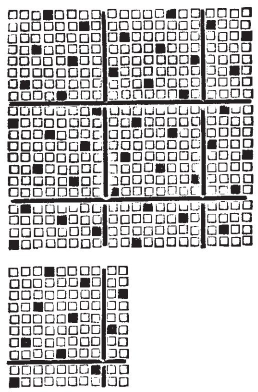
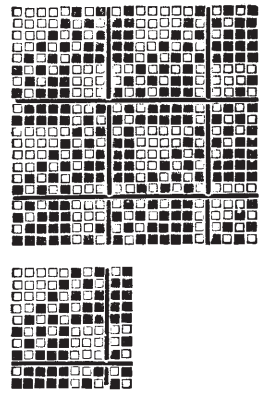
Fig. 62.



A.

Fig. 63.



B.

Fig. 64.

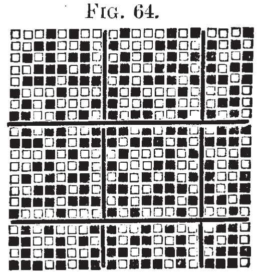
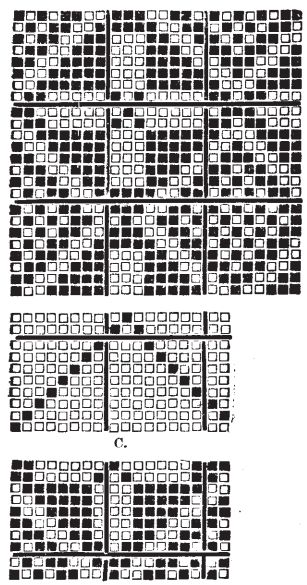


Fig. 65.



C.

D.

The 10-Shaft Twill, etc.

The exigencies of space preclude any further exposition of this phase of the subject. That already given constitutes a sufficient guide for the development and treatment of all designs capable of being made upon any shedding mechanism or apparatus in use, with the exception of the Jacquard machine, which requires a special description. The changes capable of being developed and wrought by the adaptations and combinations of the weaves and drafts already given are almost infinite, and if executed with knowledge, skill, and taste will prove of considerable monetary value.

In larger designs, such as damask figures, the satin weaves act as binders; or the ground may be warp satin, and the figures weft or sateen twills. In these classes of goods two colours are generally used, unless they are fabrics intended for bleaching. One colour is used for the warp, and another for the weft. The ground is preferentially obtained by a weft effect, as the figures stand out more boldly when constructed of a warp satin. Hence all the threads composing the figure effects will have the twill running lengthwise of the cloth, whilst the ground twill, composed of the weft, will run across.

Throughout the preceding remarks, it has been endeavoured to expound the principles of the various weaves and their combinations from a practical standpoint, in order that no difficulty might be encountered by the student in at once making a practical application of them.

Double and Multiple Cloth Weaving.

The student of the textile arts who is only familiar with the plain calico weaving which is so extensive in the cotton, will learn, perhaps with surprise, that double cloths are commonly made in some districts, and that triple cloths are occasionally made, whilst manifold cloths can be made in very ordinary looms with some little extra adjuncts. In order that the student may in some degree be equipped for and prepared to meet all requirements that may be made upon him, some description of these modes of procedure may now be given.

A true double cloth is really two cloths woven at one operation in the same loom. They may, when removed from the loom, be perfectly separate, or combined at one or both sides, or may adhere to one another more or less closely by connecting threads, or be so closely interwoven with each other in that manner that only persons with some technical knowledge really could know the true nature of the fabric. The two cloths may differ in pattern, in fineness of material, and even be of materials quite different from one another in their origin, mode of construction, and the weave by which they are put together. Two, three, or even more pieces of cloth of the width of the loom might be woven together, and being united at the sides when taken from the loom would open out into one wide sheet, three or four times the width of the loom in which it had been produced. Or two widths might be made together and joined at each side, when the fabric would be a cylindrical tube if opened out. In weaving this it might be interwoven at given distances as required, and being cut across at these, the cut lengths would form seamless bags. Many millions of these, popularly called "mutton bags," are made in Lancashire for the Australian and New Zealand frozen meat trade, each bag being of sufficient dimensions to receive the carcase of a sheep.

When double cloths are made reversible they have either two warp or weft faces. When extra weight is required, as in most woollen fabrics, and in some cotton ones, as quiltings, a backing of coarser material, either in the warp or weft, may be attached to the face cloth by what are termed stitching threads, which may be more or less in number, according to the degree of attachment required. In many cases fabrics are thus made three and

even fourfold, not only for obtaining a fine face, strength, warmth, or weight at a low cost, but for getting strange effects and fancy figures by making the cloths interchangeable. Of course when double cloths are produced the maker is endeavouring to meet some distinct requirement, and it is in this way that tubular fabrics, hose pipes and sacks have been produced.

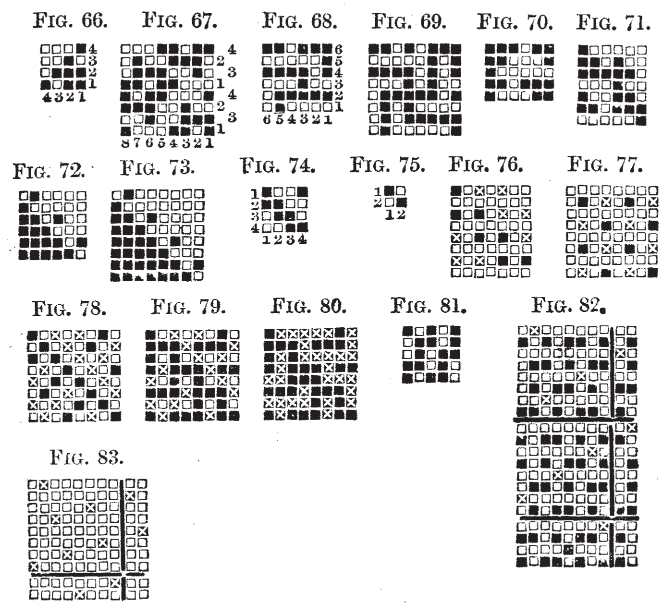
The fundamental principles of these peculiar weaves are simply and clearly stated, and may be easily understood by an examination of the following weaves, in which the dots represent that the heald shaft, and consequently the warp thread is uppermost. The figures at the foot of the weaves show the picks of weft, and those at the side the order of drawing-in the warp threads on the heald shafts. With a warp in two colours, and a pattern two white and two blue threads, the white portion of the warp would be on the first and second shafts, and the blue on the third and fourth shafts. If this pattern was woven with one shuttle, and with the skip-shaft draft of the plain weave given at the opening of these weave expositions, in which the first and third threads would be taken for the first shed, and the second and fourth for the alternate shed, only a single cloth would be formed having a stripe pattern. But by the use of two shuttles, one containing white and the other blue weft, with the weave shown in fig. 66, two separate cloths would be obtained, one all white and the other all blue. The explanation of this is as follows:—On the first pick with the blue shuttle a shed is formed for its passage by the whole of the white warp being lifted above the shuttle-race, and one-half of the blue warp as well. The blue pick taken through the shed by the shuttle gives one-half of the blue cloth; on the return passage of the blue shuttle in the next shed the blue cloth is completed, without mixture with the white warp, because the whole of the white warp is still kept up, whilst the second half of the blue warp has been lifted, and the first half sent down, as will be seen by the blank square on the second pick of the figure. In the next movement the white shuttle comes into work. The third pick is now made, all the blue and one-half of the white warp being sunk, whilst the shuttle makes its passage, the other half of the white warp being kept up to form the shed. This pick of the white weft gives one-half of the white fabric, and when the white sheds have changed their positions, and the return pick of the white shuttle is made, the white fabric will be completed, and two separate cloths, one blue and one white, will have been formed.

If one shuttle only had been used with the above weave the cloths would have been united at the selvages, and a tubular fabric would have been made. It is in this manner hose-pipe, lamp-wick, tucks, bags, etc., are formed. By the addition of a second set of four-heald shafts, making eight shafts in all, and having each coloured warp upon one distinct set, squares for vestings, fancy dress goods, bed-spreads, etc., can easily be developed. All that is necessary is to enlarge upon the weave (fig. 66) just given. Though in the last illustration two shafts were allotted to the blue warp and two to the white warp, there is no reason why ten shafts, or any other number, should not be used for one warp and an equal number for the other, or three, four, or six sets might be used for as many coloured warps and wefts. The principle would be the same, and these are merely adduced to partially show its capacity of application. The different sizes of squares depend upon the number of repeats of each colour over its own set of shafts, and the corresponding number of treads of the warp and passage of the same coloured shuttle until the square is completed. This done, another set of shafts having another coloured warp with its corresponding coloured shuttle is brought into operation.

The weave given in fig. 67 is one for two colours, blue and white, or any other two, warped end and end and drawn in as shown by the marginal figures; the draft on

each set of shafts being repeated to the extent necessary to get the required dimensions, and the treads of each section picked over for a corresponding number of times of blue and white shuttles, alternate squares of blue and white double cloth will be formed.

Fig. 68 gives a double twill cloth, the weft twill being



DOUBLE CLOTHS: WEAVES, ETC.

inside the cylinder cloth that it forms. The figures on the margin show the draft, and those at the bottom the threads. This is the three-shaft twill.

The next design (fig. 69) is the four-shaft twill double cloth. The weave given in fig. 68 is also used for this when employed for bags and tubular fabrics.

The next (fig. 70) is a weave that will produce three cloths in a loom of, say, thirty inches wide, that when woven and opened out will be ninety inches wide, or three times the width of the loom. We commend it to the attention of young students.

If the next weave (fig. 71) had a warp of three colours, warped thread and thread of each in alternation, say brown, blue, and cream, the weft to be picked one pick of each colour in succession, then three fabrics each of a distinct colour would be produced.

Fig. 72 is the same as the last with the variation of requiring only that two threads of each colour shall go together and two picks of each coloured weft be used to correspond. This does away with the necessity of using the pick-and-pick loom as three boxes on one side would do the work.

The next (fig. 73) worked on this principle will give four pieces of plain cloth, each two shafts producing a separate piece of cloth. This system may be carried to any extent, but its principal value lies in the fact that, by the introduction of a stitching thread, the whole four fabrics may be made of any thickness and be bound into one solid cloth. Such cloths if made in woollen might be felted, and of course would contain three or four times the quantity of material as the case might be.

To attempt the exposition of the principles in the fullest detail, and to give minute particulars of the constructions of double cloth fabrics, would require a volume for the task, and which, it will be obvious, cannot be given. A few examples of the system adopted in ordinary practice for backing cloths must suffice.

For backing a twill face such as is given in fig. 74, a suitable backing would be that shown in fig. 75. The first step is the face (fig. 76), and fig. 77 shows the back; fig. 78 gives face and back cloths combined; fig. 79 shows the face warp up to admit the back pick, and fig. 80 the back warp down to admit the face pick.

In these several figures a complete analysis of the method of backing a cloth is given, and it illustrates the principle upon which all such fabrics with a twill face are constructed. The crosses in the design show the position of the stitching or back points all through. A close study of these figures will thoroughly reveal the operation. The point to be determined is whether the stitch is to be obtained from a plain or satin weave. The method of obtaining the intersecting points of any satin weave has already been given, and the rule can be applied to double cloths. But the face weave, of whatever kind it may be, must always govern the back weave, because the face weave may have to be repeated in such a manner as to make it a measure for the back weave. If the flushing of the weft is somewhat long, the stitching must be got as near to the centre of the float, or flush, as possible, and with the face pick going immediately before and immediately following it. To illustrate these remarks fig. 81 is given, which is a five-shaft twill; and fig. 82 shows the repeat, so that it may be stitched with a ten-shaft satin plan. An examination of the two figures will show that the stitching is equally distributed, the face pick preceding and following the stitcher. The principle of the matter is in the count which the backing or satin weave must give. In figs. 82 and 83 it will be seen that two is the count, beginning from the left-hand side, and this counting follows the angle of the twill.

The best practice in laying out for fancy double cloths is to design the face twill or figure separately, and should it require a warp back the vertical spaces in the design are left vacant if the backing is one of face and one of back threads; if two face threads to one of back, then the design would be for the face weave two vertical rows dotted, and one row blank, and so on in this order through the design. If a weft back is required, then the transverse rows are left vacant according to the disposition of the weft picks. After duly considering a face cloth design, a suitable backing weave is drawn out on separate design paper.

This gives a complete idea of the upper and lower surfaces of the cloth, and the backing weave is then run in on the vacant spaces left in the face design. It may, and does often, occur that many designs are so peculiar that it is difficult to devise a proper backing weave for them. In these cases an irregular satin twill will often be found useful. It is of no moment how irregular the stitches may be if they do not show on the face cloth. Judgment must, of course, be exercised to prevent such blemishes. If the illustrations herewith given are carefully studied, they will be found to afford a sufficient exposition of the principles involved in the construction of double cloths, and the practice of them will make an expert.

Crimped Cloths.

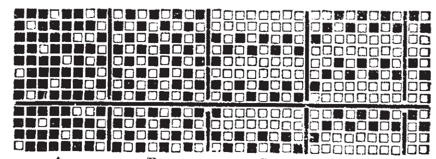
In fancy woven goods a crimped effect can often be introduced with great advantage to embellish the fabric. It contrasts very effectively with any other weave with which it may be combined, and gives ornamental results that cannot otherwise be obtained. At the time of writing this (1893), and for some while past, it has been highly popular as a component part of fancy woven fabrics.

In order to get the best effects, it is necessary to carefully consider the various combinations forming the fabric. A certain relationship that is unchanging, and that gives the maximum of beautiful effect, always exists between the different weaves when used in combination, and it is for the textile artist to discover and employ this in preference to the other dispositions not so good. The chief point to be regarded is the careful handling of the plain weave upon which the crimped effect is to be placed. The portion of the warp to be devoted to crimping, must be run upon a separate beam, for the reception of which provision must be made in the loom. This beam, which we may term the crimp beam, must be very lightly

weighted compared with the other, in order to permit the slay, when beating up the weft pick, to draw the warp from the crimp beam into horizontal ridges, as it is woven. The warp upon the other beam must be kept in a state of tight or high tension, as this is required, and also gives a better contrasting effect.

Fig. 84 shows a combination weave of satin, plain, and cord. As far as designing any weave is concerned, it is comparatively simple. Ribs of different widths may be constructed, and various arrangements of colours adopted at will. The greater the number of weft picks put in, the

Fig. 84.



A. B. C.

Crimped Cloth.

better will be the result. Fancy twills, or figure developments, may take the place of plain stripes.

In fig. 84, A shows a six-shaft satin stripe face effect; B the plain or crimped stripe; and C the corded stripe. Any number of ends may be drawn on each set of shafts, but it is advisable not to unduly extend the width of the various stripes, but to keep them in a proper proportion to each other.

The principle of the construction of these cloths is here pointed out, and all that is required further for the production of very saleable and popular fabrics is taste and judgment.

Cords, Velvets, Velveteens, Plushes, Moleskins, etc.

The term velvet, though properly belonging to a silken fabric, is now also generally applied to fine cotton fabrics made in imitation thereof. The pile of silk velvet is made from the warp, that of all cotton imitations from the weft. To be correctly described, the latter should be termed cotton velvets, to distinguish them from the heavier makes of the same class of cloths which are usually termed velveteens. Silk velvets are always made by the insertion of wires into the shed of the warp, either by the hand of the weaver or by automatic mechanism. In many cases these wires are formed into a knife-blade at one end, so that as they are withdrawn from the other they cut the pile; in other cases the plain wire is used, and the pile cut afterwards. Worsted velvets and plushes are formed in the same manner. Cotton velvets, velveteens, and other cotton-pile fabrics, are made differently, the pile always being formed by the weft, and for this the wire is not applicable. After these goods are woven the pieces are subjected to another process, that of pile-cutting, in which, either by hand or machine, the pile is cut in a direction parallel with the length of the fabric, in this respect also differing from the silk fabric, where the cutting is in the direction of its width. Dressing, dyeing, finishing, and making-up complete the goods for the market.

In the classes of cotton fabrics named above there are numerous varieties, but the examples given below are selected from the best in general use to-day, and will serve the requirements of illustration at present, which is simply to show their principles of construction, and that they belong to the division of double cloths.

Our first illustration (fig. 85) is of a tabby or plain-backed velvet; it is made on six shafts, with a straight draft, and eight picks to the round.

Our next (fig. 86) is a weave variation for velveteen, made on six shafts, and with nine picks to the round.

The third (fig. 87) is also a velveteen made on six shafts, with twelve picks to the round.

Fig. 88 represents a very popular class of velveteens, made on six shafts, with twelve picks to the round, con-

Fig. 85.

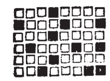


Fig. 86.

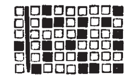


Fig. 87.

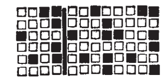


Fig. 88.

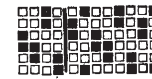


Fig. 89.

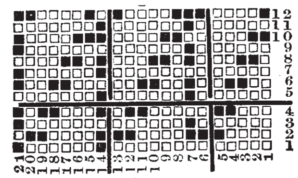


Fig. 90.

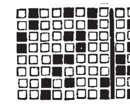


Fig. 91.

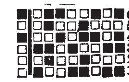


Fig. 92.

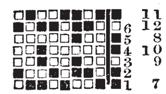


Fig. 93.

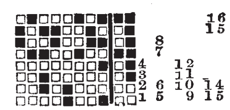


Fig. 94.

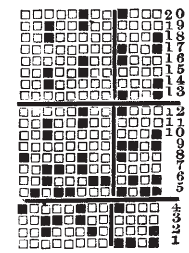


Fig. 95.

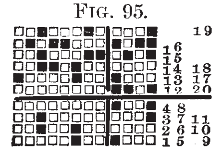
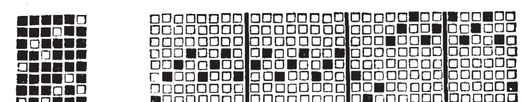
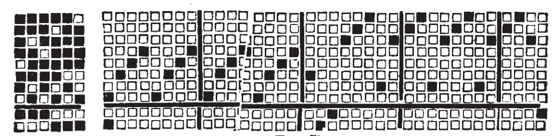


Fig. 96.



A: Draft.

Fig. 97



B: Draft.

Velvets, Velveteens, Cords, and Plushes.

taining 1,860 threads in 30 inches of width, equal to 62 warp threads in 1 inch. The warp yarn is 16^s or 18^s, the weft counts and number of picks according to requirement, this being generally a given weight per yard.

The next (fig. 89) is a velvet with a jean back. The weave shows how the pile and the stitching threads are put in, which will convey a good idea of the construction of this class of fabrics. The twelve shafts on which it is made are numbered on the margin of the plan; the treads or weft picks at the bottom from 1 to 21. The pile or weft face is formed by six picks and the stitching thread, binder, or back, as it is indifferently termed, is the seventh tread or pick; then follows another six picks for pile, which brings us to the fourteenth, forming the second stitching or binder pick tying the face and back together; and, lastly follows six more pile picks and one more stitching pick, completing the round of twenty-one picks. Thus, it will be seen, eighteen pile picks are used, with three jean twill picks for binder and back, which gives a proper and proportionate construction. The ordinary four-shaft kerseymere twill could be used for the back, but if six picks of pile weft were put between each pick of the twill back, twenty-eight picks to the round would be required, as in all backed cloths; whatever may be the weaves used for the back and face they must work in harmony with each other throughout the round, or the result will be imperfect.

Fig. 90 exhibits a ribbed velveteen, made on eight shafts, straight draft and ten picks to the round. This requires good yarns, uniformly cylindrical, to make a neat fabric, because the rib is formed from them.

Coming to the cords, which constitute another class of heavy cotton goods, kindred to the latter, the first specimen is given in the design of a thickset-cord (fig. 91), the least in size that can be constructed. The pile forms two separate cords, and in the cutting process the cutter runs his knife between the threads Nos. 2 and 5 (see the

numbers on the margin of the design, fig. 91). In the construction of the fabric a tube or longitudinal cell is formed to admit of the cutting process, and to separate the pile into the lines which form the peculiar feature of cords. The back of this example is constructed in the same manner as a velveteen, being composed of two single jean twills. The best reed in which to make it would be a 36^s Stockport count, and a 14^s single warp, with sufficient weft picks to give a weight of 10 ozs. per yard.

Fig. 92 is a seven-shaft cord, the draft of which is given in figures on the margin.

Fig. 93 is a double jean round top cord, eight shafts, sixteen ends draft, and ten picks to the round.

Fig. 94 is the analysis of a cable cord on twenty warp threads.

Fig. 95 is the reduction to ten shafts, draft on the margin; twelve picks to the round.

Fig. 96, with the draft A, will produce the hunter's cord. It is made on eight shafts, with a thirty end draft, which is given in A, and six picks to the round. With this design and draft fancy cords with stripes of various colours can be made with the greatest facility. With twenty-four dents per inch in the reed, 16^s warp, three threads in a dent, and sixty picks per inch of 14^s weft, an excellent fabric will be obtained.

In fig. 97 a variation of the hunter's cord is given, known as the "Bedford." This is often produced in woollen and worsted. It differs in its construction from the modern ladies' dress-cloth which has usurped its name. It is made on ten shafts, with a thirty-six end draft, given in B, and six picks to the round. Good useful cloths are made in it by using a 30^s reed, with three, five, and six threads per dent, and 29 inches wide.

A great variety of weft and warp cords might be brought forward, but the principal having been given they will suffice for the purpose, as it is not difficult to produce others by changes of material, weaves, and drafting.

Plush is a pile fabric having a longer pile than velvet or velveteen It is of two kinds, warp and weft plush. The former is made by the same means as silk velvet, cut-pile carpets, etc. The pile is formed by the insertion of wires, and cut by their withdrawal. The loop plushes, of which the familiar Brussels carpet is a type, are made in the same way, but the pile is not cut, as the wires are not armed with knives. Weft plush is made by merely extending the length of the pile of velvets and velveteens. It is made by the same weaves. The ground may be either plain or twilled. When woven it is cut in the same manner as velvets and cords, and dyed and finished as they are.

In making these goods it is best to use the sateen dis-

Fig. 98.

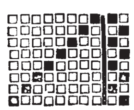
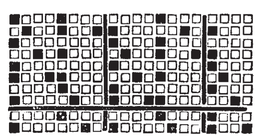


Fig. 99.



Velvets, Velveteens, Cords, and Plushes (*continued*).

tribution of the stitching or binding threads, as regular courses are thus ensured for the cutter's knives. Fig. 98 gives a plush on eight shafts with a straight draft, two weft picks, plain weave for binders to form the back, and eight plush picks.

Fig. 99 is one on ten shafts, straight draft, and twenty picks to the round, five of which are used to form the twill back.

For seal or other imitation skins, fancy coloured mottled yarns are used, and, if necessary, a greater number of shafts with more extended drafts are brought into use, but the principles of construction are the same throughout, and this being the case further examples need not be given.

Gauze or Leno Fabrics.

We now come to the exposition of a weave which differs in its principle from any that have gone before, and constitutes the fabrics into which it is introduced, a class by themselves. In all the preceding weaves, however intricate the patterns are or may be made, one principle underlies them all ; the warp and weft threads are arranged in their respective parallel orders, and more or less close together, according to the required density or openness of the fabric to be constructed. This order is also maintained in gauze or leno weaving, two names which are indifferently used to designate the same thing. The point of difference arises in the manner in which the intersections of the threads are made. Instead of the intersections being, as before, between the warp and weft threads, they are made entirely between the warp threads themselves, and bound in position by the weft threads. This is shown in the following illustration (fig. 100). There are two warp threads, A, B, and four weft threads shown. Let the student take the thread A, and examine its relationship to the weft. It will be found that it passes under every one of the four threads of weft. Now take the thread B, follow its course in the same way, and it will be found that it passes over every one of the four threads of weft. In all ordinary weaves with such an arrangement of warp and weft threads, there being no intersections between the two series of threads, there would be no fabric. The intersections, however, have been removed from the weft and transferred to the warp, and take place amongst the warp threads themselves, and only amongst them. It will be observed that the warp threads

Fig. 100.

cross one another in the spaces from right to left, and left to right alternately. But even here they are not like the intersections of the ordinary weave: in making these crossings they never go under and over each other, as do the threads of warp under and over the threads of weft. They simply cross one another from side to side, the same threads being always uppermost and always undermost throughout their respective courses. It will be obvious that mere crossings of this kind could never make an arrangement of threads that would be permanent, which is an essential requirement in the construction of a woven fabric. Steps must therefore be taken to render these crossings of the warp threads permanent. This is accomplished by the introduction of the weft threads in the manner shown. In the shedding arrangement the white thread, A, is so actuated that it is depressed first on the right of the black thread, B, and then on the left of it, so much as to allow the weft threads, 1, 2, 3, 4, etc., always to pass over it. Correspondingly, the black thread, B, is always raised to let the weft threads pass under it, it thus coming to pass that the white thread is always down and the black thread always up in their final disposition. The function of the weft, it will thus be seen, is to form a binder or retaining thread, in order to keep the warp threads permanently in the position they have been made to assume. This passage of the warp threads across and partially around each other, is ordinarily described as a twisting movement, but this is not correct. The twist or twine is mostly imperfect, as only in a few special cases in the loom do the threads make a passage around each other of more than three-quarters of a revolution, from which point they reverse their movement, returning on the track they came to the point whence they started. In the lace machine or loom the revolution is complete, but it is made by the weft passing completely around a warp thread, instead of the partial twist of two warp threads.

The method of constructing gauze weaves differs con-

siderably from that of ordinary weaves, because of certain conditions governing the twisting of the warp threads. A design for gauze is therefore more difficult to comprehend, and before attempting to construct one, it will be desirable to briefly examine the mechanical devices for crossing the warp threads. Without the acquisition of this knowledge as a preliminary, it would be wasted time investigating the construction of gauze fabrics.

In weaving gauze fabrics, or seeking to introduce gauze effects amongst other weaves, two sets of heald shafts are required. The first set, called the plain shafts, *a*, is to produce the ordinary weave that may be required, and to co-operate with the gauze or second set, which are termed the gauze healds. The second set, for the crossing or twisting operation, carry the "doup" healds, *b*. Sometimes these are made with the doup shaft at the top and sometimes at the bottom; both these methods are shown in fig. 101. They have what weavers term a double eye, or an eye or opening for receiving the warp thread below the centre of the heald, and a second one immediately above. This set of healds or doups in working are always subject to a far larger amount of friction than the ordinary healds, and therefore require to be made of material that will successfully resist the great friction to which they are subject. This should be silk, or a strong and highly finished cord that has surfaces that will permit the warp threads to glide against them with a minimum of friction, and consequently of wear and tear. The two sets of shafts are, however, connected with each other by their healds, and therefore are actually arranged in pairs. Fig. 101 gives a good illustration of the construction of the doup heald. The loop, *e*, formed by the cord, passes through the eye of

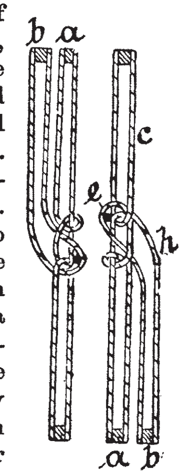


FIG. 101.

the standard heald and carries a warp thread. This it transfers, in alternation, first to one side and then the other of its companion thread in the "standard" heald which holds the doup heald. This doup, with its thread, is the chief factor in gauze weaving. The doup cord is shown at *h*, and *c* is the standard heald.

In draughting or drawing in the warp, in cases where doup healds are employed, the first warp thread is drawn in the first shaft of the standard healds, as usual in plain cloth weaving, and then through its doup, whilst the next is drawn through the second standard shaft directly over the doup thread just described, both threads entering one

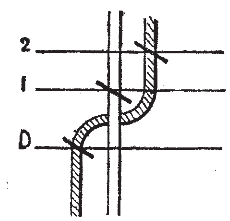


FIG. 102.

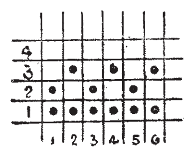


FIG. 103.

dent of the reed. And so the draft proceeds in this order across the warp. When the draft is decided upon, the drawing-in follows it as given.

In fig. 102, which is the pegging plan, D is the doup, and figs. 1, 2, the plain weave shafts. Fig. 104 shows the first thread on the first shaft, and the second thread on the second shaft, and so continued over the two shafts. In this figure the doup thread is shown at A, and, as will be observed, is passed under the threads with which it will work, and through the loop of the doup heald. The thread B is only drawn in on the regular shaft, and passes through the gauze shaft between the doup healds, without being subjected to them in any way. An examination will show that the doup thread A, in the plain

healds, is on the left of B; in the gauze healds it is on the right of B. When the threads are thus arranged, their action is always conjoined, and they are dented, or drawn through the reed into the same space together.

In fig. 103 the weave plan for an ordinary gauze is shown on design paper. Two of the vertical lines constitute a representation of fig. 102, but the representation has been extended to three repeats, in order to show its appearance more fully upon paper.

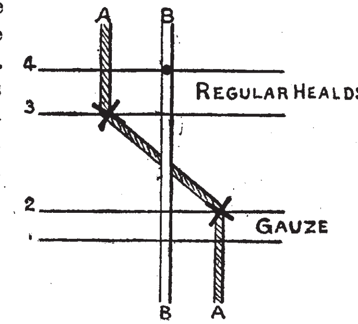


FIG. 104.

To give proper expression to the character of the gauze weave, it must have a contrasting plain or satin weave beside it in stripes, when it will stand out clearly and distinctly, forming a fine lace-like ornamentation. If it is desired to carry the ornamentation further, the fabric can be

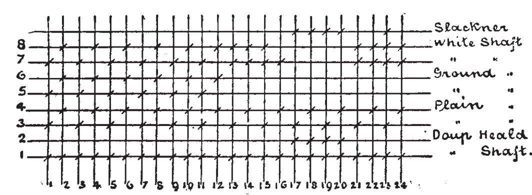


FIG. 105.

checked by a plain transverse stripe, in which case the weave must be of the same texture as the plain weave in longitudinal or plain warp stripe. The doup or whip-thread, or the ground, is double when gauze is made, but the plain weave separates them. Fig. 105 is the weave plan, numbered from 1 to 8. In this plan No. 1 gives the action of the doup shaft, which is raised at every weft pick; No. 2 is the doup heald, and it only rises with one on the four weft picks, 17, 18, 19, 20; the shafts 3 and 4 are for the plain stripe, and shafts 5 and 6 for the ground; these weave plain for twelve picks. Shafts 7 and 8 carry the doup or whip threads, which also weave plain for twelve picks. At the thirteenth pick they combine, and are up for four picks and down for four picks in alternation. During the time of this combined movement, the ground shafts 5 and 6 remain down. The ninth is the position of the slackening bar or rod, which has been introduced to obviate the necessity of employing two warp beams. It will be seen that it rises on the same picks as the doup healds, No. 2, whilst the whip shafts 7 and 8 are down; but the whip threads themselves are lifted to the opposite side of the ground threads, giving the twist or turn required. Of course the "reeding," that is, the drawing of the warp through the reed, of gauze or leno fabrics is specially considered in this case; twenty-four threads would be placed in eleven dents in the following order: four threads in the first dent, and the second dent vacant; again, four threads in the third dent, and another dent left vacant; four threads in the fourth dent, and two threads each in the next six dents. The word dent properly and primarily means tooth, and here indicates the teeth of the reed. It has, however, come to be used to designate the spaces between these teeth, and is so used above. The Scotch term of "splits" would be a more accurate one. The technical terms used in the textile industries, however, like those of nearly every other industry, require a thorough revision and clearer definition.

Very elaborate effects can be obtained with the use of gauze or leno healds, as the warp stripes and the checking can be varied to any desired extent by using a greater or less number of threads for either the plain or gauze effects.

If gauze fabrics are compared with any other cloth constructions, they will be found superior in lightness of

texture and firmness of interlacing, which is due to the partial twist of the threads around one another, and the firm manner in which the weft secures them in that position, enabling the fabric to bear a great strain.

In reference to fig. 101, the draft and weave plan of which is given in fig. 102, if the weft picks are taken in their numerical order, it will be seen that the first raises the doup thread to the right, and the gauze shafts will be lifted, 1 and 2 being raised on this first weft pick. On the second pick the doup thread is transferred to the other side, and the shafts for this are the first and third. The shedding for the next pick is the same as the first; but the doup or skeleton shaft is always up, this being necessary for operating the doup thread by the action of either the ground shaft 2, or the gauze shaft 3. The fourth shaft is always down, as it carries a stationary thread, and may be regarded as an extra shaft only. In fig. 100 the warp threads are drawn so tightly to each other, that the weft pick cannot be drawn up very closely to the preceding pick, so that an open space is left between every pick, and vacant dents being left in the reed to correspond with these spaces, the gauze effect is the result.

The "warp-slackener" or "warp-easer" is a bar or rod which separates the crossing warp from the other. It is fixed at the back of the loom, and may be termed a lever. In the plain weave portion it is inactive; but when the crossing has to be made, a connection on the arm of this rod acts upon the doup heald, causing it to deliver sufficient warp to prevent injury to the other warp threads, after which it is drawn back to its former position by a spring. This method, however, is not suitable for more than the leno fabric in which the doup thread passes under one standard thread only, and in those in which the doup thread passes under more than one standard thread at a time it is necessary to adopt the old system of two beams, in order to diminish the strain upon the doup thread, and the friction upon the doup healds.

The principles and methods thus laid down are generally followed throughout gauze weaving, any departure from them being mainly in the number of stationary threads, around which the doup threads twine, which may be increased as desired. Threads of different colours, or fancy stripes, may be produced to any extent, and gauze and figures, etc. All threads that work the same way can be drawn in on the one doup shaft. The jacquard machine and harness give an almost unlimited variety of figured gauzes; but the improvement in lace frames and their cheap productions, have caused the most elaborate forms of fancy woven gauzes to become an almost extinct branch of weaving.

Jacquard Harness.

In considering the weaves hitherto dealt with it will have been seen that the warp has always been mounted in what have been termed healds, themselves mounted upon and stretched between two staves of wood in number sufficient to meet requirements. A mount of healds of this kind is termed a leaf or shaft, and the number of these required to operate a warp are termed in turn a set of healds. As will be borne in mind, the simplest set is one of two leaves or shafts, advancing up to twenty or even twenty-five shafts; there are dobby machines will admit in extreme requirements up to forty shafts of healds, but the crowded state of the loom requires such a long stretch between the last heald shaft and back rest as to prevent their common use. Beyond these resort is had to the jacquard machine for shedding purposes, owing to its beautiful simplicity and great range of power. In the transition from the preceding system to the new one the terms hitherto used are dropped, and the set of healds becomes the jacquard harness. The simple construction of an ordinary harness is shown in fig. 106. The front now only is given. It will be seen to be composed of several parts: the first, the harness necks shown by the

figures; the couplings shown at the knots, E E; the lingoes or weights, F. The harness necks are connected to the jacquard hooks by passing them through the bottom board of the machine upon which the hooks rest when not in action; these cords are also often termed neck bands. The couplings or knots, E E, shown above the comber board, are a continuation of the neck twines carrying the mails or eyelets, D, through which the warp threads pass, as in ordinary healds. The lingoes, or weights, upon each cord are for the purpose of bringing the warp threads down to their normal position after having been lifted by the hooks in accordance with the shedding requirements of the pattern.

Jacquard harness is full, half, or sometimes otherwise incomplete, according to the nature of the requirements in which it is used. The harness generally in use is the full harness, by which every warp thread throughout the tie if required can be operated singly and independently of the others. In a word it may be called the universal harness, capable of doing whatever can be accomplished by any other build or construction of jacquard mounting. Of course, as in heald shaft shedding arrangements, in the repeats of the pattern the corresponding threads are lifted simultaneously.

There are, as might be anticipated, many varieties of jacquard harness, such as the half, the gauze, the double cloth, the pressure, etc. The half harness has every alternate warp thread drawn in through the mail eye, the other threads only pass through the doups and standard or shaft healds in front of the comber board. This arrangement is used for obtaining a certain class of gauze effects or fabrics. The pressure harness has a given number of warp threads drawn in through each mail eye, which are also operated by heald shafts in order to weave the ground of the fabric. This is no doubt a useful and economical method of forming figures in cloth and saving cards, but it has very serious drawbacks owing to the excessive friction it entails upon the yarn in shedding.

There are two plans of mounting a jacquard on the loom, both suitable for any tie or fabric. These are respectively called the London and Norwich systems, and both have their advocates. The London system arranges the jacquard at right angles with the harness; the Norwich one parallel with it. Our illustrations show the latter arrangement. Fig. 106 shows the front row of a jacquard harness. The horizontal lines A proceed to and are attached to the jacquard machine hooks; B shows the tail cords; C points out the knots connecting the upper and lower portion of the harness; D is the comber board; E the mail eyes through which the warp threads pass, and by which they are lifted to form a shed; and F, the lingoes, or weights, which draw the mails down to their normal position. In fig. 106 only the front row of the cords passing through the comber board D are shown, it not being necessary to exhibit more as all are alike. Now if in mounting the jacquard machine on the loom it be placed with its end to the front or at a right angle to the harness, the mount will be what is called the London plan, which twists the harness cords a half turn around each other. A moment's consideration will show how this happens, for whether the first cord is taken up from the front right or left-hand hole in the comber board, and secured to the front or back hooks of the jacquard machine the cords must eventually cross each other, and the constant rubbing which results in passing each other in forming every shed for the passage of the shuttle must be destructive to the cords. It is said by the admirers and advocates of this arrangement that the half twist it gives to the harness keeps the cords better within bounds, and that a heck or guide can be dispensed with. In the Norwich system the jacquard machine is arranged on the loom parallel with the harness, reed, and cloth, the strands or cords are taken up to the hooks just in the same order as a heald shaft with its complement of warp threads, and when a cord breaks it can be traced at once by separating

the entire row from the next one, which can be done without the slightest difficulty, each row being entire and clear of each other. This is a very useful feature, greatly facilitating such repairs when needed.

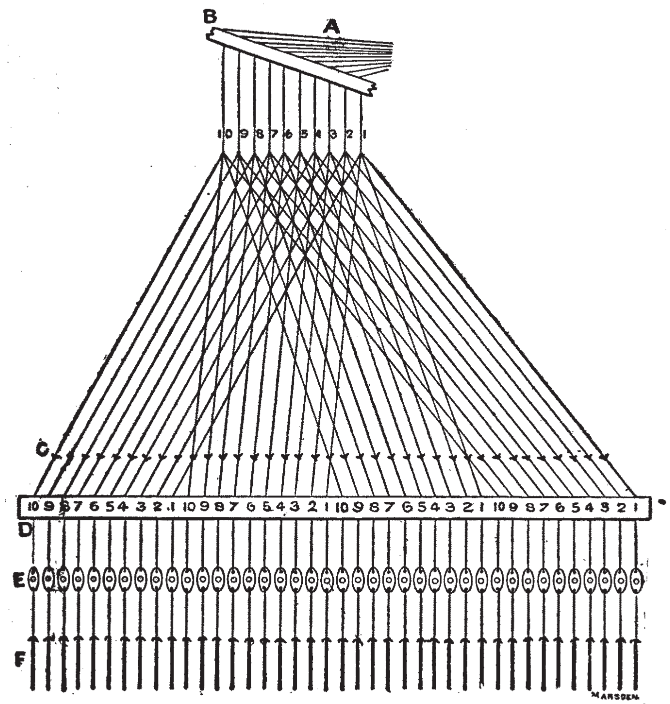


FIG. 106.—JACQUARD HARNESS, FRONT ROW ONLY.

A 400-hook jacquard really contains 408 hooks, the eight beyond the nominal count being allowed for the formation of the selvages of the cloth or other purposes. The 400 hooks are available for operating the warp threads in the production of the pattern across the field of the cloth to be made. They are, in their ultimate power, equivalent to 400 shafts of healds, as described in the exposition of shaft work, as this number of shafts would be required to produce the same capacity and extent of ornamentation.

The designer who has only 400-hook machines with which to work out his designs is limited by their capacity of work. To extend his designs he might require a 600, or two 400, two 600 machines, etc. In the case of the 400 machine, however, the comber board and the arrangement of the hooks may be taken to be eight holes across, and fifty holes in its length, with every harness cord direct from the mails through the comber board and on to the hooks in the machine, without crossing or chance of coming into contact and causing friction.

The number of holes in the comber board are regulated by the number of threads per inch in the warp, and the function of the comber board is to prevent the harness cords becoming entangled, and to maintain such an orderly arrangement amongst them as to permit of easy working; in fact, the comber board is simply a comb, combing the constantly moving harness cords into order, and from this function it has no doubt derived its name. Irrespective of any peculiar methods of tying up the harness, the comber board is divided into as many sections, or groups of holes, as there are hooks in the machine, though it may be so finely perforated that, as in healds, a given number may need to be left blank to meet requirements.

The ordinary method and the most practical and best in constructing the harness, is to take the tail of the first hook in the machine, and put a cord from it through the first division in the comber board, following with the second and succeeding hooks in a similar manner until all the hooks in the machine have as many cords attached to them as there are divisions in the board. Each of these divisions begins with a complete row, which must always be as fine as the warp reed. The form of the harness will

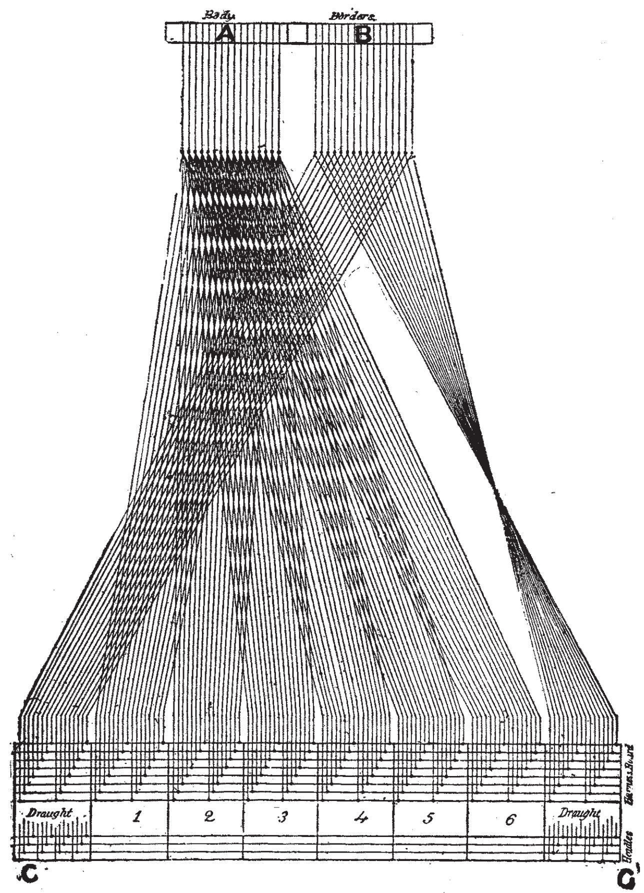


FIG. 107.—JACQUARD HARNESS FOR HANDKERCHIEFS OR BORDERED CLOTHS. NORWICH SYSTEM.

always depend, to a great extent, upon the particular fabric and style required, such as dress goods, double cloths, table-covers, bordered cloths, handkerchiefs, etc.

In fig. 107 is shown the "tie-up," "tie," or harness for a handkerchief, or bordered cloth of any kind, with full drafts and the position of the healds used to work the ground. The twist of the harness cords on the right-hand border is to prevent a reversal of the draft on this border, which would have to be made were it required that the harness should present the same appearance to the observer as it does on the opposite side. By this arrangement the inside of each border presents itself to the centre, or body, of the cloth. A careful study of the illustration (fig. 107) will clearly reveal this to the reader. It shows the body harness at A for weaving the central design of the fabric; the border harness at B and at C and C′ shafts for weaving a plain or twill ground.

It is a common practice to build a harness with such a tie as will admit of a great variety of patterns for several classes of fabrics, and then to get the designer to work, if possible, within their capacity. Of course this is from an economical consideration, a motive which though very praiseworthy should not always have absolute control.

Damask Weaving.

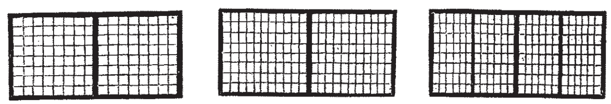
In the preceding sections of this chapter, the power accruing to the textile fabric designer from increasing the number of his heald shafts has been shown. It was not deemed necessary to carry the exposition beyond a ten shaft set of healds, as the student who has mastered the details up to that point can easily travel to the boundary of shaft work himself. Also it may be remarked that every further addition to the number of shafts increases the cumbrousness of the system, and with all the necessary complement of shedding mechanism takes up so much

space that an alternative method soon becomes highly desirable. This is found in the jacquard machine, a wonderful invention of the early part of the present century, of which a description will be given subsequently. This machine, as observed in a preceding page, practically gives the designer perfect control over the actuation of every thread in his warp, so that he can shed it independently of any other thread should he so desire, or the exigencies of his design require it. The great advantage thus resulting for the production of ornamental designs will be obvious at once.

It is in the production of the large floriated designs of damask fabrics that the designer is soon carried beyond the range of shaft work. When designs are wanted that pass beyond the scope of the latter, the sketch must be regulated by the nature of the texture required, and the size of the jacquard machines at command. Let it be assumed that a design is suitable for a 400-hook machine, and that the fabric must contain eighty warp threads per inch, by making 80 the divisor of 400 a quotient of 5 inches is arrived at, which gives the width of cloth available for one pattern. The length of the pattern depends upon the number of picks put into it, and may run to a great length. The number of picks to the round is governed by the pattern cards.

In the preparation of an original design, it is always best to make two or three repeats both in the warp and weft threads, as then, should the design prove weak in any respect, or fail to join in a satisfactory manner, the fault is easily discovered and remedied. The ornamental figures with which it is the object of the designer to decorate the fabric should, if possible, be so distributed upon the surface as to avoid the production of parallel, diagonal, or transverse rows. This can best be attained by the use of a weft sateen, or warp satin arrangement.

When it is necessary to transfer a sketch to point paper, the sketch is ruled or lined in squares to correspond with the paper, so that it can be enlarged very accurately. If a pattern is required to be copied from a fabric or drawing, then tracing paper must be used, which, placed upon a sheet of white paper, may be ruled in spaces as required. Suppose the sketch has been drawn upon point paper to appear as a cloth with sixty threads per inch, the same as the sketch, then the figure ornament must be enclosed in a square, and if it measures ·75, or three-quarters of an inch in length, and ·5 or half an inch in width, there will be in it forty-five weft threads or picks, and thirty warp threads in the entire pattern. Those who do not find it easy to rule a sketch in this manner, will find point paper a very reliable guide. Now to take this sketch upon the commonest type

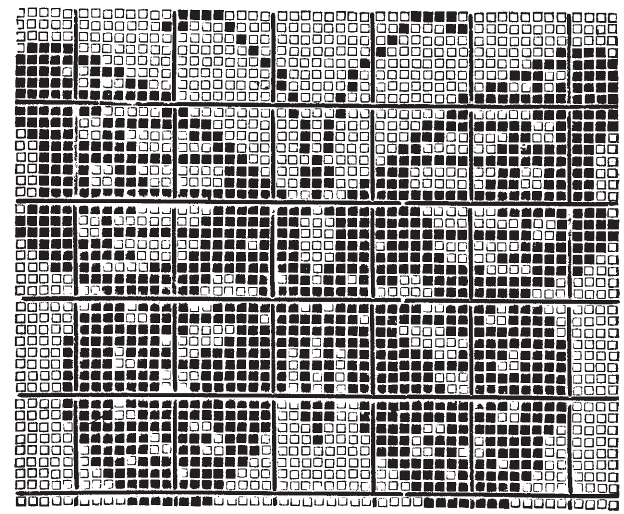


8 × 8 8 × 11 8 × 12

Fig. 108.

of point paper in use, 8 × 8 in one division—that is eight threads of warp and eight threads of weft in one of the large squares, the pattern would fill five large squares, and have five picks over in the weft way, the latter, of course, running into another square; and three large squares with six threads over in the warp way, the latter, like the weft picks, running into another large square to complete. An exact size of the sketch is thus reproduced.

Of design or point paper there are many types. Three are shown in fig. 108. It will be seen that they vary in the number of lines for weft threads. Let it be supposed that it is required to put upon paper a design containing 80 warp threads and 120 weft threads per inch, the design paper would require to be 8 × 12; if 100 weft threads, 8 × 10, and so on in proportion. Should a 5 × 5 design be required for a fabric, 80 warp threads by 120 weft threads, the sketch would have to be enlarged so as to cover 400 warp and 600 weft threads; that is, 80 × 5 = 400, and 120 × 5 = 600, which would all be represented by the squares. The



Butterfly Design.

Fig. 109.

simplest method of procedure, however, taking this as an illustration, would be to rule off on ordinary paper, 8 × 8, 400 × 600 squares, and trace the design by impression. Take, for example, the figure of the butterfly (fig. 109), which was drawn direct upon point paper. If required for a stripe, it could be produced on a dobby by a V-draft, without alteration of the figure, and with a plain ground intersecting its recurrence for a few picks. In such a reproduction twenty-five heald shafts would suffice for the figure, and four for the ground weave. But this design has been constructed for an "all-over" effect on a satin ground, each figure to be placed in position by a satin arrangement. Space, however, will hardly permit an extended description of this illustration; it must, therefore, suffice to say that the ground and figure must be a measure of each other. An examination will show that the figure covers forty-nine threads from left to right, so if a seven-shaft satin be taken for the ground, $7 \times 7 = 49$ shows the ground and figure with this would be in unison, and the joinings would be effected without a break. In its length, or weft-way, the design covers forty-one squares or picks, and as the figures require to be separatod from each other, if eight satin picks are added thereto for this purpose, forty-nine, or the same number of threads as in the warp would be used, the ground and figure thus measuring alike.

In jacquard harness there are no complex drafts, all are straight over. The pattern or design must, if possible, cover a number of threads that will be a multiple of the number of hooks in the machine. If this cannot be done, what is termed casting-out must be resorted to. This means that a given number of jacquard hooks must be thrown out of action all the time. Thus, to revert to the butterfly illustration, it has been seen that forty-nine threads cover the figure. If this was made upon a 200-hook machine, four repeats would occur, with four of a remainder, thus $200 \div 49 = 4 + 4$. These four hooks would have to remain out of work all through the width and all through the length of the warp. The same thing occurs in all cases in which the threads in the design cannot be divided by the machine hooks without a remainder.

Besides the "casting-out" thus shown, a further necessity for resort to it arises, as in healds, owing to the exigencies of orders. The harness when built, whether on

the London or Norwich principle, cannot be cut down and rebuilt to suit every change of density in the texture of warp threads per inch. It is always built to a certain proportion of threads per inch, and if a less number than this is required in a fabric, the unnecessary ones may be cast or left out in the drafting. But there is not the same liberty in the opposite direction: under no circumstances can any be added. This being the case, and the reed being a controlling factor, it becomes merely an arithmetical calculation under the rule of proportion. Take, as an illustration, the case of a harness tied up to weave ninety threads per inch, but the order in hand is for a fabric to contain eighty-six threads per inch. Therefore if the jacquard machine is a 400-hook, the problem stands as follows: As $90 : 400 :: 86 = 382$. Subtracting 382 from 400, there are 18 left, which is the number of mails in the harness, holes in the comber board, and hooks in the jacquard that will require to be left vacant. These remarks will be sufficient to show how design figures and lower reeds may be adapted to the capacity of the harness and jacquard machines, however many hooks they may have from 100 upwards.

The Analysis or Dissection of Woven Fabrics.

It often happens in actual practice that manufacturers have samples or patterns of cloth submitted to them for imitation, or "matching," as it is usually called. These often spring from some interruption of communications with the sources of the original supply, which may arise from many causes.

The points to be noted in order are, 1st, the dimensions, which simply mean width and length; 2nd, the substance, which implies weight of the warp, weft, and the sizing materials; 3rd, the quality of the yarns, and the composition and quality of the sizing materials; and 4th, the texture or weave. To ensure a satisfactory result all these points require careful examination, which can only be made by dissection, and from the knowledge thus gained accurate reconstruction on parallel lines will result by the use of proper care. It will not be enough for even the most clever experts to merely glance at a piece of cloth, count the warp and weft, and then proceed to make it from such meagre details, disappointment and dissatisfaction will almost surely result.

With the knowledge of cloth construction gained from the examples already given, in which it is traced from its simplest to moderately intricate forms, and their practical application shown, the dissection of samples will be found both simple and easy. In the simplest weaves a mere inspection of the fabric will suffice to reveal what the weave is, but in intricate patterns a much more careful procedure becomes necessary, and the following instructions should be carefully observed :—Take the sample of cloth, or a portion sufficiently large to contain an entire round and a small portion on each side. Draw from this several threads both of warp and weft, so as to leave a short fringe of both on their respective sides. This will facilitate the examination. Commence the operation by pushing back a weft thread (not pulling it out) from its position near the other still in its place. Proceed to count the intersections this pick makes with the warp threads from the right to the left. In taking out the pick all the threads of the warp which the weft passes over must be marked in their regular order on the point paper until a repeat occurs, which will be shown by the weft going over in the same order as before. In fig. 110 is given an illustration, with the warp and weft threads numbered. In relation to the first weft pick it will be observed

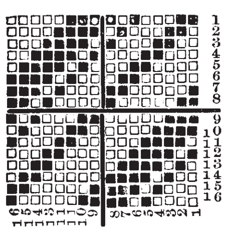


FIG. 110.

that the first two warp threads are down, three next up, one down, one up, four down, and five up. The first pick having been carefully taken out and registered, proceed as before from the same point. Here the first warp thread is up, next two down, three up, one down, one up, four down, and this is marked No. 2 on the point paper. The dissection is proceeded with in this manner until a pick is found, which repeats the positions of that first taken out and marked No. 1. Thus the round or repeat of the fabric in the weft way is found. The weave plan shows sixteen shafts or warp threads and sixteen picks of weft as the round, forming a fancy twill with the angle to the right, which is its proper inclination. The warp threads or shafts numbered show the draft to be straight over the healds, and as no two are alike this draft cannot be reduced. This illustration shows the whole process of dissection to be pursued in any weave, however complex it may be. The fringe of warp yarn will show the colour pattern, if any, and the weft pattern, if in colours, can be seen in the weft fringe. These colours and their order of succession must be written down in detail, for "costing," that is, ascertaining the cost of producing it, dyeing, warping, etc. The threads of warp and weft may be compared with well-known standard counts to discover their numbers, or better still, be accurately ascertained by means which will be found described elsewhere in these pages. If in the sample submitted for dissection the selvages are absent, the warp threads can usually be distinguished from the weft by being harder twisted, by the size upon them, and generally by being of coarser counts. Samples are sometimes dissected by taking out the warp threads and leaving in the weft picks.

We close this section with an illustration, fig. 111, of the manner in which the simple weaves that have been expounded in this chapter can be utilized for the production of variegated effects suitable for many purposes. The example given is an extract from the "Textile Mercury" of December 9th, 1893. It is a rich and beautiful design, primarily for ladies' dress goods, but suitable for many other purposes. It is a combination of the powers of the four-shaft twill, and besides being of practical value to the manufacturer as given, constitutes an exceedingly

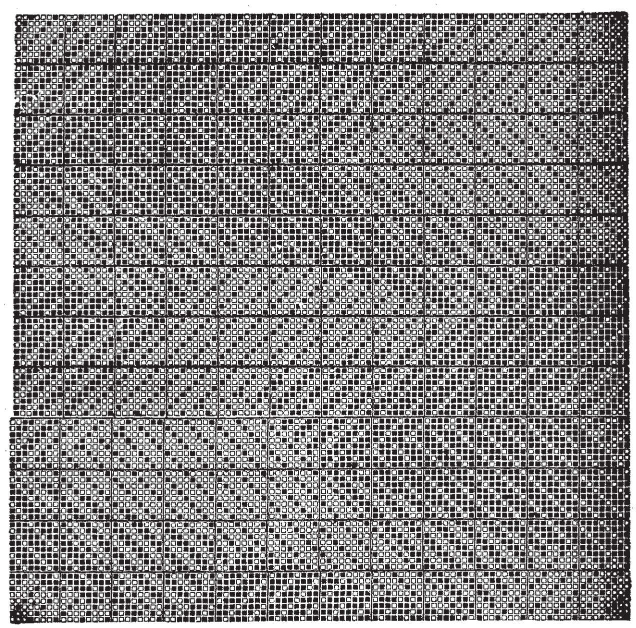


FIG. 111.—DESIGN FOR LADIES' DRESS GOODS.

valuable example to the textile student, offering an excellent study full of suggestiveness as to what may be accomplished on the same lines with other twills. If the powers of a higher twill had been employed the permutations would have become enormously greater and richer. The design as given, however, would look exceedingly well in

many classes of fabrics besides dress goods, and in many materials. The exigencies of page space have compelled the reduction of the design to rather small dimensions, but it is sufficiently clear to answer all requirements, whilst it gives a nearer approximation to its actual effect in a woven fabric than if set in larger type.

CHAPTER V.

The Modern Power-Loom.

The power-loom perfected in principle in 1841; subsequent improvement in details.—Fast reed looms *illustrated* and described in detail.—The warp protector.—The loose reed loom, *illustrated*; detailed description.—The picking motion; the shedding motion; furnishing the loom with warp; the process or mechanical action of the loom in weaving.—The speed and production of looms.—The weaver's duties.—The beauty and productive capacity of the loom, and the advantages resulting therefrom.

HAVING dealt with the principles of weaving, the instrument by which weaving is performed must now be considered. This is the modern power-loom, whose development has already been traced from its germ in the most ancient times to the period when it became a perfect automaton. This was in 1841, when the inventions of the late James Bullough, then of Blackburn, and afterwards of Accrington, added the last requirements needed to complete it, the automatic stopping motion known as the weft fork, the self-acting trough and roller temple, and the friction-driven cloth roller. Great improvements have since been effected, but they have been in details, and have gone to render more perfect in form, and more effective in power, the component parts of the loom which were already complete in principle. In many cases new, original designs have supplanted those first introduced. These have in the main been directed to enlarging the loom's capacity of production by increasing its speed, improving its control of the warp in shedding, and extending the range of its picking and shuttle-carrying power. So great have been the improvements in these respects that it may safely be said that there is nothing in the way of a woven fabric

that is now beyond the capacity of the power-loom to make. These statements will be found to have been amply demonstrated in the course of this treatise.

In figs. 112, 113, two views of a well-constructed fast-reed loom for weaving the heavier descriptions of plain cloth are given. These very effectively represent the loom

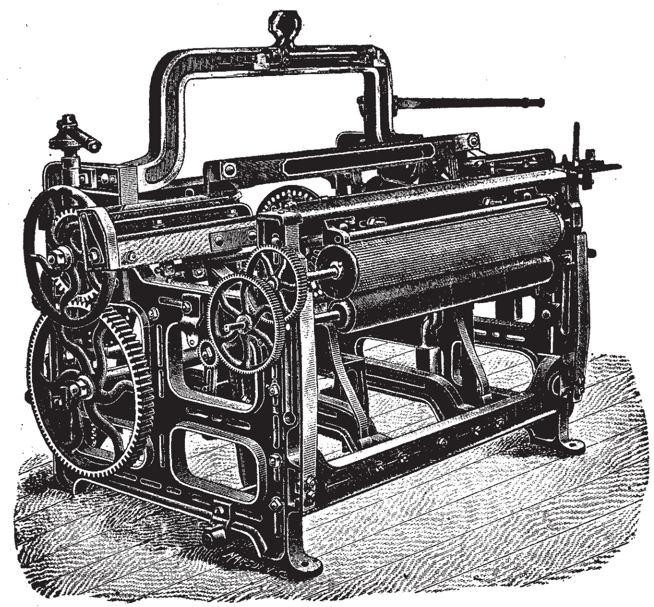


Fig. 112.—Modern Fast Reed Loom. Front and Gearing End View.

of to-day in both its strength and excellence of construction. As it is the machine itself that is under consideration it has not been thought desirable to include a representation of the warp along with it. The next illustration, fig. 114, is one of a similar class of loom, but on the loose reed principle. This type being very widely diffused and extensively used may properly be selected for detailed description. The illustration shows the working parts of a plain loom, and as this is the foundation on which what are termed "fancy looms" are constructed, its description will suffice for all except in the parts that are added to secure particular or special results. The framework, *a*, roughly speaking, describes the figure of a cube if the head or top be ignored. Within this frame, attached to the sides or bearing on them, are the working parts. The first shaft carrying the balance-wheel, *b*, extends through the centre of the frame, and projects about 8″ to 18″ beyond, this projection being for the reception of the driving pulleys, one fast, the other loose. A brake wheel is also usually carried upon this part. The shaft has its bearings on the sides of the frame. On the end opposite to that carrying the driving-pulley is mounted the driving or first spur wheel just outside the frame and between it and the fly-wheel, *b*. Just within the frame, at each side, the shaft is cranked, and by means of arms from these cranks is attached to the "slay" or lathe, *c*, which oscillates upon the "slay-swords," *h*, to which it is attached, the latter being carried upon the swing or rocking-rail, *i*, which forms their centre or pivot. The slay or lathe, *c*, has several parts. Its upper surface from end to end forms the shuttle race, the ground over which the shuttle passes backward and forward from one box to the other; this is slightly inclined towards the reed, to ease the formation of the shed. The reed occupies the space, *d*, its frame fitting into grooves at the top and bottom. At the top it is retained in position by the slay-cap, *e*, at the bottom by a similar groove in the slay-block; but in the case of a loose reed, as in the loom depicted here, there is a retaining-board, which is movable, and permits the reed to be pressed out at the bottom when obstruction of a sufficient force occurs in the warp shed. This is to prevent extensive breakages of the warp threads, or "smashes," as weavers term them. At

this point a short pause may be made to explain the difference between the loose and fast reed looms.

In the case of the fast reed loom shown in figs. 112, 113, there is a warp protector consisting of a projection, sometimes two, placed upon a horizontal rod, called the stop-rod, attached to the underside of the slay-block, and running

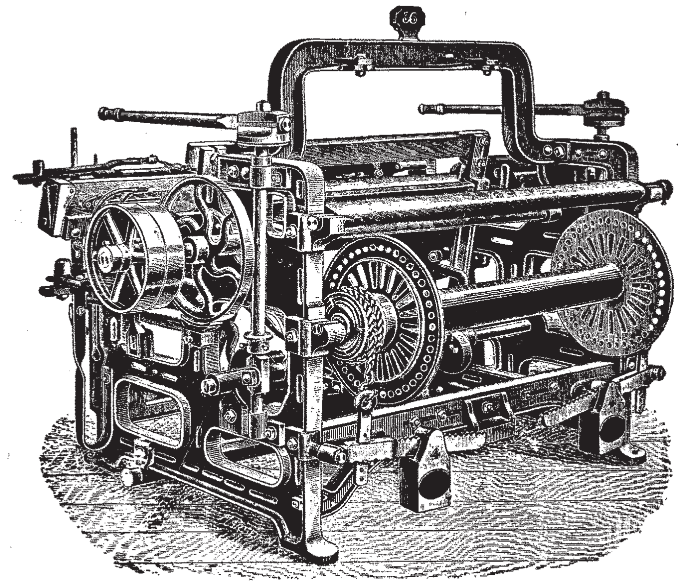


FIG. 113.—MODERN POWER-LOOM. BACK AND DRIVING END VIEW.

its entire length. Behind each shuttle-box, fixed upon this rod, there is a bent lever, which curves up to the back of the shuttle-box, where it presses against the rear of a swell placed within the shuttle-box back. This it pushes into the box to its normal position. In this state the projection on the rod, termed the "protector," is depressed into the position placing it on guard, and unless it were raised from this it would not permit the slay to advance to the edge of the cloth to drive home the newly inserted pick of weft. The shuttle on its passage to and fro does this every time it properly enters the boxes. Wanting the space the swell has taken up within the box it pushes it back, and this in turn presses back the curved lever upon the stop-rod, causing it to turn through a small segment of a circle, which has the effect of lifting the face of the protector over the face of a stop-block, called a "frog," from a rude profile likeness to the frog of our fields. Should the shuttle fail to clear the warp shed in time the protector is not raised and comes into contact with the stop-block, which instantly arrests the advance of the slay, and thus prevents the breakage of the warp that would otherwise follow. The shock that takes place on this impact is a severe one, and when looms were made with a lighter frame than is the case to-day the loom sides were occasionally broken, which was a much greater damage than would have been the smash of the warp. Even now it is deemed prudent to provide against this risk, and the front view, fig. 112, shows two vertical, strong, flat springs, termed front springs, on the front of the frame, which soften the concussion, and relieve the frame from risk of breakage. To return to fig. 114, the shuttle-boxes are formed by the metal plate, *f*, a board forming the back, and the end plate of iron which is fixed upon the extremity of the slay-block; the bottom is composed of a slotted plate of iron laid upon the slay-block itself, which for the length of the box has a groove cut into it for the reception of the picker foot. To complete the equipment of the box the fly-spindle, *g*, is required which has one end inserted in the spindle-stud slightly to the left of the letter *d*, the opposite end passing through the box end into a "pap" or socket upon the top of a flat spring secured by a screw bolt to the end of the slay, *c*.

The taking-up roller, *j*, is actuated through the train of wheels shown at the end of the loom by the oscillation of

the slay communicated through the pin, *l*, attached to the slay sword, *h*, and working in the slotted lever, *m*, called the taking-up lever. On the top of this lever is a catch termed the taking-up lever catch; this is a misnomer, for it is rather a propeller pushing the ratchet wheel around, one tooth at a movement. As the wheel is pushed forward, a retaining catch takes hold and keeps it in the position to which it has been pushed. This taking-up

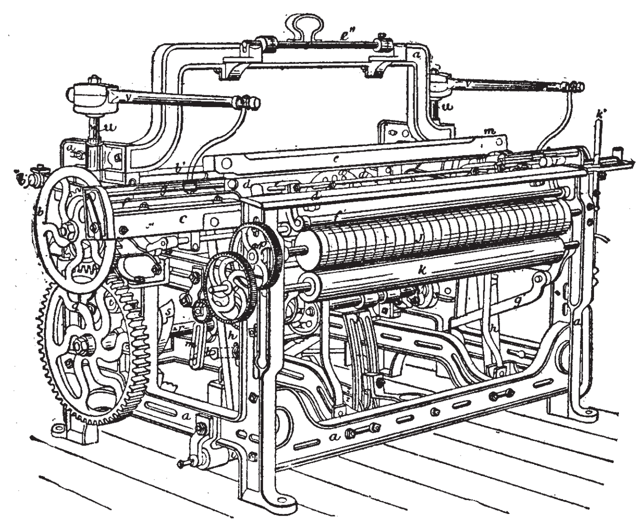


FIG. 114.—MODERN LOOSE REED POWER-LOOM.

gear is a very important part of the loom, and on this account will be brought under notice subsequently along with improved variations of it. The stud carrying the rack wheel passes through a bracket to the outside of the loom frame where it receives the change pinion, *n*, and from this fact is called the pinion wheel stud. This pinion gears into the carrier wheel, *o*, which is loose upon its stud, and has a pinion cast upon its boss that in turn gears into the beam wheel, *p*, keyed or fixed with a set screw upon the axis of the taking-up roller, *j*. The quantity of picks put into the cloth is governed by the number of teeth contained in the change pinion, *n*; the smaller the number the more are the picks put in; the greater the number, the fewer will the cloth contain. To save reference we may here briefly observe that the rack wheel in the ordinary system of taking-up gear contains 50 teeth; the carrier, or stud wheel as it is sometimes called, 120, the pinion 15; and the beam or taking-up wheel 75 teeth, the circumference of the beam being 15 inches. These particulars worked out in the usual manner, and including an allowance agreed upon in the formation of the standard list for weaving, give a constant number of 507, termed the dividend. The change wheel, *n*, may have any number of teeth, but when the cloth requires a very large one, the effect is often obtained by giving the actuating catch a double lift, that is, making it take up two teeth at once. The taking-up roller, *j*, drives the cloth roller, *k*, by friction, winding up the cloth as it is woven. Contact between the two rollers is maintained by the weighted levers, *g'*. This taking-up movement is obtained from the crank, or driving shaft of the loom, as it is indifferently called, delivered through the reciprocating movement of the slay.

The tappet shaft drives what may be termed the second half of the mechanism of the loom. The crank shaft carries upon one end a spur wheel, which gears into and drives the tappet shaft, *r*, through the large spur wheel, *q*, fixed upon its end, and termed the tappet shaft wheel. The crank shaft wheel usually contains thirty-seven teeth, and the tappet shaft wheel twice that number. The crank shaft therefore makes two revolutions for the tappet shaft one. The reason for the diminution of the speed will soon be obvious. Both the picking and the shedding motions require it. On the shaft, *r*, immediately inside the loom frame, are the picking cones or plates, *s*, one at

each side, formed of two pieces termed the plate and the neb or pick point, the latter being case hardened. As the shaft, *r*, revolves, it carries these around, and in each revolution they strike their respective bowls, *t*, carried on studs on the bottom of the vertical picking shafts, *u*. The picking plates are set upon the shaft, *r*, with their points exactly opposite to each other so that their strokes upon their bowls shall accurately alternate. The sharp impact of the cone point, *s*, upon the bowl, *t*, causes the vertical picking-shaft, *u*, to make about one-third of a revolution, and this carries the head of the picking-stick through the corresponding arc of a much larger circle. This is a very quick action and shoots the shuttle through the warp shed. When the shaft, *u*, is at rest the picking stick, *v*, carried upon its top, has its head, *w*, over the end of the shuttle box, *f*. The partial revolution of the shaft, *u*, caused by the impact of the revolving picking cone, *s*, sharply sends the picking-stick forward to the position shown in the left-hand side of the illustration. A leather band, termed the picking band, descends from the head of the picking-stick, *w*, to the picker upon the fly spindle, *g*, the sudden drag upon which projects the shuttle through the warp shed to the opposite box, whence it is returned by the corresponding action of the opposite side. This reciprocal action constitutes the picking motion of the loom.

The shedding motion next invites attention. This is performed by the tappets, *x*, which are two eccentric cams cast together on one boss carried upon the shaft, *r*, and from which it receives its name of the tappet shaft. These as the shaft revolves alternately depress the treadles, two levers which have their fulcrum upon a pin in the back or front cross rail of the loom as may be arranged; in the present illustration it is the back position, but the loom being without its warp, they are only shown out of their working position with their ends, *z*, at the bottom of the treadle grate, *y*. When the beam, *a'*, which is seen to much better effect in fig. 113, contains a warp, the latter is drawn over the carrier beam or roller, b', the healds are suspended upon the heald roller, e^2, by means of cords attached to straps securely fixed upon its bosses, the other ends being attached to the heald shafts. Similar cords on the bottom staves of the healds form through what are termed lams a connexion with the treadles.

Whilst this illustration is before the reader, the operation of weaving may be briefly described as it would be performed were the loom it represents in a proper site and connected with the necessary driving power. A warp with the requisite set of healds and reed having been placed in position is drawn forward, the healds are hung upon the heald roller, e^2, the reed is secured in the space, d, the warp is drawn over the breast beam, d', whence it passes obliquely down and under the roller, f', though this is not a necessary or even frequent appendage to the loom, only being occasionally introduced to increase the grip of the taking-up roller upon the fabric, when strong cloths are being made, by bringing it into contact with a greater portion of its periphery. The cloth thus passes around about two-thirds of the taking-up roller and upon the cloth roller, k, where the end is secured in a slot by means of a rod extending across its length. The temples, e', are adjusted, and the healds tied up so as to shed properly, with such other little arrangements as the specialities of the case may call for, and then the loom is ready for work.

The shuttle is supplied with weft, placed in the box, the spring lever K′ is pushed to the opposite extremity of the slot where it is retained by a detent. This movement of the spring handle K′ actuates the strap fork which carries the strap from the loose to the fast pulley of the loom, causing the latter to commence work. The following motions then simultaneously and in harmonious order take place: The slay is sent forward and withdrawn by the crank shaft, the warp is shedded or opened by the tappets, and the shuttle is projected from one side to the other

through the open shed leaving a thread of weft in its track. The slay again advancing carrying the reed presses home the weft thread to a given position near the temple roller, at which the warp closes upon it, securing it there. This completes the first series of movements, which are then immediately recommenced. The slay retires and the shed opens in the opposite direction, the warp threads that were up before being now down, and the ones that were down being now up. The shuttle is thrown back to the box from which it first started, again leaving a trail of thread behind. The slay again advances and drives home the weft, completing the insertion of the second pick. The continuity of these simultaneous and successive movements constitutes the operation of power loom weaving.

The speed of a loom is described by the number of picks —the times it throws the shuttle across the warp—per minute. The plain loom as illustrated and described here will pick 200-240 times per minute, according to its width, which is measured by its reed space. Widths ordinarily range from 26 inches to 60 inches, widths below or above these dimensions being of special requirement and construction. The narrowest looms run the quickest. A loom working at 240 picks per minute will weave 3″ of cloth per minute containing 20 picks per quarter inch, or allowing 10 per cent. for stoppages, for piecing broken warp threads, changing shuttles and a number of other small matters, 45 yards per working day of 10 hours. Therefore one weaver superintending four looms of this kind—a very common thing—would produce 180 yards of such cloth per day, or say 1,000 yards per week, and 50,000 yards per annum, working fifty weeks in the year.

It will have been seen that the loom is perfectly automatic in its operations, wanting only the power derived from the steam-engine, and a little supervision by the attendant, who is called the weaver, but to whom this name no longer properly appertains, he or she being simply an attendant upon an automatic weaving machine. The loom when the weft in the shuttle has been exhausted automatically stops, and the duty of the weaver is to replenish the shuttle or substitute a filled one and restart the loom. Two shuttles are allowed to each loom, one to be kept ready filled to replace the exhausted one, so that time and engine power may not be wasted as would be the case were the loom to be kept idle until the shuttle was refilled. The loom of course may stop for other causes, or owing to the breakage of warp threads, or other matters going wrong, of which it cannot automatically take cognizance, so may require to be stopped by the attendant, who for convenience may still be called the weaver. The duty of the weaver is to keep a strict supervision over the looms committed to his or her charge in order to prevent matters going wrong. Owing to the perfection to which looms have been brought, they require comparatively little supervision at the present day, so that weavers can now tend from two to six looms each according to the character of the work being performed.

This beautiful automaton, the power-loom, may justly be regarded, even in its simplest form as here described, as one of the wonders of mechanical science. It has a still greater claim to man's estimation owing to the enormous degree to which it has relieved him from laborious drudgery. The extent to which it has accomplished this will be seen in the fact that a good hand-loom weaver of the past days would never and could never for any length of time together make more than fifty picks per minute, whilst the power-loom's capacity is from 180 to 260 picks per minute, according to the widths of cloth being made. In some branches of the worsted trade the speed has attained 400 picks per minute. Thus at an easy estimate each power-loom is equivalent to five hand-loom weavers, and as four of these looms on an average can be superintended by one power-loom weaver, it follows that one person with the aid of power-looms can produce as much as twenty weavers of the early days of the present century.

But even this estimate falls far below the facts because the hand-loom weaver was never a persistent worker, whilst the power-loom is absolutely tireless, working as well at the close of the day as at the beginning, and if necessary it could work all round the twenty-four hours of the day, and the seven days of the week. The quality of work produced from the power-loom is also uniformly much superior to that which could be obtained from human labour. Such is the power-loom of to-day: to its creators the world is deeply indebted; it has emancipated millions from the drudgery of a sedentary labour task, it has brought clothing within the reach of millions more, who, without its aid, would never have been able to shield themselves from the cold and heat of the varying seasons and of the different climes of the world. Many more if clothed at all would have had to go about in rags and tatters, as the periodical renewal of the clothing of the greatest portion of the populations of nearly every civilized country would have been impossible on account of the expense. It was no uncommon practice a century or two ago to hand down personal clothing from father to son and from mother to daughter amongst the lower classes, whilst amongst those socially above them, the contents of the wardrobes were carefully bequeathed for distribution amongst the friends of the deceased. This was a practice that from a sanitary point of view was decidedly objectionable, whilst from an æsthetic one it was still more so. Fancy the present generation of Englishmen and women promenading in the cast-off clothes of its recent predecessors. Yet this is what the modern power-loom has saved them from. The rags and tatters and patched clothing that formerly distinguished the working classes have almost everywhere disappeared, for when clothing has been so far worn as to require patching, the wearer in the humblest sphere of life can now in almost every case afford to renew it.

CHAPTER VI.

THE DEVELOPMENT OF THE SHEDDING MOTION.

Specialization of cotton manufacturing.—Shedding power of the loom; plain cloth, *illustrated.*—Four-leaved twill, *illustrated.*—Spring headpiece, *illustrated.*—The cylinder motion.—Jamieson's shedding motion, *illustrated.*—The Bradford shedding motion, *illustrated.*—Fustian loom with Woodcroft tappets, *illustrated.*—The draw-loom.—The drawboy machine.—The jacquard machine.—Joseph Marie Jacquard, brief sketch.—Introduction of the machine to England and rapid spread in the weaving districts.—Variety of types.—Sizes of the machine, how expressed.—Double-lift jacquard, *illustrated.*—The parts of the machine described and *illustrated;* the hooks, the needles, the griffes, the batten, the cylinder, the card.—Function of the cylinder.—Hooks and needles as combined for work, *illustrated.*—Function of the cards.—The needle-board and lintel-frame.—The spring-box, *illustrated.*—Various types of jacquards, single-lift, double machines, compound machines, and leno machine, all *illustrated.*—Brierley's improved driving arrangement, *illustrated.*—The dobby, a modified jacquard.—Its development.—Hattersley and Smith's dobby, and Eccles's, *illustrated.*—Various types of dobbies.—The patent cardless, automatic, cross-border, combination dobby, described and *illustrated.*—Its great capacity for the production and variations of patterns.—Patterns, *illustrated.*

HAVING described in detail the automatic power-loom in its simplest form, the task may now be taken up of tracing its further development in a very important respect, namely, its shedding power.

In the cotton trade, where the manufacture of the various cloths is, to a large extent, specialized or confined to particular classes of manufacturers, business goes on with comparatively few changes. Consequently the man who makes the production of plain cloths his staple pursuit is rarely prepared to undertake orders for even the simplest twills, this needing an extension of the shedding capacity of his looms which he has not provided. Again,

another manufacturer may equip his looms for the production of cloth from plain up to five or six-shaft twills. Others, again, who do what is termed a mixed business, will furnish their establishments with looms of various capacities so as to be able to undertake any orders that may be offered to them. It should be borne in mind, however, that the different varieties of cloth are most economically and advantageously made upon looms that are specially suited to them, as in the use of a loom, the full capacity of which is not brought into activity, there is generally some mechanism to actuate, or weight to carry, which involves the expenditure of steam-power without any return; and further, the capital represented by this portion is put out of use, for the time being, and lies unproductive. This, of course, involves waste that ought, wherever possible, to be avoided. The best manufacturers and managers will constantly bear this in mind, and the student will do well to do so likewise.

What is meant by the shedding power of a loom is its ability to raise and depress the threads of the warp, in the manner required to meet the necessities of the design intended to be woven. As shown in the loom just described, this capacity is very limited, consisting merely of simultaneously raising one half of the warp and depressing the other to a similar extent, to allow of the passage of the shuttle between. In ordinary practice the threads of the warp being alternatingly placed in the ascending and descending heald shafts produce the plain fabric shown in fig. 23, *ante*, p. 103, and delineated in design, fig. 24, *ante*, p. 104. It is produced as shown in fig. 115, which shows the whole arrangement. The tappets, A B, as before described, are carried upon the second or tappet-shaft of the loom, and in revolving A depresses the treadle, C, which latter, through its connection with D, by way of the heald roller, E, as shown, elevates D. In turn D is depressed in the same way, and correspondingly elevates C. This is the simplest form of the shedding process, and however complex it may become, as will be shown in the description of the more intricate developments, the principle remains the same. It should, perhaps, be remarked here, that in all cases where there are heald rollers, as at E, the movements of the healds are rendered as easy as possible by being counterpoised with one another. This advantage is lost

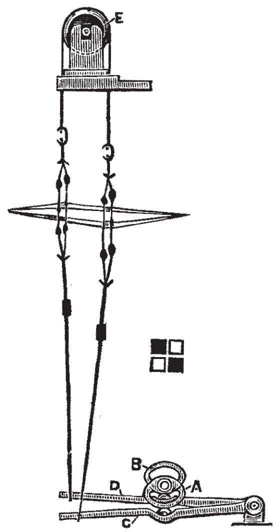


FIG. 115.

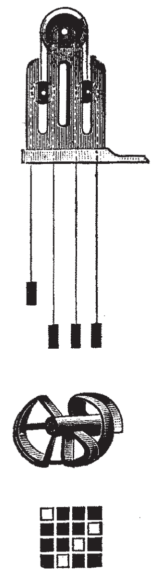


FIG. 116.

when the shedding arrangement becomes more complex, but it matters comparatively little in the latter cases, as the weight to be moved is much diminished, at least until the lingoes of the jacquard come in.

It would occupy far too much space to trace in detail every forward step made in the shedding power of the loom, but progress has been steady, and very seldom interrupted for any length of time. It will serve the

present purpose if the tappets and top motion, the heald roller arrangement, of a four-shaft twill be described, premising that up to about six shafts they are all of the same type. Fig. 116 shows the head-gear and tappets and design of a four-shaft twill in which the arrangement is for a tread of three shafts down and one up. A four-twill tappet can be arranged to tread two shafts down and two up, and one down and three up. Similar arrangements can be made in others as may be desired.

After a certain number of shafts, say about six, have been reached, a top motion or head-gear on the roller principle, as shown, becomes cumbrous, and what is termed a spring top motion was formerly much in use.

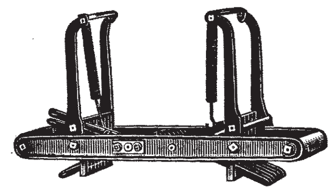


FIG. 117.

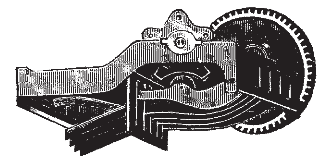


FIG. 118.

One of these is shown in fig. 117. As will be seen, it consists of a small iron frame, having within it a number of compound levers, each series pivoted upon a common centre. The two series individually connect with each other in the middle of the frame by means of sector ends. Each lever is attached to a helical spring, as shown, which holds them up, this being their normal position. By means of cords depending from their under side they are attached to the heald shafts, which similarly from their bottom staves are connected with the treadles. The tappet forms the shed in the usual way; when released the spring in the headpiece draws the heald shaft back to its first position. This spring headpiece can be made for any number of shafts. The type of tappet already shown has also to be modified or much reduced in size.

An excellent treading arrangement, and of great capacity, was one well-known and extensively in use thirty years ago, called the barrel or cylinder motion. It came near the jacquard machine in its capacity for variation within the narrow range of stave work, but it was somewhat cumbrous to work and especially to change, and therefore disappeared when the modified jacquard known as the dobby came into the field. As it is not at present in use no further time need be spent in its description. It is interesting, however, as having been the invention of Richard Roberts.

Where it was desired to retain the tappet treading arrangement, the motion of which is an easy glide from one position to another, and therefore rather less severe upon the warp, a later invention, known as Jamieson's treading motion, afterwards came into favour. This is shown in fig. 118, and consists of the requisite number of tappets and treadles of the ordinary type, much reduced in size, arranged in a frame and operated through gearing connected with the second shaft of the loom. These tappets could be adjusted to tread in any order required. With the improvement of the dobby machine this also has practically disappeared.

Another arrangement of multiple tappets is that known as the Bradford treading motion. It is in great favour in the Yorkshire districts in weaving woollen and worsted, or mixed materials in dress goods because of the facilities it offers for making changes. In the cotton trade, where the orders run much larger on a design or figure, it would be objectionable on account of the extra space it requires. As will be seen in the illustration (fig. 119), the tappets, are arranged outside the loom, which permits of their being very easily taken off when changes are required. From the ends of the treadles connecting-rods ascend to the levers carried upon the horizontal shafts which carry the quadrant levers. To these the healds are attached, and are lifted in the order of the tappet arrangement.

Any of these shafts can be thrown out of action when not needed, the remainder being available for weaving fabrics requiring any number of shafts up to the full complement that the arrangement may contain. All that is required beside is to simply change the tappet and wheel. This illustration shows the loom with revolving shuttle-boxes.

In the manufacture of very heavy fabrics, where a num-

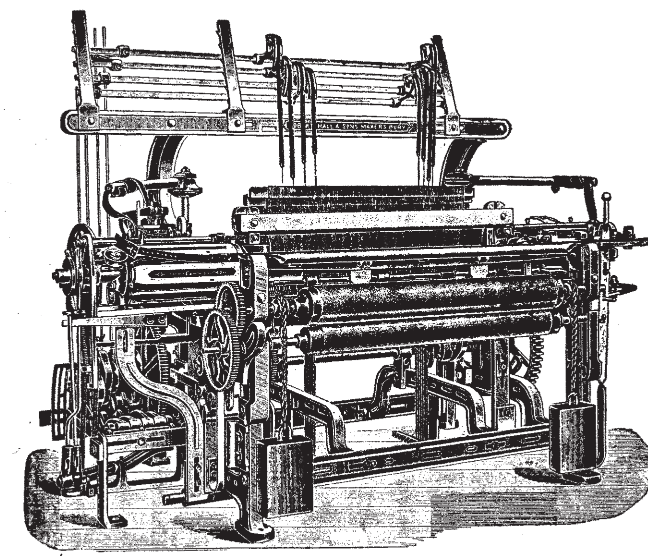


FIG. 119.—LOOM WITH BRADFORD SHEDDING MOTION.

ber of shafts are required for the purpose, it is essential to have looms with very strong frames, and all the appointments to correspond. These looms are termed fustian and heavy fabric looms, and usually have several special motions not frequently seen in most other looms. In the generality of cases, however, they are furnished with a special treading motion known as Woodcroft's section tappets, from the name of the patentee, the late Mr.

Bennet Woodcroft, who, however, we believe was not the inventor. It is shown in fig. 120.

This treading motion is arranged on the outside of the loom frame. It is built up of a number of plates or discs, which are perforated to permit the easy attachment of certain parts termed sinkers and risers, from the fact that through their connections they elevate and depress the healds in the manner required by the pattern. Underneath the loom are a set of jacks or levers to which the healds are connected. A corresponding set are mounted upon the top of the loom, and connections formed between them and the treadles, which in the illustration are seen upon the cylinder at the end of the loom, and which is formed of the combination of tappet plates. When these plates have been arranged for work they present to the treadles, if we may use a homely illustration, a succession of hills and dales, up and down which the treadles have to ascend and descend, according to the exigencies of the design of the fabric. Continuing our metaphor, these treadles may be regarded as travellers who are moving in company to one destination, that being the end of the cloth. There is this important difference, however, they, unlike actual travellers, are fixed to a certain position and mark time merely, whilst the hills and valleys move underneath them, lifting them up and letting them down in exact correspondence. These movements by elevating and depressing the shafts of healds every time a change takes place, form a shed in the warp for the passage of the shuttle. When the cycle of changes has been gone through, the design has been completed, and the operations begin anew. This goes on as long as desired.

The risers and sinkers fitted upon the plates operate the treadles in a positive manner. The treadles carry anti-friction bowls to ease the passage of the risers and sinkers. They transmit their motion through connecting-rods or cords to the levers, which raise and lower the healds in the manner already shown.

This treading motion can be and is commonly used to weave fabrics requiring up to twelve shafts, and by varying the arrangement of the risers and sinkers upon the plates a considerable variety of patterns can be obtained. It is, however, a very cumbrous motion to work, taking a considerable time to pull to pieces and to put together

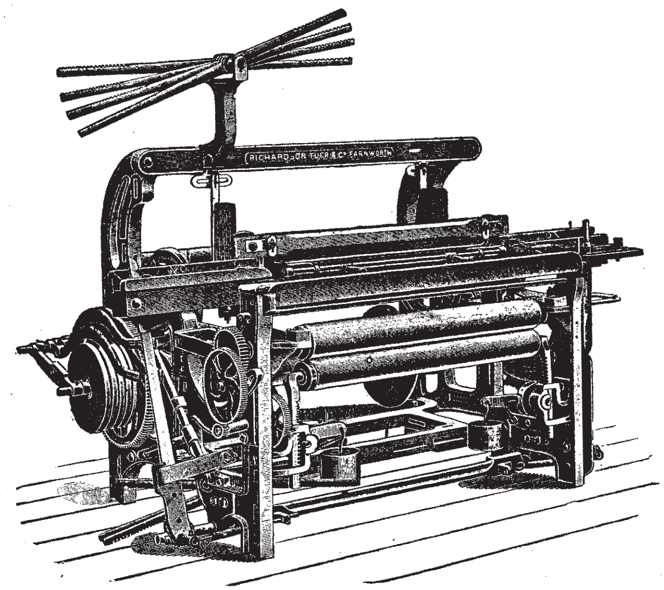


FIG. 120.—FUSTIAN LOOM WITH WOODCROFT TAPPETS.

again for re-arrangement, whilst if a mistake happens to be made in the work it is all to do over again. The task, besides stopping the loom for a considerable time while changes are made, is also a dirty one. When at work it is also slow and exceedingly noisy, adding very greatly to the inevitable clatter of a weaving-shed. Thus it has been dispensed with wherever possible, and is now retained only for cords, moleskins, heavy velveteens, belt-webbing, hose-pipes, and kindred classes of fabrics.

On the line chosen, namely, that of development from the lower to the higher capacity of the shedding power of the loom, we now come, though somewhat out of time and place, to the draw-loom. A brief notice must suffice as it has disappeared from practical work, superseded by the jacquard.

Persons familiar with the history of weaving know that for the production of decorated fabrics which required something beyond the capacity of the appliances that have been described, there was in concurrent use the draw-loom, a machine that practically gave the weaver individual command, for shedding purposes, of every thread of his warp. Damasks, by which these figure-decorated fabrics have long been known in textile history, are supposed to have been first, or at least, so extensively made in Damascus, as to have derived their name from that city. They were no doubt introduced into this country by ecclesiastics at an early date, and it is supposed that the draw-loom itself came from the same place, brought over by the Crusaders. Improvements in details subsequently occurred, but they were not of great importance until the drawboy machine made its appearance. Who invented this can hardly be said to be definitely known, but the best records discoverable in the English Patent Office would favour the claim of one Joseph Mason, who patented a machine for an equivalent purpose in 1687. This patent was No. 257 of the year named, and was dated October 3rd. Unfortunately no specification was enrolled.

The draw-loom, as an ancient loom of the highest capacity, and the one on which the wondrous fabrics of the olden times were wrought, for the sake of the student deserves a brief description before we come to the consideration of its great successor, the jacquard machine.

In the draw-loom the warp threads were drawn through separate and independent healds or mails, so named because they carry the threads, the cords of which were passed through the comber board to keep them from entanglement. Next, a number of these, according to requirement, were tied or harnessed to other cords, which thus governed a number, so that when one of the latter cords was pulled several warp threads were controlled, precisely as a coach-driver controlled his horses by the harness, and hence, no doubt, was borrowed the name of harness, from the similarity of the function. The harness cords ascended from the comber board to the pulley box, some height above, whence, after passing through the bottom of the box and over the pulleys, they took a horizontal direction for some distance over and beyond the loom side and were then attached to a staple or bar on a level with them. These horizontal cords were termed the tail of the harness. At their mid-length other cords, termed "the simple," were attached to them. These cords descended to near the ground, where they were secured to a horizontal rod sufficiently long to take the whole. It was upon these that the pattern was arranged. There were other details also, but as they were only to facilitate the operator's getting hold of the "simple" cords, they hardly call for more particular description. This was done in the order of rotation required by the pattern. The cords of the simple were pulled down and raised the corresponding portion of the harness, and its leashes or healds opened the warp in the same order, which was kept open until the requisite portion of the pattern was woven, when the necessary succeeding changes were then made. The working of the simple was the drawboy's task, which was far from being an easy one. The weight of the lingoes, of which there were often thousands, more or less of which he was constantly engaged in lifting, became appreciably burdensome before a day passed over. There was also a great deal of friction to overcome in operating them. No wonder, therefore, that attempts were made to ameliorate this burden.

The first practical improvement that sprang from these efforts was the invention of the drawboy machine. This consisted of an oblong frame about as high as it was long, and about half of the dimension in width. Within this frame was arranged a rocking shaft, connected with a sector picker, which had a lateral traverse the length of the frame. The two sides of the frame were perforated for the reception of the lingoes, and the picker in its passage drew down the lingoes, and through the connections already explained shedded the warp. This appliance gradually came into extensive use, but, though an improvement in many respects, it greatly increased the toil of the weaver's daily task without giving him much compensation in economy, as the master weaver, having to provide it, made a charge for its use not much below the cost of a drawboy. The dawn of the happy days of the weaving industry, in which the employer provides everything, as in the modern factory system, had not then broken upon the weaver's vision, though they were nearing. The invention of the drawboy machine was a distinct advance in the direction of a perfect system of mechanical shedding, and as such deserves this brief reference.

The drawboy in the first instance, and the drawboy machine after him, drew the "simple" cords in regular sequence, according to the plan or design which he had before him, whilst the weaver operated the loom, and put in the weft either straight forward or in a corresponding order, if colours were in requisition. Thus it will be seen was developed the harness of the artist weaver. As experience increased in the use of this harness different systems of grouping the healds thus to be controlled were developed. These were called "ties," or "tie-ups," of which there are a fair number. The simplest and the ones most commonly in use in this country, are those known as the London and Norwich ties, which differ from one another only in the London tie being mounted upon the loom with its frame parallel to that of the loom, whilst the Norwich one is mounted with its frame transversely to that of the loom.

We have now arrived at the time when the grandest of all the mechanical inventions ever designed for the purpose of warp shedding made its appearance. This is the jacquard machine, which was invented originally as an attachment to the hand-loom and not to the power-loom, which it almost anticipated as a practical working invention of value. Its primary purpose was to relieve the hand-loom weaver of the difficulty he experienced with both the drawboy and the drawboy machine. At that time it is very improbable that its inventor ever contemplated its adoption to the power-loom as a shedding appliance, and much less would he do so to the many other useful purposes in which it is so frequently met with, and giving every satisfaction in these days.

As with many other important inventions there are rival claimants for the honoür of being the inventor of this machine, and no doubt strong and important and well-founded arguments have been advanced to prove that the merit ought at least to be divided between Jacquard and some of his predecessors in the field of mechanical science. In the interest of the technical student a short space may be devoted to a review of Jacquard's career.

Joseph Marié Jacquard was a native of the great silk manufacturing city of Lyons, where he was born on July 7th, 1752. His father was a silk weaver, and his mother was also engaged in the trade. Though thus cradled in the weaving industry at the outset of his working career he preferred and adopted bookbinding, and afterwards followed on with type-founding, and subsequent to this he transferred his energies to cutlery manufacturing. Whilst at this occupation the death of his father, who left him a cottage and a silk loom, brought him back to the silk trade. He does not, however, appear to have met with any success, but rather otherwise, as after his marriage he would seem to have reverted to his earlier industrial pursuits. In 1792 he became involved in the whirl of the Revolution, and in the following year was engaged in the defence of Lyons against the forces of the Convention. It is stated that his son was killed by his side, which caused him to retire from the profession of arms. Previously to this episode of soldiering, in 1790, he had begun to contemplate the feasibility of constructing the machine with which his name has since become identified. The design, however, was probably laid aside during the troublous and distracting times of the progress of the Revolution. When it was resumed we have no knowledge, but in 1804 the machine appears to have been completed, and near the same time was exhibited at the National Exposition, and secured for him the barren reward of a bronze medal, which Jacquard did not know how to turn to account, as he lived before advertising became a fine art. About this time also he seems to have obtained a prize for the invention of a loom for weaving fishing-nets, offered by the English Society of Arts. He got a patent for his shedding machine which seems to have included a right to a premium of £2 for every machine made and sold. About 1804 he returned to Lyons to push his invention. In its introduction, however, he met with the ill-luck of most inventors in those early days, namely, bitter opposition. Its merits having begun to be appreciated they were leading to its extensive adoption, when its opponents gathered in force, denounced both the machine and its parent, tore them from the weaving-rooms in which they had found adoption, and destroyed and publicly burned the fragments in the streets. Even the "Conseil des Prud'hommes," belying its name, condemned both the invention and its author, and he had to fly from the place to save his life, as his great forerunner in the field of textile invention, James Hargreaves, had had to fly from the Blackburn district, the great weaving centre in Lancashire. But, like other destroyers of machinery, the French could not burn the idea. The machine was reconstructed with improvements in details, and its value having been demonstrated, it was again rapidly adopted in France, and soon spread to other weaving centres of the Continent, and at last found its way into England.

In the meantime Jacquard continued to live on, witnessing the increasing usefulness of his machine, until August 7th, 1834, when he died at Quillins, near Lyons, in the eighty-third year of his age.

It is in his native country that Jacquard's claim to recognition and merit on account of this invention is most contested. M. Marin, a Lyons professor of weaving, exhibited a series of models, showing the development of Jacquard's shedding apparatus from the inventions of earlier mechanicians, namely, M. Bouchon, who, in 1725, is alleged to have employed a band of perforated paper which was pressed by a hand-bar against horizontal wires, and pushed forward those which happened to be opposite blank spaces, whilst the others entering the perforations, similar results followed to those with which we are acquainted to-day. Three years afterwards, in 1728, M. Falcon is said to have improved on this by introducing a chain of cards, and the square prism in common use to-day, and known as the cylinder. No further progress appears to have been made until about 1745, when Vaucanson, a well-known early mechanician and inventor, dispensed with the tail cords of the draw-loom, and made the loom capable of being operated by the weaver alone by placing the perforated paper, or chain of cards, upon the surface of a large pierced cylinder which had a backward and forward traverse each stroke, and which was caused to revolve through a small segment of a circle by means of ratchet work making a movement coincidently with its lateral traverse. The same inventor is said to have introduced the rising and falling griffe, and thus nearly anticipated Jacquard in every detail of his shedding machine. Whether these allegations are, or are not, true either in whole or part, we are not concerned to inquire. They are made by a Frenchman against a Frenchman, and have, like the most of this class of charges, come too late to be of either advantage or disadvantage to the parties principally concerned. Jacquard is in possession of the reputation of being the inventor, and the Municipality of Lyons has erected a statue to his memory on the spot where it formerly burnt his invention, and has thus satisfied the claims of poetic justice, and there the remainder of the world may be content to let the matter rest. We may add, however, that Dr., afterwards Sir, John Bowring, before a Committee of Parliament in 1831-2, gave particulars of an interview he had had with Jacquard, in which the latter practically admitted his indebtedness to Vaucanson, so that this precludes to a considerable extent any charge of ingratitude that might be alleged in advancing Vaucanson's claim.

Jacquard's invention was rather late in finding its way into England, probably owing to the almost constant warfare that prevailed until after the battle of Waterloo. The first Englishman who appears to have seen it was Mr. W. Hale, a Spitalfields silk manufacturer, who made known his discovery to a Mr. Stephen Wilson, also in the silk trade. After some time this gentleman went over to France, procured a machine, and on his return seems to have invented a card-cutting machine, and to have patented the two together (No. 4543, March 8th, 1821). Jacquard's machine was soon afterwards heard of in Coventry, Macclesfield, Manchester, Halifax, and other places, and no doubt very quickly met with general adoption.

We have given this brief sketch of Joseph Marié Jacquard and his invention, because of the great influence it has had upon the weaving art, and the numerous purposes to which it has been adapted outside that for which he originally designed it. Whether in this instance he

was the inventor, or only an adapter of other people's ideas is not very material, as, like Arkwright, he is certainly entitled to the credit of making practicable devices that, up to the time he took them in hand, were failures.

The Jacquard Machine.

The jacquard shedding apparatus, the story of the invention of which has just been narrated, will now be described in detail, so that its construction and operation may be correctly understood. The inventor's name has long been transferred to the machine, therefore, in consonance with this convenient custom, and for the sake of brevity, it will be called by this designation.

Of jacquards there are a number of types, each varying in capacity from very small ones containing about 100 needles to large ones ranging up to 2,000 needles. Of course were larger than these required there would be no difficulty in making them.

The number of needles expresses the size or capability of the machine: thus there are 400s, 800s, and 1,200s machines, and intermediate sizes. Those usually employed in the trade are regarded as standard sizes, and departures from them are looked upon as specialities. But whatever be the size or type of the machine, its chief parts are essentially the same, however modified for adaptation to particular requirements.

The accompanying illustration, fig. 121, represents a standard make and type of jacquard, containing 400 needles and one cylinder, and arranged for what is termed the double lift: that is, it is a 400 needle machine, but instead of having only 400 hooks it has 800 or two to each needle, and also two griffes instead of one. This machine is extensively used in weaving cotton goods and all fabrics in which high speed is desirable, as it can be worked to shed for 200 picks per minute, though not more than 160 to 180 are recommended.

The jacquard, it will be seen from the illustration, consists of an iron frame which stands about eighteen inches high, its lateral dimensions varying according to the number of hooks and needles it contains. In this frame are mounted the working parts which are actuated through various connecting rods, shafts, and levers, from the

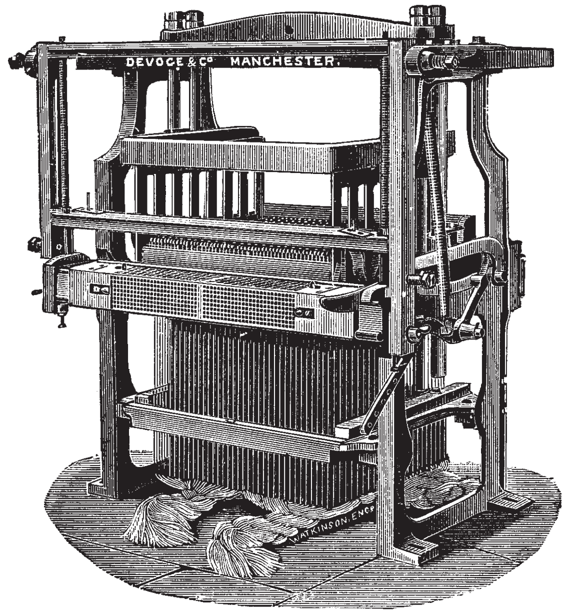


FIG. 121.—DOUBLE-LIFT JACQUARD 400^s, ONE CYLINDER.

crank and second motion shafts of the loom. The cords seen upon the ground of the illustration are termed the neck-bands or neck-cords. These are looped upon the tail-pieces of the hooks of the jacquard, otherwise their lower extremities. They are then passed downward, occasionally through a perforated board at the bottom of the frame

called the bottom board. In modern makes of jacquards this board, on which the hooks rested when out of action, has been superseded by some bars or blades, termed hook rests. This avoids the wear and tear of the neck cords which took place with the boards. The cords are attached by a slip-knot to the leashes or harness, as shown previously in fig. 106, p. 151. The slip-knot is to permit of a perfectly level adjustment being made of the harness-mails.

The following are the principal parts of the jacquard:

1st. The hooks. The hook shown in fig. 122 is made out of wire of about 16^s gauge. The wire is first cut into lengths and made perfectly straight in a machine specially designed for the work. It is then bent in the shape shown in the illustration. The top is formed into a hook to admit of its being lifted by the griffe. The bottom, A, is bent for the reception of the neck-cord, and is turned up a good distance to prevent all risk of its slipping off. The top of the end thus turned up is formed into a hook as shown, for the purpose of resting the hook upon the bar, B, when out of action. This bar is called the hook-rest.

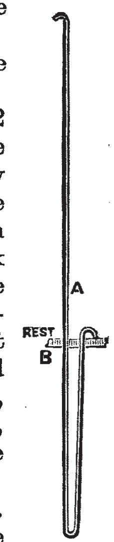


FIG. 122.

2nd. The needles. These govern the hooks. The hooks are normally in a position to be actuated by the griffe, and would be lifted every time it ascended were it not for the control exercised over them by the needles which leave them in or put them out of action as required. In the illustration, fig. 123, three kinds of needles are shown: *a* represents the needle as used in a single-lift jacquard; it has a loop or eyelet formed in its length through which the shaft of the hook passes. In *b* is shown the kind used in a double-lift machine; this has two bends, not eyelets as before, to enable it to operate two hooks, there being, as stated before, two hooks to each needle in the double-lift jacquard. In *c* is delineated the kind used in a double-cylinder machine; this contains only one bend. All jacquard needles are bent at one end in the manner shown in order to form a butt-end for impact against the springs in the spring-box.

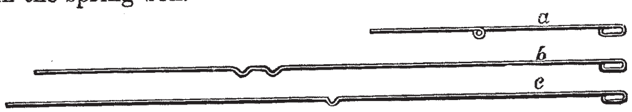


FIG. 123.

3rd. The griffes, fig. 124. In a single-lift machine there is one griffe; in a double-lift there are two as shown here. The griffe in a jacquard loom is the equivalent of the tappet in a plain loom, as it forms the warp-shed. A more rational name for it, at least in English, would be the hook-lifter. It has an ascending and descending movement. It is,

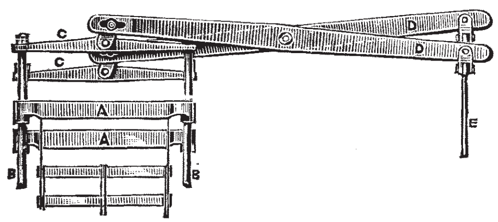


FIG. 124.

roughly speaking, a square frame, A, mounted upon the vertical cylindrical rods B, which slide in appropriate ears or lugs cast upon the frame. Fig. 124 shows them in detail and detached from the frame; in fig. 121 they are seen with their connections in their working position.

4th. The batten, A, fig. 125. The batten is somewhat like the lathe or lay of the old hand-loom both in its construction, action, and function. It is composed of two arms and the block called the cylinder. It has a semi-oscillating movement which would be best described by

saying that it is equivalent to the half of the movement made by a clock pendulum. It derives its name from its function of beating back the needles and so putting the hooks out of action as required. It is shown in the front of fig. 121 with its cylinder, the horizontal block with the numerous small perforations. This block is not solid but hollow, being built up of four perforated slabs. The batten is a principal feature of the machine.

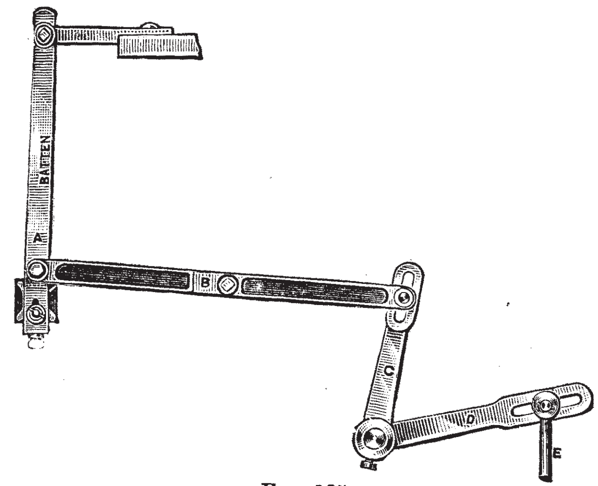


FIG. 125.

5th. The cylinder, fig. 126. This, as just observed, is a part of the batten. Strictly speaking, it is a prism of four sides. Its function is to press back the needles which govern the hooks and so put them out of action when their threads are not required to be lifted for forming the shed. It has four faces, as will be seen from the sectional view in fig. 126. It is so actuated as to make one-fourth of a revolution with every pick made by the loom, thus bringing its different faces in successive order into contact with the needles. If the faces of this cylinder were without the perforations shown, A A′, at each impact every needle in the jacquard would be pressed back and every hook thrown out of action, not a single thread would be lifted, and consequently no shed would be formed. It becomes, therefore, a necessity to make the small circular holes in it in order that the needle-ends may enter, and the hooks which they control may not be pushed back when they are required to be left in operation. As this is in turn needed with all the warp threads it becomes necessary that the faces of

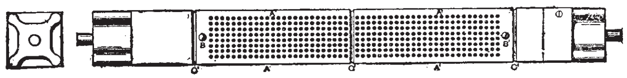


FIG. 126

the cylinder shall have as many holes as there are hooks in the machine. This being the case, we are confronted with another important fact, namely, that if left in this condition the face of the cylinder, when carried by the batten into impact with the needles, would receive the point of every needle into its corresponding hole and thus everyone would be left in position to be lifted, and would be lifted by the griffe in its ascent. Every thread in the warp would then be brought up with them, and thus again

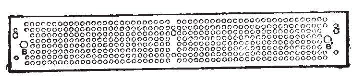


FIG. 127.

there would be no shed for the passage of the shuttle. In the first instance given the shuttle would pass over every thread, in this it would pass under them. It will now have become obvious that something more is required which shall discriminate or select the hooks that shall be lifted and those which shall not lift. This is:

6th. The card, fig. 127, which is so called because it is composed of cardboard specially made for this purpose. The card might appropriately be termed the hook-selector, for that is its function. It does this by intervening between the

cylinder and the needle-points, blocking the entrance to the cylinder-holes, and causing to be pushed back those needles whose hooks are not essential to form any particular shed, and leaving undisturbed in their position those required to make it. This is accomplished by the cards being perforated according to the requirements of the design to be woven. If a blank or unperforated card were placed between the cylinder and the needles it would have the same result as we have seen would be the case in the event of the cylinder-face being without perforations: every hook would be thrown out of action and no portion of the warp would be lifted. Similarly, if a card had as many perforations as there were needles every hook would be left in position to be lifted and the whole warp would be raised. Therefore, when it is desired to raise any given thread, a perforation is made for the needle of the hook carrying it, the needle-end passing through the hole in the card and into that of the cylinder, thus leaving its hook to be lifted. As the lifting of the warp threads varies with every pick the loom makes, to accomplish this the cards require to be perforated in like varied manner. Thus it comes to pass that a different and special card is needed for every pick required to complete a textile design, excepting, and this is sometimes an important exception, one card can be repeated many times. When this is the case an arrangement is brought into action by which the revolution of the cylinder is arrested and the repetition is accomplished. The "round" of a design, or the number of picks required to complete it necessarily varies; in small designs a few hundreds suffice, whilst in large and elaborate ones the number will run into thousands.

To keep cards in consecutive and proper order they are tied or laced together. Let the reader revert for a moment to the illustration of the cylinder, fig. 126. The two central sections, A A′, form the face for the reception of the card, and its other three faces are exact replicas. The two larger circles, B B′, at the outer ends of the cylinder-face represent the card-pegs which, when the card comes upon the cylinder, enter the holes indicated by the corresponding circles B and B′ in the card, fig. 127. These pegs are sometimes simply solid, but in modern practice they are generally mounted upon small helical springs, in order that in the event of a card getting displaced and missing presenting its hole from any cause, which sometimes happens, the pegs may yield and sink into the the cylinder until it passes, rather than break or otherwise damage it. It is to be preferred that cylinders should be furnished with spring-pegs rather than not. The cards are laced together generally at three places: each end and in the middle. This is done by means of a fine, strong hemp-twine which is passed through the holes marked C, fig. 127, in such a manner as that, whilst leaving the cards perfectly pliable and easy to fold backward or forward, they shall be held without the slightest chance of slipping from their proper positions. The grooves, C′, in the cylinder, fig. 126, are cut for the reception of these cords, so that the card shall not be prevented from lying close to the cylinder-face. The remainder of the perforations in the card are for the needles.

7th. The hooks and needles. In fig. 128 are shown eight hooks, A, and needles, B, arranged as when mounted in the jacquard for work. As shown here the hooks repose, when out of action, upon the hook-rest shown at C. Ascending from this rest it will be seen that the hooks are received into the eyelets or the bent parts of the needles, beyond which they project a short distance, and terminate in the hooks, D, at their head, by which they are lifted by the griffe-bars, blades, or knives, E, as these are variously called in different localities. It is from these hooks at the top that the name is derived. The griffe-blades are shown in section. The horizontal wires, B, are the needles, which have already been sufficiently described.

The function of the cylinder, it has already been explained, is by means of the needles to push out of action for

the moment those hooks whose services are not required, and that of the card to discriminate which are these. Of the series of eight needles and hooks shown, five are represented

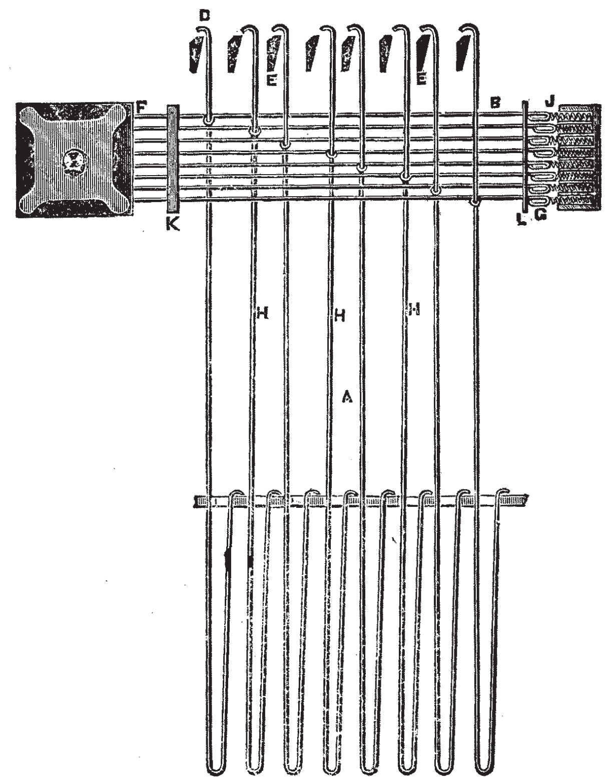


Fig. 128.

as in action, and three, marked H, as pushed out. The ends, F, of the latter's needles presenting themselves before a blank space in the card, in the swing of the batten are pushed back, their opposite ends, G, compressing the small helical springs, J, of which each needle has its own. The needles thus pushed back deflect their respective hooks so far from the perpendicular that they get clear of the line of movement along which the griffe-knives, E, ascend. They are therefore just left out of action. As, however, they may be wanted to rise in the next shed it is necessary they should immediately be returned with perfect certainty to the position within range of the action of the griffe. In the meantime the batten has swung away in order to admit of the cylinder making another quarter-turn, and bringing a new card into operation. This action removes the

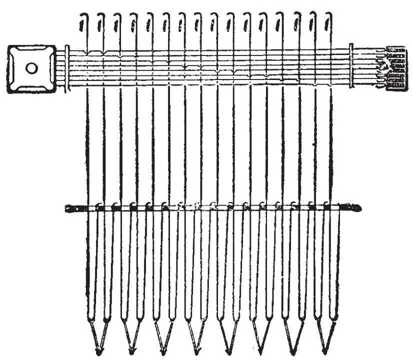


FIG. 129.

pressure from the needles and permits the springs to instantly return them to their first position ready for duty if called upon. If they should not be wanted they are again pressed back and are again returned in a similar manner. In fig. 129 is shown the combination of hooks and needles as required for a double-lift machine with a single cylinder. In this arrangement, as before observed, the needles have two bends to enable them to operate two hooks each. Fig. 130 is a similar diagram, illustrating the arrangement of the hooks and needles in a double-cylinder machine.

8th. The needle-board and lintel-frame. It will be observed that the needles are arranged horizontally in fig. 128. This position is requisite to enable them to be presented with their points directly opposite their respective holes in the cylinder-face, and at the opposite end to the springs, so that they may not work in any way improperly, be deranged, or miss performing their duty. At the end nearest the cylinder, therefore, there is arranged a perforated board, K, about half an inch thick and set on its edge. It is of the same dimensions as the face of the

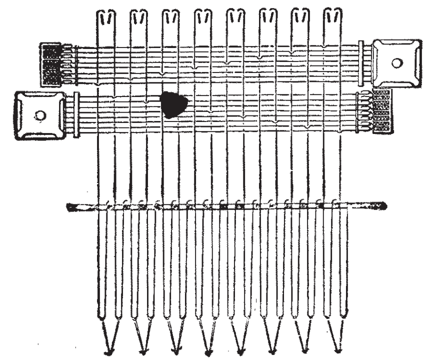


FIG. 130.

cylinder, and has a perforation for every needle. This board is termed the needle-board. On the opposite side, outside the last line of hooks, is a wire-grid or frame, L, composed of vertical wires set with a small space between them and crossed with a horizontal wire or two, thus constituting small square spaces through which, in mounting them, the ends of the needles are passed and pushed home, leaving the looped ends supported in the wire frame as the points are in the needle-board. This is termed the lintel-frame.

9th. The spring-box, fig. 131. There still remains the springs, J, to be described. It has been shown what their function is. They are composed of fine brass wire to prevent destruction from oxidation. There is one for each needle. The number therefore is considerable. In order to maintain them in a proper position in relation to their work they are arranged in a box composed of a block of wood in which the requisite number of holes are bored for their reception. These holes go through the block but have a vertical wire pin let down through their centre at the back, which prevents the spring being pushed out, and against which it is compressed. Should the spring become weak or break, by withdrawing the pin it can be easily replaced. The box is fixed horizontally in the frame in such a position that, when the needles are pushed back by the batten, their bent ends, G, shall compress the springs so

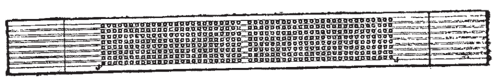


FIG. 131.

much that, when the pressure is removed, the springs shall return the needles to their first position as previously shown. This box is termed the spring-box.

The preceding description will have made clear to the reader the function of the jacquard as an adjunct to the loom, its construction and method of operation. The example described and illustrated represents the one in probably the most common use. For the sake of the student we may, however, illustrate a few more types. They need very little further description.

In fig. 132 is shown a single-lift jacquard of 400 needles and the swing batten as before. This term is used to distinguish this method of operation from the horizontal motion. This machine is used for weaving silk, cotton, and other goods where a high speed is not required, as it is not adapted to work at more than 120 picks per minute. It will be observed that it has only one cylinder.

A machine of very high working capacity is shown in fig. 133, which illustrates a double machine, 400^s, having two cylinders and batten actuated by the swing motion. This machine is used for weaving cotton, linen, and other fabrics that will permit of being worked at a very high speed; it is capable of shedding 220 turns per minute, though from 180 to 200 is what is recommended. As the cylinders work alternatively it permits of this high speed

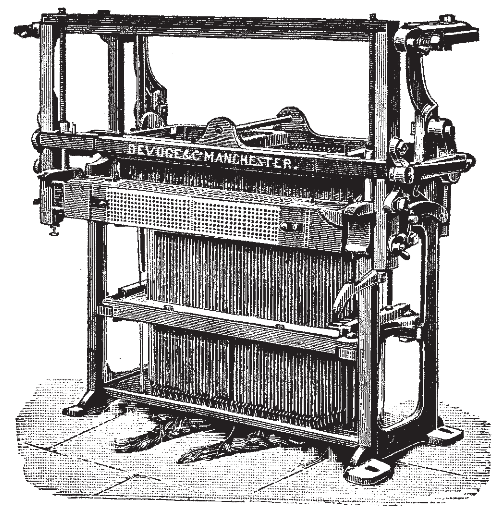


FIG. 132.

with less vibration than when a single-cylinder machine is used.

Fig. 134 shows another double machine of the same capacity, and for the same purposes as the last one. In this the battens, instead of being swung from the frame as in the preceding instances, have a horizontal reciprocal sliding motion, termed the horizontal motion.

In fig. 135 is shown a machine of still greater capacity.

This is a compound machine, with two cylinders, and adapted to weave cross borders, that is, to put borders into the fabric at specified distances according to requirement. It can be arranged to work as a double machine, with the cylinders working alternatively; or it can at option be worked as an 800-needle machine, single lift, in

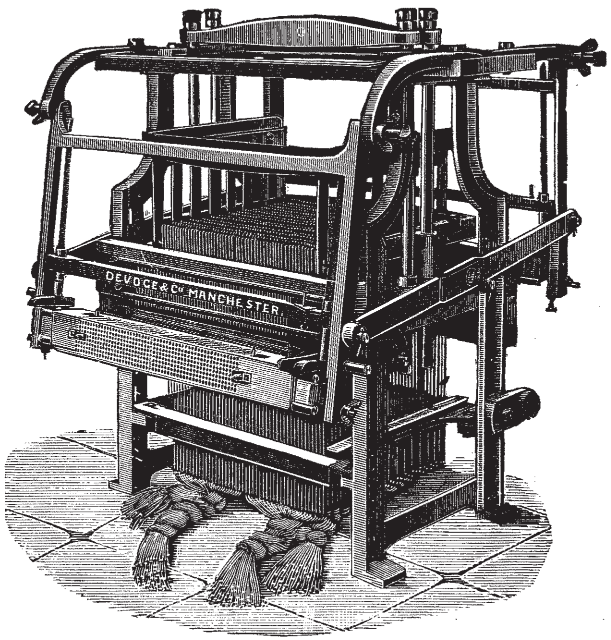


FIG. 133.

which case the cylinders are worked together. When used as a cross-border machine, the cross-border cards are put upon one cylinder, and the middle or ground cards upon the other. The cylinders can be thrown out of or brought into action according to requirement by the attendant weaver, or by automatic action as desired.

One more illustration will fully serve all necessities. Fig. 136 shows a patent leno machine, a recent invention. This is a valuable machine where leno or lace effects are wanted. It may, therefore, be described at more length. The leno or gauze weave has been sufficiently explained in a previous chapter, and therefore need not be repeated

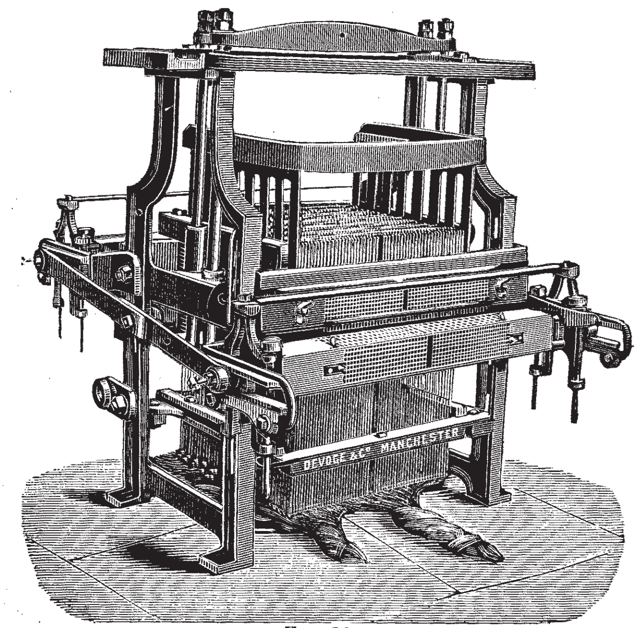


FIG. 134.

here. The machine, of which the illustration is a representation, is used for weaving leno or gauze fabrics with 4 threads per dent of the reed. By casting out the necessary hooks it can also be used with 3 threads per dent. The machine has 612 hooks, 51 rows, 12 in a row, besides selvage holes. Of these, 100 hooks are allotted to the doup harness; 400 for the middle or figure harness; and 100 for the warp-easing or slackening harness. This disposes of 600 hooks and leaves a spare row. With these 600 hooks it is only necessary to use 500 needles, as those allotted to actuate the doup hooks also each operate a warp-slackening hook. The double duty these needles

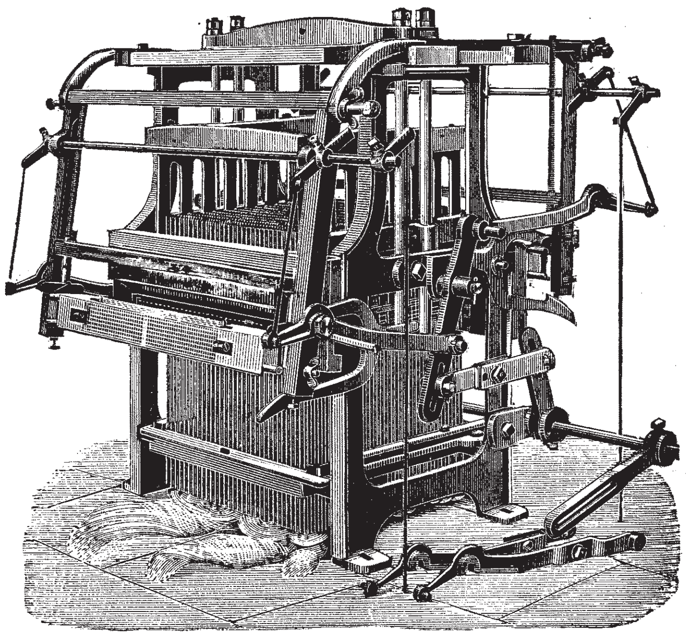


FIG. 135.

perform is a great advantage, because a doup warp thread can never be shedded without at the same time being slackened to permit it to make its three-quarter twist around its fellow thread. Thus both strain upon the warp and the doup harness is perfectly avoided. Each dent of the doup and the slackening harness is worked indepen-

dently, so that several styles or patterns of leno can be made in the same fabric if desired. There are two griffes used in this machine, the original one to lift the doup and figuring harness, and a small one to lift the slackening harness. The first is lifted by the ordinary lever arrange-

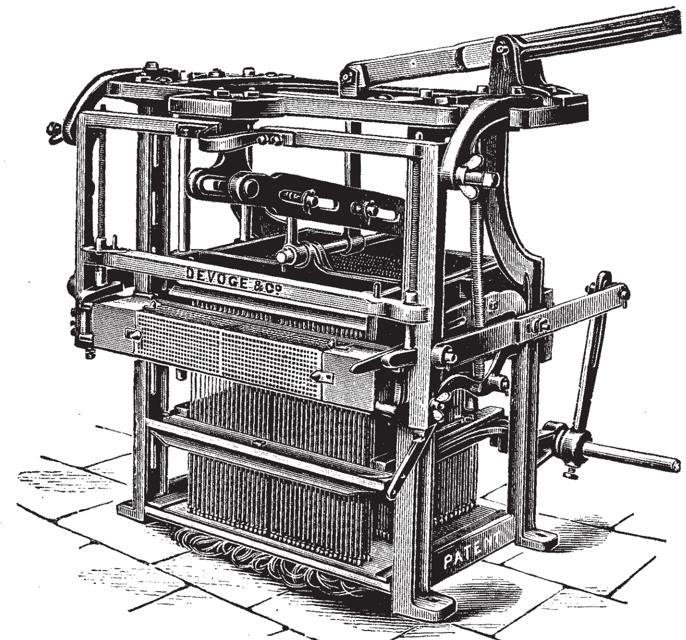


FIG. 136.

ment, and an additional lever, the slotted one shown in the middle of the upper part of the frame, arranged at right angles to the large lever, lifts the small griffe. Being constructed with an adjustable fulcrum, a considerable variation can be made in the lift according to requirement. For instance, suppose that the lift of the large griffe is 4 inches, that of the small one can be set at any point, $1\frac{5}{8}$ and $2\frac{3}{8}$ inches inclusive, so that as great a range of variation is provided for as is ever likely to be required. The slackening griffe is arranged to commence lifting slightly in advance of the upward movement of the large griffe, in order to slacken the leno portion of the warp in advance of the lifting of the doups, and thus to prevent either friction or strain. By this arrangement the wear and tear of both yarn and healds is greatly diminished. The machine is operated in the same manner as ordinary single-lift machines, namely, by the lever shown on the top of the illustration, which is connected by crank or eccentric to the loom shaft. It is fitted with a simple and effective reversing motion for the cylinder.

The machine is made with what are termed hooked hooks, which permit any or all of the three harnesses to be taken off. By removing the doup and slackening harness, and using a 400^s cylinder, this jacquard is converted into a 400^s single-lift machine for weaving ordinary fabrics, and of a range of power commensurate with the ordinary jacquard.

Until quite recently, however, one considerable defect in the method of actuating jacquards remained without remedy. It will have been observed throughout all the preceding description that the jacquard griffes have been lifted by means of horizontal levers which have their fulcrum some distance away from the centres of the jacquard. The consequence is that as the ends of these levers in lifting the griffes and returning them to their position pass through a small arc of a circle, and instead of lifting them vertically, pull them against their guide bearings inducing friction, wear and tear, and the expenditure of considerable power in order to overcome it. These defects having engaged the attention of Mr. Brierley, manager for Messrs. Swainson and Birley, Preston, he has endeavoured to remedy them and has succeeded. His improvement is illustrated herewith, fig. 137, and, as will

be seen, the horizontal levers are dispensed with, a rack and pinion arrangement taking their place. The machine is actuated as before from the tappet shaft of the loom, one end of which carries a crank disc to which the connecting rod is attached. The top of this rod is secured to an adjustable link which is connected with the lower end

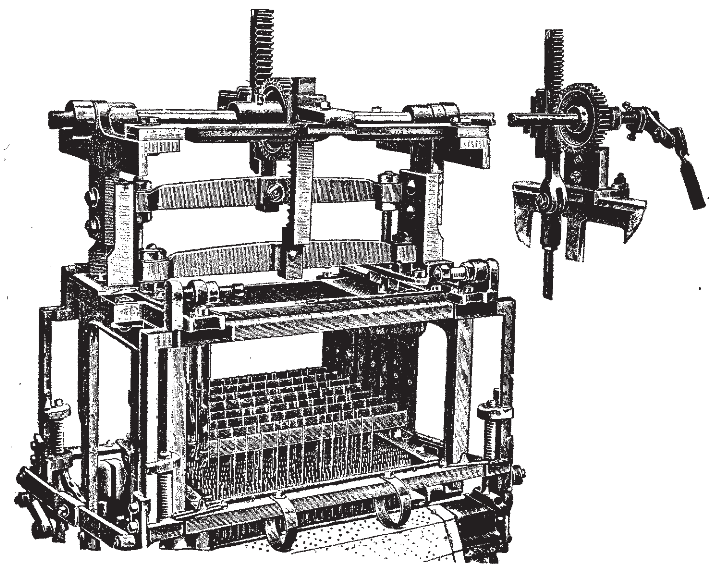


FIG. 137.

of a vertically sliding bar, the upper portion of which constitutes a rack. Into this rack gears a pinion carried upon the end of a shaft extending across the top of the jacquard frame and supported upon it. Over the middle of the jacquard frame, upon this shaft, is another pinion which gears into the two racks as shown, and through them operates the jacquard.

It will be seen that the lift thus obtained is a perfectly vertical one, and that connection between the two griffes constitutes them each a counterpoise of the other, which results in a much easier drive. The outside rack and connecting rod find their counterpoise in the action of the spiral spring shown.

The result may be summed up in a few sentences. The driving, with this new arrangement, absorbs much less power than under the old form; wear and tear is greatly diminished; all the destructive vibration through the loom is obviated, by which the breakage of the warp yarn is diminished; and, not least, a much higher speed can be obtained than from the old forms. These are claims that ought to ensure the attention of manufacturers using these machines.

The jacquard having now been described in such a manner as we trust will render its principle, construction, and action perfectly clear to the simplest understanding, we may pass to a brief description of some subsequent developments, chiefly modifications and simplifications, of the jacquard for more limited ranges of work. These are generally known as dobbies, which are in reality small jacquards.

The changes and improvements in the jacquard, which finally eventuated in the production of the dobby, began to appear comparatively soon after the jacquard had been somewhat extensively adopted. One of the first of these, and the first to which we have found the name of the dobby attached, was an invention by Mr. S. Denn, of Spitalfields. This was an important improvement, as it accelerated the shedding operation, and led the way to the next improvement—the introduction of the double-action principle in an invention patented in 1849 by Mr. Alfred Barlow. This also was a considerable step in advance, but showed some defects, which were subsequently obviated by improvements made in 1855 and 1870. About 1858 a German invention on the same lines was introduced into

Lancashire, and a considerable number of machines were made by the Blackburn loom makers during the succeeding three or four years when the introduction of the manufacture of bordered dhootie cloths for India took place. In 1867 the dobby assumed a more perfectly developed type as a shedding appliance, in the invention of the Keighley dobby by Messrs. Hattersley and Smith, than had been seen before. This dobby, with some subsequent improvements,

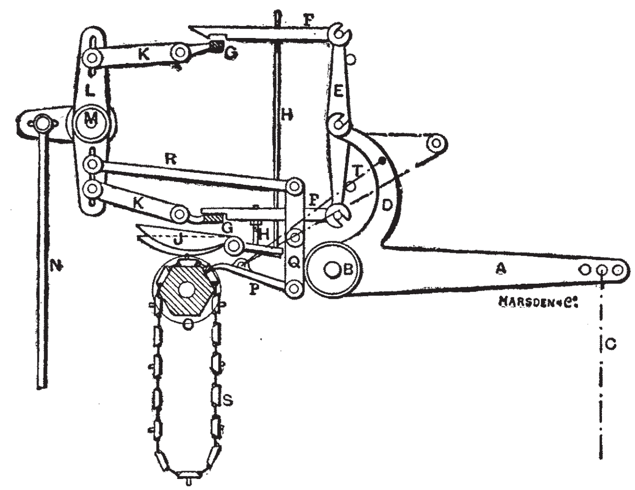


FIG. 138.

has held a strong position to this day. Its construction is shown in the accompanying illustration, fig. 138, which also incorporates the improvement patented by Mr. J. Eccles, of Preston, in 1877. It is on the double-action principle, one cylinder carrying two sets of cards instead of two cylinders with a set of cards each. The illustration shows the working details divested of the frame for the sake of clearness. Mr. Eccles's improvement consisted in adapting it to work intermittently, so as to make cross-bordered dhooties, and in the intervals between their insertion to permit the loom to weave plain cloth. The illustration shows a side elevation. The front crank lever, A, is one of a series mounted upon the shaft, B, which is supported upon the machine frame. The long arms of these levers are connected by cords, C, to the healds, the bent arm, D, being connected to a vertical rocking-bar, E. This bar is attached to two hooks or catches, F F, arranged horizontally. These catches engage with the knives, or lifting bars, G G, when they are not held out of contact by the vertical rods, H H, which are connected with the weighted levers, J. The knives with which the hooks engage are carried upon and operated by the projections, K, from the compound lever, L, carried upon a shaft, M, resting upon the frame. The short arm of this lever is connected by the rod, N, to a crank carried upon the tappet shaft of the loom, and by this means an oscillatory motion is imparted to it. The cylinder, O, is a hexagon, and is actuated by the pawl, P, carried upon the lower arm of the vertical lever, Q. This lever, through the connecting rod, R, being actuated by the oscillating lever, L. Upon the cylinder there is shown in side view an endless chain of lags, S, as they are termed, these being strips of wood, each perforated with a number of holes for the reception of pegs, which are inserted in such a manner as by their action to produce the pattern required. These pegged lags are the equivalents of the cards in the jacquard machines, and if it were thought desirable could be substituted by cards. As the chain travels around the cylinder the projecting pegs upon the lags are brought under and lift the levers, J, which through their connections raise the hooks out of action. This it will be seen is the function of the cards in the jacquard.

As we have described this dobby up to this point it is as invented by Messrs. Hattersley and Smith, Keighley. In Mr. Eccles's improvement, the first bent lever of the series, the one marked A, is diverted from the purpose we have described, and is arranged to automatically arrest the operation of the dobby, and permit the loom to proceed in the weaving of plain cloth. It accomplishes this by being made to lift the pawl, P, from its gearing with the ratchet-wheel upon the cylinder by means of the connection, T, shown between the pawl and the bent arm of the lever, A. This at once arrests the action of the dobby, which remains inactive until its services are further required.

There are several types of dobbies, which, however, differ more in details than principle. There are single lifts and double lifts, and different methods of operating them. Some have the healds drawn down by springs, and others by jacks or levers. Taken all round, however, these differences are only different ways to the attainment of the same results. Fig. 139 shows a loom mounted with a dobby and its connection with the loom.

In this realm of the textile arts, there has, however, recently appeared a most remarkable invention in the shape of a dobby of exhaustless capacity of pattern variation, and that without the entailment of additional cost upon the first expenditure upon the machine to produce them. As it fell to the duty of the writer to carefully examine and describe this invention, upon its introduction from Germany, he cannot do better than quote from "The Textile Mercury" the article in which this was done, and which appeared in that journal on October 17th, 1891.

This novel machine has been termed by its sole English makers, Messrs. Robert Hall and Sons, Hope Foundry, Bury, the patent cardless, automatic, cross-border, combination dobby. The following is the article referred to:

"That the textile arts are very ancient admits of no dispute. It is almost equally certain that ornamental weaving was a very early development of those arts. The numerous references in ancient and classic writers to ornamental fabrics prove this beyond all question. It is not, however, until mediæval times are approached that existing divisions of the art begin to be recognized. Amongst the most permanent styles of the present day are those known as diapers and damasks. These come into view in this country about the thirteenth century. It is very probable that they are of much older date in their origin than the time mentioned, as the latter have generally been supposed to have derived their name from Damascus, which was famous in ancient times for its textile manufactures. In an English romance of the thirteenth century, entitled 'The Squire of Low Degree,' we read of

> "'Damask white and azure blewe
> Well diapered with lilies new.'

The origin of diaper is more a matter of dispute, some affirming that it is derived from the name of the city of Ypres, thus cloth de Ypres, afterwards contracted into the form we now know. Others contend that it is traceable to the Italian word *diaspro*, the jasper, which it is supposed to resemble from its shifting lights. Though entertaining, these are points which must be left to antiquarians.

"Whatever may have been the material in which these cloths were originally made, the terms long ago came to mean the character of the weave, and thus we now have linen and cotton diapers, silk and linen damasks, and practically both these weaves are one. Diaper generally signifies a cloth covered with geometrical figures, scroll or lattice work, small flowers and other like devices. Damasks have larger and more elaborate patterns. This description roughly defines the character of these kindred types of textile fabrics.

"The means employed to produce these figured fabrics in ancient times have not come down to us, but from late mediæval times it appears to have been the draw loom. After this the jacquard machine came into use, and subsequently its modification the dobby, the latter for the

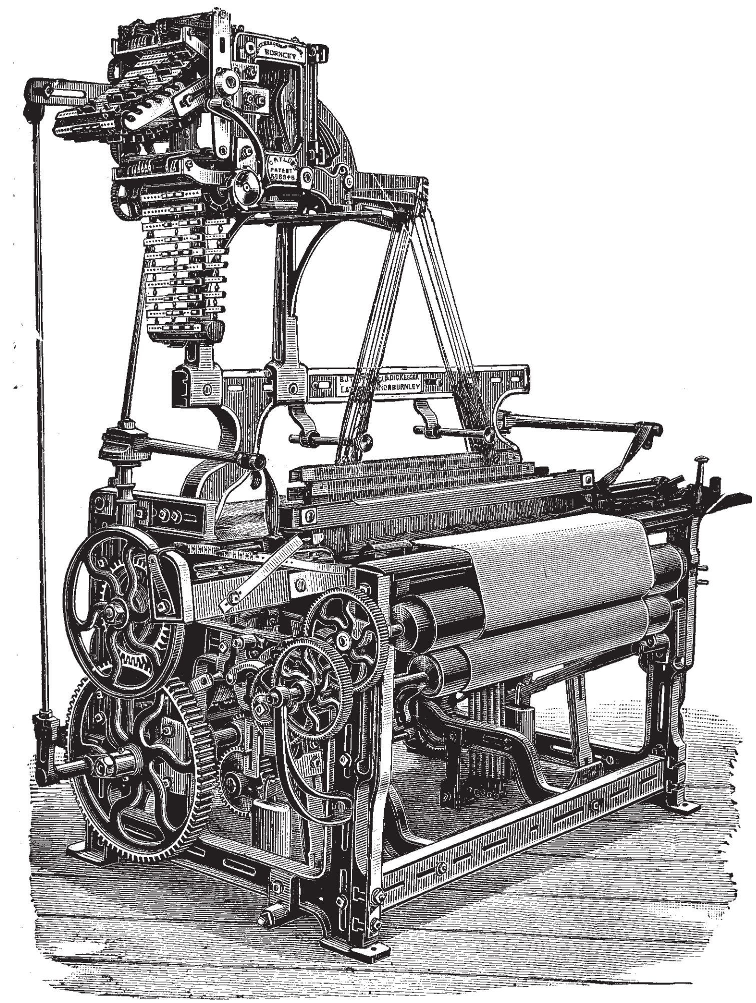


FIG. 139.—LOOM MOUNTED WITH DOBBY.

smaller and simpler diaper patterns mostly. Several other, now disused, appliances intervened. In damasks, however, the jacquard continued to prevail, notwithstanding its great drawback in the shape of cost for cards, etc. There has for a long time now been a steady and continuous movement, endeavouring to diminish this item, which has been attended with a great degree of success, in the invention of repeating motions by which the number of cards required has been greatly reduced in both diapers and damasks. Still there has been room for further advancement, and now we have to record and describe an invention that, so far as diapers go, will dispense with cards altogether.

"The invention under notice removes this great obstacle out of the way by reducing the cost to a point not worth mentioning, by providing the manufacturer with an appliance by which he can produce an innumerable quantity of patterns at one first cost of a few shillings, where by all other known appliances it would be hundreds, indeed we may write thousands, of pounds in the matter of cards alone. The dobby we now introduce to the notice of our readers will weave a large bordered serviette or table-cloth, with a cross border, automatically and absolutely without the aid of cards. The manner in which this is accomplished is as follows: All diaper patterns, such as we see in ordinary linen table-cloths, serviettes, and kindred articles, are combinations of four-shaft twills or five-shaft satins, and the various patterns are formed by floating the warp threads in one position, whilst the weft threads are depressed, and *vice versâ*, this being done in a certain well-defined order that gives the desired patterns. In this invention the needles are arranged in sections of four or five, as the case may be, and each set is raised or lowered, according to the requirements of the pattern. When they are raised, the weft is thrown upon the surface, and when they are lowered the weft is depressed, and the warp brought up. This result is obtained by the cylinder

faces having two rows of holes, one arranged for warp effects, and the other for those obtained by the weft. The cylinder is constructed with as many faces as there are picks to the round; if a four-shaft twill, there are four faces; if a five-shaft satin, there will be five faces. The needles actuate the hooks of the dobby, and raise the healds in the ordinary way. The needles are raised and lowered by small pattern chains, composed of high and low links. These links act upon levers fixed to slides, which have holes drilled in them so as to form guides to the ends of a set of needles. One link in the chain controls the needles for one revolution of the cylinder, and thus puts in four or five picks, as the case may be. By this arrangement the number of links is reduced one-fourth or one-fifth of the number of cards that would be required with ordinary arrangements. But even with this reduction, the chain composed of these links would need to be of great length in order to make a long serviette or table-cloth with cross-border, and do it automatically. But here, again, the ingenuity of the inventor has served him well, for when one pattern has been completed, by an ingenious device the movement of the chain is reversed. By repetitions of these movements the entire centre of a serviette or table-cloth, no matter how long, can be obtained from a few links of the chain. We now come to the cross-border, in making which the inventor has adroitly availed himself of the reversing principle just noted. To the portion of the pattern chain that forms the centre of the fabric is attached a second part, the whole forming an endless chain, though it is not called upon to make a complete traverse. The second part of the chain is arranged to form the cross-border. When the centre part has been completed this border chain comes into action and controls the working of the healds until the border is made. This completed, and the marginal parts woven, a reversing motion sets the border chain upon its return movement, during which the commencing border of the next serviette or table-cloth is woven. These chains are carried upon a barrel. Thus, it will be seen, these pattern chains are reduced to the smallest possible minimum. The invention is shown in fig. 140.

"The cylinder is actuated in the ordinary manner by a

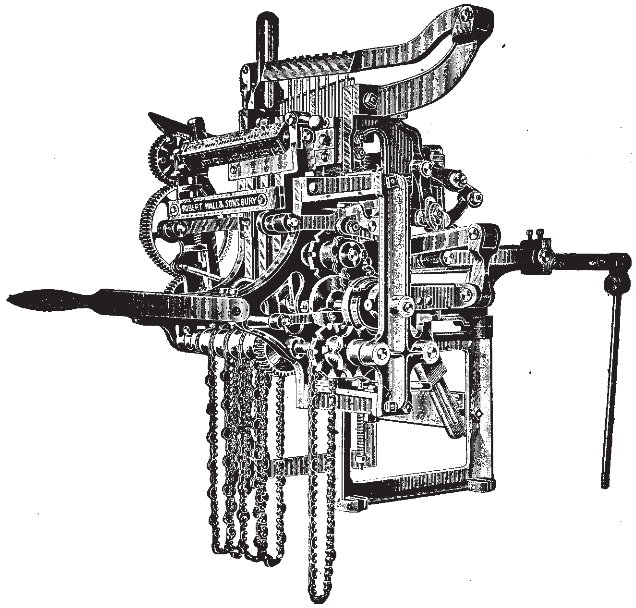


FIG. 140.

peg wheel and catch, and by a wheel on its axis communicates motion through a carrier wheel to a chain barrel in such a regulated manner that the barrel moves the chain one link for every complete revolution of the cylinder. This is done by means of a peg or ring wheel acting upon a star wheel, carried upon the shaft of the chain barrel.

The reverse movement of the pattern chain is obtained by means of another chain, which may be termed a governing chain, carried upon the same shaft as the chain barrel. When a high or tappet link occurs in this chain, it acts through a lever and clutch upon a peg wheel, placing it in gear with another star wheel, which controls another chain, called the reversing chain, and moves it forward one link. If the link succeeding the one moved forward is a duplicate of the one sent on, no reversal takes place; but if it is either a higher or a lower one, then the pattern chains are caused to reverse their movement by the operation of a lever acting on a clutch, which controls the movements of a double peg wheel that by this action is taken out of direct gear with the pattern chain barrel, and put into gear indirectly with it through a pair of spur wheels. We have now followed the mechanical construction of this remarkable invention as far as can be done with clearness and interest without the aid of numerous and elaborate diagrams, and will now invite attention to its capacity in the production of patterns.

"In order to show what the inventor has achieved, we may observe that to make a serviette of ordinary length automatically, about 1,000 punched cards are required, and for a table-cloth, from 2,500 to a much larger figure, depending upon its size. And these quantities of cards would be necessary for every separate pattern, whereas by this machine only four or five small endless chains, about sixteen inches long, are required. These chains will not cost more than 1*s.* 6*d.* each, or 7*s.* 6*d.* for a set of five, and they are, of course, supplied with the dobby itself, and will never need renewing.

"The wonderful capacity of the machine is discovered in the use the inventor has made of these chains. The series are numbered consecutively, 1, 2, 3, 4, 5, and the inventor manipulates these as the ringers in a church-steeple do a peal of bells. By, as it were, ringing the changes upon them he obtains the most surprising kaleidoscopic effects in the 120 patterns that can be produced from the first arrangement without altering the positions of the links in the chains, the only change required being the alteration of the position of the chain, which can be made from one pattern to another in a single minute, and without cost. In the ordinary arrangements, in which cards are used, the change would require several hours to make, and entail a great expense. Take the case of the range of patterns, 120 in number, that can be produced from a primary pattern, and all beautiful and varying as the figures in a kaleidoscope: the punched cards of these alone would cost £300, the blank cards themselves costing £1 per 1,000.

"But this is far from exhausting the pattern-producing capacity of the invention. We see no reason why one, two, three, or four more chains should not be introduced, in which case, from every primary pattern for which the chains were first arranged, the astonishing number of 362,880 patterns could be evolved. As the primary patterns could be varied as often as desired, it will be clear that the variety obtainable, and this practically at no expense, would run into many millions. We question, however, whether there is not an illimitable field even beyond this, which is yet unexplored. All these come out of the first arrangement of the pattern chains, in which the tappet links are placed in a horizontal line. By ringing the changes on the positions of these links, it is probable that an incalculable number of further variations could be obtained. But, as we have said, this is yet an unexplored field, which must therefore be left with this suggestive conjecture.

"We invite the attention of all classes of textile manufacturers to this invention, which we believe to be perfectly unique, and of inestimable value to them. It opens new realms of design to every one of them, which they can explore at quite a nominal expenditure, a fact that will be more likely to command their attention than any

other quality we can name. The linen, cotton, silk, worsted, and woollen trades, will, we believe, find it of the

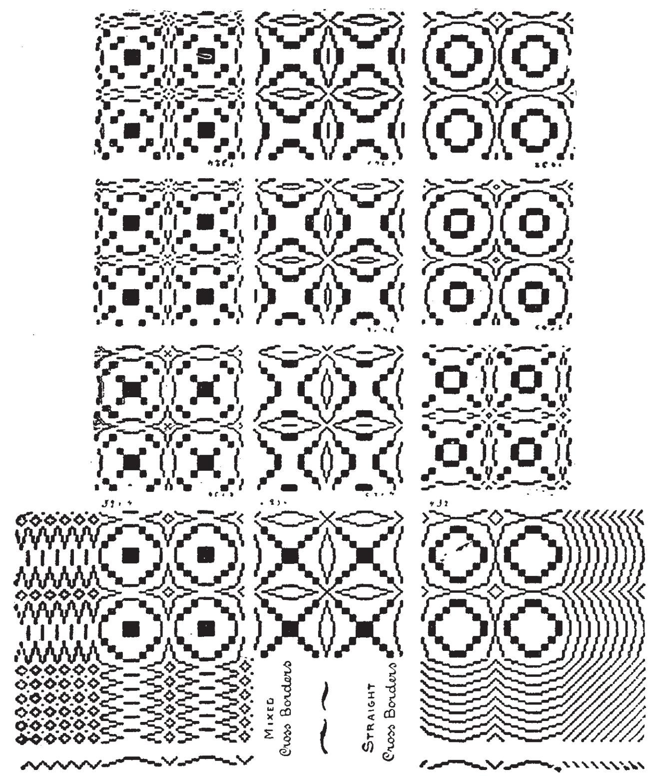


FIG. 141.—PATTERNS MADE UPON THE CARDLESS DOBBY.

greatest value, and, where not directly useful, it will be capable of easy adaptation to all special requirements. Messrs. Robert Hall and Sons will be pleased to show interested persons a loom at work with this invention applied, and also specimens of the work produced; and any other information may be obtained on application to them as above."

Fig. 140 gives a very good representation of the machine, and fig. 141 shows a few of the patterns produced upon it.

CHAPTER VII.

The Development of the Picking Motion.

The limited picking power of the loom.—Its development required for cross-stripes and checks.—Robert Kay's invention of the drop-box.—Its working described.—The hand-loom lay with drop-boxes at each end, *illustrated.*—Dr. Cartwright's power-loom multi-chambered shuttle-boxes.—Duncan's suggestion of drop-boxes.—Morison's, and Naylor and Crighton's patents.—Luke Smith's revolving boxes.—Gradual supersession of the hand-loom by the power-loom; suffering incident thereto.—The manufacture of hand-loom fancy goods the latest to be affected.—Their decay and final extinction by the improvements of the power-loom.—Final disappearance of the hand-loom cotton weaver.—Steady expansion of the shedding and picking capacity of the power-loom.—Diggles chain motion for drop-boxes.—Wright Shaw's check loom, 1868.—Shaw's further improvements, 1887.—The improved loom described and *illustrated.*—Further improvements in 1889.—Hall's revolving shuttle-box loom, *illustrated.*—Conclusion of the subject.

HAVING traced the development, and sufficiently described the shedding capacity of the loom, the growth of its picking powers may now be shown at somewhat less length. This capability, whilst very great, is not at all commensurate with the former. The shedding capacity rings, as it were, a wonderful series of changes upon the warp threads, and binds the beautiful pictures so created upon the fabric by the weft threads, as put in by the simplest arrangement of the picking power in use, the one shuttle reciprocating pick. This suffices for the most elaborate work that can be produced by the shedding capacity of the loom. It is only when another class of effects is desired, namely, transverse stripes of different materials or colour, that increased picking power is demanded from the loom. Striped textile fabrics are best and most economically constructed with the stripe parallel to the length of the fabric, and formed by the introduction of the striping material into the warp. For all the varieties thus made the ordinary picking motion suffices. But sometimes, though rarely, a transverse or cross-over striped effect may be wanted, and then an extended picking capacity is needed. Very much oftener a new series of effects, termed checks, in which warp stripes are crossed by weft stripes, are required, and as these are of almost infinite variety, it is for their production that the inventor has been called upon to provide the means.

Checked fabrics are probably as old as the art of weaving, or very nearly so. This knowledge will have been gleaned already by the careful student from the preceding chapters, therefore the ground need not be gone over again. When, as has been seen, John Kay made his great improvement in the art of weaving by the invention of the fly-shuttle and new method of picking or throwing it through the warp, he provided receptacles at each end of the slay or lay for the reception of the shuttle, in substitution for the weaver's hands, which had up to that time received it. These were termed the shuttle-boxes, and as will be obvious, they could only take one shuttle at a time. A weaver, therefore, who was engaged in making checked fabrics, especially if the changes of material or colour were frequent, would find little advantage in Kay's invention, as the changes would have to be made by hand almost as before. The fact that it was twenty-five years or more from the time of John Kay's invention before the picking capacity of the loom was further improved, to enable it to form transverse stripes, or assist in the production of checks, shows how intellectually slow were the generations of the first half of the last century in the matter of mechanical invention; or otherwise expressed, how feeble, if existent in other individuals at all, was the faculty. The improvement was made by John Kay's son Robert, a little before or in the year 1760. There is no record of this invention having been patented; perhaps Robert was fully aware of the practical valuelessness of a patent for protecting an inventor's interests, as illustrated in the experience of his father. The invention consisted at first in the addition of a second shuttle-box at one end of the lay for the reception of a second shuttle containing a different material or colour of weft. Necessarily these boxes needed to be movable to requirement, and were therefore imposed one upon the other, or otherwise were made of a single box with two compartments. This was placed within a frame at the right hand of the lay, and mounted upon vertical guide rods. Its range of motion was such that either compartment could be brought into a straight line with the shuttle race, thereby allowing the shuttle it contained to be brought into use when required. This arrangement was generally known as the drop-box, because the box not in use was ordinarily kept below the level of the shuttle race. To the top of the double box a cord was attached which extended upward to a horizontal lever, to which it was connected. This lever was pivoted near its centre upon a small bracket fixed upon the arm of the lay. From the second end of the lever a cord descended to another horizontal lever, arranged just over the lay cap, the free end of which came within range of the hand of the weaver operating the lay, thus, through the connections described, bringing the boxes within the control of the weaver. When work was commenced the weaver would place the shuttle containing the wefts to be used in their respective compartments or boxes, as they are called, and begin his work with the first the pattern required. This, it may be assumed, was the one in the top box. With this he would work as long as the pattern demanded; and, as there was only one box at the second end of the lay, when done with it would have to be returned to its original receptacle, in order to leave the way of the other clear from any encumbrance. A change having then to be made, the weaver, without any cessation of his work, by a finger or thumb of the hand upon the lay cap pressed down the lever close to it, and through its connections raised the shuttle-box so as to bring the lower compartment in line with the shuttle race, and thus allow its shuttle to be brought into work. The movement by which this was accomplished at the same time carried the first box and its shuttle outside the range of action of the picker. The weaver, by keeping his finger upon the finger lever by which he had effected this change, maintained it as long as required. When this was a considerable time, say several minutes, it was usual to keep down the lever by means of a detent, or catch, which was brought to bear upon it. The demand upon the contents of this shuttle having terminated, the former condition was restored by the weaver allowing the finger lever to rise, which permitted the shuttle-boxes to drop into their first position, when the shuttle first used could again be brought into work. The operations were then continued according to the requirements of the pattern.

The above description will make it clear that a stripe of two picks wide, formed by an outward and return passage of one shuttle, might be put into any fabric, or they might consist of any even number of picks in regular order, or in such varied order as might best conduce to the attainment of an attractive design: these always limited, of course, in this simple arrangement of the duplicate shuttle-box by the carrying capacity of two shuttles, which is merely two colours or materials.

This invention opened out a vista along which its principle could be much further extended, and the boxes were therefore soon increased to three or four, and were also duplicated at the opposite end of the lay, this obviating the necessity of always returning the shuttle to the box whence it had started before another could be used, and so enabling the weaver to insert a single pick, or any odd number of picks as might be required, with the same facility as he had done two or any other even number

before. From this was derived the modern pick-and-pick-loom, a loom little known in the cotton trade, but in extensive use in the woollen and worsted industries.

In fig. 142, A, is shown a front view of a hand-loom lay fitted with three boxes, A A, at each end. These are connected by cords to the horizontal levers, B, and from the opposite ends a connection is established with the finger lever C. Both sets of boxes being connected to this lever are elevated simultaneously when the lever, C, is pressed down. The weaver operates the lay with his left hand, the right being employed to throw the shuttle. Placing his hand near

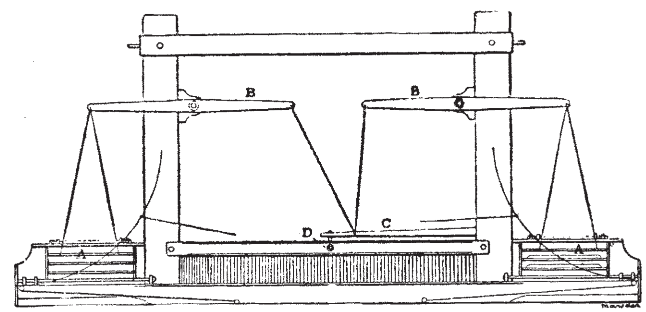


FIG. 142.—HAND-LOOM LAY WITH DROP-BOXES.

the centre of the lay cap, D, his thumb is in contact with the end of the lever, C, or may be actually upon it. When the requirement for a change of shuttle comes round he presses down the lever, brings up the desired box with its shuttle, and maintains it there until another change is made. This simply illustrates the principle of action embodied in the most highly developed box power-loom of the present day, as will be seen later on.

It is not necessary to trace in minute detail the development of the picking capacity in connection with the hand-loom after having thus shown its origin and delineated its principle. The great rival and successor of the hand-loom was upon the doorstep as it were. Dr. Cartwright, the inventor of the power-loom, after, as he says, having invented his first loom and then condescended to go and see a hand-loom weaver at work, learnt a great deal from the inspection, one of these things no doubt being the existence of multi-chambered shuttle-boxes, with which, it will be remembered, he had not attempted to provide his first loom. But, as has been seen, no difficulty, however great, deterred him from endeavouring to overcome it. It is not surprising, therefore, to find that in his patent of 1792, the last he took out in connection with his loom, he provided these boxes. Instead, however, of arranging them in vertical order, he placed them side by side, providing mechanism to give them a horizontal movement backward or forward according to requirement. This, however, does not appear to have been successful, as little or nothing was afterwards heard of it. In fact, the doctor's loom in its best form was too crude and imperfect to justify any attempt to render it still more difficult to manage by adding to its complexity mechanism to perform more than the simple process of weaving plain fabrics. The science of mechanics was too young, and the art of machine construction far too crude and rough at that date to permit of the successful embodiment in a machine of all the doctor's brilliant conceptions.

Thirty years of slow progress had to pass away before multiple shuttle-boxes became a practicable reality in the power-loom. Still it appears they were successfully introduced on the type of Robert Kay's plan, termed the drop-box, but when or by whom we have not discovered. Mr. Barlow in his "History of Weaving," referring to this matter, says: "It seems, however, not to have been carried out successfully until many years afterwards, for, in 1830, Mr. Duncan states, in an article 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." This introduces the principle of a revolving arrangement of the boxes. It seems, however, almost incredible that the simpler form of the drop-box system had not come into use before then, as in 1836 James Morison took out a patent for actuating a system of boxes in conjunction with the working of a jacquard on an improved plan. In this the boxes seem so numerous, and the working arrangement so complex, that it is fair to assume that they must, on a smaller scale and simpler plan, have been at work for a long time. Three years later, Naylor and Crighton, two inventors, jointly patented an improvement for actuating the drop-boxes of a loom.

On November 16th, 1843, a patent was granted to Luke Smith, for "the construction of a revolving shuttle-box, containing a number of compartments arranged round the axis of the box, each of which is formed to hold a shuttle." This realizes the principle just named. On the axis of the shuttle-box two plates were fixed, each having three projections, or catches, which corresponded in number to the compartments in the shuttle-box. These catches were actuated by two levers on a stud fixed in a bar attached to the breast-beam; one lever turned the shuttle-box in one, and the other lever in the opposite direction. The levers were brought into operation by studs on a belt attached to a drum which was turned by a ratchet-wheel and lever, actuated by the lay.

These details show that between 1830, if not before, and 1845, both drop and revolving boxes had been successfully adapted to the power-loom. We say adapted, because the first if not both had long enough been in use upon the hand-loom.

For the first twenty years of the present century the power-loom, owing to its numerous defects, had only made little progress. In 1813, there were only 2,400 in all Great Britain, and a rather large proportion of these were Robert Miller's "Wiper" loom, as it was called. In 1817, there were only 2,000 in Lancashire, half of which were unemployed. But the slow process of improvement was now beginning to make it a formidable competitor of the hand-loom. From the opening of the century to 1820 the number of hand-looms had probably ranged between 250,000 to 300,000, employing probably 400,000 to 460,000 persons. The greatest proportion of these looms were, of course, engaged upon the manufacture of plain fabrics, and it was these that first fell beneath the competition of the new loom. In the year 1823, Mr. Guest, one of the early historians of the cotton trade, estimated that there were 10,000 power-looms in England alone. These supplanted a much larger number of hand-loom weavers. The process was one purely of supplanting, as under the commercial *régime* then existing there was not much room for the extension of trade in old, or the opening up of new markets, as tariff laws made it impracticable to accept for cotton goods such productions as foreign populations could offer in exchange. For several years, the displacement of the hand-loom by the power-loom went on at an accelerated rate, as in 1825 the number of the latter had risen to 30,000, reducing wages and throwing large numbers out of employment. The bad harvests and commercial panic of 1825-6 suddenly and heavily accentuated this trouble, and led to the rise of the weavers in semi-rebellion, the result being the loom-breaking riots by which that period was distinguished. Thus the second chapter in the history of the new industry became a singular reflection, both in causes and consequences, of the first. In the last-named, as we have seen, the invention of the spinning-jenny, the water frame, and the mule displaced the services of the hand-wheel spinners, and led to rioting and serious disorder. This, however, was not so severe and prolonged as that

which sprang from the power-loom's displacement of the hand-loom and the weavers who wrought upon it. The number of the latter was far larger, and the processes of extinction and absorption were much slower. Better harvests, and an improvement in trade during the year or two after the riots we have named, softened the transition from the manual to the mechanical system, the younger people and the children taking to the new occupation, and so by their earnings compensating to some extent for the loss of those of their parents. By 1833 the number of power-looms had risen, in England to 85,000, and in Scotland to 15,000. At this time a power-loom weaver, assisted by a child of twelve or thirteen years of age, could attend to four looms, and weave eighteen pieces of 9-8 shirtings per week as against two pieces of the same by a hand-loom weaver. This was the death-warrant of the plain cloth hand-loom weaver. This great change was brought about immediately by the invention of the Blackburn loom by the late William Dickinson, which was first made at the Eagle Foundry, Blackburn, in 1828. Before 1840 this, which had been the largest branch of the hand-loom weaver's occupation, was extinct, and the younger portion of those who had followed it had been absorbed in the new system, the middle generation utilized as labourers in the mills, whilst the oldest had become dependants upon the younger members of their families or had sought refuge beneath the wings of public charity.

There was one considerable section of the industry however which, up to this date, had not been much affected, namely the manufacture of stripes, checks, spots, and figured fabrics, comprehensively termed the fancy trade. The weavers in this branch flattered themselves that these goods could never be made upon the power-loom, and that their occupation could not be successfully assailed. In this they were of course mistaken. No sooner was the loom made approximately perfect for the production of plain goods than inventors set to work to develop its capacity in the production of fancy articles. These attempts began about 1820, and though little progress was made during the first ten or fifteen years, it was quite sufficient to justify a continuance of effort. One problem after another got solved, and every year that passed saw new territory conquered from the hand-loom and annexed by the power-loom. By 1850 it became obvious that the extinction of even this branch of the old industry had been brought within a measurable time. The adoption of a free trade policy by the country accelerated its arrival, and the American Civil War gave it its *coup de grâce*. At that time the sole surviving demand for hand-loom muslins came from the Western States of the Union and from Canada. That from both sources was destroyed by the war. The small number of hand-loom manufacturers who had remained in the trade closed up their businesses and transferred their capital to other industries, or retired from active commercial life. A few entered the new cotton trade as employers, and as long as they lived kept their old weavers around them as semi-charitable dependants. Time, however, speedily diminished their numbers. The Ribblesdale valley from Preston to Clitheroe was the locality in which they lingered longest. During the years 1885-90 perhaps three or four might have been found in the neighbourhood of Longridge and Ribchester. One of these whose craft had abandoned him was brought from his retirement in the almshouses at Knowl Green, near Stoneyhurst, to the Manchester Jubilee Exhibition in 1887, where, in the " Old Manchester " section, he plied his craft to show modern weavers how their forefathers used to work. From a conversation with him, the writer gleaned that he was an octogenarian, and, as far as he knew, he was almost the last survivor of his industrious race. It is doubtful now (1894) whether a single one survives. Thus passed away a type of industry, picturesque far beyond its successor, that from 1750 to 1850 found employment for several millions of people. Though it has

only just disappeared, it has hardly left as many footprints behind it as have the Roman legions that sixteen or seventeen hundred years ago tramped over the country in which it was carried on.

The causes of this disappearance of the old form of the weaving industry were the invention and steady expansion of the capability of the power-loom, as seen in the improvement of its shedding and picking powers. In reviewing the development of the latter it is only intended to make a brief allusion to the various inventions that have proved steps to the highest and most recent achievements that inventors have made. The latter seem to leave little to be accomplished or even desired, and of these a fuller description may be given.

It has already been stated that James Morison took out a patent for actuating the shuttle-boxes by connection with the jacquard. This was an important invention in its suggestiveness, as it indicated the principle by which any kind of action of the shuttle-boxes could be obtained according to desire. Whether immediately subsequent inventors utilized the plan or not does not matter much now, but it is certain that it has proved the most successful of all principles in the actuation of boxes.

The invention by Luke Smith of the revolving system of boxes has also been already referred to. He appears to have been the pioneer in the construction and application of this plan to power-looms.

On January 11th, 1845, a patent, No. 10,462 was granted to Squire Diggle for an invention which has proved to have been of the highest merit, having held its ground almost to the present day, and which has been known ever since as Diggle's chain motion. The chain, which is the feature of the invention, is constructed of a number of plates or cams of different shapes and sizes. The length of the chain depends upon that of the pattern. Each cam or link constitutes a tappet for a certain box, and any box can be kept in action by repeating the cam which first brought it into position. Also any box, whatever be its position, can be brought into action by a cam of the requisite size to raise or depress it to the position needed from the one it occupies at the moment. The invention incorporates the principle of the jacquard.

The next advance of considerable importance in this direction consisted of the improvements made in the drop-box check-loom by Wright Shaw, and covered by patent No. 2219, July 14th, 1868.

The first of these consisted in the introduction of double-acting levers, reciprocating in opposite directions and acting in combination with a bowl mounted on one of the levers, which was caused to slide in a lateral direction by a lever motion, governed by the pattern chain, so as to bring the bowl in contact with one of two tappets of different diameters, thereby giving movement to the double-acting levers and bars suspended from them, and which were provided at their lower extremities with notches or teeth. When in contact with either of the tappets, the bowl was held or locked in position by means of a finger attached to the lever motion, which caused the bolt to slide. The second was an improved construction of the box-rod, the lower part of which was provided with a series of notches corresponding with those on the suspended bars. The pattern chain through these bars gave the required motion to the drop-boxes. The third was an improved method of actuating the chain; and the fourth an apparatus for varying or retaining at requirement the number of picks from any one card. The same patent also covered a number of other improvements of a minor character. The whole, in their effect, constituted a large advance upon what had gone before, and "the Wright Shaw loom," as it became known, soon took a leading position in the estimation of the trade. It was extensively adopted, and still continues largely in use. Students who desire to learn more of its details will find them given at length in the patent

specification, the number and date of which are given above.

A few years ago the same inventor made further improvements upon this loom, and which appear to have left little space for future progress. As now constructed our illustration (fig. 143) gives a good idea of its general

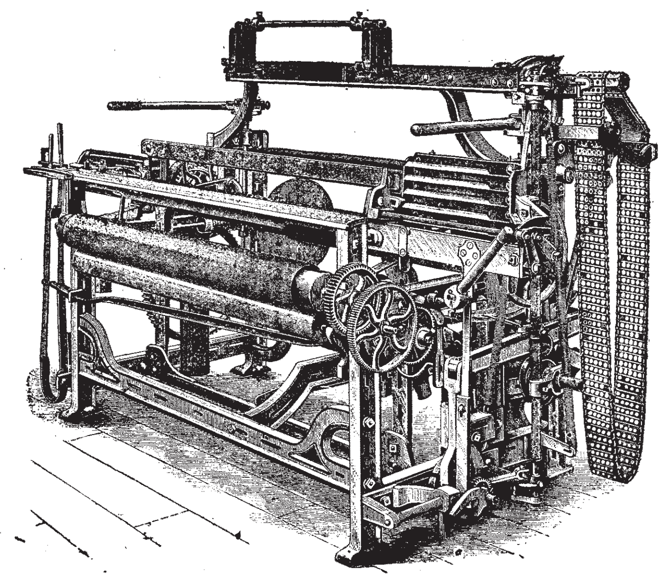


FIG. 143.—SHAW'S DROP-BOX POWER-LOOM.

appearance, whilst the group of illustrations in fig. 144 exhibit the various parts and explain their functions.

The object the inventor had in view was to simplify the construction of the drop-box motion, and to bring its principal parts within cognizance of the eye and easy reach of the hand of the weaver, by which liability to derangement would be diminished; to facilitate access to the working parts; to increase production; and to economize space. The details by which these ends are accomplished are shown in the group of illustrations under the general number 144. They are, however, numbered with subordinate numbers, from 1 to 6, and these are used in

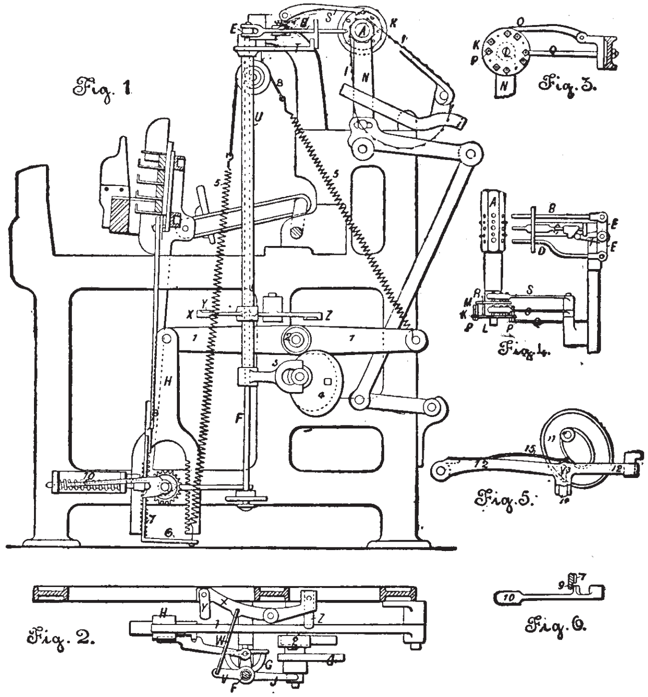


FIG. 144.—SHAW'S DROP-BOX LOOM (DETAILS).

the description. These ends he accomplished by removing the pattern cylinder, A (figs. 1, 4), and the horizontal rods, B, C, D, in same figs., from the bottom of the loom, where they are usually placed, to the top of the loom frame to which in the alteration they are bracketed.

The construction was simplified by dispensing with two of the pegged cylinders usually employed. The swivel bracket, E (figs. 1, 4), formerly attached to the outside of the sliding rods, is now fixed upon the top of an upright shaft, F, to the bottom of which is attached a second swivel bracket, G (fig. 2), which moves the "boot-jack" into or out of gear. The pattern chain, I (fig. 1), is economized by mounting a disc, K (figs. 1, 3, 4), upon the peg cylinder, L. On one face of this disc are a number of pegs, M, which, by the oscillation of the cylinder bracket, N, are brought within reach of the hook, O, which causes the disc to make a portion of a revolution. On the opposite side of the disc, K, are a number of screw-pins, P (figs. 3, 4), which in the revolution of the disc are brought into contact with a stop, Q (figs. 3, 4), fixed to the frame. When this occurs a second disc, or spider-wheel, R (fig. 4), of similar construction, fails to get within reach of its hooked catch, S, and thus the pattern cylinder, A, is arrested in its revolution, which permits the pattern on the card facing the horizontal sliding rods, B, C, D, to be repeated a definite number of times, until the omission of one of the screw-pins, P, allows the bracket to beat up its full distance, and the catch, S, to fall into gear with the spider-wheel, R, and by giving an eighth of a revolution to the cylinder, A, to bring up a fresh card and to make the required change. By this arrangement a pattern card can be made to repeat itself four, six, eight, or twelve to twenty-four times. This effects a great economy in the length of the chain.

The arrest of the normal movement of the cylinder bracket is also effected when one of the screw-pins, P, comes against the stop of the cam, 11, shown in fig. 5. This cam actuates the lever, 12, which in its turn operates the cylinder bracket. It is made with a groove, and the bowl, 13, on the lever, 12, is mounted in a sliding fixing, 14, on which the plate-spring, 15, presses, allowing the lever to give way, although the bowl, 13, still keeps travelling in the groove. By this means the ball weight usually employed is dispensed with. The same effect follows when the lever, 12, is held down by the ordinary action of the weft-fork motion when the weft thread breaks or runs out.

The lever, T, attached to the central sliding rod, C (figs. 1, 4), is mounted on a tube, U, through the centre of which passes the upright shaft, F (fig. 1, marked with dotted lines in its upper portion), and on this tube is fixed the short arm, V (fig. 2), connected by the link, W, to the lever, X, which carries two short plate-springs, Y, Z. When the two outer sliding rods, B and D (fig. 4), are working for a single lift of the shuttle-boxes, only the spring, Z, just above the bowl, 2, acts upon the boot-jack lever, 1, and prevents any jumping of the boxes when working at high speeds. But when the central sliding rod, C, comes into action, the arm, V, on the tube, U (fig. 2), acting on the spring-lever, X, removes the spring, Z, from the boot-jack lever, and causes the spring, Y, to act on the same a point further from the fulcrum, by which it exerts an increased pressure when a double lift of the shuttle-boxes is being made. At the lower end of the tube, U, is fixed the fork, 3, for throwing the double-lift cam into or out of gear.

For a long time great drawbacks to the use of rising or falling boxes for checking purposes were experienced in the wear and tear caused by the fall of the boxes from one position to another, and the large amount of power required to raise them, especially when "skipping," that is, passing over more than one box in a single movement, took place, and which arose from there being no counterpoise. These have been overcome by Mr. Wright Shaw in a simple manner. Two long helical springs, 5 and 5′, have been introduced; one is attached to the loom frame at the back, and the other to a horizontal bracket, 6, fixed to the foot of the vertical rack which carries the shuttle-boxes. The two springs are connected by a strap, 8, passing over a small carrier-pulley. In an instance like

this long springs are an advantage, as they enable the strain incident to working to be distributed over a considerable length. On the side of the shuttle-box rack a projecting flange, 9 (fig. 6), is fixed, against which the action of a stud or projection throws back the rack, removing it from its gear with the pinion when it is desired to readjust the boxes. The same thing occurs when any derangement of the working parts takes place. The flexibility thus secured very effectually prevents the breakages that often occur where no such provision is made.

In fig. 1 it will be seen there are two spring hand-levers. The ordinary one is for transferring the driving-strap to or from the driving-pulley, whilst the second is to control the pattern-card motion. In operation the weft-fork motion controls not only the strap lever, but also the lever in front of the illustration, which through its connections governs the action of the pattern-chain. This arrangement gives the weaver great facility in securing correctness in the patterns, which is a very important matter in the manufacture of checked goods.

This loom as we have described it, was shown in the Jubilee Exhibition at Manchester, and very deservedly excited a great deal of interest. Its author, however, under the restlessness which distinguishes a full measure of the inventive faculty, could not leave it alone, and within the next three years introduced several further improvements, having for their object increased simplification, to be attained by removal of every part of the mechanism which the closest study might discover could be spared. The result was that two or three further modifications of a very useful character were made.

The first was the introduction of a new pattern arrangement. The front spring lever handle seen in the illustration, as previously described, is the pattern rod lever, which has an attachment extending across the frame of the loom in front of the swing rail. On the end of this rod is a projection which is made thick towards the end in order to bring it nearer to its work. When the loom is at work this is held out of action by the pattern rod handle standing in its detent. When the weft breaks, or is exhausted, the weft-fork lever pushes both the spring handles out of their detents, and the change of position of the pattern handle instantly carries the projection at the end of its rod to a position which immediately stops the revolution of the pattern chain. Though the loom may run a pick or two further, the pattern chain remains in the right position for immediate resumption of work at the point where the weft broke, thus dispensing with the general requirement for readjustment and the loss of time usually involved, and also the risk of damage or depreciation of the cloth when this is not accurately done. The manufacturer of these classes of goods will fully appreciate the value of this improvement. Better work and a greater production are the outcome.

Another useful change was made by the introduction of a single-lift cam placed upon the end of the picking shaft. This cam has an eccentric cast upon the end of its boss, which does away with one setting point, the eccentric having previously had to be set separately and in perfect harmony of movement with the cam, which was a task not easy of accomplishment. The combination of these two parts left the interior of the loom perfectly free from every encumbrance, and available for tappets, twill motions, jacquard harness or any shedding appliance that it may be desired to introduce. The picking mechanism is entirely placed outside, thus becoming much more convenient of access.

The eccentric just named has a groove cut into its periphery into which a connecting rod descends, its end thus acting as a retainer of the clip in its position. The upper extremity of the connecting is attached to a sliding and rocking bracket, which is grooved in its upper part. By this groove it is attached to a bell-crank lever on

the extremity of which are cast two studs, upon which the bracket is placed. The bell-crank lever carries a fixed bolt, to which is attached, through a connecting rod, the pattern rod and the mechanism it governs.

We may now very briefly deal with the revolving shuttle-box. Though extensively used in the worsted districts, the revolving box-loom is not an important one in the cotton trade. It is so called because, as has already been explained, the shuttle-boxes are arranged round the circumference of a circle, and revolve on a shaft or axle forming the centre or axis. The two illustrations, figs. 145 and 146, the first showing the general appearance of the loom carrying revolving boxes, and the second their mounting and details, clearly explain the mechanism. The parts referred to are lettered alike as far as this can be done. The shuttle-boxes are mounted around the shaft or axle, A, which is arranged in a suitable frame in such a manner as to permit it to revolve freely. Round the boxes at the end nearest the reed a metal ring B is introduced, on the outside of which is fixed a second metal ring, with an arrangement to form a brake upon the ring B, in order to prevent the boxes going too far when put in motion. The boxes are actuated by two hooks, C C^1, placed at the end opposite the one just mentioned. These hooks are placed one on each side of a pegged disc, D, and have an intermittent ascending and descending movement. The position of the boxes is changed in the descending motion, the ascending one being simply to place the hooks in position ready for operating when required. The hooks, C C^1, being placed on opposite sides of the pegged disc D, can work the boxes to the right or left; that is, can cause them to revolve backward or forward accordingly as they are operated by one hook or the other. The hooks are brought into action by the steel plates, commonly called steel cards, E, which are changed according to the colours required to be put into the fabric, the change bringing the box containing the shuttle with the colour of weft required into action. These steel cards are carried on a revolving barrel, F; some are blank whilst others have holes punched into them. Two inverted levers, L, with pendant needles, H H^1, at one end are presented to the steel cards. If the card present on the cylinder be blank, no change can occur in the position of the boxes; should it be perforated, the needle enters, and the end of the lever, L,

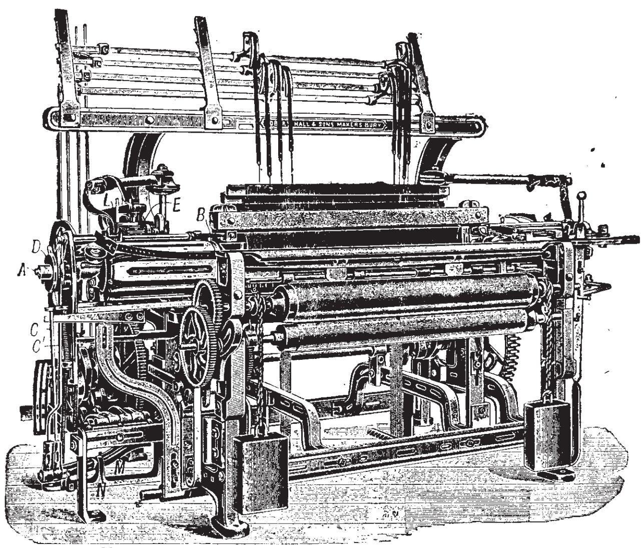


FIG. 145.—REVOLVING SHUTTLE BOX-LOOM.

carrying it descends to a lower point than it would have done had the card been blank. The opposite end of the lever then operates one of the two hooks, I, which are fixed in the path of the lever K, this having a continuous alternating up-and-down movement. The lever K on its ascending movement raises the hook I, and this hook being connected to the hooks, C C^1, by means of a lever, M, having its fulcrum at N, depresses one of the hooks, C C^1, changing

the position of the boxes as desired. The lever K is actuated by an eccentric, P, placed generally upon the tappet or second motion shaft of the loom. The needle end of the levers, L, have a suitable motion to elevate and depress them, and each time they are raised the card

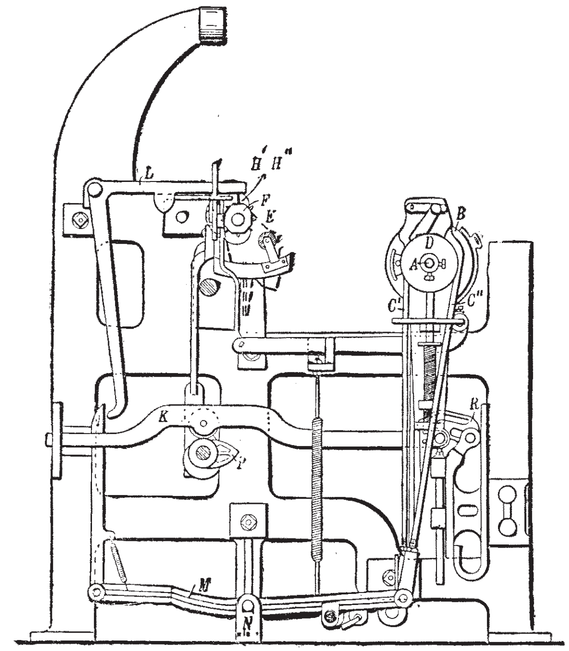


FIG. 146.—REVOLVING SHUTTLE BOX-LOOM. (SECTION.)

barrel, F, is changed in its position, and made to present a different card to the needles. At R an arrangement is made which will permit the lever K to slip in the event of a shuttle not getting into the box, thereby avoiding breakages.

This is one of several systems adopted for actuating revolving shuttle-boxes. They differ only in details of construction, each, like this, embodying the principle of Jacquard's invention.

At this point we may appropriately close our notice of the development of the picking or shuttling capacity of the loom. There are, of course, many inventions that might seem, with equal justice, to demand as much notice as has been accorded to some of those described; but as a rule they either embody the principles of those noticed or find little place for their use in connection with the cotton trade. To describe every good invention would also carry this work far beyond the compass originally designed, which even now threatens to be considerably exceeded.

Having thus thoroughly dealt with the loom, the various preparatory processes now call for description. In connection with these the machinery employed in them will come under review, but the machines being for the most part simple and modern, the task of reviewing them will neither be a heavy nor a prolonged one.

CHAPTER VIII.

The Winding and Warping Processes and Machinery.

The accumulation of yarns in cop and bobbin forms, *illustrated.*—Indian winding, reeling, and warping, *illustrated.*—Old English peg warping, *illustrated.*—The old textile technical words, "beer" and "porter."—Invention of the old circular or ball-warping mill; description; *illustrated.*—The multiple spindle winding machine; inventor not known; description; *illustrated.* — Mangle-wheel motion, *illustrated.*—Improved bobbin winding machine for ring-frame bobbins, *illustrated.*—The coloured goods trade.—Improved hank reel, reeling from cops, *illustrated.*—The Coleby reels, *illustrated.*—The yarn bundling press, *illustrated.*—Reeled yarns for bleaching and dyeing, and their treatment.—Hank winding, and hank winding machines, *illustrated.*—The invention of dressing and sizing machines materially change the method of warping, namely, to beaming.—The invention of the beaming machine.—Its improvement by William Kenworthy.—Rosseter's and Singleton's automatic-stopping beaming machines, described and *illustrated.*—The measurement of yarn upon beaming-machine beams.—Coloured goods trade; section-warping machine, described and *illustrated.*—Method of working it.—The section-beaming or "running-off" machine, *illustrated.*—A new warping mill for making ball warps for bleaching or dyeing purposes, *illustrated.*—A new dressing and beaming machine for coloured warps, *illustrated.*—The warp chaining machine, *illustrated.*

IN the cotton manufacture, as it exists to-day, the winding and warping processes are sometimes found connected with the first or spinning division, but most generally with the second or manufacturing division, the one forming the subject of this essay. Occasionally, though less rarely now than thirty or forty years ago, they are found combined as an intermediate and independent branch, that is, are conducted as a business separate from either of the principal divisions. They have, however, as such almost disappeared, having been absorbed by the principal sections.

These two processes are rendered necessary by the forms given to the yarn as it accumulates in the spinning processes. It has been shown in preceding pages that the distaff spinner accumulated it upon the spindle, winding it length by length as it was spun, and forming copes at each end of the mass, in order to prevent entanglement. The hand-wheel spinner followed the same plan, both in making rove and yarn. The necessities of the situation compelled Hargreaves in his jenny to do the same, and the like inexorable power forced Samuel Crompton into the same groove. Subsequent inventors, who have added improvement after improvement to the mule, have retained the same method of accumulating the yarn and the same form of the accumulation. The form of the figure is a cylinder, with two conical ends of unequal length. The shortest cone forms the base or bottom, and the longer the top or nose. This is yarn in the "cop" form, which is a word derived from and a contraction of the word cope, indicative of the coped extremities of these cylinders of yarn. This word, or its equivalents in various languages, is of very ancient origin and use. These cops, until the time and invention of Richard Roberts' self-acting mule, were always formed by the manual skill of the spinner. After that time they were made automatically on his "self-acting mule." A full description of this, along with the construction of the cop, will be found in the present writer's work on "Cotton Spinning." Both warps and weft yarns were accumulated in this style. For the sake of students who may not be in contact with either branch of the trade, several illustrations (fig. 147) are given of cops and bobbins from the self-acting mule, and the ring spinning frame. The first two, A B, are cops from the self-acting mule, A being a cop of weft yarn, and B of warp yarn or "twist" as it is most commonly but erroneously called. The third, C, shows the ordinary ring frame bobbin filled with yarn; and D a ring frame bobbin with what is termed the parallel build. These are all shown about one-third their actual size.

The first departure from the cop form of accumulating the yarn was made by the inventor of the Saxony or flax spinning-wheel, on the spindle of which a "flyer" was carried. In winding the yarn with this method of spinning it could not be coped, hence double-headed or flanged bobbins became necessary, and were accordingly provided.

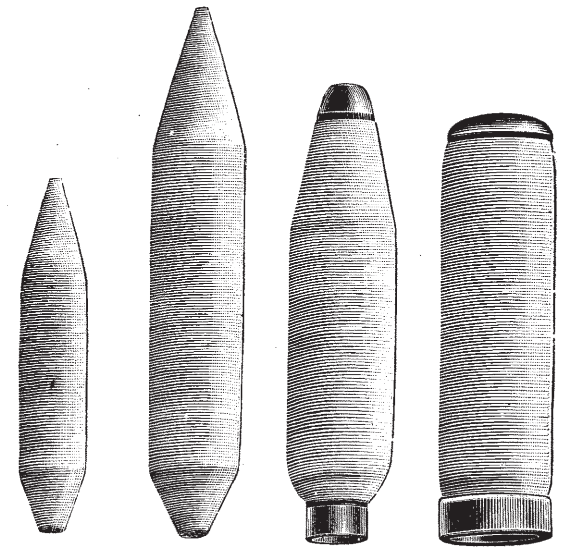


FIG. 147.—MULE AND RING FRAME YARNS ON COPS, SPOOL, AND BOBBIN.

Arkwright adopted this spindle and flyer in his water-frame, and of necessity the flanged bobbin. It was continued in the improved water or throstle frame, but has in most cases been discarded in its successor, the ring spinning frame. In a recent and valuable invention, the improved ring spindle of Mr. Thomas Wrigley of Todmorden, the cylindrical build and the double flanged bobbin have been reintroduced. The above illustration, D, is from Mr. Wrigley's bobbin.

As each of these cops and bobbins contains only one strand of yarn, it will be obvious that to put from one to three thousand of them behind a loom in order to make a warp, would be inconvenient if not impossible, therefore some intermediate process or processes are necessary.

FIG. 148.—INDIAN WINDER.

These we find in what are termed winding and reeling, and warping.

In India, the primitive home of the cotton industry, the operative wound the yarn from the spindle cop upon a bamboo frame, as shown in the illustration, fig. 148. This was practically a single thread reel, and the yarn was no doubt thus reeled into the hank form, in order to admit more readily of being sized or starched in order to increase its strength, and enable it the better to resist the friction incident to weaving. It would also be necessary for the dyeing process. The sizing was performed by

immersion and saturation in rice water. A further advantage would also probably accrue, in that the contents of several small cops would be reeled into one length, and thus fit it better for a warp length.

When the sizing had been properly performed and the yarn dried, it was again put upon the hand reel and straightway formed into a warp. The manner in which this was done is shown in the illustration, fig. 149, where it will be seen the warper having put a number of sticks into the ground, fastens the yarn to the end one, and then

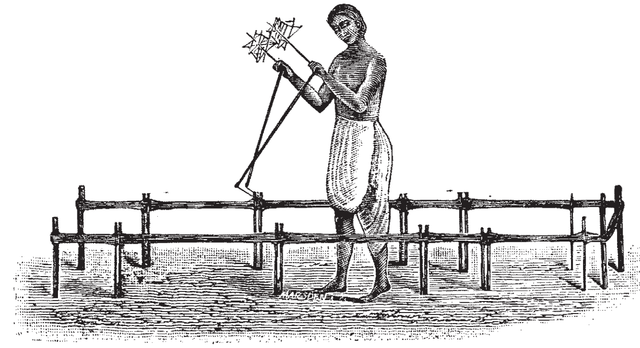


FIG. 149.—INDIAN WARPER.

proceeds to unwrap the yarn from the reel around them. It will be observed that the warping is not continued all around the arrangement of the sticks, but when the warper arrives at the last stick, the yarn is passed around it, and the first course is gone over again in a backward direction. Thus a journey from the first stick to the last and back again adds two threads to the warp, or according to the arrangement, two lengths of one thread. This is continued until a sufficient number are obtained, when the warp is completed. It will be quite obvious that this is a very monotonous and laborious process, as it compels the worker to pass over a distance equal to the united lengths of every thread the warp contains, it not appearing that the warper carries more than two threads. This system is not only the ancient one, but has come down to the present day, and is the method in most cases now followed where the domestic industry still survives. But both spinning and weaving in India in the ancient forms have greatly diminished, and must ultimately disappear before the modern systems, just as they have already become extinct in this country.

Before the invention of the water frame by Arkwright, the so-called cotton goods were really unions, having linen warps filled with cotton weft. The yarn of these warps was delivered to the weaver in hanks. This was the weaver's raw material, just as cop or bundle yarns commonly are to-day. The weft, when it was not dyed, was usually received in the cop form. When it was found that cotton yarn from the water frame could be used for warps, this was also delivered to the weaver in the hank state, as being most convenient to the spinner and most in accord with the habits of the weaver.

Cotton yarn was subjected to the same processes that linen passed through. Both were boiled in the hank, in water to which soap or potash had been added. Afterwards flour was added to the water in which cotton yarns were boiled in order to increase its firmness and tenacity. When the yarn had been thoroughly dried it was wound upon bobbins upon the common one-spindle hand-wheel, which may occasionally be seen in use to-day in our smaller weaving mills for the purpose of winding heading yarns. The hank was extended upon and between two small wheels called whisks, fixed upon an upright post and revolving upon their centres.

The bobbins thus prepared were delivered to the warper for him to form into a warp of a given length and breadth. Warping is merely the laying of a number of threads in parallel order, and equal in length, and in number sufficient to make the required width of cloth. In the

early days of the industry this process was almost identical with that of the Hindoo as previously described. This will be seen from the accompanying illustration, fig. 150, which is from an old print. Here it will be seen the pegs instead of being stuck in the ground are fixed in a wall, and the warper takes the yarn, attaches it to the outer peg, passes it under and over the others in alternation to form a lease, and then carries it to the most distant one, around

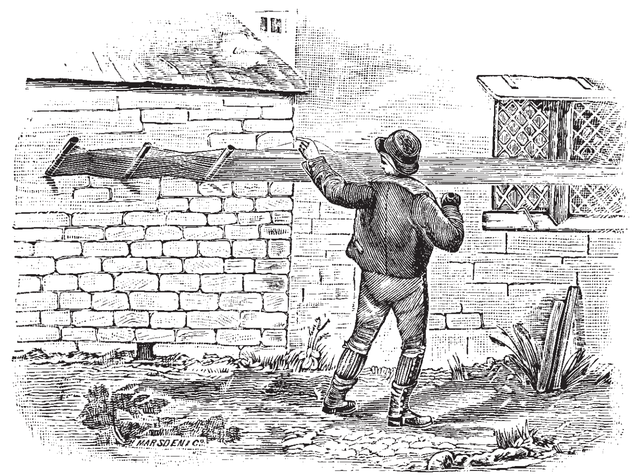


FIG. 150.—PEG WARPING, AN ANCIENT ENGLISH METHOD.

which having passed it, he returns to his first position and repeats the operation. Undoubtedly in the earliest times the English warper would thus carry every thread as does the Hindoo, but some time or other, it is undiscoverable when, he would find that his walking would be greatly diminished if he carried more than one thread at a time. The new idea was accordingly put into practice with great advantage. The warper having got a number of clues or balls of yarn together, placed them in a box or some kind of vessel, gathered the ends of the threads together, and having attached them to the peg in the wall as stated above, he took them all in his hand, and permitting them to slide between his fingers, walked to the other end of the warp course, passed them around the peg placed there, and then returned to the first. This double journey formed the length of the warp, and was called a *bout* or a warp *gang*, meaning once about the length, or a going of the distance equal to the length the warp had to be made. Assuming that the warper carried 20 threads with him, 100 journeys, or "gangings," to use the Scotch term, would give him a warp of 2,000 threads. If he carried 40 threads, 50 "bouts" would do the same.

In these days many students of the textile industries in reading and otherwise investigating the origin and progress of the textile arts will come across names that are apparently quite inexplicable, and will fail to gather any idea of their proper meaning in the relationship in which they are employed. Amongst these not the least puzzling are the English word "beer" and the Scotch word "porter," as used in the textile industries. He may hastily conclude that they are somehow derived from the two drinks of those names; to do so, however, would be very erroneous. They are synonymous terms, meaning exactly the same thing on opposite sides of the Tweed. It is in these journeys of the old warpers that we shall discover their origin. In both cases they represent the standard maximum number of threads the warper would carry in one going, or one bout, and this would probably be forty threads. His bearing or portering of these threads would soon come to be called a "bear," subsequently corrupted into a "beer" in England, and a "porter" in Scotland, from the thing ported or carried. The quantity of threads included in these terms afterwards became a unit of measure, and thus having lost their original significance, came to indicate something entirely different, this being a unit of reed measure equal to twenty dents,

as they would be expressed in England, or splits according to Scottish nomenclature. Thus 100 dents or splits in all kinds of reed measures are, or rather were, for the terms have largely gone out of use, divided into five equal portions of twenty each, and these names given to them. As each dent or split usually carried two threads, we get forty threads to the "beer" or "porter." In making the warp, if the warper was not both skilful and careful, there was a great liability for these beers to get slightly twisted, in which state they became very troublesome to the weaver when they reached him. In putting the warp upon the weaver's beam, or beaming, as this was called, these "beers" were usually divided into two portions by the teeth of the "wraithe" or "raddel," a coarse comb used to guide the warp upon the beam in an even manner. This explanation, by disabusing and clearing the minds of students of the liability to attach wrong significances to these terms, will enable them to read with more understanding the older literature of the textile industries.

The winding on the common hand-wheel, and the peg-warping described and illustrated, were universal in this country until 1760, when the warping mill was invented and first introduced. Like all other things in those times its adoption was slow, and the old system, especially in the Lancashire woollen trade, did not disappear until more than the first third of the present century had passed away. In the cotton trade, however, it was adopted earlier, as the money made in the new invention was a stimulus to enterprises at the same time that it provided the means of carrying them out. The old warping mill and the warper are shown in fig. 151. As will be seen the mill, as it was called, consisted of the vertical creel containing the four rows of yarn bobbins, and the large vertical reel, B, mounted within the frame extending over it. On the bottom of the vertical shaft or axis of the reel there was fixed a grooved pulley, I, connected with the driving pulley, C, by means of the rope, D. In working it the warper took his seat as shown at A, turned the handle behind him fitted on the shaft of the pulley, C. As this revolved it transmitted motion to the reel, B, which began to revolve. The driving pulley being about double the diameter of the pulley on the shaft of the reel, the latter made two revolutions for one of the former. In an earlier form the driving band passed around the reel itself.

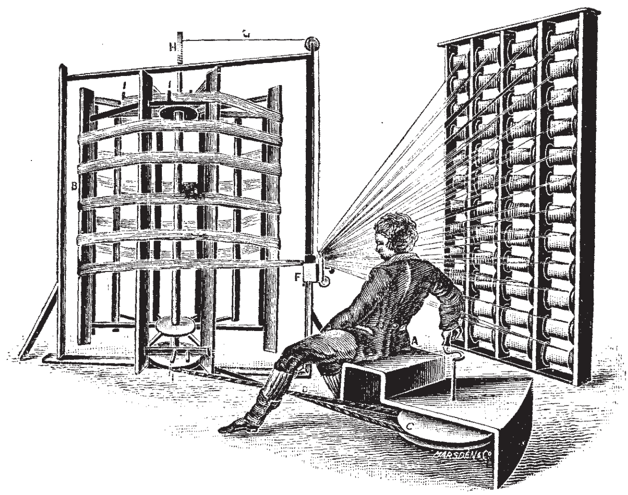


FIG. 151.—THE WARPING MILL ABOUT 1810.

This shows the great advance made by this invention in the amount of work that could be produced from this machine as compared with peg warping, and the extent to which it diminished the labour of the workman. As shown here the creel contained only forty-eight bobbins, a small increase upon the "beer." It ought to have been previously observed that before commencing work the warper gathered together the threads from the bobbins, and passed them in certain proportions between the teeth of a coarse comb carried in the frame, F, and attached them

tied together to a peg upon the reel, and then under and over the lease pegs similar in manner to what is shown in fig. 150. The yarn was then traversed upon the reel automatically by means of an extension of its axle at the top, where it is seen to rise above the frame at H. To this extension a cord was attached which extended horizontally to the small pulley shown over which it passed, and was attached to the frame, F, carrying the comb. When commencing work the cord was wound upon the axis, and gradually uncoiled as the reel revolved until it had all run off, and the frame, F, was at the bottom. The yarn was then passed around a retaining peg, and the revolution of the reel reversed, the cord winding upon the axis, and the comb frame ascending. These courses were repeated as often as necessary to get the number of threads sufficient to make the width of cloth required. When this was accomplished the warp was ready for "doffing." The warper disconnected the threads coming from the creel, took one end of the newly formed warp in one hand, and drawing the warp from the creel with the other, cleverly wrapped it around the arm, holding the end, and so ingeniously and skilfully formed it into a ball, tying it in the middle with the last portion of its length. The making of this ball of the product gave the name of ball-warping to the method. Subsequently both reel and creel were greatly enlarged, the former in diameter and the latter in the number of bobbins it would contain. It was also adapted to be driven by water or steam power. It still holds its ground in some of the more remote country districts where a conservative sentiment prevails, and old warps are believed to be the best.

The multiple spindle winding machine appears to have been a somewhat later invention than the warping mill. It is very likely a suggestion derived from Hargreaves' spinning jenny; hardly any thoughtful person could see that machine without it suggesting its suitability for winding purposes, with very slight modification in the way of simplifying it. There is no record of its invention, and no doubt like Topsy in "Uncle Tom's Cabin," it "growed," and no one could have claimed to be its parent with certainty. Notwithstanding this, it formed a considerable advance. The first recorded patent we have found is that of William Pride, No. 4,666, granted April 16th, 1822. This improvement consisted in putting on the driving shaft of "the spooling frame," "two wheels of different sizes, which drive a tin roller, the larger wheel being used until the spool is half full, then that is thrown out of gear and the smaller one is thrown in gear. The traverse motion is worked by a heart wheel." This is practically the only patented invention relating to the ordinary winding frame up to 1860. The two speeds or sizes of driving wheels were required, the first or larger to get sufficient speed whilst the tubes of the bobbins were bare or did not contain much yarn. As they filled they would take up the yarn much more quickly, more quickly, in fact, than its quality at that time warranted, and so would cause too much breakage for the winders to keep their ends up. A reduction of speed would moderate this. These have long ago been discarded, and high speeds of the spindle attained and maintained, which give a gradually accelerating draft of yarn, as the periphery speed of the bobbin increases from the successively added layers of yarn. The heart cam, which actuates the yarn traverse rail and distributes the yarn evenly upon the tube of the bobbin, was an important invention, and is retained in some winding frames to-day. It is this which imparts a barrel shape to the filled bobbin of yarn.

Winding machines or frames, as they are ordinarily called, and which are intended for the usual processes of manufacture, are about the simplest machines in the whole of the cotton trade. One of the most modern type is shown in the illustration, fig. 152. In size they are made according to requirement, and differ but very slightly in

construction from whatever machine-making establishment they may come. It consists of an oblong frame, and really constitutes a double machine, being furnished with two sets of spindles on each side. This is dictated by economical considerations, as the working parts will drive two sets of spindles as well as one, and at only a small additional consumption of power. The two rows of the spindles on each side are arranged in zigzag, or diagonal order to each other, the gauge being about five inches. This order is adopted to utilize space, and to secure clearance for the spindle driving-bands.

The driving-shaft extends along the length of the frame carrying the fast and loose pulley at the headstock end. There is also mounted upon it a tin cylinder, about seven inches in diameter which extends the length of the frame. This drives the spindles, the power being transmitted by cotton bands which pass around a small pulley or wharve. The bobbin rests upon a disc plate carried upon the spindle, and its weight gives all the friction necessary to secure rotation, and to overcome the drag of the yarn. The operative passes steel skewers through the holes left in the cops of yarn by the spinning spindles, which are then placed in the cop-holders. These are carried upon a rod extending the length of the frame, and are placed in this at such an angle as to admit of the easy draft of the yarn. This in its course to the bobbin passes over the board shown at the front and generally called the knee-board, an incorrect name if regard be had to its function. This board is usually covered with flannel, and forms a check upon the too easy delivery of the yarn to the draught of the spindle, thereby securing uniformity of tension in the winding. It is therefore really a drag or tension board, and so should be called. The wire loops inserted into the bottom of the board are merely to keep the threads apart, and to prevent entanglement in cases of breakage. Passing this, each thread goes through the bristles of the clearer brush, shown by the long dark line

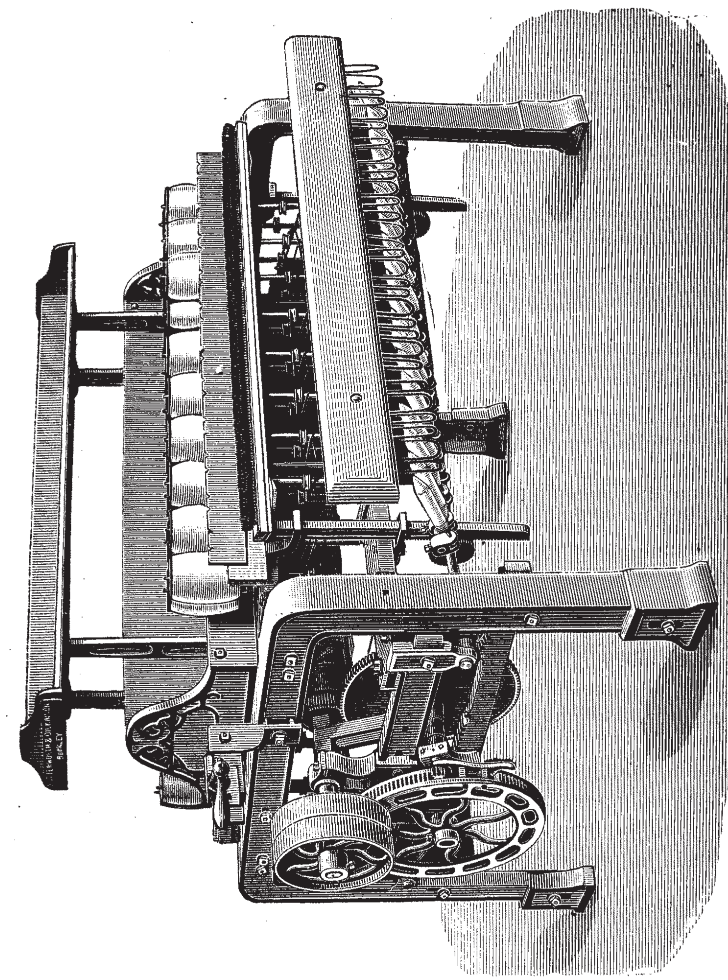


Fig. 152.—Cop Winding Machine.

above the drag-board. The function of this is to clear the yarn from loose fibres, seed leaf, etc., and to break the yarn down in soft and single places, so that these may be taken out at this stage. The meaning of these terms will be explained further on. This at one time was a most important function of this brush, but owing to the great improvement made during the past fifteen or twenty years, it is not now nearly so much required. In fact, it might, so far as single and soft places are concerned, be almost dispensed with.

Immediately the yarn has passed the brush it is received by a guide-plate, which, besides guiding the yarn to the bobbin, acts as a snarl and knot catcher or detector. It contains a series of slits, one for each spindle, and equidistant. It is generally called the "crowfoot" guide-plate, because the vertical slits which receive the threads have two branch slits made from them, one to the right and the other to the left, and inclined outwards; the whole presents a distant resemblance to the extended foot of a bird. It has already been shown with what facility the operatives in the machine shops and mills resort to nature for object names in connection with machines, rather than to the terms of mechanical science; this instance affords another illustration, and there are many more. The purpose of these diagonal cuts is to retain the threads in their proper slits when once placed there. Without these they would occasionally escape and become entangled with the others.

The brush and guide-plate are secured together, and thus form a horizontal rail which is mounted upon vertical iron bars, or rods, usually termed lifting pokers, which slide up and down in suitable brackets. Each of these has at its lower extremity a small foot or horizontal projection prepared for connection with a chain by which the traverse of the guide rail is effected, and the yarn properly distributed upon the bobbin. This is usually so arranged that the bobbin, when filled, becomes of a barrel shape.

The lift extends from flange to flange of the bobbin, a distance generally of five and a half inches. The speed of the traverse rail is not quite uniform, slightly diminishing about the middle of that portion of the bobbin by which that part receives more yarn, and thus gradually fills into the desired form.

We have called the winding-frame the simplest machine in the series used in the manufacturing division of the trade. Though this is true, it usually contains, as now

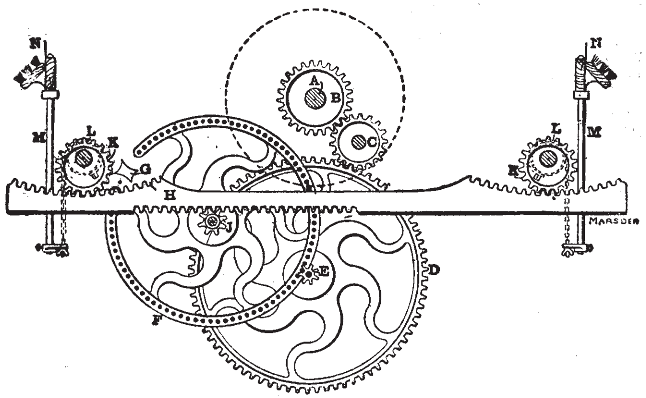


FIG. 153.—MANGLE WHEEL MOTION IN WINDING MACHINE.

generally made, a most ingenious mechanical arrangement which, for the sake of the student, may be described. This is called the mangle-wheel driving system, and is illustrated in fig. 153. It is shown apart from the machine frame for the sake of clearness.

Upon the driving-shaft, A, is mounted a spur-wheel, B, which drives through the carrier-wheel, C, the arm-wheel, D. On the same stud as the wheel, D, is the reverser pinion, E, which engages with and drives the mangle-wheel, F. This wheel is composed of two sides, which we may term imperfect rings, as they are not complete circles.

These are united by a series of pegs set in close gauge, and shown by the small circles on the wheel, F. Where the circle is broken a stop-block, G, is introduced, set a little back from the ring.

This wheel is a remarkable one, constituting as it does an external and an internal wheel, otherwise a wheel that will gear with a driver either on its outer or inner circle. In the use made of it in this instance both circles are utilized. The effect gained when the change is made is a reversion of its revolution, which is what is required. As the pinion, E, revolves, the wheel, F, is driven by it until the break in its periphery comes round to the pinion, E, when the block stops its further progress, whilst the pinion, E, forces the wheel, F, to admit it to its interior, where, then being in gear with the interior circle and revolving in the same direction, it reverses the revolution of the wheel, F, which is then driven in the new direction until the break in its circle again approaches the pinion, E, which again encounters the block, and runs this time to the outside as before it did to the inside, and then rotates the wheel in the first direction. These movements are continuously repeated.

The use of the reversing motion thus obtained will soon become apparent. The pinion, J, which revolves in the mangle-wheel, F, as will be seen, gears into the rack, H, the circular movement of the first becoming transformed into a horizontal movement of the second. As the revolution of the wheel, F, changes, so does the direction of movement of the rack.

It will be observed that each end of the rack on its upper surface is constructed to form a segment of a circle, each being furnished with rack teeth, which engage with the wheels K K, and in their traverse partially rotate them. The wheels, K K, are eccentrically mounted upon the lifting shaft, L, which extends the length of the frame and carries a number of chain blocks placed at intervals throughout its length. To each of these a chain is attached, which at its opposite extremity is linked to the foot of the lifting pokers as previously mentioned, and thus is completed the circuit by which the movement of the traverse rail and the wind of the bobbin is connected. It only remains to state that the object sought by mounting the wheels, K K, eccentrically is the variation in the rate of the movement of the rail which gives the barrel formation to the bobbin. The diagram shows the position of the various parts represented at the time when the rail is about midway of its traverse.

This variation in the traverse can also be obtained in several other ways, as, for instance, by mounting the pinion, J, eccentrically on the mangle wheel stud instead of the wheels, K K, as shown here. Again it may be had by making the pinion, J, drive the rack, H, through two eccentrically mounted pinions.

The introduction of ring spinning on a somewhat extensive scale during the past twenty years has revealed the desirability of modifying winding machines to adapt them to meet the altered conditions, the principal of which is that the yarn has to be wound from the ring bobbin, from which it comes more freely than from the mule cop. In some cases the creel or bank in which the ring bobbins are mounted is furnished with ring spindles arranged at a slight angle from the horizontal position. The yarn is then drawn off from the side instead of from the cone of the bobbin, the drag resulting being sufficient to secure delivery at a uniform tension.

In fig. 154 is shown an improved frame for winding from ring frame bobbins, in which the ring bobbins are arranged horizontally and the yarn drawn off at the nose or cone. The speciality in it is that there is a tension wire placed at the front of the nose, through which the yarn has to pass immediately it gets off the bobbin. This secures uniformity of tension in the winding and obviates the necessity for the presence of the drag-board as shown in fig. 152. The illustration also shows a good view of

the driving end of the machine and its gearing. Here it will be seen the rack is of a different construction, and is carried upon bowls in order to diminish the power needed to actuate it. The variation of the movement required for the traverse is also obtained in a simpler way than as shown before, being got from a slight eccentricity in the mount of the pinion driving the rack. This eccen-

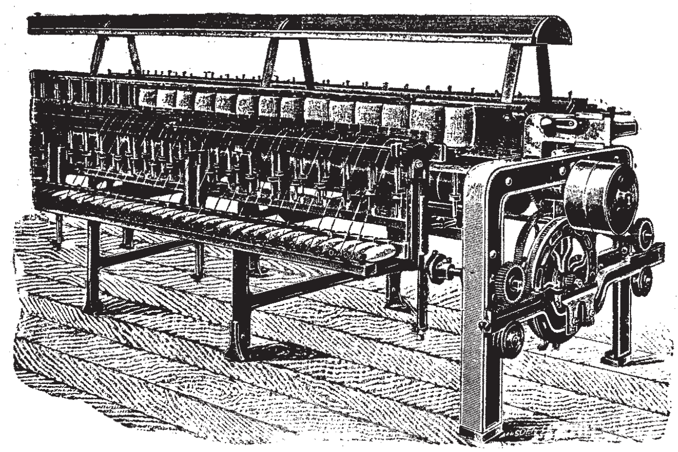


FIG. 154.

tricity is so small as not to be discoverable in the illustration.

The above types of machines are in almost general use throughout the great weaving districts of North-east Lancashire, and in others where similar plain goods are manufactured, or such fancy goods as do not need any preliminary treatment, such as bleaching or dyeing of the yarn previously to its being woven.

In many places, however, what is called the coloured goods trade is the staple industry. This prevails in Rochdale, Heywood, Radcliffe, Farnworth, Swinton, Newton Heath, Failsworth, and a few other smaller places. In these a large proportion of the yarns used, both warp and weft, have to be bleached or dyed, mostly the latter, before the weaving process. In these cases the winding process is changed for what is termed reeling. The yarn, instead of being wound upon bobbins from the cops or ring bobbins, is wound upon reels, and when doffed is in the loose form of hanks and in a condition to easily admit of dyeing or bleaching as may be required.

An improved reel is shown in the illustration (fig. 155). This reel, or others of similar type, is in use in almost every mill where reeling is required. It will be seen that the frame is a very light one, being composed of two ends made of iron, and the cop creel of wood, and a second bar just beyond it carrying the yarn guide-wires. The reel proper is a hexagon composed of six bars of wood carried upon arms loosely mounted upon the horizontal shaft shown. A circuit of this hexagon is fifty-four inches, the hank being generally reeled in that length, though sometimes in seventy-two inches. The method of driving is shown, and is so simple as to require no description. The reel being in its normal form of a hexagon has the threads attached by the reeler, as the attendant is called, the reel is started, and the yarn reeled in hanks of 840 yards. In straight reeling the hank is divided by ties into seven leas of 120 yards = 840, this being mostly the case for the eastern trade. When the hank is completed the arms of the reel are pressed together, as shown in the illustration, and the hank slided off at the end. The speciality in the machine shown is in the facility it affords for doffing.

In fig. 156 is shown the Coleby reel. As compared with ordinary reels it presents some considerable differences in appearance. The first alteration shows that the frame of the machine has been dispensed with, having been substituted by a central stand, the reels projecting from this on each side. This change permits much freer use of the space beneath the frame, and facilitates doffing

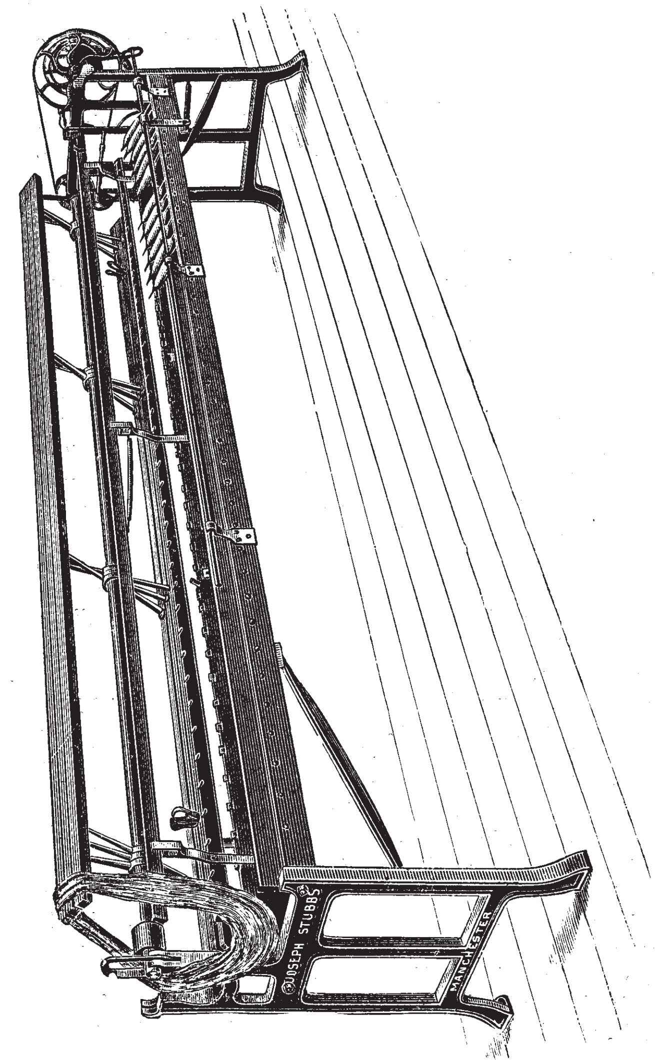


Fig. 155.—Improved Yarn Reel, Reeling from Cops.

very greatly. One shaft drives the four reels upon one stand, through and by means of two short shafts carrying a pulley for each reel. On each extremity of these shafts is a small driving pulley from which the reels are driven by a fast pulley upon the axle of each reel. There is no loose pulley, as the reels are driven by means of a slack strap, which has its tension adjusted to drive the reel by means of a small bowl carried upon the extremity of the starting lever; this lever also carries a brake which is put out of action when the reel is started, and brought into work when it is stopped. By this simple arrangement the starting and stopping of the reel is instantaneously performed with the greatest ease. The speed of the reel is also regulated by the same means, as when the strap is brought to a proper tension it runs at full speed; at half tension it runs slowly in order to permit of the winding off of cop bottoms with more ease. It ought to be added that the machine can be readily changed to reel from either cops, bobbins, or tubes. Some important advantages result from this arrangement. Each section being separately driven, only one containing ten ends is stopped at a time for "setting-in," "piecing-up," or "doffing," instead of forty as in reels of the ordinary construction. This yields a very considerable gain in the production. By an improved manner of laying in the yarn this is done more quickly, and a further gain made. The skill and strength required are both less, and children can easily perform the work that previously required skilled adults. As compared with the old type there is a saving in cost, in space, and in wages. As will be seen, it is adapted for winding from cops, and ring-frame bobbins, or can be made for throstle bobbins and for the reeling of hard-twisted yarns, as seen in fig. 157. In the latter form it is supplied with an excellent tension adjuster, also the invention of Mr. Coleby.

Reeling for the home trade is often done in the spinning-mills, and in most cases it is of the kind called "cross

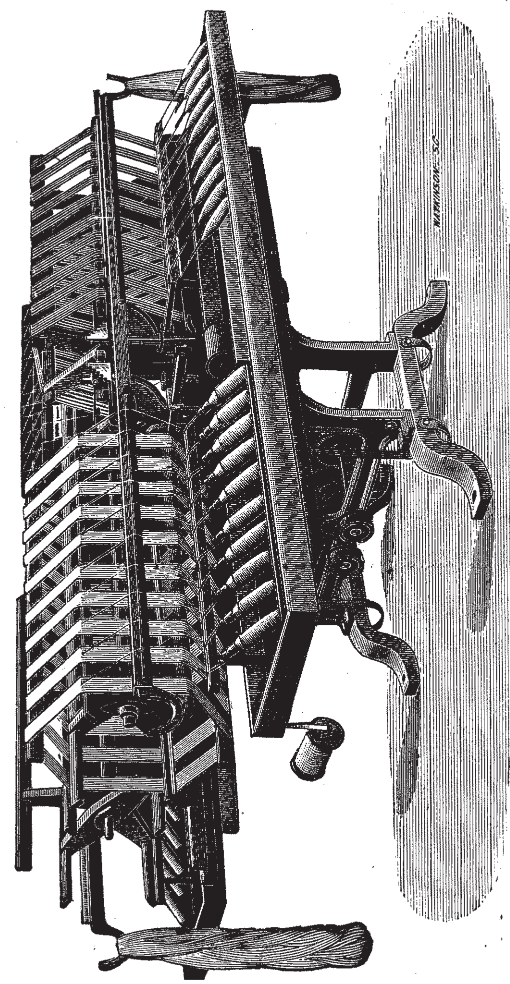


FIG. 156.—THE COLEBY REEL. REELING FROM BOTH COPS AND RING-FRAME TUBES.

reeling;" that is, the threads are rapidly traversed in a lateral direction backward and forward, so that they never lie parallel to each other, but rather diagonally across each other all through the hank. The object of this is to ensure that in the event of a thread breaking the end shall be soon and easily found as it always lies upon the surface, which would not be the case were the system of parallel winding used. Thus much loss of time is prevented, in the first place to the reeler, and in the second to the hank winder in the subsequent process of winding from the hank after bleaching or dyeing. The advantages of cross reeling seem to be appreciated mostly by the home and continental trades, as in yarns for exportation to the great eastern markets, straight reeling seems invariably adopted.

Cross-reeled yarns for the home trade are made up in long bundles and are not pressed, as are straight-reeled bundles, for export to the east. It sometimes happens that in a manufactory reeling its own yarns that its capacity of production may occasionally exceed that of the consumption of the establishment. In these cases it sometimes becomes economical to turn the reels upon straight reeling and sell the yarn. In this case there will be required a short-bundle yarn press such as that shown in fig. 158, a very excellent automatic press invented by the gentleman whose improved reel has just been described.

Ordinarily the yarn bundling press consists of a small oblong table and a number of vertical bars affixed against each of the longer sides, so as to enclose on two sides a cubic space, the ends being open. To the back bars are attached a third series, hinged to them, so as to be brought over to those in front. The yarn having been placed in position, the covering bars are brought down and the table raised by the usual means, the motive power being either manual or steam-power, which may be most convenient. The yarn having been pressed, the press is wound down, the bars lifted, and the bundle taken out. This is the

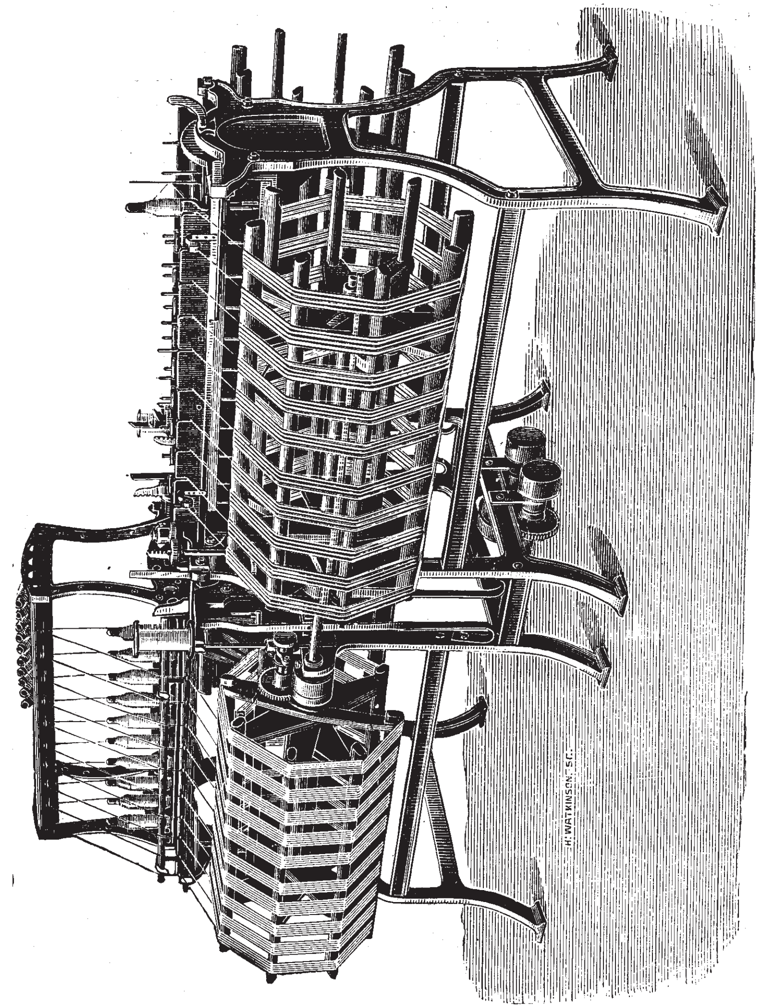


FIG. 157.—THE COLBY REEL. ADAPTED FOR RING-FRAME TUBES AND DOUBLING BOBBINS.

ordinary method, upon which Mr. Coleby has effected great improvements, as he has made the whole automatic, so that when the yarn has been placed in position the attendant has only to start the press, and the bars are automatically brought down, self-locked, and the bundle pressed, when the attendant simply ties the cords and reverses the action, and the press, running down, releases and lifts the top bars, leaving nothing more to do than to remove the bundle and commence the process anew. The improvements consist of the introduction into the back vertical bars, which are made hollow for the purpose, of a series of rack rods, whilst the top bars, also made hollow, receive a corresponding series of locking rods. A connection is formed between the two series by means of a sector wheel. When the top bars are brought down into the position for pressing, a coiled spring, with which each is supplied, shoots these rods into the holes prepared for their reception, and thus firmly locks them for pressing. When the action of the press is reversed these are withdrawn by the descending rack rods acting through the sector wheels. By means of this improvement considerable economy is effected, as the labour of boys suffices where previously that of men was required.

If the yarn reeled as described is for bleaching or dyeing upon the same premises it is not necessary to bundle it in any form, but simply to pass it forward to the bleaching or dyeing departments. If the yarn is sold in the bundle for the home trade it is usually made up in long cross-reeled bundles; if for export, in short pressed bundles, that may be either straight or cross-reeled. Whichever be the method, it is ready for the bleacher or dyer, or for rewinding in the grey state which is often done with yarn exported and sold to the handloom weavers of eastern countries in retail quantities.

To the processes of bleaching and dyeing a brief separate chapter must be allotted, which will be found following the present one.

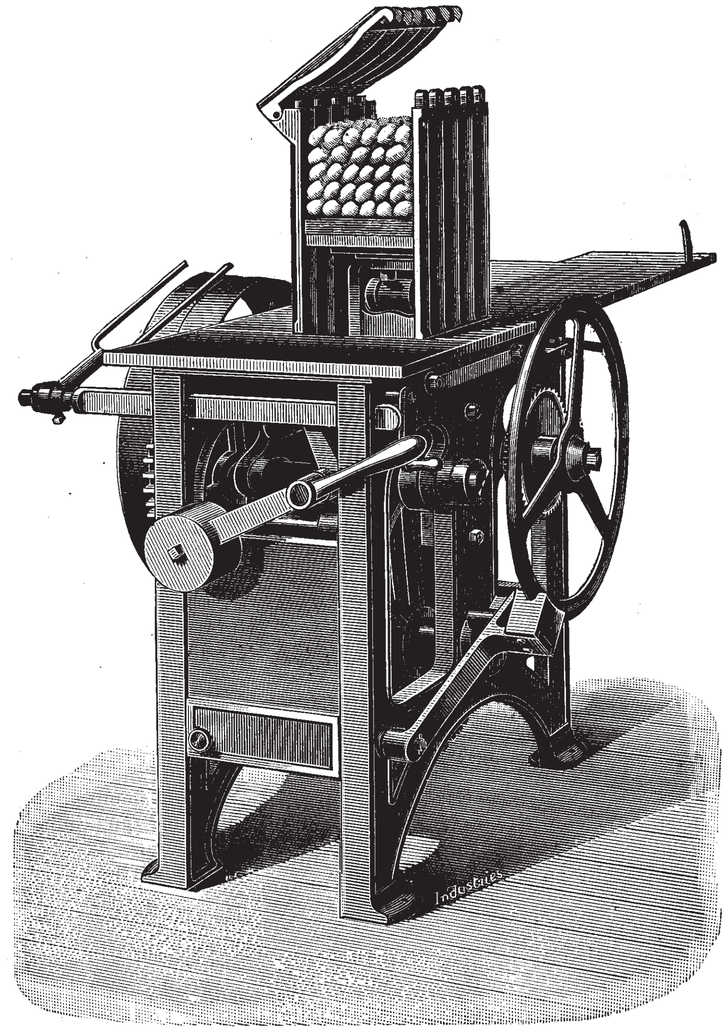


FIG. 158.—IMPROVED YARN BUNDLING PRESS.

Assuming that it has passed through these stages, and been returned to the winding department, the description may be resumed at the point left off.

The yarn is now ready for re-winding, and for this purpose a winding machine of another type is usually adopted. This is termed the hank-winding machine, and one of these of the latest and most improved type is shown in fig. 159. It is especially made for winding bleached or coloured and sized yarns from the hank. As will be seen, its construction is entirely different from that of the simple cop-winder. The bobbins, instead of being mounted upon vertical spindles, are carried in cradles lying horizontally. Upon the driving-shaft, which extends across the top of the frame in the direction of its length, are mounted a number of bobbin-driving drums. The cradles, having received their bobbins by suitable arrangements, carry them into contact with the faces of the revolving drums, which thus drive them by friction. The hanks are placed upon light, collapsible hexagon reels termed rices, which are easily lifted out of their position for the reception of the hank. They are very light, and easily revolve with the pull of the thread. This is termed the rice creel. There is an alternative creel termed the barrel-creel, formed by two small skeleton barrels, or bird-cages, as they are sometimes called. These are seen in fig. 159, the creel on the back of the machine being of this type. The bottom barrels only are shown; each of these has a corresponding barrel mounted above it, and the hank is extended between them, and so wound off as in the other case. In the winding the yarn is slowly traversed from side to side of the bobbin so as to place the successive layers evenly upon it.

In the machine here illustrated are a number of improvements which it may be desirable to point out. The first is in the bobbin cradles, which are mounted on brackets attached to a rail placed within and extending the length of the machine frame. Each cradle is fitted with a new