{0}{0}$
2	= $5\frac{1}{2}\frac{8}{0}$	6	= $17\frac{1}{2}\frac{5}{0}$	10	= $29\frac{1}{2}\frac{3}{0}$	14	= $41\frac{9}{0}$
3	= $8\frac{1}{2}\frac{8}{0}$	7	= $20\frac{1}{2}\frac{5}{0}$	11	= $32\frac{1}{2}\frac{2}{0}$	15	= $44\frac{9}{0}$
4	= $11\frac{1}{2}\frac{7}{0}$	8	= $23\frac{1}{2}\frac{4}{0}$	12	= $35\frac{1}{2}\frac{1}{0}$	16	= $47\frac{8}{0}$

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 ?

$$100 \times 70 = 7000 \div 288 = 24 \text{ spyndles, 1 hank, } 2\frac{2}{3} \text{ cuts.}$$

“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 :—

$$100 \text{ ells} = 125 \text{ yards} \times 70 = 8750 \div 360 = 24 \text{ spyndles, 1 hank, } 2\frac{2}{3} \text{ cuts.}$$

“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 24¼ 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 ⁰⁰	13	16½	26	18 ⁰⁰	49	59	98
6 ⁰⁰	16	20	32	19 ⁰⁰	51	62½	102
7 ⁰⁰	19	23	38	20 ⁰⁰	54	65½	108
8 ⁰⁰	22	26	44	21 ⁰⁰	57	69	114
9 ⁰⁰	24	29½	48	22 ⁰⁰	60	72	120
10 ⁰⁰	27	33	54	23 ⁰⁰	62	75½	124
11 ⁰⁰	30	36	60	24 ⁰⁰	65	79	130
12 ⁰⁰	32	39½	64	25 ⁰⁰	68	82	136
13 ⁰⁰	35	42½	70	26 ⁰⁰	71	85½	142
14 ⁰⁰	38	46	76	27 ⁰⁰	74	89	148
15 ⁰⁰	41	49	82	28 ⁰⁰	76	92	152
16 ⁰⁰	43	52½	86	29 ⁰⁰	79	95	158
17 ⁰⁰	46	56	92	30 ⁰⁰	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.