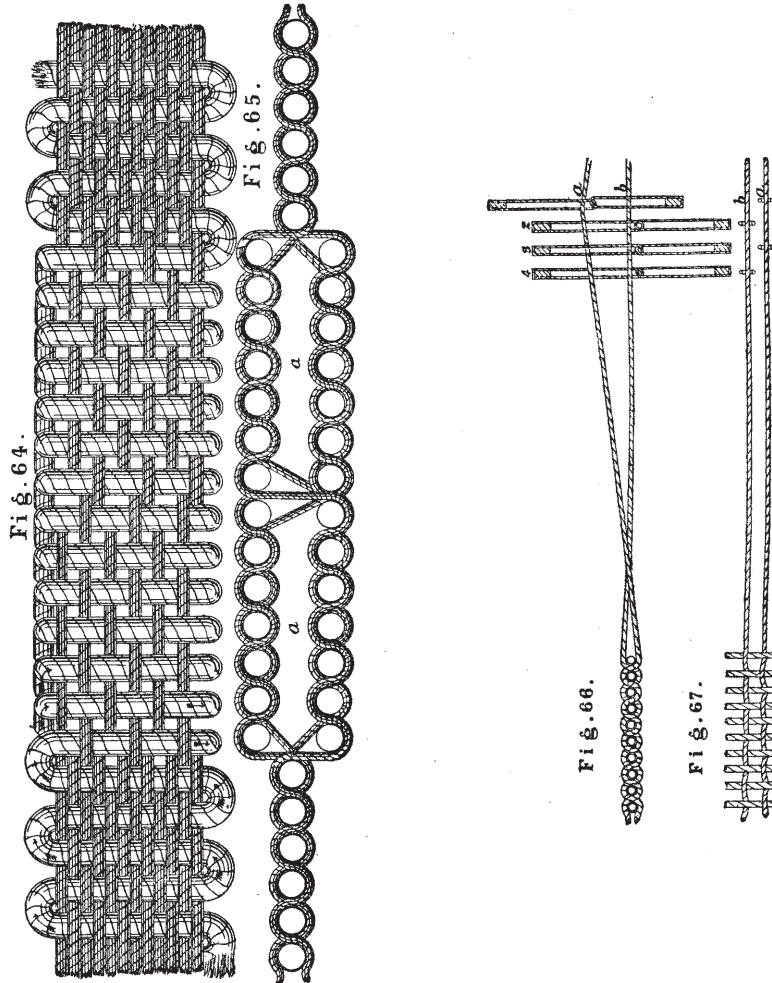


varieties of weft may in this manner be used. The central thread, which is hidden, whether weft or warp, is called the wadding, or stuffing, and cannot be observed on either surface of the cloth. Examples of this class of weaving are well shown in Figs. 332 and 333, &c.



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

warp threads shown, instead of being woven firmly as in plain weaving. This may be understood by referring to Fig. 59.

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

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

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

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

stickiness of the warp, owing to its ever-crowded state, and hence the name and use of breaker treadles. Some weavers put greater strain on the warp to effect the same purpose, but it is a questionable plan, as will be hereafter shown.

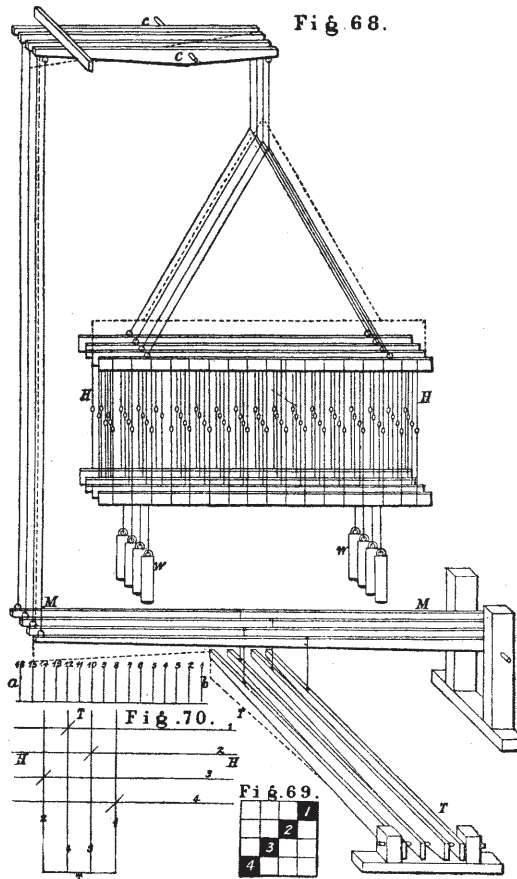
CHAPTER VII.

SHEDDING MOTIONS FOR HAND LOOMS.

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

In Fig. 41 is shown a common hand loom mounted with four headles, the manner in which these headles were connected to the loom being represented. Fig. 68, subjoined, represents the four headles as seen from the front of the loom, but all the other parts of the latter are omitted. As before described, the headles *HH* are each connected to a separate couper or tumbler *CC*, and thence by the long cords to the ends of the marches *MM*, and finally to the treadles *TT*. Each headle is held down by two spiral springs or two weights—or sometimes one weight only in the form of a lath or plate—but in this case by the weights *WW*. In this instance the loom is arranged to weave a single thread twill, as shown at Fig. 49, and at Fig. 69, annexed. For this purpose it is only necessary to connect one of the marches by a cord to one of the treadles, as shown; consequently only one of the headles can be raised at each movement of a treadle, and the operation of weaving the twill, shown, is simply to raise the headles in consecutive order as represented in Fig. 69. But it will be observed, on tracing the con-

nexion of the treadles to the marches, and thence to the headles, that they are not placed in consecutive order, as shown in Fig. 69, but they are corded in a different order. The reason for this is, that, in working the treadles with his feet, the weaver could not conveniently press upon them in consecutive order without crossing one leg over the other. The weaver, therefore, adopts some other



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

This he does in a very simple and effectual way, and in the present instance Fig. 70 shows the draught and tie-up, as it is called, for weaving the twill, Fig. 69. It is simply a rough plan of the headles

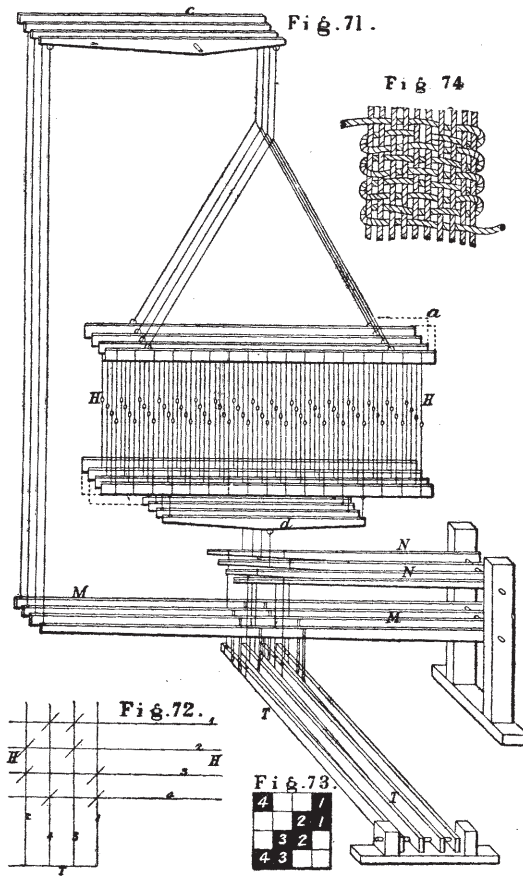
and the treadles, in which the single lines $H H^1$ represent the four headles, and the lines $T T$ represent the treadles. Near H^1 four numbers, 1, 2, 3, 4, are placed in a diagonal position. These numbers represent the first four warp threads (exclusive of the selvage), and show the order in which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

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

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

even, for by so doing the five headles are worked twice over by working over the treadles once. This, however, increases the number of treadles. But there are cases where the weaver can diminish the number of treadles, *i. e.*, where the same headle or headles are repeated in the compass of one design.

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



treadles by means of a series of levers. In this instance the weights to hold down the headles are dispensed with, for one portion of the harness is made to balance the other portion, the action being similar to tabby weaving. It will be seen that, in this case, the long marches *MM* are connected to the headles in the same way as those in Fig. 68, and they raise the leaves exactly in the same way. Now the only difference is, that the remainder of the

headles which are not attached to the long marches are all attached to the short marches or counter-marches, *N N*. The effect is that by pressing upon any of the treadles part of the headles rise, and the remainder sink. The connecting cords between the treadles *T T* and the long marches are shown with thick lines, and the cords to the short marches with thin lines, and it will be observed that each of the treadles is connected with all of the headles, but in different arrangement. The dotted lines *a* and *b* show the extent of the rising and falling of the two front and two back headles which would be caused by pressing upon the outer right hand treadle. Under each of the headles is attached a strong lath *d*, which is used when the headles are of extra length and require strengthening.

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

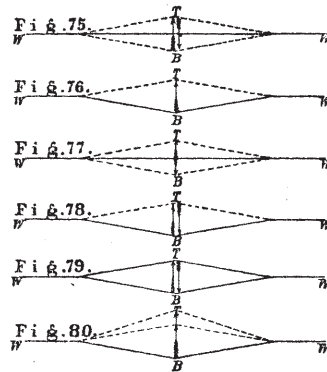
The system, last described, applies best when the number of the leaves or shafts to be raised are equal in number to those which sink. Under these conditions the headles are equally balanced and worked with freedom. But where only one headle at a time, or a comparatively small number is raised, the system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

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

In Fig. 75, *W W* represents the warp as in plain weaving with two headles only. The dotted lines show the form of the shed when open, and the arrows show that some threads rise direct to the point *T* from the bottom *B*, at the same time that the other threads

from *T* to *B*. In this instance the threads move from top to bottom and from bottom to top without any stoppage, consequently it is called a through shed. It also counterbalances itself, and the motion is performed in the shortest possible time and with the least friction.

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

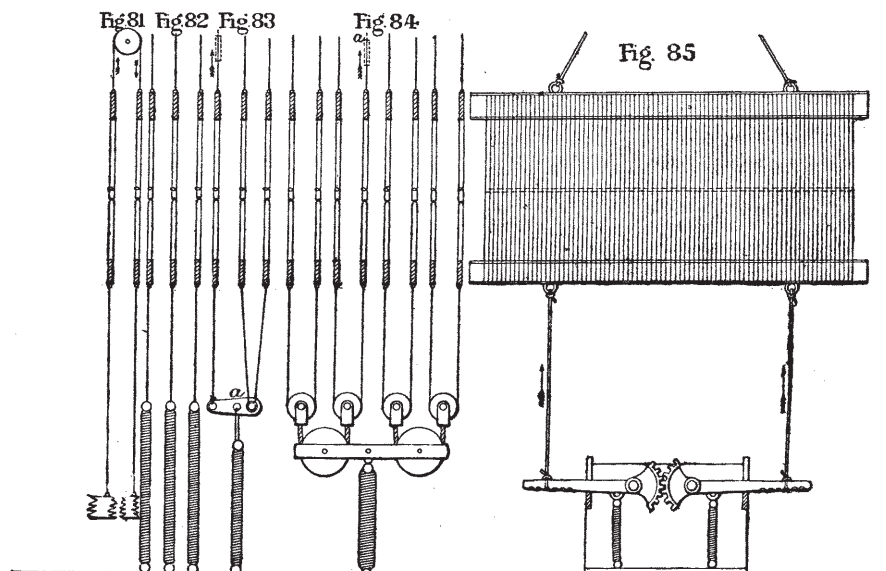


to that performed by the common Jacquard machine, and may be called a rising shed.

But if two of the headles were used simultaneously—one rising while the other was falling—as would be the case if two of the four treadles in Fig. 68 were worked with both feet, then the motion would be the same as represented in Fig. 78, where the arrows denote a rising and falling shed with the bottom stationary or standing. Fig. 77 represents the motion of the warp that would be caused by the arrangement shown at Fig. 71. In this case it is simply a rising shed with sinking bottom. Fig. 79 shows the warp stationary at both top and bottom of the shed, and those threads which are required to rise or fall, do so simultaneously. Therefore the top and bottom are stationary with rising and falling shed. Fig. 80 shows a double shed. This is used when two tiers of shuttles are used at one time. The most perfect of these motions is the through

shed, Fig. 75; whilst the most imperfect are the rising sheds, Figs. 76 and 80. Their imperfection consists in taking double the time to be formed, and they do not counterbalance themselves as in the case of Figs. 78 and 79.

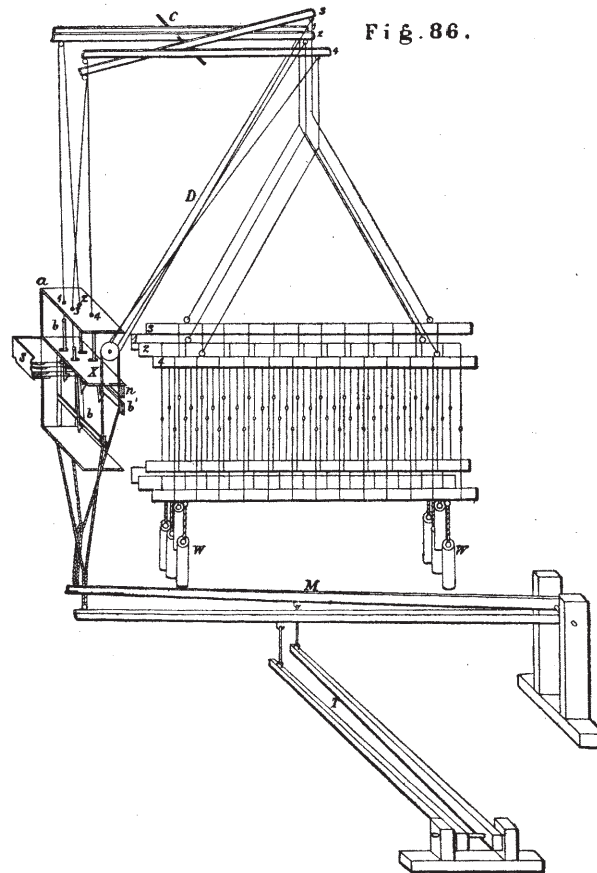
As a great variety of apparatus for forming the sheds require to have the headles held down by weights or springs, various contrivances are resorted to to avoid the direct action of either, for they operate more or less detrimentally on the action of the loom. Thus in Fig. 81 are shown the counterbalanced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



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

spring should break, or only one be sufficient in strength, it can be worked all the same. This motion is applied to power looms.

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



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

The machine alluded to is a shedding motion with the action similar to Fig. 78, viz., a rising and falling shed with a stationary

bottom, and is represented in Fig. 86 attached to the healds, but detached from the loom. It consists of a box, *a*, which contains a number of wooden hooks which move in slots. In order to show them, one end of the box has been omitted in the drawing. Each hook is connected with a separate tumbler *c*, in such a manner that when the hook is drawn downwards it raises the headle to which it is fixed. After the hook traverses the slot board *x*, it passes through a ring or eye to which, on one side, is tied an elastic cord or spring *s*, while on the other it is attached to a cord that leads up to the opposite ends of the tumblers *C*. Two flat bars *b b'* are made to slide up and down in slots in the ends of the machine. These bars are each connected to a separate march *M*, and thence to the treadles *T*, and they are counterbalanced by having the connecting cords placed in the groove of the pulleys, one of which is shown at *c*. As the treadles rise and fall so do the bars to which they are connected. Each of the hooks is connected to the headles, according to the numbers shown.

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

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

CHAPTER VIII.

FIGURED WEAVING WITHOUT THE AID OF AUTOMATIC MACHINES.

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

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

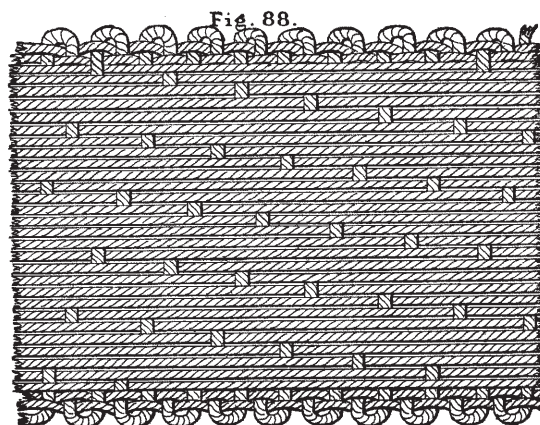
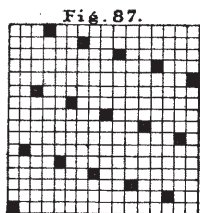
When a loom is arranged to be worked by an automatic machine, all that is required in order to weave a new design is to make the alterations in the machine itself—equivalent to altering the position of the pegs upon the barrel of a musical instrument—either by changing the barrel, or using various sets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

There are several ways in which this can be done, each having its own advantages, according to the extent of the pattern to be woven, sometimes a few healds being sufficient, and at other times several hundreds being required. Even when these numbers are used, many contrivances are employed which increase their power to an extent scarcely to be thought possible. Numberless plans have been

adopted according to the peculiarity of the cloth, or the pattern to be woven, but they may be classed under certain distinct systems which, when fairly understood, will render the subject clear.

They may be classified as follows :—

1. The use of healds in any practicable number, in regular or irregular order, as in weaving satins, twills, spots, or small figures.
2. In forming the healds into groups of two or more divisions, in such a manner that any of the divisions may be brought into action, each division having a distinct and separate control over the whole of the warp, at the same time each warp thread to pass through one eye or leash only of the healds.
3. In passing the warp through two separate harnesses, so that



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

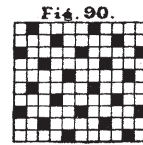
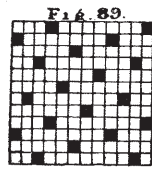
There are other kinds of weaving, such as gauze, velvet, &c., but they are produced by entirely different processes to the above, and will be described separately.

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

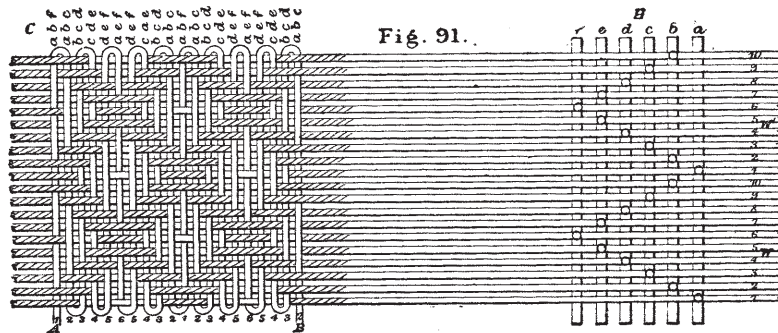
In silk weaving as many as sixteen leaves and upwards are used in making very rich satins. Fig. 87 represents the order in which the intersections are made, and Fig. 88 shows the appear-

ance of the face of a sixteen-leaved satin when magnified. The intersections only occurring once in sixteen times, the weft threads, although they may be of a different colour, are scarcely discernible in the face of the cloth. The warp threads, when very numerous and crowded together, naturally tend to cover over the few intersections, and the threads thereby give that smooth and unintersected appearance by which rich satins are distinguished.

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



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

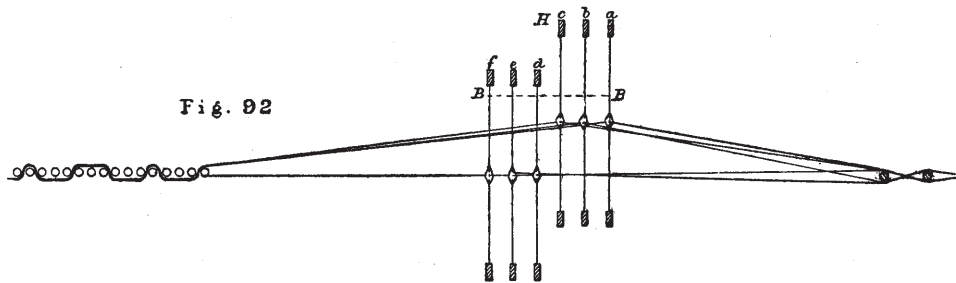


on the warp and the labour of the process is not only proportionately saved, but the appearance and quality of the cloth is improved.

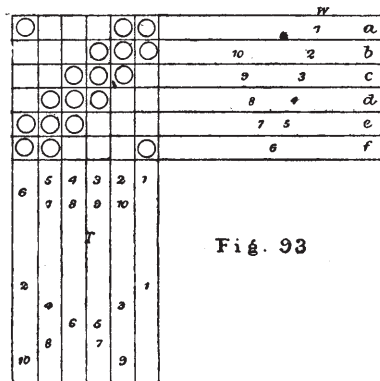
The principle upon which the regular twills and zigzags are produced having been explained by the aid of Fig. 49, &c., in a former chapter, we shall now show how it is extended for the production of small figures. Fig. 91 is a plan of a warp with six headles, and shows a portion of cloth woven. No reed is shown, nor anything that would tend to complicate the figure, and it will be understood

that only a few threads are represented, for the pattern in actual cloth would be simply repeated. *W* and *W'* show the warp threads which are passed through the eyes of the headles *H*, in the order shown by the circles, which represent a sectional plan of the headles at the line *BB*, Fig. 92.

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



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



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

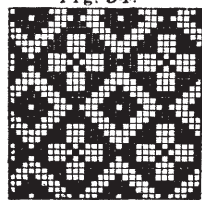
At first sight, there appears no clue to connect or associate the plan Fig. 93 with the pattern woven Fig. 91, but a little attention to the matter will be repaid by learning the ingenious and simple manner in which the subject is planned by the weaver. In a former instance lines with marks at their intersections were shown, but

weavers also use spaces as well as lines for the purpose. Hence the circles in the spaces Fig. 93, correspond to the marks at the intersections before mentioned. Sometimes two or three descriptions of marks are used, and in this case the use of spaces instead of lines is desirable as affording more room and distinctness.

On comparing the warp threads W and W' , Fig. 91, with the figures 1, 2, 3, 4, &c., at W , Fig. 93, a resemblance is at once detected in the arrangement of the figures with the circles, representing the eyes of the headles H , Fig. 91. In short, the spaces marked by the letters $a b c d e f$, Fig. 93, represent the headles marked with the same letters in Fig. 91, and the order of entering the warp threads W , Fig. 91, is the same as shown at W , Fig. 93. In the same figure the treadles, six in number, are shown at T . The numbers above T represent the consecutive order in which the treadles are worked, which is simply backwards and forwards, and by this means the diamond form of the pattern is woven.

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

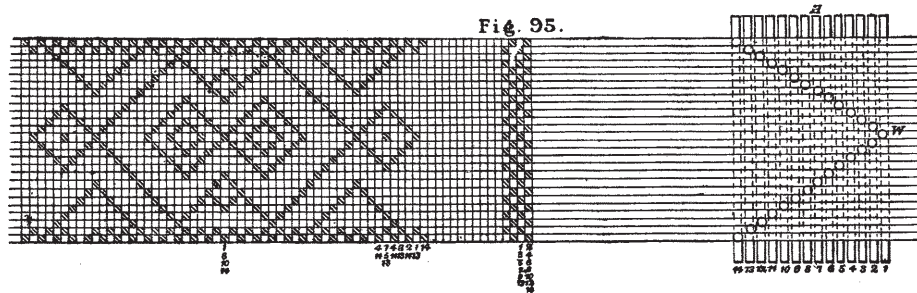
A great variety of figures can thus be made with comparatively few headles, and combinations of figures can also be made; one example of which, Fig. 94, may be sufficient to give an idea of the system. In this instance a cross and a diamond are combined in alternate order, or the figures are “bosomed”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



By another modification of the same principle a great variety of figures may be woven at pleasure. This is shown at Fig. 95, and can be conveniently used

for forming spots, or small figures; hence it is known as spotting harness. As the figures and letters in Fig. 95 correspond with the descriptions given of Fig. 91, they scarcely need any further explanation.

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



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

CHAPTER IX.

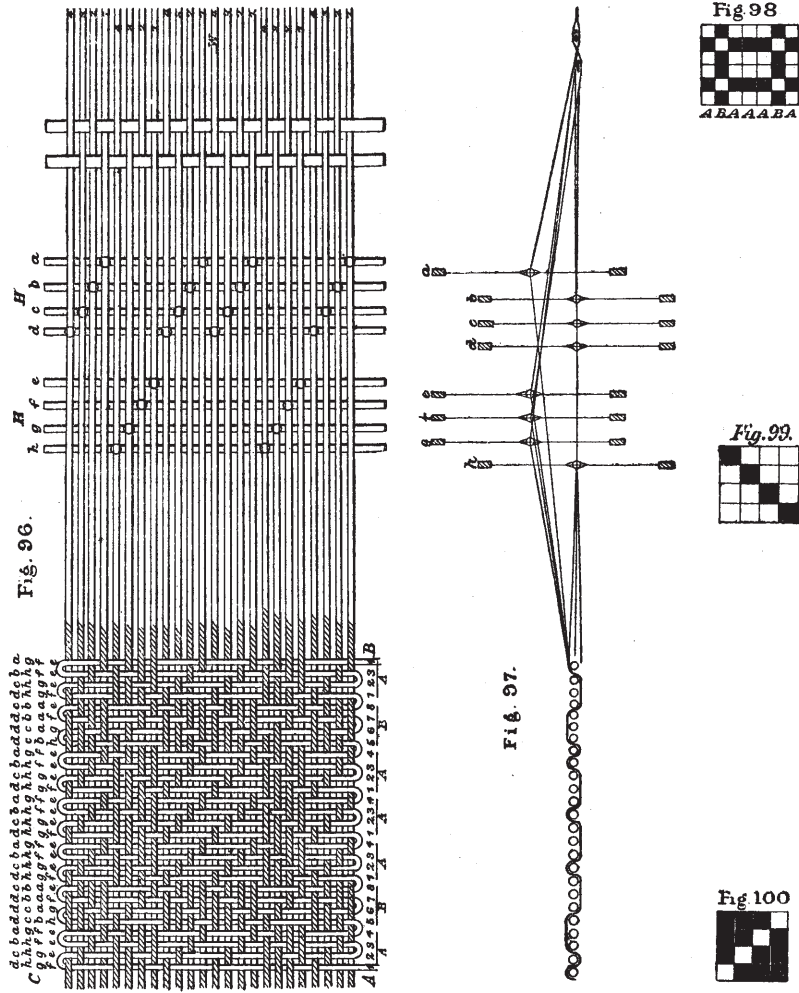
DIAPER WEAVING.

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

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

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

Fig. 101 represents, as the weaver would show it and as before explained, the connexions of the healds with the treadles at the intersections marked with circles. In this plan the healds *H* and *H'* represent the two divisions, and the treadles *T* are likewise divided in two divisions, as shown in *A* and *B*.



In order to weave the pattern, as shown in Figs. 96 and 98, the treadles must be worked in the consecutive order from 1 to 28, as shown at *T*, Fig. 101. It will be noticed that the treadles in division *A* are first used, then those in division *B*, and so on to the completion of the pattern. But it must be observed that although the healds must be raised in the consecutive order shown, still the

weaver would deviate from that order to suit the alternate action of his feet, as before explained. Figs. 96 and 98 show the parts of the pattern effected by each of the divisions or sets of treadles *A* and *B*, and the numbers of each of the treadles are given as they are shown at Fig. 101.

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

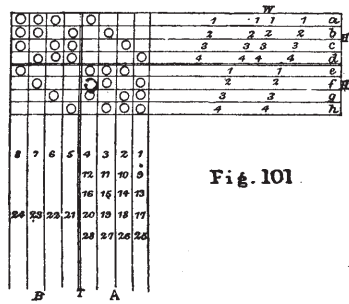


Fig. 101.

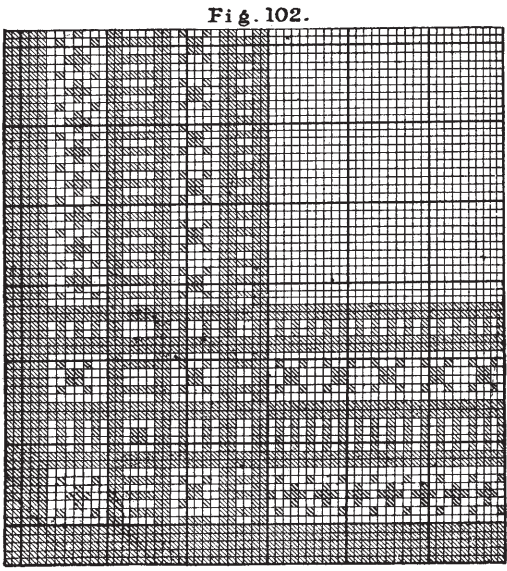


Fig. 102.

Fig. 103.



Fig. 104.



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

When this method is understood it will be seen that it affords very extensive means for the production of large patterns. The example above given comprises the use of two divisions only; but

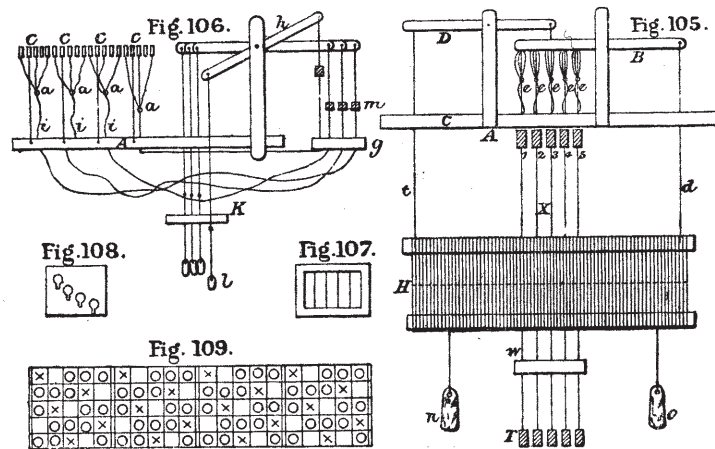
the healds may be made in six or seven divisions, and their efficiency is thereby increased in far greater proportion than to the number of divisions used. Thus the efficiency of a harness with seven divisions would be greater in effect than two divisions only, or would increase in geometrical proportion.

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

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

It will be evident that the use of several divisions with four or five treadles in each would be almost impracticable for the weaver to work, consequently a plan has been devised whereby the use of one set of treadles only is required, the different divisions being thrown in and out of action by a separate contrivance; and it is here that we again find resort to complicated but ingenious arrangements to overcome difficulties. In the matter to which we are now referring, the desired end is obtained by using one set of foot-treadles only, and substituting for the other treadles auxiliary levers which can, each set, be thrown in or out of action by a separate contrivance. By so doing, the weaver may have command over six or more divisions or series of levers, and still only use one set of treadles. In other words, he substitutes for the various divisions of treadles (excepting one set) a number of levers, or sets of levers, corresponding to the divisions of the treadles, and by throwing in or out of action, by means of connecting cords, any of these divisions or sets, he avoids the use of more treadles than are required for one set only. This plan is ingeniously carried out as follows:— Fig. 105 is a front view of the mounting of a loom, *C* being the top castle, and *H* the headles, twenty in number in this instance, or four sets of a five-leaved twill. *B* is a set of coupers, one for each leaf connected to it by the cords *d*, which are rising cords to raise the

leaves, it being simply a rising shed. The ends of the coupers are seen at *C*, Fig. 106. There is another set of coupers shown at *D*, Fig. 105, equal in number to the former, and to which they are connected for the purpose of raising the opposite ends of the leaves by the cords *t*. In this case the marches are not placed below the levers, but above them, as shown at *A*, 1, 2, 3, 4, 5, or one for each leaf of the twill, a side view of which is shown at *A*, Fig. 106. Each of these levers is connected to a treadle below by means of the cords *X*, Fig. 105, which pass through the warp, and are held in position by being passed through holes in the board *w*. The weights *n* and *o* are the ordinary weights for sinking the leaves after they have been raised.



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

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

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

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

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

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

Fig. 110.



Fig. 111



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

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

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

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

In the construction of all the healds we have hitherto shown, they are formed by stretching the leashes between two laths. This system does not admit of a large number being used in a loom, although by placing them in two or three tiers, as shown in section by Figs. 110 and 111, as many as eighty or ninety may be used, for the laths need not be more than $\frac{1}{8}$ in. thick. But this number is quite inadequate to the quantity required in figure-weaving, where the numbers usually amount to 300, 400, 600, or 900, and upwards. Therefore, in forming the healds, the laths are entirely dispensed with, and single leashes, or several tied together forming a heald, are used instead. Small weights, called "lingoes," made of iron or lead wire, are attached to the end of each leash, and the leashes are held in position in the loom by being passed through holes in a board, sometimes, as in power looms, made in one piece, and in hand looms formed of thin slips inserted in a frame, similar to a school-slate, excepting that there are a number of slips; this is called the comber-board. These healds will be explained as we proceed, for it is upon the advantages they give of being placed in any desired order that a great deal of the power of the loom depends.

CHAPTER X.

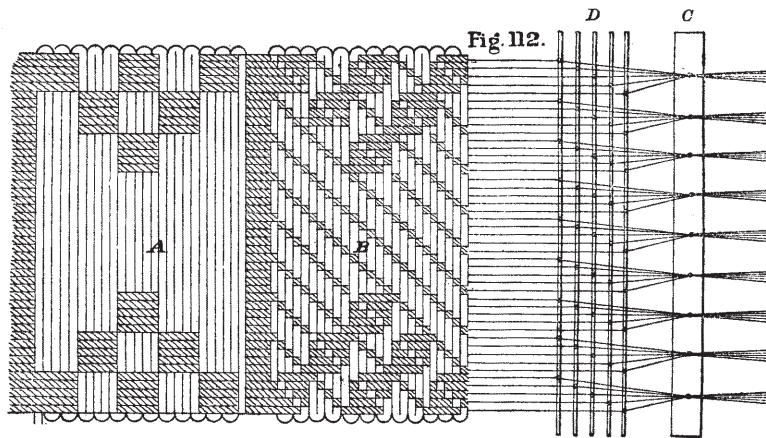
THE DRAW LOOM AND DRAW-BOY MACHINE.

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

The first harness through which the warp passes is for the purpose of forming the pattern, as it were, on a large scale, and the purpose of the second harness is to break up this pattern into detail, and complete the necessary minute intersections. In other words, in the first instance the outline of the pattern is formed, and in the next

case that outline is woven in detail, so that each thread is intersected or woven together, as in twill or satin, of any desired description.

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



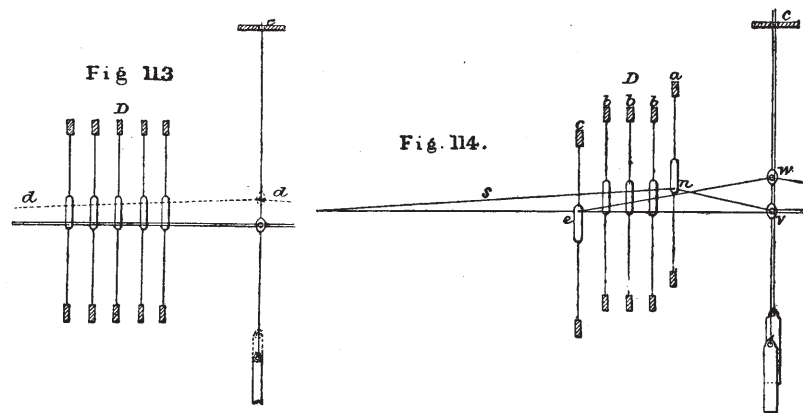
This is effected by passing the weft threads, in groups of five, in this instance, through the eyes of the healds at *C*, and thence through the healds at *D*, where they are distributed, each thread having a separate eye. The eyes in these healds are made of considerable length, as shown in section,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

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

independently of the healds *D*, but it will be observed at *e*, Fig. 114, the heald *c* being depressed has carried with it its corresponding warp thread, one thread being sunk and four raised of the five threads in the leash *C*.

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

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



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

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

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

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

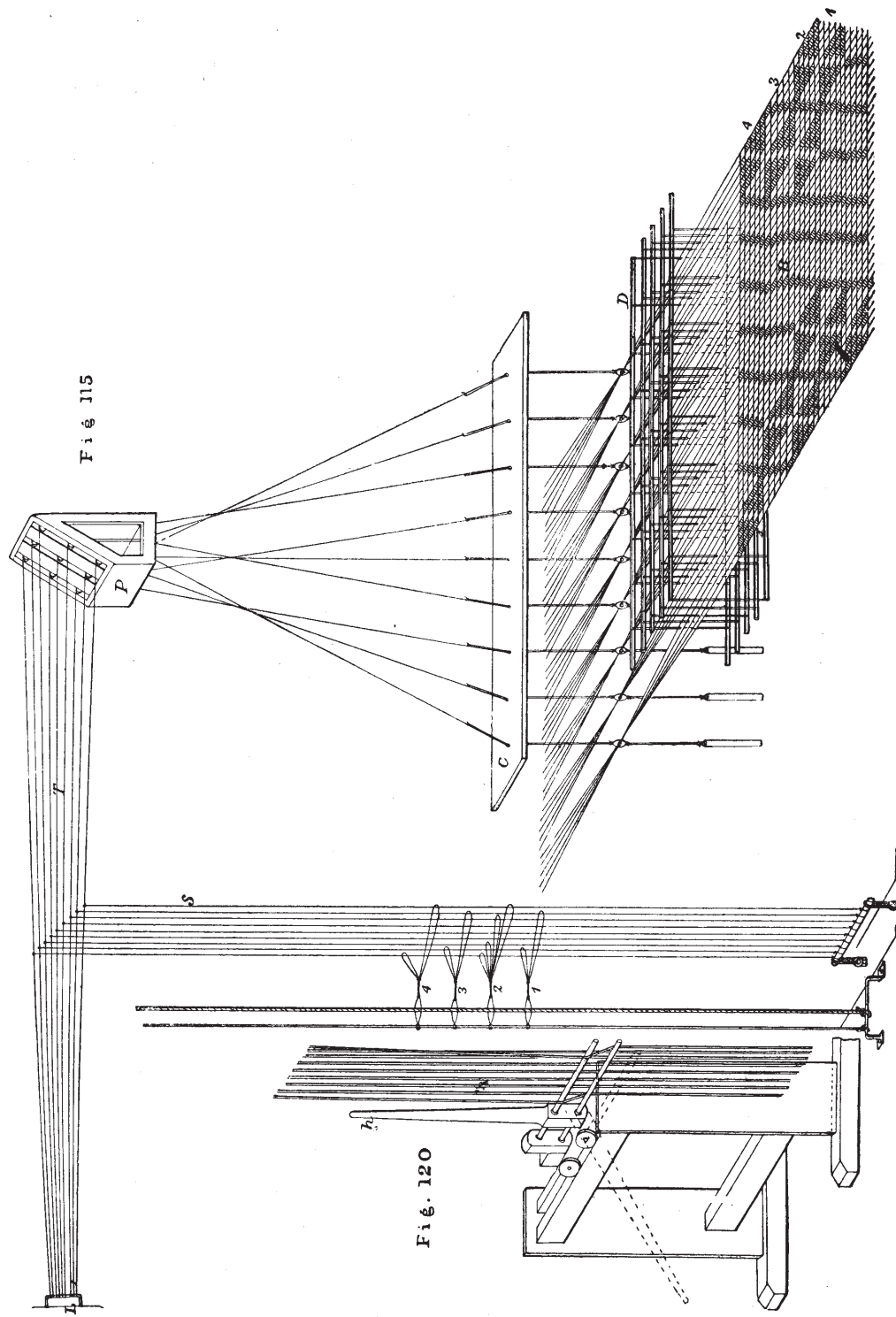
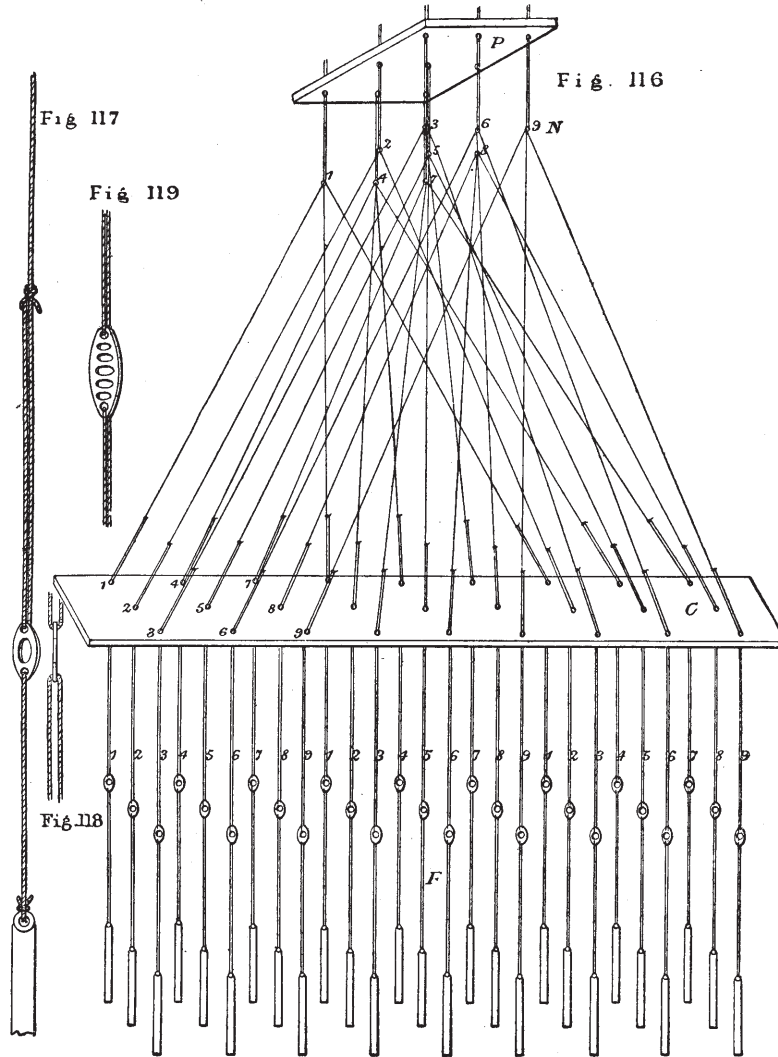


Fig. 115

Fig. 120

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



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

It will be observed that there are two strong cords placed vertically, which form an attachment and a guide to a number of loops

marked 1, 2, 3, 4. By drawing or pulling any of these knots of loops it draws with it the corresponding simple cords, and these being grasped by the hand and pulled or drawn downwards, they raise the corresponding leashes *C*, and thus the shed is opened in the warp so far as this part of the harness is concerned.

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

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

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

The weight of the lingo, when some thousands are used, becomes great, and it was necessary that some means should be adopted to assist the draw-boy in raising them. The simple often consisted of three or four hundred cords, and as each of these cords had several leashes and lingo attached, the constant lifting was attended with inconvenience. The friction of so many cords was almost equal to their weight, which made matters worse. To assist the draw-boy,

as the weaver's assistant was called, a fork, shown at Fig. 120, was used. It was made to run to and fro upon a carriage, so that when the leashes of the simple were drawn outwards one spike of the fork was passed through the shed or opening formed, instead of the hand as previously described. The fork being depressed by means of the handle *h*, it caused the uppermost spike to fall, whilst the other remained stationary, and in this manner the cords were drawn downwards and held there until the weaver had worked the ground of the cloth by means of the front healds as already mentioned.

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

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

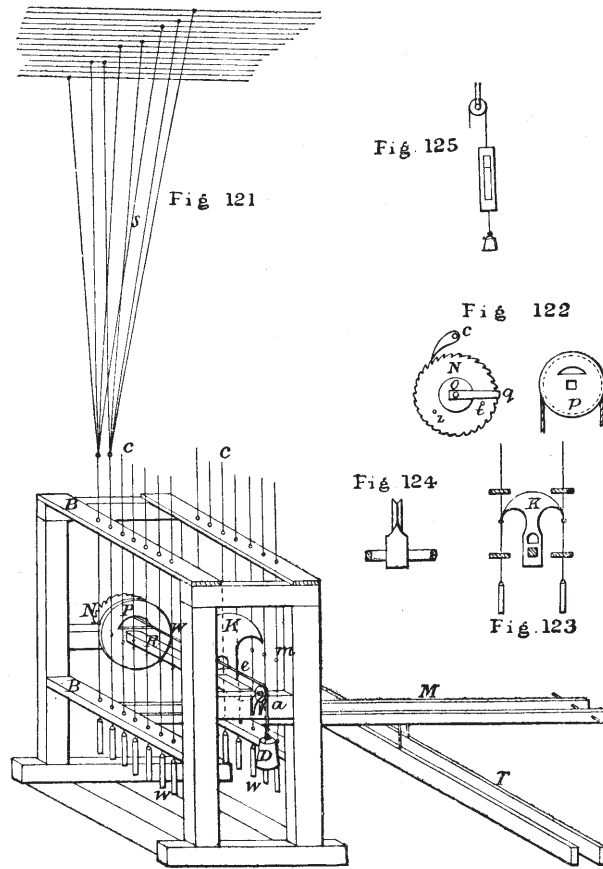
When they were introduced in Spitalfields the weavers hoped to reap great advantage from them, for instance they would save the draw-boy's wages. But they began to find they had adopted a mistaken notion. They found that if they had not to pay the draw-boy, they had to pay the manufacturers for the use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

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

The draw-boy machine was not only adapted to draw the tail cords of the draw loom, but it was also employed, as before stated, when considerable numbers of common healds were used, and the

ends of the coupers were attached to the machine instead of being fastened to the long marches, as shown in Figs. 68 and 71. This will be readily understood when the action of the machine is shown.

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



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

The cords *S* being arranged so as to form the pattern by raising

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

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

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

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

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

is attached to the marches and works vertically by means of the pulley, weight, and cord, as shown in the figure.

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

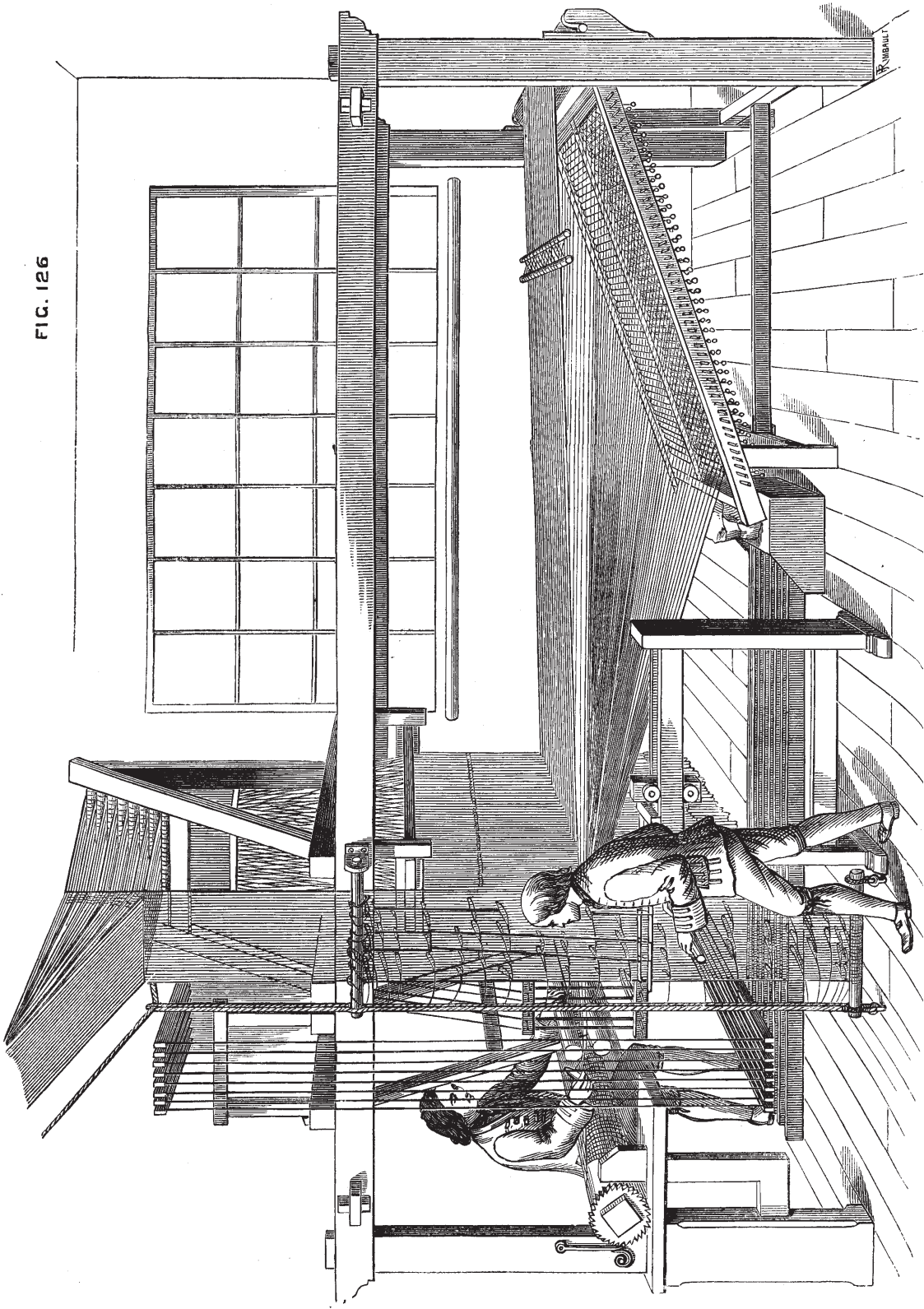
The Chinese have a rude description of draw loom in which the draw boy stands upon the top of the loom, and pulls up the neck cords.

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

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

Although frequent allusion is made respecting the invention of

FIG. 126



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

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

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

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

CHAPTER XI.

THE JACQUARD MACHINE—INTRODUCTION.

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

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

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

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

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

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

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

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

Now, if a band of paper *p* be placed upon a roller *b*, and fixed into a frame *f*, and be pressed against the points of the needles that protrude through the front board of the box D, it will force back all

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

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

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

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

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

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

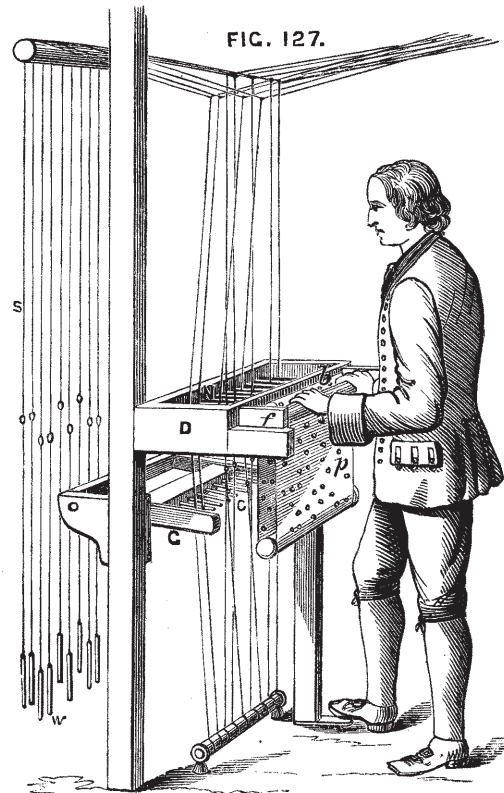
“In making a tour through Switzerland and Italy in 1816, with my family, I was the first individual who saw it (the Jacquard loom).

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

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

"Is it confined to his own manufactory?"

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



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

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

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

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

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

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

“He told me he was originally a straw hat manufacturer; his attention had never been turned to mechanical topics till the Peace of Amiens opened the communication of France with England; at the same time an extract from an English newspaper fell into his hands, in which it was stated that a society here offered a premium to any man who should weave a net by machinery. He told me that his thoughts were thus turned upon this subject, which, by the way, if there had been any interruption to intercourse would never have taken place; he did produce a net, which he threw aside for

some time, and afterwards gave it to a friend as a matter of indifference. The net by some means or other got into the hands of the authorities, and was sent to Paris. When some time had passed and Jacquard had completely forgotten his production, he was sent for by the prefect, who said, 'You have directed your attention to the weaving of nets by machinery.' He did not immediately recollect it, but the net was produced to him, and that called it to his mind. The prefect said, 'I require you to make the machine which led to this result.' He asked three weeks for its completion, and brought it to the prefect, and desired him to strike with his foot, by which a mesh was added to the net. It was sent to Paris and an order came for his arrest. It was in Buonaparte's time, when things were done in a rash and very arbitrary way. He found himself under the keeping of a gendarme, and was not allowed to go home to provide himself with the necessaries for his journey.

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

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

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

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

now extensively employed through the whole of the manufacturing districts of France.”

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

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

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

As Mr. Stephen Wilson went over to France after being told by Mr. Hale in 1816 of the value of the new Jacquard machine, it is probable that he saw one very shortly afterwards. It is said that he

procured one, and had it taken to pieces in France, so as to enable him to pack it in parts, and thus to smuggle it over to England. This may have been in 1817 or 1818.

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

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

CHAPTER XII.

THE JACQUARD MACHINE.

THERE is, perhaps, no machine more simple in its construction than the Jacquard machine, and when it is considered that it is almost unlimited in its extent and power—far beyond the compass of any other machine—it well deserves the high estimation in which it has, since its general introduction, been held. So simple, indeed, is it in its details that it will be the best course to describe the machine itself and its mode of application before any other class of automatic machine is explained. By doing so the principles of the most elaborate figured weaving may be readily shown, as well as the advantages and disadvantages of the machine in its operation, which have led to a great variety of modifications of more or less merit, in order to

adapt the Jacquard apparatus to the power loom. The various descriptions of shedding motions, or machines for weaving small figures, will, also, be rendered clear and their actions understood, and by the aid of simple diagrams the principles of different looms will be far more easily explained than by any other means.

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

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

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

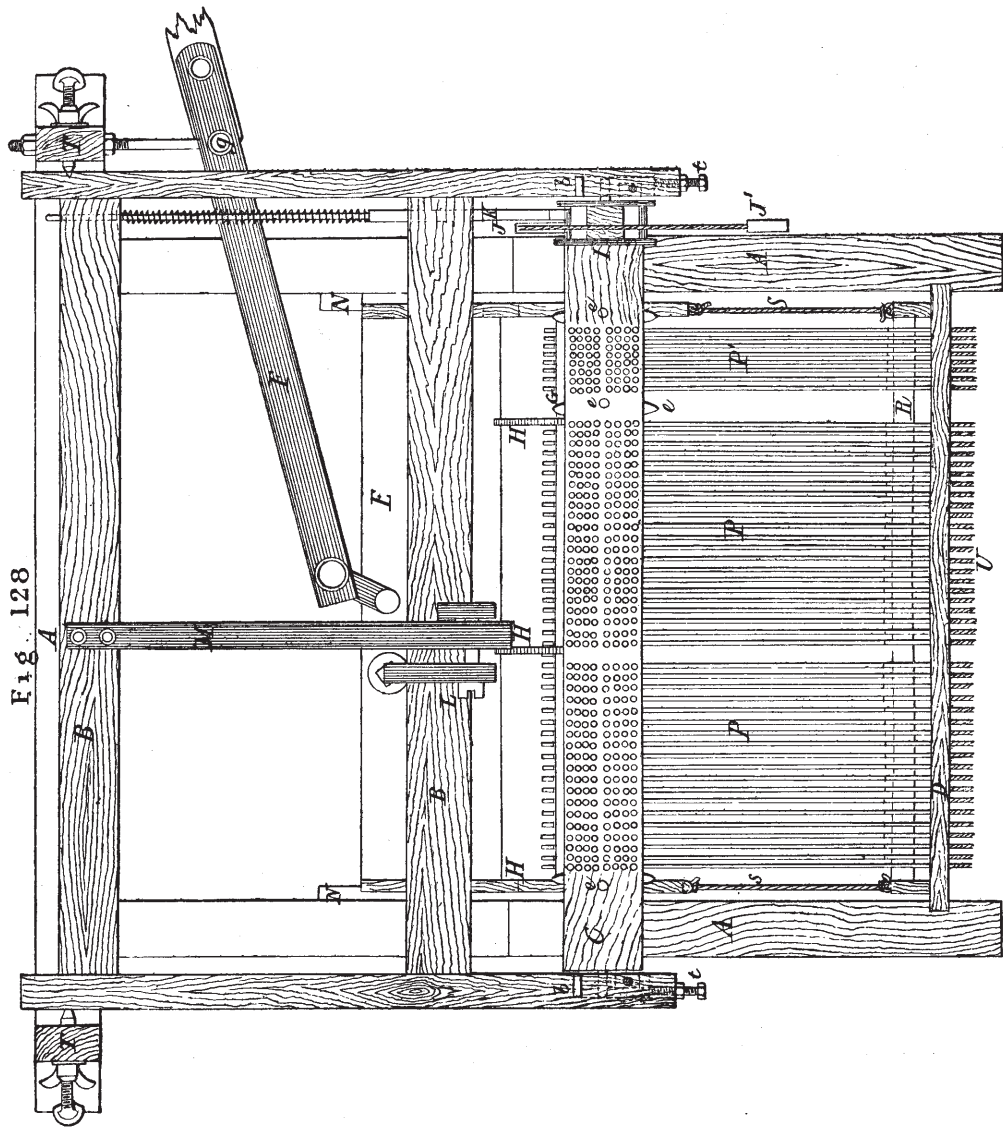


Fig. 128

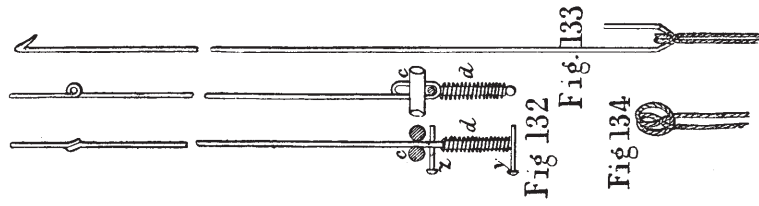


Fig. 132

Fig. 133

Fig. 134

which allows of the pin z being inserted. The loops being passed between the strong wires $c c$, are held firmly, but with sufficient play for longitudinal motion to press against the spiral springs $d d$. The opposite ends of the needles protrude about $\frac{1}{4}$ in. through the needle-board b , Fig. 131. It is against this end of the needle that the cards N act, these cards turning upon the prism C , or cylinder, as it is technically called.

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

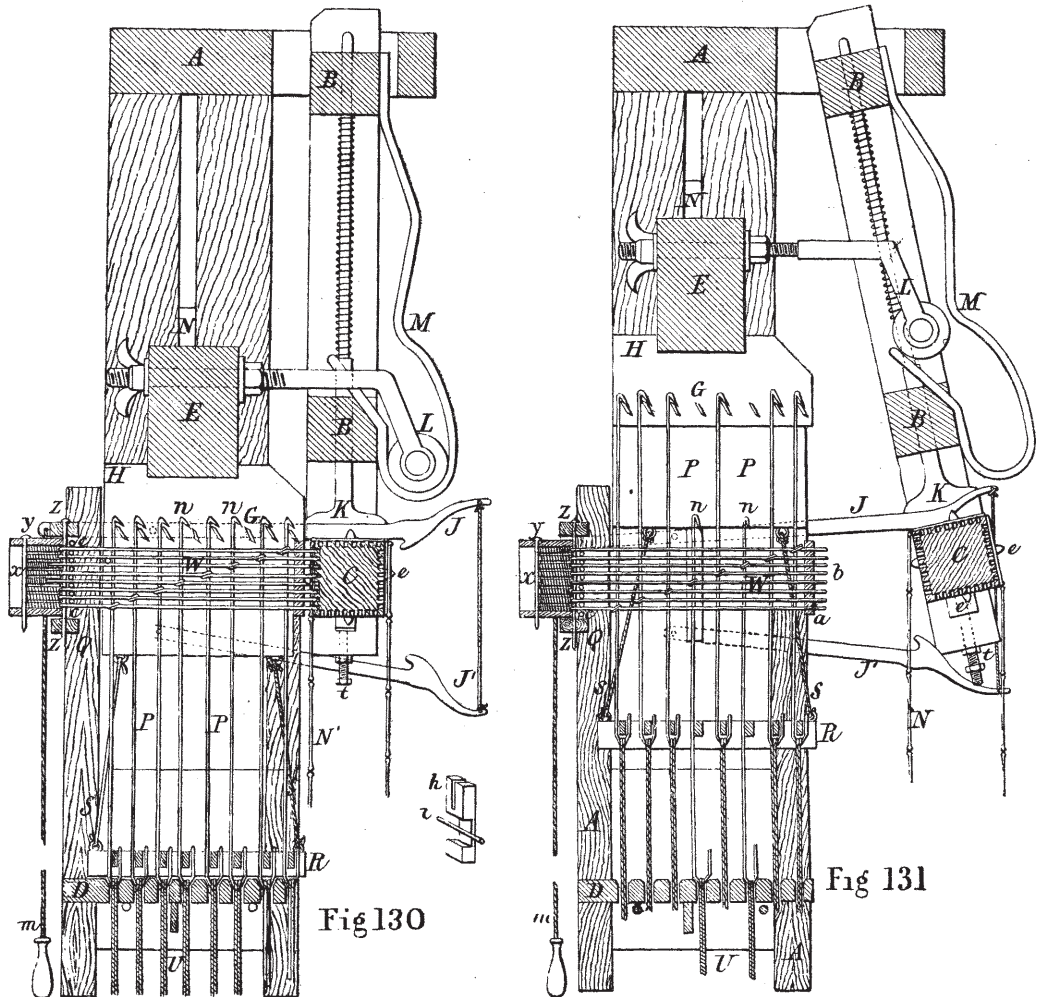
Immediately above the hooks there is a sliding block, E , shown in section in Figs. 130 and 131, and in elevation in Fig. 128. In the latter figure a lever F is shown attached, with its fulcrum at g , suspended from a bolt secured to the cap A . From the block E , the plates H are suspended, and through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

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

The details of the machine may now be described. The small spiral springs (made of thin brass wire), are enclosed in a "spring

DESCRIPTION OF THE JACQUARD MACHINE. 151

box," shown in section at *x*, Figs. 130 and 131. The perforations pass completely through the wood, and the spring is held in the hole by means of the pin *y*. By removing one of these pins any of the springs in the corresponding tier may be taken out and replaced. Of course there is a separate pin for each vertical row of needles.



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

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

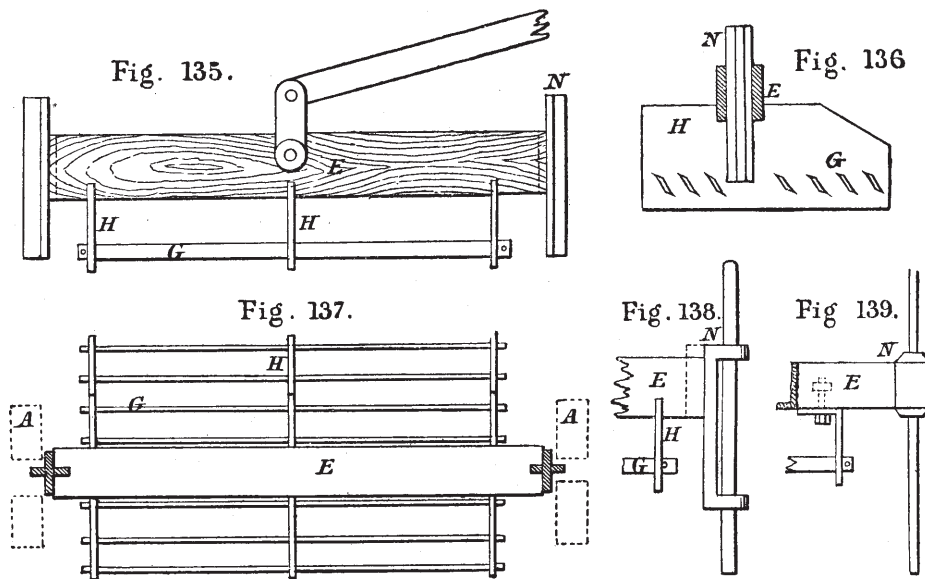
The "neck" cords attached to the hooks are not fastened on by a knot, but the cord is made into a double hitch, as shown in Fig. 134. If this were not so, the constant and rapid fall of the griffe and hooks would very quickly cut the knotty projections through.

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

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

The griffe is shown separately, and detached from the machine, in Fig. 135. In this figure the slide *N* fixed at the ends of the block *E* are shown. Fig. 136 is an end view of same, and Fig. 137 is

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



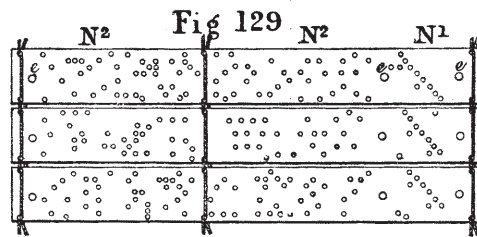
This plan is by far the most perfect and the best adapted for steady and rapid motion required in power-loom weaving.

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

The action of the cylinder will be best seen in Figs. 140 to 142.

In Fig. 140 the cylinder is shown when pressing the card against the needle-board and needles. In these diagrams the catches are shown upon a different principle to that shown in Figs. 130 and 131, where they are simply catches connected with a cord at their ends. The cord *m* is attached to the top catch, and when the weaver requires the cylinder to reverse or "turn back," he pulls the handle, and it raises both the catches, thus throwing the bottom catch into contact with the lantern and reversing its motion. But for power-loom Jacquards the plan shown in Fig. 140 is preferred.

In this case the bottom catch raises the top one by means of the pin *l*, as shown by the dotted lines. Fig. 141 shows the cylinder thrown about half-way out, and Fig. 142 when it is turned a quarter of a revolution. Now it often happens that before the cylinder completes the turn, and stops on edge similar to the position shown in Fig. 141, that the edge of the cylinder would be brought into con-



tact with the needle-board, and produce more or less damage. To prevent this from occurring an additional catch, *V*, is placed upon the same fulcrum as the lower catch *J'*. This catch is held up by means of the spring fixed at the end of it, as shown. When the cylinder is being turned the catch *V* gives way, in consequence of the spring, and then resumes its normal position, as shown. Now, it will be evident that in the case of the cylinder being placed in position, Fig. 141, the lower pin in the lantern would come into contact with the point of the catch *V*, and would, therefore, be turned "square on."

The cylinder is kept in position by means of a presser *KK*, shown in the diagram, and this presser, or as it is technically called the "hammer," is forced down by means of the spiral spring as shown.

On referring to Fig. 129, the three cards represented show the way the cards are laced together. The large holes *e e e* are for the purpose of fitting upon the pegs *e e e* of the cylinder as shown in

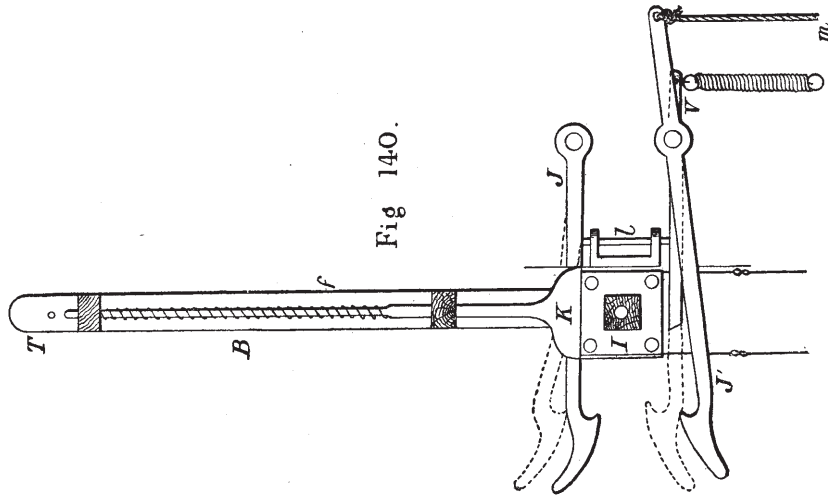


Fig 140.

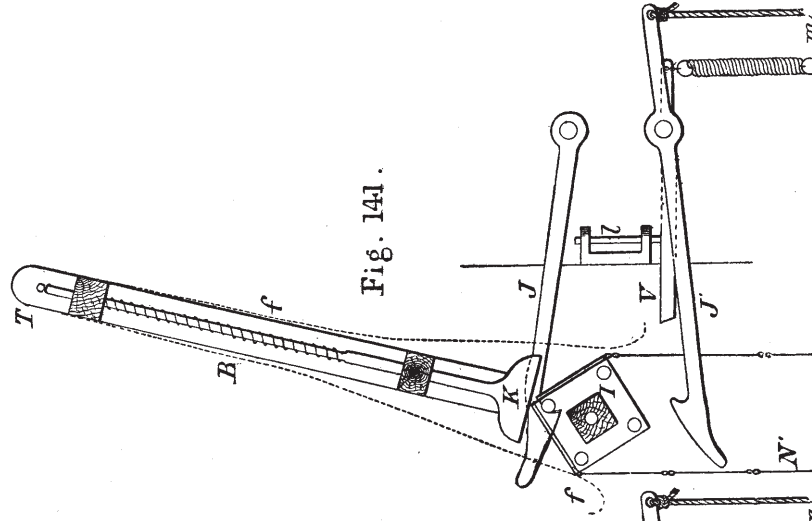


Fig. 141.

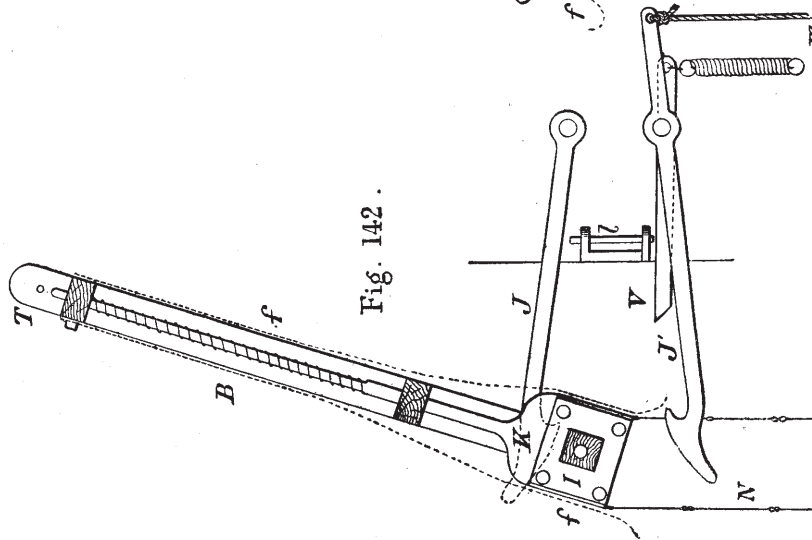


Fig. 142.

Figs. 130 and 131. These pegs are made adjustable, for the slightest movement of the card would prevent its coming into exact position against the needle-board, therefore it requires very exact and sure means to press the cards against the needles correctly.

It will be noticed in Fig. 131 that the cards N' hang loosely, and do not touch the cylinder on the side next the needles. Thus there would be a great liability for the card to strike the needles out of its proper position. This is in power looms an important though simple matter, for the cards would be liable to stick upon the pegs, if forced against the needle-board wrongly, they would possibly get wound round the cylinder, and not only get torn or destroyed, but in their motion the needles would suffer. To avoid accidents of this kind flat springs are used, of just sufficient strength to hold the cards against the cylinder on both sides. The position of these springs is shown by the dotted lines in Figs. 141 and 142.

When not more than 100 or 200 cards are used, they are allowed to fall into a curved tin frame placed beneath the cylinder, but when larger numbers are used they are made to fold into a "festoon" form. This is done by attaching a wire about 2 in. longer than the cards at the junction of about every twenty cards. The cards fall between two curved wires, but the wires attached to the cards being longer than the cards themselves cannot pass between the curved wires, consequently the cards remain suspended, and fold together in a very compact manner.

This will be observed in the drawing of the ordinary silk loom, Fig. 143.

In Fig. 128, it may now be mentioned, that the hooks $P P$ correspond to the purposes of the leashes shown at C , Fig. 115, and the hooks P^1 correspond to the purpose of the healds, as shown at D in the same figure. In the case of the Jacquard machine, now described, means for working the compound harness of the draw loom is thus provided for, as we shall hereafter find. But these additional hooks are by no means applied to all Jacquards, and they are shown here in order that a complete machine should be represented. Thus a glance at the cards Fig. 129 will show at the part N^1 a consecutive order of arrangement, while the portion N^2 is irregular. This arises from the fact that the part N^1 forms the "ground" of the cloth, and the part N^2 the outline or figure.

Previous to describing the action of the machine upon the warp, we have given in Fig. 143 a representation of a hand loom, such as is

used in Spitalfields, and other figured silk-weaving districts. It will be observed the machine occupies the position of the pulley box of the old draw loom. In fact, it has simply replaced the draw loom apparatus. The lever for raising the griffe, passes over the weaver's head, and to the end of it is attached a cord connecting it with the treadle.

The needle wire is generally made of No. 15 or 16 B.W.G., and the hooks of No. 14 and 15. Formerly the Jacquard maker straightened the wire from the ring or coil, but the wire-drawer now supplies, in a much more perfect manner, the straight lengths cut as required.

The needles are placed at about $\frac{1}{4}$ in. apart. The holes in the spring-box, &c., are very truly drilled by means of almost self-acting drilling machines, and the various hooks, eyes, and bends, are made by very simple and ingenious tools which insure them to be exactly of a size, and taken altogether, with the thousands of wires, it forms a wonderfully compact and perfect machine.

There are several matters concerning the working of the Jacquard that we have purposely left unnoticed until the machine itself was described. Let it be supposed that the griffe be raised without any hooks upon it. Now when it is lowered, and the hooks are not pushed back, the inclined face of the griffe bars will strike against the face of the hook and force it backwards until the bars have passed below the points of the hooks. Then upon raising the griffe it carries the hooks up with it. Upon lowering the griffe again, let it now be desired that all the hooks should be pushed off by means of a blank card placed upon the cylinder. It will be found that the card strikes the needles before the hooks have landed upon the bottom board, consequently the weight upon the hooks adds to their friction, and they require a greater force to push them off the bars. The most perfect action would be if the griffe could be allowed to drop to its full extent before the cylinder was pressed against the needles, for it would save much wear of the needles and the cards also. But to accomplish this two motions are required, viz., a rotary motion, by a cam, or crank to raise the griffe, and another cam upon the same shaft to press the cylinder; by this means the objectionable action would be overcome. This plan has for some time past been adopted in power-loom Jacquards, as we shall hereafter describe.

In Fig. 130 at *h*, one of the brasses, into which the cylinder works, is shown. It is held in the slot made in the batten by means of the pin *i*. In Fig. 128 slots are shown in front of batten at *b. b.* The

cylinder is placed or taken from the batten by the gudgeons being passed through these slots. The dotted lines show the position of the brasses, and the adjusting screws to regulate their height. The screw centre pins at the top of the machine, upon which the batten is supported, afford the means of adjustment in a lateral direction. The hammer is held up by means of a small catch which is placed in a notch in the hammer bar when the cylinder is removed, otherwise the hammer would be forced out of the frame by the spring.

Jacquard machines have various names applied to them, such as "machine," "engine," "jigger," (expressive of its noise when working), &c. They are modified in a great variety of ways; but after we have shown the system of working the machine, these modifications will be easily understood.

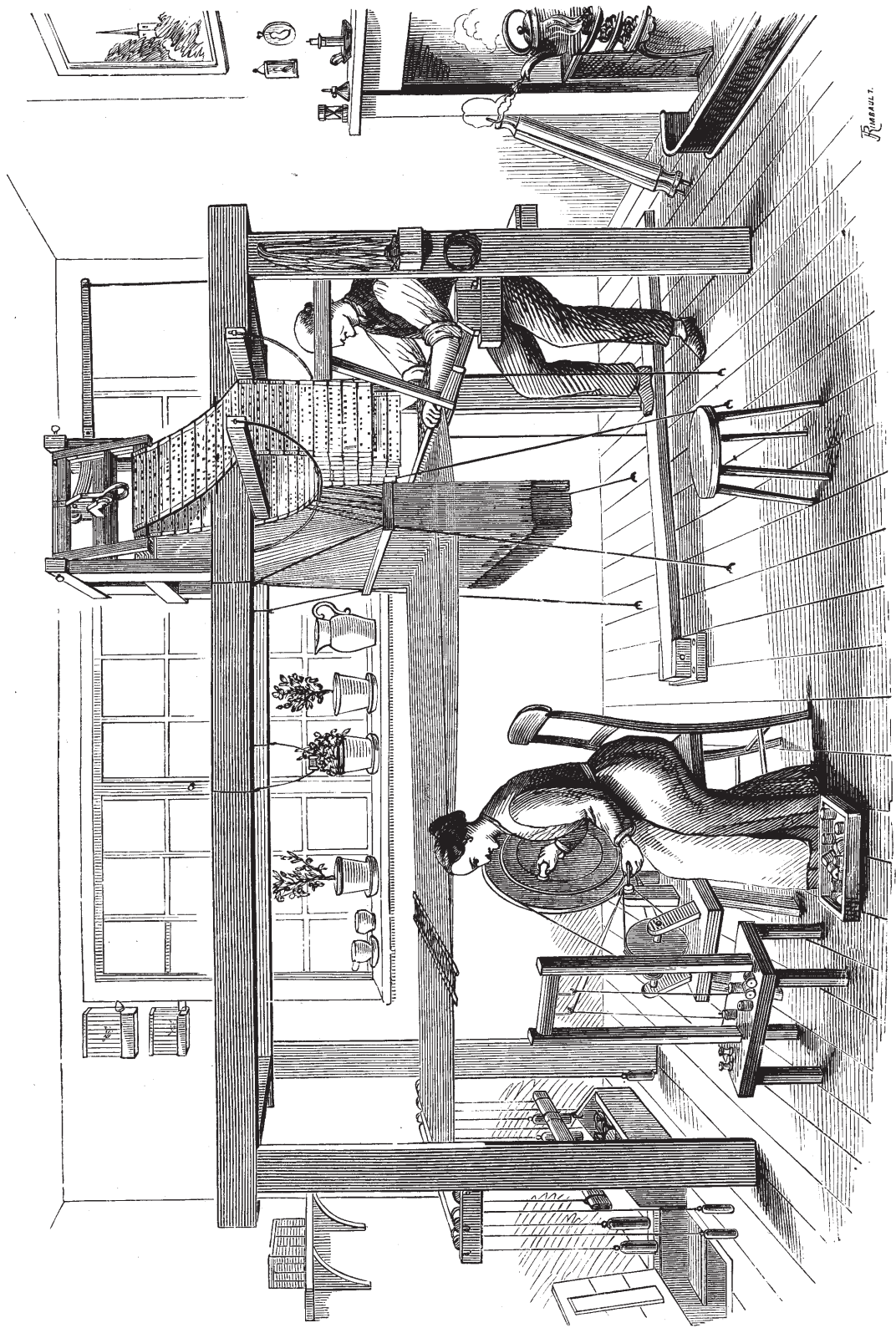
CHAPTER XIII.

THE JACQUARD HARNESS.

IN Chapters xi. and xii. we have shown that the Jacquard machine is simply a frame containing a number of wire hooks, and these hooks can be raised in any required number or order corresponding to the warp threads to be raised for the passage of the shuttle and the formation of the patterns to be woven. For instance, when the selected hooks are raised, they also raise the warp threads to which they are connected, and after the shuttle has been thrown through the shed made thereby, the hooks are lowered to their former or normal position, and a fresh selection is made for the next throw of the shuttle.

Before the paper duty was taken off, the cost of cards was far more severely felt than at the present time, and many attempts were made to substitute other materials and contrivances to avoid the expense. Bands of thin paper were tried, and several other methods, which we shall hereafter allude to; but at the present time, owing to the reduction of cost, it does not appear likely that any contrivance will supplant the ordinary cards, and these are used both in single and double action machines with perfect success.

We purpose now to describe the action of the common form of



the machine and the different ways it is applied, when the purpose of the various modifications above alluded to will be easily understood.

Fig. 143 represents a common hand loom mounted with a 400-needle Jacquard, such as is generally used for the production of the rich figured silk used for gentlemen's scarves. The cloth is woven in widths from 24 in. to 36 in., but we will assume it, in this instance, to be of the narrower width. The number of warp threads vary considerably, but 400 threads per inch in width is a common number, and that would amount to a total number of 9600 threads—exclusive of the selvage—in the narrow width of 24 in.

If each of these threads was provided with a separate hook it would of course take 9600 hooks—a number quite unknown in practice. But whenever a loom is supplied with a separate hook for each warp thread, it is the most perfect, and is capable of producing every form of design. The loom is, therefore, comparatively perfect when each thread has a separate hook. But as this could scarcely be carried out in practice, various means are adopted to make the loom as effectual as possible with the smallest number of hooks. The various ways of doing this may be divided as follows:—

1. A repetition of the same figure.
2. A repetition, by reversing the figure, as in weaving the two opposite borders of the cloth.
3. The use of compound harness, as already described in Fig. 112.
4. A modification of the compound harness called the "split harness."
5. Various combinations of the above systems.

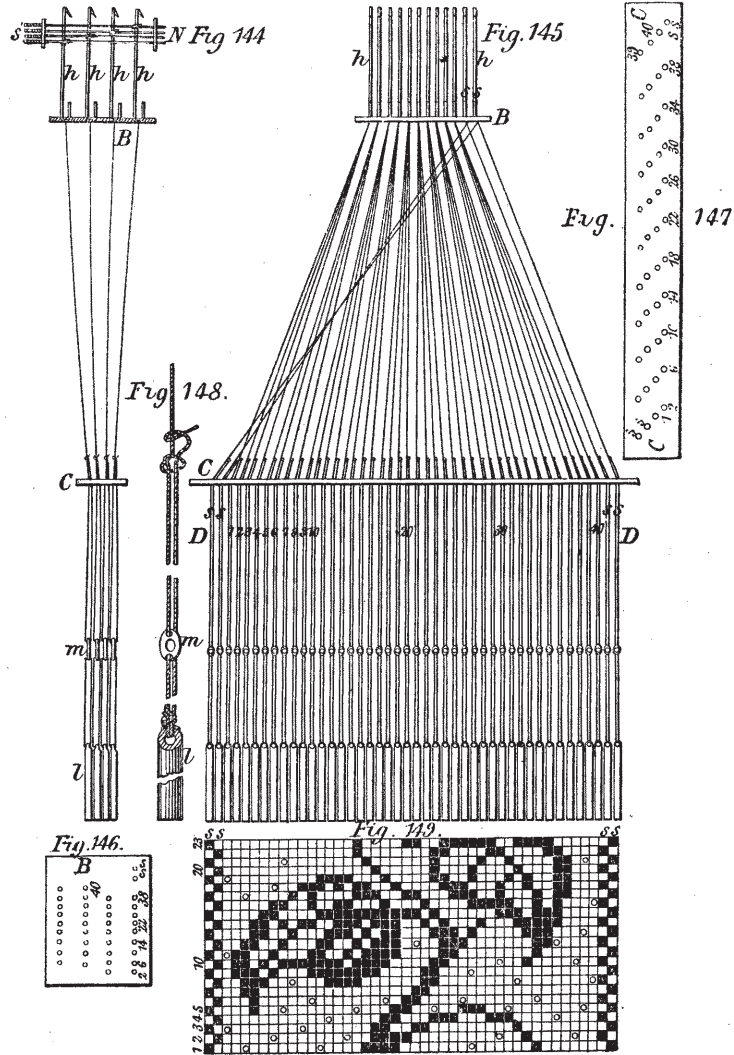
Now, it will be evident that the most perfect loom—so far as its capability of weaving elaborate figures is concerned—is the most simple, for it merely consists in having a separate hook for every thread of the warp, and no complication exists such as is found in the systems above alluded to. We shall only represent one row or line of hooks in each case, so as to avoid the complication that a representation of eight or twelve rows would give rise to; also show the hooks in the most direct position to connect them with the warp threads. For instance, on referring to Fig. 143, it will be seen that the Jacquard is placed with the cards hanging over the side of the loom, but in power looms the cards usually hang over the warp. These positions require a different method of connecting the leashes or cords from the hooks to the warp threads in order to bring them in consecutive order, and to make the arrangement as direct and

free as possible. There are many ways of tying up the harness to effect this, and different names are given to them, such as the "London tie-up" and the "Norwich tie," alluding to the places where they originated or were mostly in use. But whatever method may be adopted, the most direct plan is always attempted, and tying up the harness, or "building the monture" (mounting of the loom), often gives rise to a considerable amount of ingenuity on the part of the designer and weaver, for the perforations of the cards must follow in consecutive order the tying up of the harness, and sometimes this order runs longitudinally—row after row—upon the cards, and sometimes vertically. This, however, in no way affects the principles upon which the matter depends, although it is necessary that it should be stated here before showing the action of it in detail. The harness used in silk weaving is made of fine specially made thread, and soap-stone or French chalk is sometimes used to prevent the friction of the threads from wearing them away, and at the same time to prevent them sticking together, and causing defects in the weaving. Strong thread is used in power looms, and it is usually dressed so as to resemble cat-gut. This is effected by dressing or soaking it, the principal ingredients being linseed oil, tallow, and bees'-wax, with other things, according to the experience of the harness builder. When so prepared a harness will last for several years, and wear exceedingly smooth.

Fig. 144 represents an end elevation of a Jacquard machine and harness, and Fig. 145 is a front elevation of the same. It contains forty hooks, and each hook is connected to one thread only of the warp, excepting the two hooks which are used for forming the selvages *SS*.

They rest upon the bottom board of the Jacquard, *B*, which is the only portion of the machine necessary to represent, and the leashes which are attached to the hooks pass through the board to the comber-board *C*, where they are also passed through in the order required for the warp. The mails are shown at *m*, and the lingoos or weights at *l*. In Fig. 145 it will be seen at *DD* that the leashes descend in consecutive order, from 1 to 40; but the hooks *h h*, being arranged in four rows, require some means to connect them in the most direct manner to suit the consecutive order arranged in the warp. In this instance the hooks are numbered. See Fig. 146, which is a plan of the board *B*, upon which the hooks rest, and Fig. 147 is a plan of the comber board *C*,

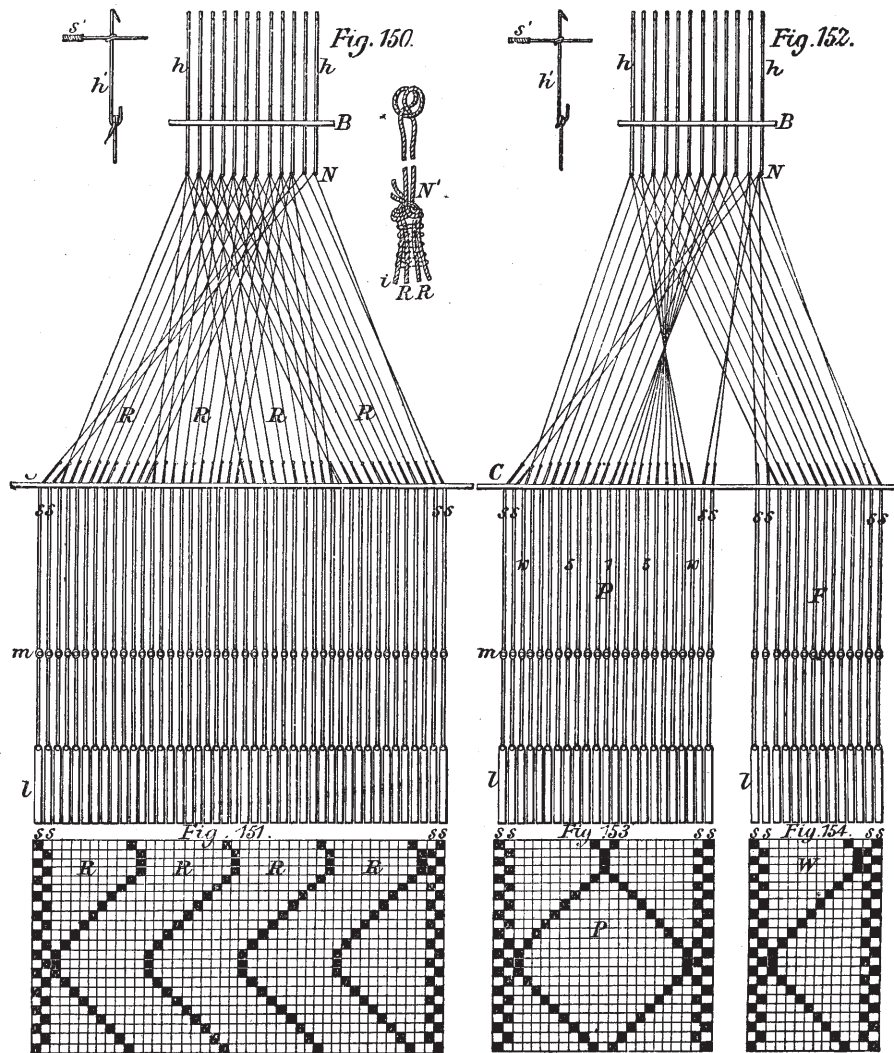
through which the cords pass. Now, by comparing the figure 144 to 147, in which all the letters and figures refer to the same parts, the connexion of the hooks with the mails to govern the warp may be traced.



It follows, therefore, that if any of the hooks are raised, they will also raise the corresponding warp threads, and the figure upon the cloth will be formed accordingly. Fig. 149 shows a design or piece of cloth that could be woven by the harness—the black squares may represent the warp, and the white squares the weft—and by

raising the hooks accordingly the cloth may be woven. The design shows the extent of twenty-three cards, and thirteen warp threads are raised, exclusive of the selvages.

On the design will be noticed the small circles on the squares.



These are merely placed instead of shading the squares, in order to show that these intersections are the necessary intersections called the "ground" to give firmness or bond to the cloth, and they are drawn so as not to interfere with the rest of the figure. In this instance the intersections represent an ordinary eight-leaf satin

ground, and the cards would require to be perforated for each of the intersections. A twill or satin ground of any other kind may be substituted, but fresh cards would have to be made or "cut." In compound harnesses the ground is formed by self-acting means, as we shall presently describe.

The selvage cords are attached to the hooks *SS*, and these hooks are raised alternately, as may be observed at *SS*, Fig. 149, and form a plain or "tabby" selvage. Only two threads are shown on each selvage, but it will be apparent that any number may be used by simply attaching in proper order more leashes to the two hooks *SS*.

Fig. 148 shows on a larger scale one method of attachment of the mail to the leash, &c.

It will be evident that when many thousands of warp threads are required, that other means must be used than to provide a separate hook to each thread. In weaving figured stuff cloths, having from sixty to seventy threads per inch, and in other fabrics, the harness has a number of threads attached to each hook, and in this way the pattern is repeated six or eight times across the surface of the cloth. Fig. 150 shows a harness of this kind, in which ten hooks are used, and where the pattern is repeated four times. *RRRR*, Fig. 151, shows its effect upon the cloth, for whatever figure is formed upon the cards it would be repeated four times on the cloth.

In this instance we have only shown one row of hooks *hh*, an end elevation of which is shown at *h'*. The leashes *RR* are attached to the neck cords, as shown enlarged at *N'*, where it will be seen that the leashes *RR* are stitched together in a flat form, to allow of their being raised without obstruction from the adjoining necks. The selvages are formed in a similar manner as in Fig. 145.

Fig. 152 shows what is known as a point harness, and consists in twisting or reversing the leashes in such a manner that any design consisting of two similar parts, such as a diamond or square figure of a shawl, may be woven by merely cutting half of the design or one border upon the cards. This will be understood by reference to Fig. 153 at *P*, which shows the effect the point harness would have upon the design, shown at Fig. 151. In this arrangement it will be noticed that all the hooks have two cords each, except that which governs the centre or point leash, which is a single leash to which the others converge.

At *F*, Fig. 152, it is shown that the same hooks may be attached

to a separate warp or piece of cloth, and it is in this mode of separation that ribbons, &c., are woven, or where narrow figured stripes are interwoven with plain weaving. Thus the effect from one set of hooks, Fig. 152, is represented at Figs. 153 and 154.

Some idea may be formed of the manner in which weaving is generally carried on in Spitalfields at the present time from the sketch at page 159. The weaver's cottage is provided with large windows on the first floor, which is usually only one room—extending from front to back of the cottage. There are two looms generally in the room, one at each window.

The framework of the loom, perhaps, always belongs to the weaver, but the machine and harness (the Jacquard) more frequently belongs to his employer. The warp is fetched from the manufacturer's warehouse, and very often returned woven with a variety of differently coloured weft, so as to produce from the same cards such effect as may be desired.

It is often remarked of the weavers that many traces of their French extraction may be observed, especially in their fondness for flowers and singing birds. Still the English character is quite as often shown.

Formerly the Spitalfields weavers had a good reputation for various studies, such as entomology and botany, and it is not a very long time since a "Mathematical Society" was held at a house near Spitalfields market. Indeed, the well-known mathematician, Thomas Simpson, who became professor of mathematics at Woolwich, in the last century, worked at his trade as a weaver and taught mathematics to the weavers of Spitalfields. He was born at Market Bosworth and was brought up as a weaver. After working at Nuneaton and Derby, he removed to London, when he ultimately obtained the honourable appointment alluded to.

In 1765 the Spitalfields weavers, owing to the general use of foreign manufactured silks, became exceedingly riotous, and the Government were induced to prohibit the importation, which act remained in force till 1826 when a duty of 30 per cent. was substituted.

In the year 1773 an Act was passed called the "Spitalfields Act," for the settlement of wages, so as to prevent disputes between masters and workmen, and prices for weaving were fixed, at which each description of silk fabric was to be paid for in the London district. Unfortunately for the silk trade of Spitalfields this policy

favoured the country manufacturers, for they very shortly competed with them, and beat them in their own markets. It was not, however, till the year 1824, that the Act was repealed, but it was then too late for them to recover their prestige; and from that time to the present the business has gradually declined. Not only was the home competition to be encountered, but owing to the reduction of the duties on foreign silks in 1845, and their total repeal in 1860, a still further difficulty was thrown in the way, and the trade of this once famous district is now but as a shadow of its former importance.

Before the Act was passed the prices paid for weaving were arranged between master and man as well as could be expected, and printed "Lists" were provided. But notwithstanding their mutual agreement disputed cases continually occurred, and the Act above named, was obtained to prevent further misunderstandings. One of the "List of Prices" was published in the year 1769, "At the expense of those manufacturers, who were subscribers for carrying on the work." It is entitled, "A List of the Prices in those Branches of the Weaving Manufactory called the Black Branch and the Fancy Branch, together with the Persians, Sarsnets, Druggets, Modes, Fringed and Italian Handkerchiefs, Cyprus and Draught Gauzes, and plain and black-laced Nets."

The prices were fixed and settled by a number of masters and men on behalf of themselves and those whom they represented, and their names are given. The "List" comprises twenty-eight pages, and concludes with a curious composition of verses the last four lines of which are as follows :—

"May upright masters still augment their treasure,
And journeymen pursue their work with pleasure;
May arts and manufactures still increase—
And Spitalfields be blest with prosperous peace."

In the International Exhibition, 1873, Messrs. Norris and Co. exhibited a Spitalfields loom weaving a rich damask from the design of the late Owen Jones. There were 29,088 warp threads. The design when woven was 28 inches long, and required 9312 cards weighing $5\frac{1}{2}$ cwts., for its formation. To cut these cards the design on ruled paper measured 16 feet by 9 feet 3 inches. Portraits and pictures have been frequently produced of such excellence that they have all the appearance of fine engravings.

CHAPTER XIV.

COMPOUND HARNESS FOR THE JACQUARD LOOM.

IN the last chapter the method of applying the Jacquard apparatus in its most simple form was shown, and it was evident that each hook having but one thread to raise in each figure woven, that the extent of the pattern or figure was confined to the number of hooks in the machine, except in using the point harness, where an apparent advantage was obtained.

In Fig. 112, the principle upon which a compound harness is formed is shown, as applied to the draw loom for the weaving of damasks. In that instance the effect produced was that five threads were raised by each leash or cord instead of one, consequently five times the width of pattern was produced. This system suited very well for the production of table-cloths and curtains, and whenever large designs were required, but for smaller and more exact figures it was not so well adapted. The Jacquard machine is often used in exactly the same way as the draw loom above alluded to, and instead of the draw boy (as shown in Fig. 126), holding the raised threads while the weaver worked the headles, the griffe is raised with the required hooks, and held in that position until the headles are worked over. In power looms this raising of the griffe at every fifth or eighth pick, or whatever number of headles are used, gives rise to many contrivances to effect the intermittent motion with as easy and quick a change as possible.

Soon after the introduction of the Jacquard, two very valuable contrivances were applied to the harness, based upon the principle of the draw loom as before mentioned. But they have this difference, in the draw loom the drawing of the cords was done every fifth, eighth, or whatever number of picks were desired, but in the new contrivances the cords are drawn at every pick, and from two to eight times the effect of the Jacquard machine may be produced. The first is for weaving rich silk damask, and operates like the draw loom

damask harness ; and the second is generally used in weaving the richest silks now made, and is termed the split harness, or "shaft monture."

These two plans are peculiarly adapted for the work they are employed in, for when it is considered that about 400 warp threads and upwards, are used in each inch in width of the warp or cloth, and only about one-fifth of that number in the weft, it follows that for the intersections to be equal in the warp and weft, five threads of the warp may be raised together in order to accomplish that effect. But the richness or fineness of the face of the cloth would be lost thereby. Now it is the object of the manufacturer to keep on the surface of the cloth the fine threads, and to do so he must be able to intersect the threads separately, and not in numbers of two or upwards. Therefore he requires that the machine shall be able to raise every alternate thread if desired, or the power to intersect every third, fourth, or eighth thread as may be desired for the formation of the ground or body of the cloth. This part of the subject, however, is the especial business of the manufacturer and designer, rather than of the weaver, although the loom must be made capable of producing every effect desired by the designer, upon whose ability the beauty and soundness of the work greatly depends.

The application of headles to the Jacquard damask loom of this description, although it is the same in principle to the headles when applied to the draw loom, is very different in other respects, as will be seen by comparing the two systems. Figs. 155, 156, and 157 represent a front elevation, a side elevation, and a plan of one row of hooks only of a Jacquard applied to this kind of harness. The same letters and numbers refer to the same parts in each of the figures. The warp *W* is divided into ten portions of four threads each, and each of these portions are passed through the ten mails or eyes *M*¹ to *M*⁰, Fig. 157. After they leave the mails they are passed through eyes of the four headles *H*¹ *H*² *H*³ *H*⁴ in consecutive order, as shown in the same figure. These headles are raised by the hooks *h*¹ of the Jacquard, as shown in Fig. 156, and it is in this portion of the harness where the difference between the two looms above mentioned exists, and it displays an amount of ingenuity, when combined with the Jacquard, not easily to be surpassed.

Each headle is attached to two of the hooks *h*¹ by means of a cord passing under a pulley, as shown at *p*¹ *p*² *p*³ *p*⁴. If both the hooks

attached to one of the headles be raised they will lift the headle to the full extent, but if only one of the hooks be raised, then the headle will be raised only half the distance, as will be evident on

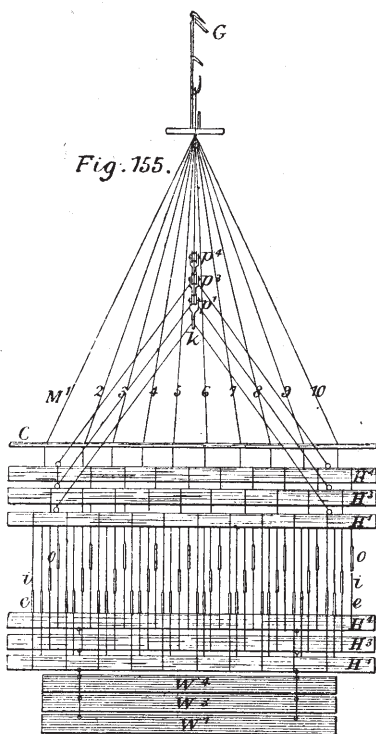


Fig. 155.

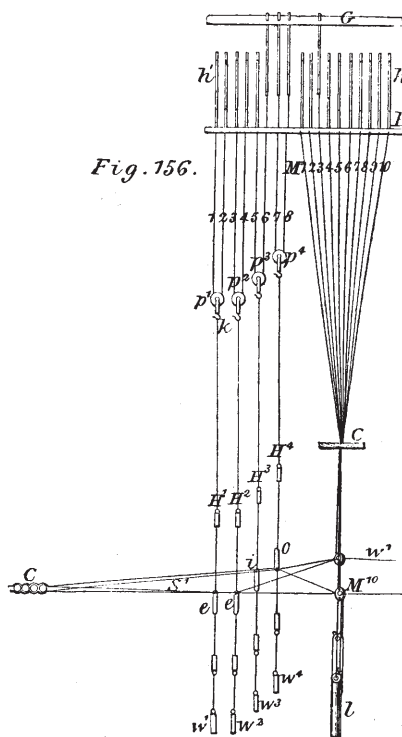


Fig. 156.

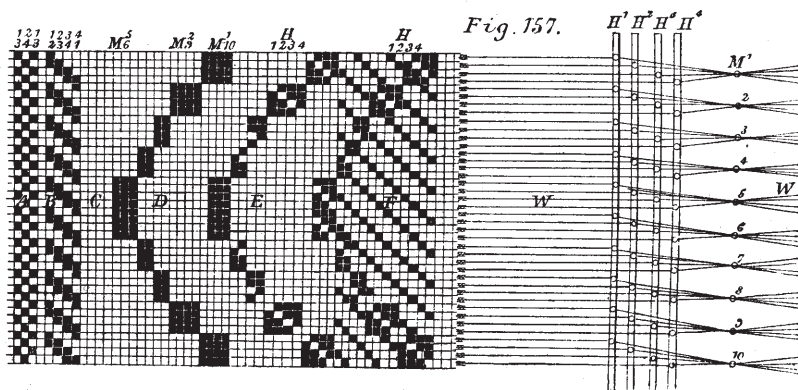


Fig. 157.

referring to the headles H^3 and H^4 , in which case H^3 is raised half the distance that H^4 is raised. The eyes in the headles are made much longer than usual, and of sufficient length that when any of the

headles are raised half way it does not raise the warp thread which passes through it. But if the headle be raised to the full height then it lifts the warp thread and forms the shed, as shown at S^1 , which has been formed by the thread raised by the eye in the headle H^1 .

Now it will be seen that when all the headles are at their lowest position, none of the warp threads can be raised, so as to form a shed, by the mails M^1 — 10 . On the other hand, when all the headles are raised to their full height, the mails M^1 — 10 have still no effect upon the warp threads. But if all the headles be raised half high, as shown at H^2 Fig. 156, then the mails M^1 may raise the warp threads in any required order.

The effect of the separate and combined operation of the two harnesses may be traced to the design, or cloth, shown at $A B C D E F$. At A the alternate threads have been raised by means of the headles 1 3 and 2 4 and form "tabby" or plain weaving. At B the headles are raised in a different order, as denoted by the numbers at the edge of the cloth. At D the headles have been raised and held stationary, and the effect of raising the mails alone is shown. At E the same arrangement is shown, but in this case the headles have been depressed, singly, and in consecutive order, thus forming a twill on the surface of the figure formed by the raising of the threads by the mails M . At F the same order is not only continued as at E , but the headles have been raised to their full height in consecutive order as well as being lowered. Thus the outline of the figure is formed by the mails M , and the minor intersections, forming the ground of the cloth, are made by the headles, and whatever outline or figure so formed is made, the headles have the same effect. In this manner, according to the number of headles, any kind of twill, satin, or other ground can be made, and one design may be woven with an endless variety of effect by simply altering the order or working of the headles to form the ground either on the surface of the figure or the plain portion or ground of the cloth.

The above contrivance entirely dispenses with a separate set of treadles to work the shaft harness. To alter the ground without affecting the design the cards can be used in two sets; thus the space on the cylinder to work the shaft hooks 1 to 8, Fig. 156, may have a separate set of cards, or a small Jacquard can be worked in conjunction with the Jacquard that forms the figure.

It appears to have been the invention of Mr. W. Rooke, of Hope

Rooke also received another reward of 5*l.* for an invention to apply "swivels" to the broad loom, which being in common use we shall hereafter describe; and on another occasion he appears to have sent to the society a model of an improvement in horsehair weaving. Rooke's plan was to work the iron shafts by a small Jacquard independently of the Jacquard in connexion with the monture. But its power was more limited than the full mounted damask harness, for it could not sink any of the raised threads to bind the figure.

The split harness is an important improvement upon Rooke's invention, and it is ascribed to Mr. James Gough, also of Bethnal Green. Fig. 158 represents a front elevation of the split harness. Fig. 159 shows a side elevation, and Fig. 160 is a plan of the same. In each figure the same letters and numbers refer to the same parts.

The hooks of the Jacquard are divided into two divisions in the same way as in the damask harness, as shown at *h* and *h*¹ *h*² *h*³ *h*⁴. Each leash is passed through the comber board *c* in the usual way, but it is at this point where the alteration takes place. Figs. 161 and 162 give an enlarged plan of the leashes and the way the split is formed. It will be seen that the leashes *t* connected to the Jacquard are here attached to two separate leashes which pass through the comber board, and each of these leashes is looped through another leash *s* which has a mail and lingo attached, as shown at *m m* and *ll*. It follows that whenever any of the leashes *t* are raised two warp threads are also raised, viz., the two adjoining threads. Through the loops of the leashes *s* a "shaft" or flat enamelled hoop iron bar is placed, so that when the bar is raised it lifts with it all the leashes upon it and the corresponding warp threads. In Fig. 159 four only of these bars are represented, but in practice 24 are generally used. Each bar is connected to a hook by the strong cords *T*, shown also in Figs. 159 and 143.

In Fig. 160 the pairs of leashes are still more clearly shown at 1, 2, 3 to 20, and the shafts *a b c d* to which they are looped.

Now whenever any of the hooks *h* are raised to form the pattern, the cloth will be woven with double threads at each intersection, and the figure can be varied to a distance of $\frac{1}{20}$ in. at each step, *i. e.*, when 400 threads per inch are used in the warp. At the same time those threads which are not raised to form the figure by the hooks *h* can be raised by the shafts by means of the hooks *h* 1, 2, 3, 4, and by raising these shafts in any desired order so the ground of the

cloth will be woven. In other words, the pattern can be woven to a fineness of two warp threads at each intersection without being affected by the shafts, and the remainder of the cloth can be woven as plain cloth with every alternate thread intersected, or in twills, satins, or other required ground, according to the number of shafts that may be employed.

With four shafts and twenty pairs of leashes, as shown in Fig. 160, the effect that may be produced will be noticed at *A B C D E* and *F*. At *A* "tabby" is woven by raising the shafts *a c* and *b d* as shown. At *B* a zigzag is woven by raising the shafts in the order denoted by the letters. At *E* the pattern is formed by raising the leashes only. At *D* the leashes are raised and the shafts also, in this case the ground is woven as a single-thread four-leaf twill. At *F* the ground is a four-leaf satin or broken twill.

When the leashes are raised by the shafts the upper part of the split leash is slackened as shown at *n* Fig. 161, but it in no way causes any inconvenience in working. In Fig. 158 one of the leashes is shown raised at *d'* by the hook *h*, shown on the griffe bar *G* Fig. 159, and one of the shafts *d* is also shown raised in Figs. 158 and 159.

In the split harness, as in the shaft harness before described, a separate set of cards for working the ground can be used, so that it can be changed at pleasure. Or a small Jacquard may be worked in connexion with the larger one for that purpose. If a separate set of cards be used at one end of the cylinder to work the hooks as at *P*¹, Fig. 128, the cylinder is shown adapted to receive them. Although, as shown in Fig. 129, the two sets may be connected as at *N*¹ and *N*², and form one set of cards only. In the use of a separate set of cards for the ground of the cloth, a considerable saving is effected in the cost of the cards, for the ground requires but a few only. This saving, however, is of disadvantage to the weaver, for it gives extra trouble in working two sets.

CHAPTER XV.

TISSUE WEAVING—SWIVELS.

THE general principles upon which the harness or mounting of the loom is constructed for the formation of the figures upon the cloth having been shown, it is now necessary to describe how the same is employed when various colours of weft are to be used for the purpose of making the design to the best advantage, and with the greatest economy of materials to be used. For instance, if the warp and weft consist of materials alike in colour and texture, then the figure would show in a manner similar to the appearance of the woven figures upon white linen table-cloths, not very distinct but still quite observable. If the warp be composed of a different material to the weft, then a much greater distinctness is produced, although both warp and weft may be alike in colour. This effect may be noticed in figured stuffs, which are composed of cotton warps and worsted weft. Again, if a different coloured warp and weft be used a far more distinct appearance will be produced, as shown in coloured table-cloths.

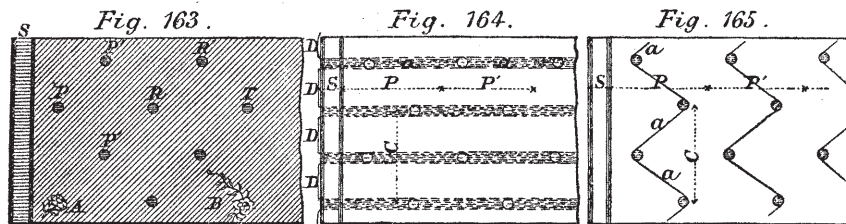
A great variety of effect may evidently be made by varying the colours of the warp itself, by arranging it in stripes, &c., as previously alluded to; but the best effect is produced by using various kinds of shuttles, as will now be shown, when the advantages to be derived from their use will be apparent.

In Fig. 41 a loom with drop boxes for using two or more kinds of shuttles was shown for weaving plaids or other goods requiring two or more separate colours. In such cases each shuttle supplied a substantial portion of the thread or weft to form the cloth. Now, in distinction to that class of weaving there is a widely different one, viz., where separate shuttles are employed to produce the figure upon the face of the cloth resembling embroidery, and the figure so produced has little or nothing, in its texture, to do in the forming of the substance of the cloth. In fact, so distinct are the threads

kept, that only just sufficient intersections are made to keep them held together. They float or flush upon the surface of the cloth rather than form a component part of its substance. It is known as tissue weaving, and the richest figured silks are produced by its means.

Let Fig. 163 represent a portion of figured silk such as made for scarves, as before alluded to. Fig. 164 is the reverse side of the same cloth. It is supposed to have been woven by a Jacquard machine with 400 needles, such as we have already described, and composed of 400 warp threads per inch in width; thus the spaces *P* and *P'* are 2 in. wide each, for in consequence of the split harness being employed, the 400 needle machine governs 800 threads or double the width of cloth, as before described.

The face of the cloth, Fig. 163, shows that the plain portion, or ground, is woven to form a twill; but any other ground, as described



in the last Chapter, may be substituted by altering the working of the harness shafts without affecting the figure itself.

A simple circle or spot is the figure shown to be produced, but it may be designed as a flower as at *A*, or a running flower as at *B*. In either case the full width of the figure that could be woven would be equal to 2 in. or the spaces *P* and *P'*, Fig. 164. The space *C* shows the extent or length of the pattern in this instance, which would take about 200 cards to produce. The threads *DD* are seen to run across the cloth with a broken appearance, which is to show that they intersect the body of the cloth at certain distances merely to bind them together, otherwise they would float perfectly loose, or "pick-overs," and detached from the cloth in the spaces betwixt the spots. The thread *DD* is, therefore, the thread that forms the spots, and the shuttle which has inserted it is only used in the line of spots, and is merely inserted to throw upon the surface a different colour or material to that which forms the ground of the cloth.

Now, upon comparing Fig. 165 with Fig. 164, a marked difference appears. The thread which forms the figure, or spot, in this case, Fig. 165, simply runs from one spot to another, and only the single thread as shown at *a a* travels, and it is merely the length of that one thread that is lost or of no use in the body of the cloth.

In Fig. 164, on the other hand, the floating threads at *a a* have really been thrown away, for they are of no practical use. Thus, it will be evident, a considerable saving may be effected by adopting the plan of weaving shown at Fig. 165. It is effected by the use of separate shuttles for each line of spots, and the shuttles are only brought into use where the spots are required.

There are, consequently, two methods that can be used for flushing or throwing the thread to form the tissue figure, namely, by ordinary shuttles thrown across the whole width of the cloth, or small shuttles used at the requisite intervals.

The first of these methods may be distinctly understood by referring to Fig. 166, where the piece of cloth shown at Fig. 163 is represented as it would appear in the loom. The loom is provided with two shuttles, one of which—namely, that which inserts the thread to form the figure—is seen entering the shed at *r*, the ground shuttle being in the other or lower box, but the thread leading from it is seen at *x*.

The face or right side of the cloth is woven downwards, as shown at *T*, where the corner of the cloth is represented as turned over, and, as before explained, is woven in this manner for the purpose of raising only as few of the lingoes and threads as possible at each shoot, which would otherwise have to be raised in case the cloth was woven with the face upwards. Therefore, where the spots are being formed, more threads of the warp are raised, and the thread now inserted by the shuttle, as shown, will be more exposed, and appear distinctly on the under side of the cloth. Between each spot a few threads only are shown raised, and these threads are those, before alluded to, which are required only to bind slightly together the tissue shoot with the back face of the cloth.

In the same figure the lower portion of the Jacquard harness *m m* is shown, and the comber board *C* through which it passes. The strong cords *E E* are the cords which raise the shafts *s* of the split harness. One of the shafts *s'* is shown raised, and the slackening of the leashes by so raising them is also represented.

The ordinary drop boxes for two shuttles are shown at *b b*, which

are raised by the lever *d*, according to the shuttle to be used. At *H* are shown several small bobbins with a little of the various colours of the weft that may be used, that is, when several kinds are employed. They are called tokens, and are raised by the Jacquard hooks attached, so as to remind the weaver which shuttle to use. This plan is, however, only practised occasionally. At *P'* an iron bar termed a presser is shown. It is held downwards by means of the cords, shown also in Fig. 148. Temples are not required for this description of work, but a press bar cannot be dispensed with. The great number of 400 threads per inch passing between the reed are liable, when raised, to stick and not to fall back freely to their proper level. The bar has the effect of throwing sufficient strain upon them to prevent them sticking or remaining partially up, and thus allow the shuttle passing above instead of below them.

It is in this manner that rich figured silks are generally woven, and several shuttles may be used, and the figure may cover the whole surface of the cloth. But the use of smaller shuttles for the production of small figures or spots not only gives a better appearance to the figure by throwing it more prominently upon the surface of the cloth, but saves, as before observed, a considerable amount of the silk. Certainly, the amount saved is not altogether gained, for the weaver is paid considerably more wages for weaving with them; but the saving is still sufficient, besides the improvement in the appearance of the cloth, to induce manufacturers to adopt them whenever convenient.

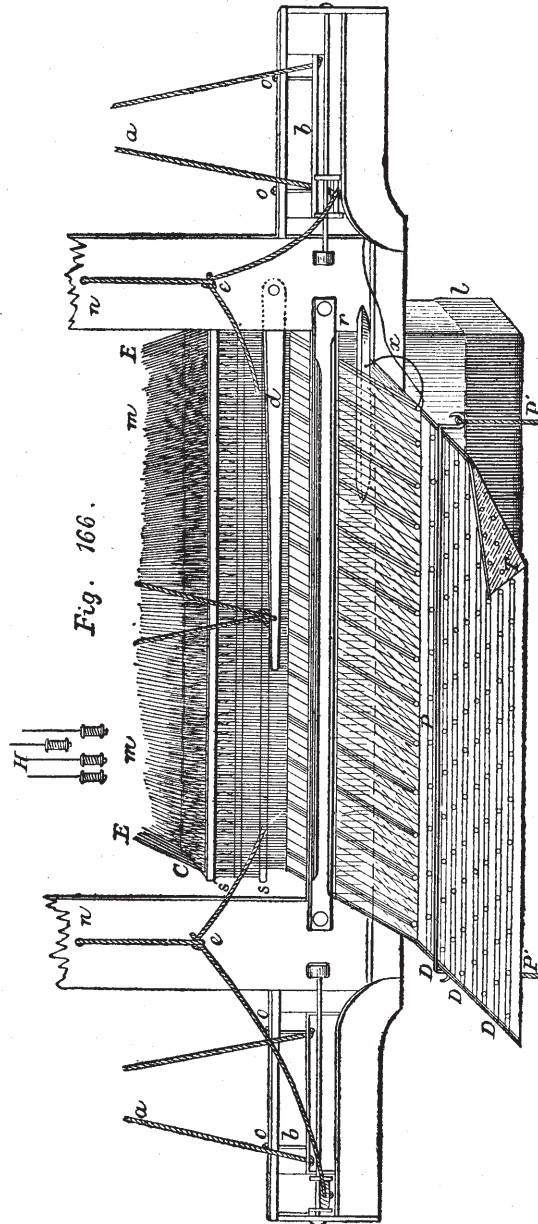
Small shuttles are used in conjunction with the larger ones, and consist of three kinds:—

1. Small shuttles, called swivels, fitted in a movable frame.
2. Ditto, called circles, fitted in a movable frame.
3. Ditto, used separately by hand.

Fig. 167 represents an ordinary fly shuttle batten fitted with swivels, and engaged in the same kind of work as that shown in Fig. 166.

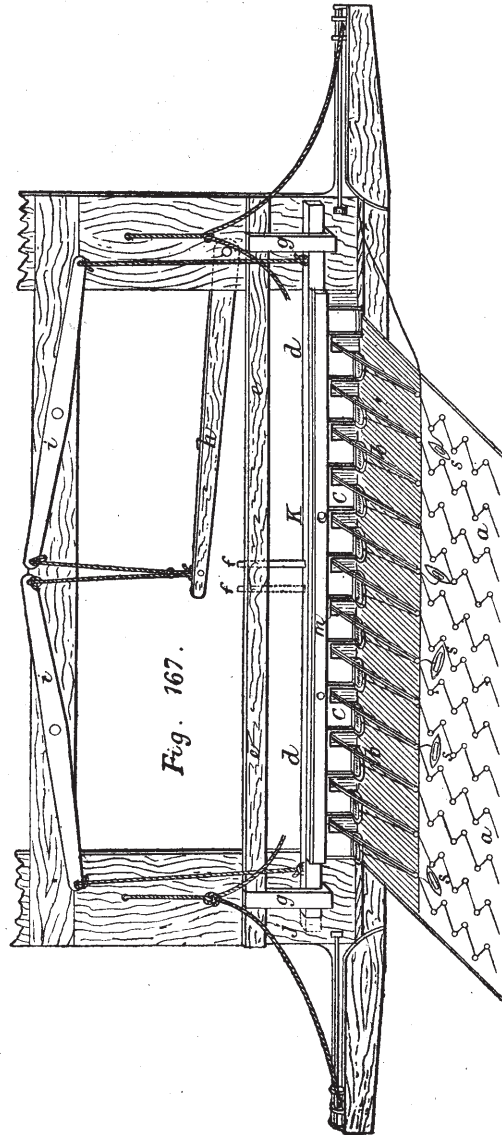
The swivels are fitted into the frame *d d*, which is simply an addition to the common batten, and can be attached to any loom. It can be raised or lowered by the lever *h*, acting upon the two levers *i i*. Upon the frame *d d* are placed two slides *m*, into which are fixed pegs, and by sliding backwards and forwards these slides, by means of the knob *k*, the swivels are moved to and fro. In this instance, the Jacquard having raised the threads to form the spots,

the swivel frame is lowered, and by moving the knob *k* to the right hand and then to the left, the swivels may be passed underneath



the threads the requisite number of shoots until the figure is woven —the ground shuttle being used alternately for the formation of the ground of the cloth in this process as in the former.

On the surface of the cloth several detached small shuttles are shown. Now, if it were desired to give better effect to the appearance of a figure, say the flower *A*, Fig. 163, by introducing

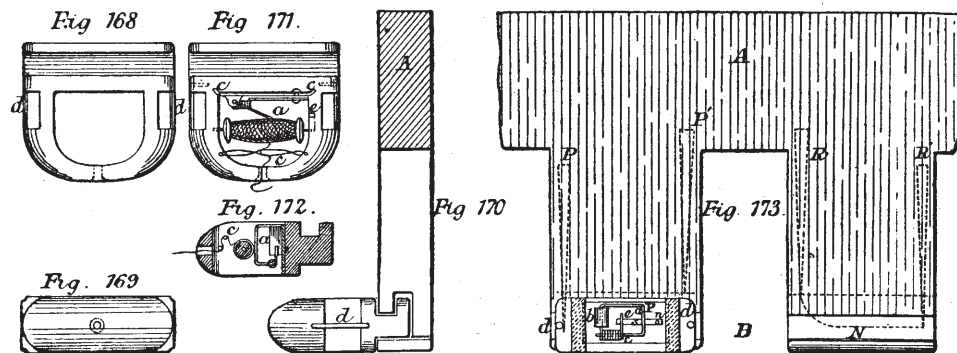


only one intersection of a different colour, then it could be done by merely passing them through by hand, as may be seen.

The frame *d d* is capable of being moved laterally, as shown at *j* and at *f* and *f*¹. By this means, when the lateral alteration of the

position of the figure takes place, the swivel frame is moved so as to drop the swivels in the places or openings in the warp made for them. When the frame is so moved, a spring locks the peg *f* fast until the next removal. No threads between the spots need be raised in this case for binding the tissue thread, as was shown in Fig. 166, for they are not required.

In Fig. 167 twelve swivels, or small shuttles, are shown fitted in the frame *d d* fixed to the front of the batten, which corresponds to the number of spots or figures to be woven in the width of the cloth. Fig. 168 represents a plan of one of the swivels, and Fig. 169 a front view, showing the eye through which the weft passes. In all shuttles the eye is formed of china ware, glass, or metal, and is fixed firmly into the box wood, which is the material generally used for



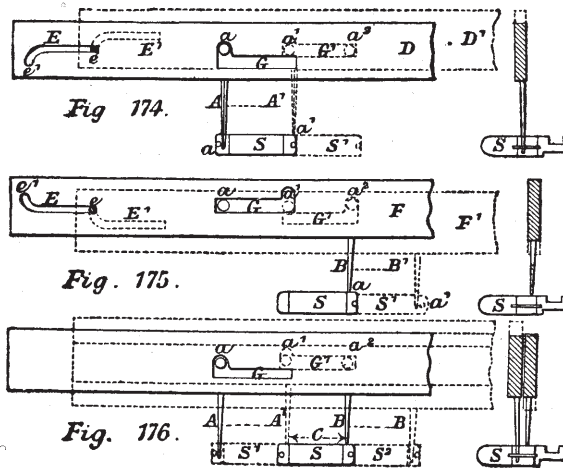
shuttles. At *A*, Figs. 170 and 173, a portion of the plank or grooved wood, into which the swivels slide, is shown.

In the former figure an end view of the shuttle is seen, with the groove and lip upon the plank and swivel. At *d* is a wire staple, seen also on both sides of the swivel in Figs. 168 and 171.

Now, on referring to Fig. 167, it will be evident that the swivel must slide freely under the raised threads, or across the space shown at *B*, Fig. 173, and it must pass without any obstruction or contact with the warp threads. This is effected in the following manner:—

There are two sets of pegs fixed into two slides. One slide by means of the pegs—there being one peg for each swivel in each of the slides—advances or pushes the swivel across the gap or opening in the plank *B*, into which the warp threads are raised, and immediately it arrives at the opposite side it is caught by the peg in the other slide bar and drawn clearly through the opening. At *P*, Fig.

173, is seen in dotted lines the position of the peg at the commencement of the movement, and at P is shown the same peg in its position after it has advanced the swivel, so as to land it on the opposite side N. When it has reached that position, the peg R descends behind the staple d, and draws the swivel completely across the opening, and of course into the same place as the swivel which has last occupied that space, but which has been pushed further on. Thus, by the combined movement of pushing and drawing the swivel and raising and lowering the pegs, the operation of throwing the swivel, or shuttle, is not only effectually done, but it cannot stop in its course. If the movement were to be so imperfect as to cause any stoppage of the shuttle during its passage across the opening,



it would often give rise to serious damage to the warp, for it would be "trapped," or stick between the threads, and on the next blow of the batten the threads would be cut or broken.

The slides into which the pegs are fixed are moved by means of a peg working into a groove formed in each of the slides. When one slide has been advanced to the appointed distance, it is stopped, and thrown out of gear or contact; at the same time the other slide has been held stationary, and then thrown into gear or contact.

This will be understood by referring to the diagrams Figs. 174, 175, and 176. Fig. 174 shows the first slide in elevation and section. D shows its position at the commencement of its motion, and D', in dotted lines, the termination of its motion. The peg a is shown as working into the groove G, and is in the slot at the com-

mencement of the groove. Now, on moving the peg from a to a^1 , it will carry with it the bar D to that distance, but no further. The bar at this point rises, and the peg, being released from the slot, continues its course to the end of the groove G , and terminates its motion at a^2 .

Fig. 175 represents the second bar, which is placed behind the bar Fig. 174, and it is made with the slots in a reversed position. Both bars are worked by the same peg a (seen also at K , Fig. 167), but are shown separately in Figs. 174 and 175, but in Fig. 176 they are shown in connexion. It will be evident that (see Fig. 175) when the peg a is moved from a to a^1 , the bar F will remain stationary, for the peg is traversing the groove during that time, but when it arrives at a^1 the bar falls, and the peg, entering the slot, carries the bar forward to a^2 . The pin a , therefore, by being moved backwards and forwards, causes the two bars to be moved as required for the movement of the shuttles, which is represented in all the Figs. 174 to 176 at S .

In Fig. 174 the peg A is shown to have moved the shuttles to the position S^1 , and in Fig. 175 the shuttle is carried further on by the peg B to the position shown at B^1 . The combined action of the pegs is seen in Fig. 176, where the shuttle is represented in the middle of its traverse, or at the point to which the peg A has pushed it, and the peg B commences its motion to draw it the remaining distance.

In Figs. 174 and 175 a peg e is shown working into the slot or groove E . There are two grooves in each bar, one at each end; but only one is shown in the diagram, to avoid complexity. The groove in the bar F is curved in a reverse manner to the groove in the bar D . The purpose of the peg e and the groove E is that they not only assist in raising and steadying the bars when moved by the peg a , but when each bar has traversed its allotted distance, the pin e prevents the pin a from carrying the bar too far. This may be observed by referring to Fig. 174, where, in moving the peg a to a^1 , the slot E has advanced to E^1 , and the peg e , being stationary, has prevented the bar being carried farther through, the slot e^1 having arrived at the pin. The slot being curved, of course corresponds with the motion of the traversing pin a , and assists in the vertical motions of the two bars.

The details of the swivel are shown in Figs. 171 to 173. Fig. 171 shows a plan of the swivel with the weft bobbin fixed in it, and Fig.

172 represents a section of the same. Both figures are about two-thirds full size.

The bobbin is fitted upon a wire spindle, one end of which is inserted into a hole, and the other end into a slot or groove, shown by the dotted lines at *e*. The bobbin spindle is held sufficiently firm in the groove by means of the presser *a*, which presses against the bobbin, and not only holds it in position, but the friction caused by the pressure prevents the thread from being unwound too easily. Another view of the spring and presser is shown at Fig. 172, a thin brass plate which is firmly fixed into the back of the swivel by means of the ends being inserted into saw cuts, as shown at *c c*, Fig. 171. Upon the plate there is a boss (Fig. 172), through which a hole is drilled for inserting the presser *a*. The presser is formed by turning a spiral tube at one end of a fine wire, and after passing the long end through the boss in the form shown, it is inserted into the wire tube to give the presser sufficient rigidity. The other or short end of the wire forms a stud, against which a thin flat spring *s*, which is rivetted at *n* to the brass plate, presses.

These pressers are of various forms, but the one shown, being easily made, can be repaired by the weaver when out of order, and well answers the purpose it is intended for.

At *c*, Figs. 171 and 172, the weft thread is seen to pass between a loop made of horsehair, which is fastened to the shuttle through holes bored at the sides.

The purpose for using the horsehair is of some importance, for it not only, by the slight friction it gives upon the weft thread, keeps it in position, but by the weft being properly inserted between the loops by slightly twisting the hair, as shown at *c* in Figs. 171 and 172, it has a tendency to take up or coil the slack of the weft. But this will be better understood when the details of the circles or modification of the swivel is shown, and which will be next described.

CHAPTER XVI.

CIRCULAR SWIVELS—LAPPETS.

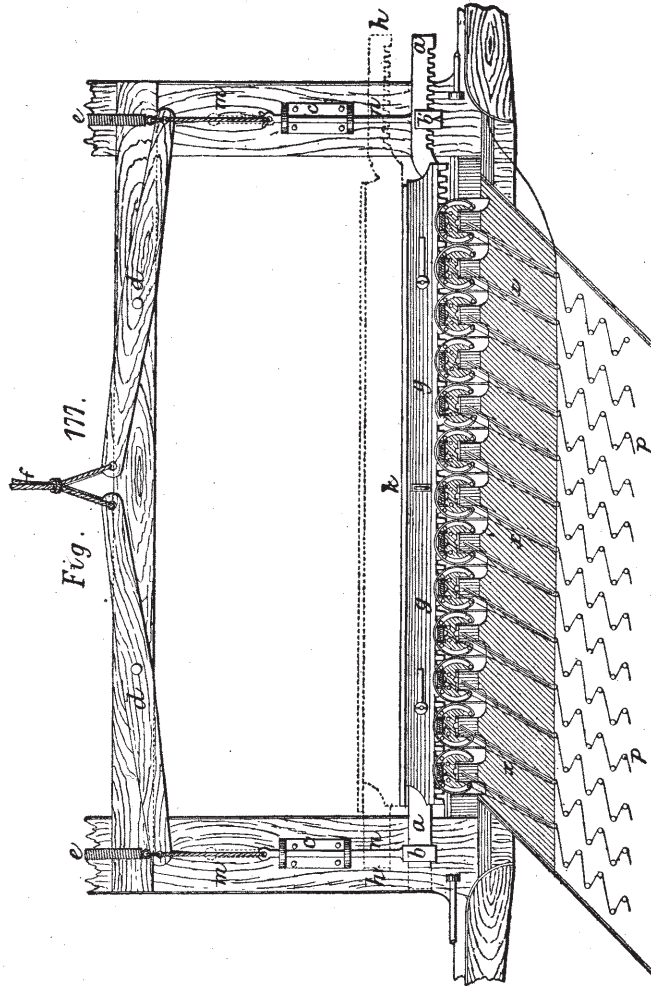
THE small shuttles called "circles," are an elaborate substitute for the simple swivel, over which they have certain advantages. In the first place they can be put into less compass, consequently more can be employed in a given width of cloth. Two sets may also be employed by placing them back to back, thus being able to use two kinds of weft with them. With swivels this would scarcely be possible owing to their greater size, although, when first introduced by William Rooke (the inventor of the shaft monture), he placed two sets of swivels back to back in this manner. Circles appear to be a French invention, and are generally made in Lyons or Paris. They are sometimes entirely composed of metal—brass and steel—and they are fixed to the front of the batten, opposite to the reed, in the same manner as the swivel frame. They are lowered down into the shed in the same manner, and are used in every way the same and for a similar purpose as the swivel.

The principle of their action consists, as their name implies, in moving in a circular path, the shuttle itself being formed something like the shape of a horseshoe, upon the front of which is placed the weft bobbin. The warp threads being raised through the opening and into the centre part of the shuttle, it is then revolved by means of a rack motion, which, when in proper order, works exceedingly easy, and is very suitable for the purpose. In addition to this, the bobbins are made to work in a perfect manner, for the weft thread has not only a constant amount of tension put upon it, but the slack is drawn back to the extent of several inches with ease.

These circles are more costly than swivels, and require great care in using them, which may account for their not being so generally adopted.

Fig. 177 represents the front of an ordinary batten with fly shuttle, similar to that shown at Fig. 167. At the front and upon the swords

m m are screwed two brackets, through each of which a sliding bolt is made to work freely. At the lower part of the bolts there is a slot or pocket, into which the bar *a a'* fits. At the end *a'* the upper part of the slot is open, to allow of the bar being taken completely out or to be moved laterally, and there is a knife edge at the bottom



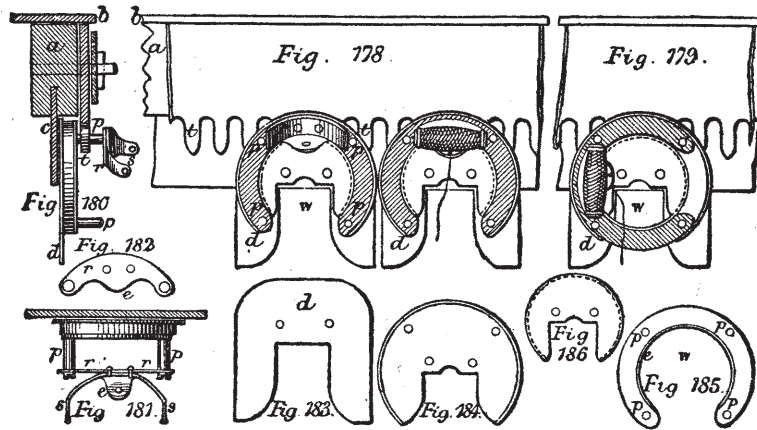
of the slot *b'*, upon which the notches in the bar at *a'* may rest. These notches are simply for the purpose of adjusting or regulating the lateral position of the circles when weaving the spots.

The bar *a a'* is shown as lowered down into the shed by means of the two levers *d d*. The cord *f* is fastened to a hook in the Jacquard,

so that whenever the hook is raised it depresses the bar *a a'* to the position shown.

Now by moving the knob *k*, which is fixed upon the rack plate *g g*, the circles are made to revolve completely round the raised warp threads *x x*, and when the Jacquard is next lowered the hook attached to the cord *f* is lowered, and then the bar *a a'* will be lifted by means of the springs *e e* clear of the shed, ready for the fly shuttle to be used for the formation of the ground of the cloth, as before described in the case of the swivels.

The zigzag or diagonal position of the spots or figures *p p* are the same in this instance as in Fig. 167, and when the bar *a a'* is moved laterally, to correspond to the shed, the particular notch at *b'* is



selected, and the bar is dropped upon the knife edge before mentioned.

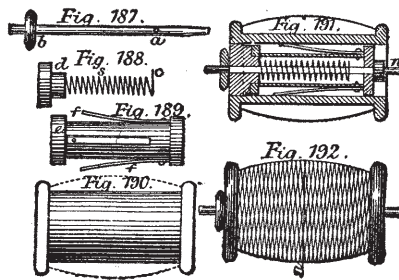
By having a number of notches, as shown, these positions may be made gradually, and thus may produce a running figure, such as shown at *B*, Fig. 163.

Fig. 180 shows a half-sized section of the bar *a a'*, upon which the circles are placed. It is composed of a wood bar *a*, upon which is screwed the brass plate *b*. A plate *c* is fitted into the wood *a*, upon which the plates *d d* (see also Figs. 178 and 183) are screwed.

Upon these plates the frame plates carrying the circles are secured, which have flanges turned up round the edges to keep the circles in position, as seen at Fig. 184, which represents a plate, and Fig. 185 a circle or shuttle. There is a rebate *e* sunk in the inside edge of

the circle, into which the cover plate, Fig. 186, fits, to hold it loosely in position on the frame, Fig. 184. There are four pins *p p p p* fixed to each circle, as shown in Figs. 180, 178, and 185, which being geared into the rack teeth *t*, Fig. 178, cause the circle to be revolved when the rack is moved. Thus, Fig. 179 represents a quarter revolution of a circle only, but by continuing the motion of the rack a whole revolution can be made, and in this manner the circle revolves to the right or left, according to the motion of the rack, and when the threads for the formation of the spot are raised, they occupy the centre of the circle, as shown at *w*, Figs. 178, 179, 185, and the bobbin is thereby passed beneath them.

The bobbin spindle is held firm enough to prevent its turning in the bracket *s*, Figs. 180 and 181, which is secured to a plate *r r* fixed upon the pins *p p*, see Figs. 181 and 182, and the thread passes from



the bobbin through the eye *e*, which is made in the lower side of the plate *r*, Fig. 182.

The bobbin and spindle is a very neat and ingenious contrivance, and is represented considerably larger than full size in Figs. 187 to 192. Fig. 187 is a spindle upon which is fastened a brass disc *b*, and there is a hole drilled through the spindle at *a*. Fig. 188 shows a double collar to which is attached a thin wire spring. The collar is made to fit loosely on the spindle, Fig. 187, and the end *c* of the wire spring *s* is inserted into the hole *a*. Fig. 189 is a barrel, which is fitted with four weak springs in the manner shown at *ff*, and the collar *e* is bored to fit tightly upon the collar *d*, Fig. 188. Fig. 190 is the bobbin, the dotted lines representing the outline when filled with weft. The bobbin fits upon the barrel, Fig. 189, and the springs have just sufficient power to cause a slight friction when the thread is drawn off.

Fig. 191 shows a section of the bobbin when fixed upon the barrel

and spindle, and the barrel is there shown fixed and held in position by the nut *n*.

Now it will be evident that if the weft thread be drawn as at *n n'* Fig. 192, the spring Fig. 188 will give way to its full extent, but if the thread be drawn beyond the power or stretch of the spring, then the friction of the springs *ff* upon the barrel will be overcome and the thread be unwound; but the spring Fig. 188 has the effect of always taking up, and therefore keeping in tension the irregular strain upon the thread caused by the various motions of the circles. The thread may be unwound and rewound in this way several inches without the barrel springs *ff* giving way, and thus cause an equal tension of the weft thread during the process of weaving, which is a matter of great importance in the production of all woven fabrics.

In using either the swivels or the circles, the operation being the same, they may be raised or lowered by means of a lever as at *h*, Fig. 167, or by the Jacquard as at Fig. 177. The reed and batten is in no way affected by the application of either contrivance, with the exception that the weaver holds the batten by either an extra cap or by the top piece of the frame *e e*, Fig. 167, instead of the cap over the reed, for it will be evident that the position of the slides, &c. at *d d*, Fig. 167, would prevent him from holding the batten in the usual way.

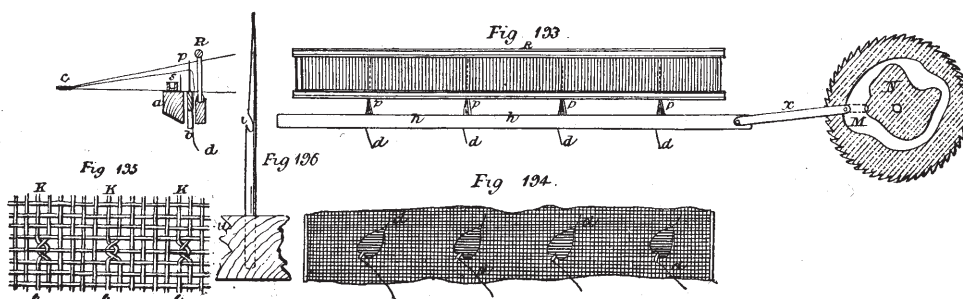
Swivels have been repeatedly worked upon power looms for the production of silk spots, or figures upon alpaca and stuff dresses, and attempts have been made to work them at the same time that the ground shuttle was being worked. To do so, it requires that two separate sheds should be made by raising the warp threads for the swivels at a higher level than usual, whereby both ground shuttle and swivels could pass at the same time. See Fig. 300.

Before swivels were introduced, a system of weaving was used for producing figures upon the surface of the cloth by means of needles placed in a sliding frame. Each needle was provided with a separate thread, and when the shed was opened for the passage of the shuttle the needle frame was raised so that the threads could be intersected by the weft thread with the body of the cloth. But it is evident that the threads could only be bound at the edges of the figures so formed, and they consequently hung loosely or floated on the surface. Two or more bars could be employed in this manner, so as to extend the design. They were placed immediately in front of the reed, so that the shuttle could pass in front of them, a row of wire pegs being

placed so as to prevent the shuttle touching them. They were raised when required in a similar, although a reverse manner, to the lowering of the swivels. The pattern was formed by means of a ratchet wheel, placed at the end of the batten, and a groove in the side of the wheel was cut in such a manner, that when it had completed a revolution the pattern was woven. Thus the operation was repeated, and the figure formed without aid of the Jacquard or other machine for producing the figure. This plan, applied to ordinary power looms, is at present much used in Scotland, and known as lappet weaving.

Fig. 193 will show the principle upon which it is worked, and represents a front elevation and section of the lappet frame with four needles only fitted to a loom. In both figures the letters refer to the same parts.

The needles *p p* are fixed in the guide or bar *h h*, and each needle has a thread *d d* passed through the eye near the point of the needle.



When the frame is raised the needles pass through the warp at the back of the shuttle *s* and guide pins, but in front of the reed *R*, consequently on the passage of the shuttle the needle thread is bound in the cloth by the weft thread. The frame is then lowered, and moved right or left as desired, and again raised, and so the figure is produced; but the threads, as before stated, are only bound or intersected at the edges of the figure. The lateral motion to form the figure is regulated by the groove *M* in the ratchet wheel *N*. The pin upon the end of the connecting lever *x*, being worked alternately from side to side of the groove, regulates the distance of the traverse of the needles; in fact the groove is really the development of the pattern, and a fresh one is required for every new pattern. The ratchet wheel moves one tooth for each pick of weft, and contains as many teeth as the extent or length of the pattern.

Grooves may be placed on the circumference of a drum cylinder in

like manner, or two or more grooves and needle bars may be used. The threads *d d* are supplied from a beam or beams beneath the loom, and Fig. 194 will show the kind of work produced—where the threads float from side to side of the figure without any intersection with the cloth—although the pattern may be so arranged as to make intersections to a small extent in the intermediate distances.

At Fig. 195 a modification of the lappet apparatus is shown. In this case the needles were not supplied with separate threads, but when the shed was raised certain threads were left down, so that when the needles were drawn across the under surface of the cloth they came into contact with them, and after carrying them a given distance the needles were then raised and by means of a notch cut in the side of the needle, the threads were also raised out of their normal position. This plan caused a kind of cross-weaving something similar to gauze weaving, and the effect produced may be represented in Fig. 195, which shows that the warp threads *e e e* have been raised and occupy the place of the warp threads *K K K*. The needles were formed, as seen in Fig. 196, and were inserted in a slide bar similar to those before described. The notch *i*, during the lateral motion of the needles taking hold of the warp threads purposely left down for them, carried them laterally the appointed distance, and then raised them to form the crossing of the threads.

In this way one or more threads could be moved and crossed by each needle, according to design made by means of the Jacquard or other similar contrivance, but in the figure only one thread has been moved by each of the three needles used in the space represented.

Numerous modifications of the above systems have been made with more or less success, but the simple swivel and circles as described seem to answer every purpose in a most effectual way, and are generally used for weaving small figures.

CHAPTER XVII.

CROSS WEAVING.

PREVIOUS to the application of the Jacquard apparatus to lace machinery, gauze and net weaving was much practised, but at the present time it is not so often used in silk weaving, although it may at any time be again extensively employed, as very beautiful fabrics can be produced by it.

There is one purpose to which it is often applied which is of considerable advantage — viz.: to form artificial selvages to cloth when woven in wide widths, and afterwards cut up into narrower pieces. Brunel (Sir M. I.) so far back as 1802 took out a patent, No. 2663, for weaving narrow fabrics by cutting wide widths, in which he says, “in all cases adopted to prevent its ravelling out in washing, and of any breadth not exceeding ten inches.” As no drawing accompanies the specification, the description is not very clear, but it does not appear that he used cross weaving, or gauze, as at the present time.

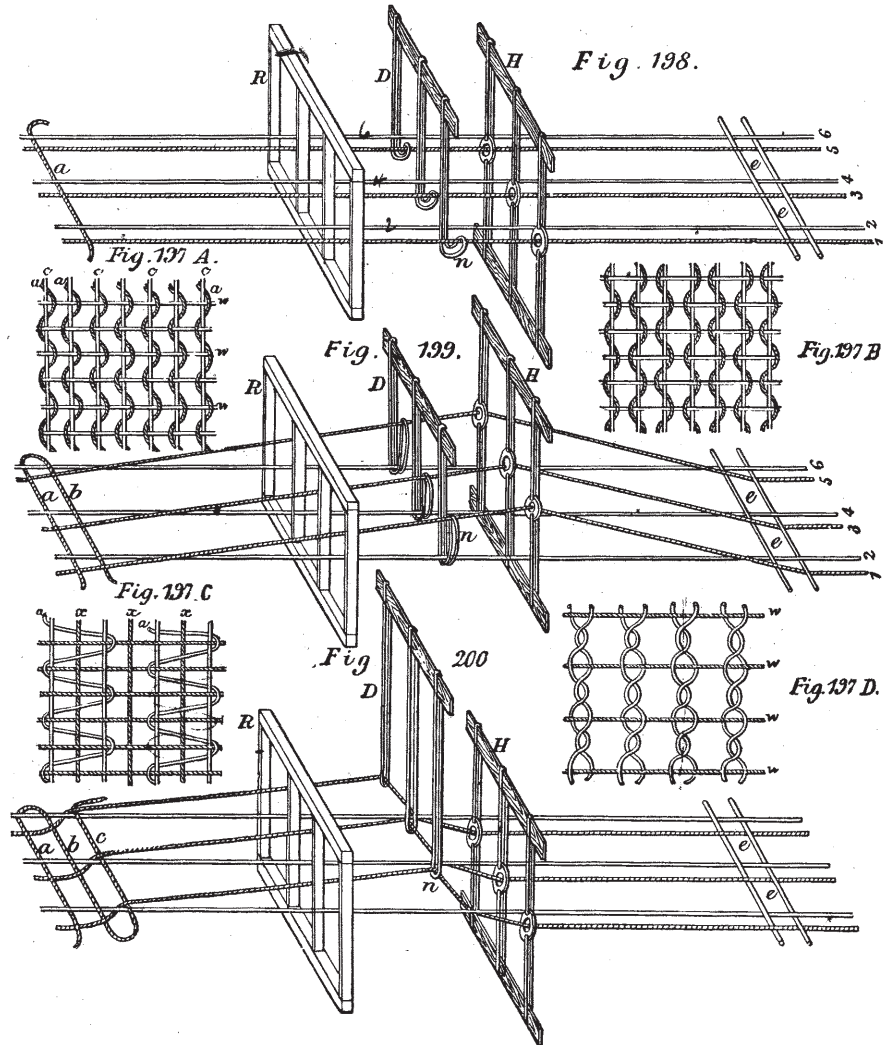
Cross weaving, as its name implies, enables the weaver to twist the warp threads more or less around each other, after the manner of lace, but more limited in extent. It is called *gauze*, a name supposed to be derived from Gaza, a city of Palestine, where this method of weaving is said to have been originated or practised.

Fig. 197 *A, B, C, D*, represents four kinds of gauze. The warp threads of the first are marked *a* and *c*. The threads *a a* will be observed to twist alternately from one side of the threads *c c* to the other, and at each crossing they are held in position by means of the weft threads *w w*, which intersect them at the crossings.

In the second example, 197 *B*, the same process is gone through, but with this difference, every alternate thread twists the reverse way. This, however, is merely a matter of arranging the harness. The third, 197 *C*, shows the thread *a a* exactly the same as in the first; but in this case, instead of its twisting round one thread

only, it twists round three, as will be seen on referring to the figure.

Now in each of the cases shown the cross thread, or "whip," as it is called, merely twists half round the adjoining thread or



threads, and not a whole turn. But in the example 197 D, the threads are shown to make a complete turn or twist round each other, and are held in that position by the weft threads *w w* as in the former instances.

The principle upon which the cross or twist depends will be

best shown by means of the diagrams, Figs. 198, 199, and 200. The numbers and letters refer to the same parts in each figure.

In Fig. 198 six warp threads only are shown numbered 1 to 6. The threads 1, 3, 5 are passed through mails in the leashes of the headle *H*, and thence through loops called "doups" fixed to a headle, as shown at *D*. These doups will be noticed to pass beneath the threads 2, 4, 6.

The warp threads pass forward through the reed *R*, and thence to the cloth beam, which, however, it is not necessary to show. By this arrangement the threads 1, 3, 5 are passed through two eyes, in the headles, but the threads 2, 4, 6 are passed through none whatever, and are merely held in position by the lease or cross *e e* and the reed *R*.

Fig. 198 shows the warp at rest, or in its normal position. Fig. 199 shows the headle *H* raised, and the weft thread *b* passed through the shed formed by the headle. Fig. 200 shows the headle *H* lowered to its first position and the doup headle raised.

Now it will be observed in Fig. 200 that the doups have drawn the threads 1, 3, 5 underneath the adjoining threads 2, 4, 6, and consequently effect a half twisting of the threads, as may be seen at *c*. This, therefore, when repeated, is the simple process of cross weaving, and we have now to follow it through various modifications, but still dependent upon the principle shown.

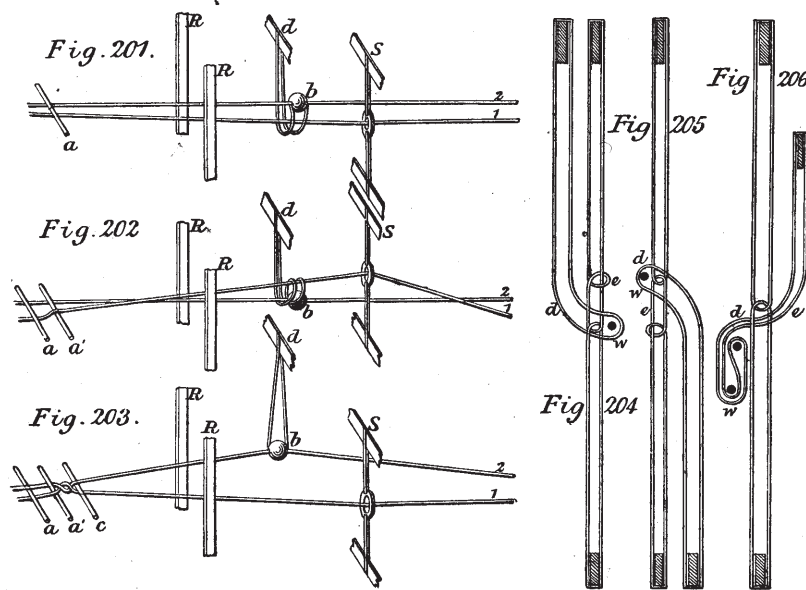
Figs. 201, 202, and 203 show how the threads are made to twist completely, or a whole turn, round each other. It is effected by carrying the doup not only under the thread 1, but over it, and then to clip the thread 2. In this case beads are shown at *b*, in each of the figures through which the warp and doup threads pass. But beads are not used now, having been dispensed with many years ago. Still, they had certain advantages, and it may be as well not to omit showing them in this instance, although the complete twisting of the thread as shown can be effected just the same without the beads on the doups.

As in the case of the half twisting of the threads last shown, the complete twisting is accomplished by first raising the headle *S* and then the doup headle *d*, and the twisting so effected is held in position by the weft thread shown at *a a'* and *c*.

R R represents two of the dents of the reed; and it may be here noticed that all such threads in gauze weaving intended to cross each other must pass through the same opening in the reed, other-

wise they could not be twisted. The distance between the dent or teeth of the reed in practice may be one thirty-fifth or one fortieth of an inch only, although we are compelled to show them many times that distance apart. Therefore, when it is remembered that the threads lie so near together, the care required for working of the doup leash will be better understood.

But notwithstanding the apparent simplicity of the operation of gauze weaving, as above represented, there would be found in practice a difficulty in keeping the doups in order, for, as shown, they hang loosely from the headle, shaft, or lath, and have no strain



or tension upon them similar to an ordinary headle, which is provided with a shaft at the bottom as well as the top of the leashes. Certainly when beads were used they gave a slight amount of tension to the doups, but to overcome the difficulty in order to work the loom as fast as this kind of weaving will allow, a plan is adopted of using an additional headle merely for the purpose of supporting and guiding the doup leashes, and has nothing to do with the twisting of the threads. Let Fig. 204 represent an ordinary headle with eye below the knot *e*. Then the doup leash *d* is shown to pass through the eye in such a manner that it cannot be separated from the headle, for it is linked in the bottom loop of the eye. Now the whip thread *w*,

shown in section, is held by the doup against the side of the eye, but the doup cannot draw the thread any further, although the whip thread, when the doup is slackened, may be moved to some distance from the eye. Fig. 205 shows a set of doups attached to the lower shafts of the loom, so that rising and falling sheds may be used, as in plain weaving. Fig. 206 represents the doup for effecting a complete twist to the warp threads when attached to a clasp leash. In each instance the doups are arranged upon a shaft, and it follows that the whole of them must work at one time, consequently nothing but plain gauze either in continuous or broken lengths could be woven.

In Fig. 206 the doup leash *e* does not clasp the eye at *a*, as in Figs. 204 and 205, consequently should the whip thread to which it is connected break, the doup would become loose from the standard, and would have to be replaced. This, however, was the plan used before the method of clasping them was adopted.

In figured gauze weaving it is necessary that any single doup or any assortment of them, or the whole of them may be brought into use whenever required, otherwise figured gauze could not be produced.

By describing how this is accomplished in the Jacquard loom, the principle of the action of Figs. 204 to 206 may be easily understood, as gauze work is produced by it in a peculiarly simple and ingenious manner.

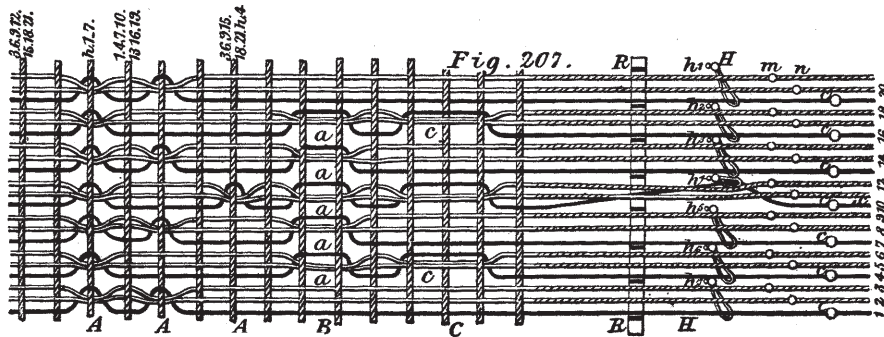


Fig. 207 may represent a plan of a portion of gauze as it would appear in the loom. At *A*, *B*, and *C* three different kinds of twisting are shown. In the first instance the whip thread is twisted half round the two adjoining threads and only one shoot of the weft is

made. At *B* the whip thread is retained in its position while two shoots of weft are inserted, and at *C* three shoots are passed through before the whip thread returns to its normal position.

Now to use twistings as at *A* in connexion with fine silk weaving would be almost impossible, for there would be no room for the threads, consequently spaces such as at *B* and *C* are used. It does not follow, also, that the whip thread should pass under one thread only, but two, four, or six threads may be used, and the whip thread itself may be composed of two threads. But in the figure we have assumed that there is only one whip thread to two warp threads.

Figs. 208, 209, and 210 form a diagram of a front elevation of the harness shown on plan at *H H*, Fig. 207; and Fig. 211 represents a side elevation of the same. In all five figures the same numbers and letters refer to the same parts.

Fig. 208 represents four ordinary Jacquard leashes with mails and warp threads, &c., of which *a* is one; this latter being connected with the doup *h*, controuls the whip thread to enable it to be drawn under the warp threads by means of the doup *h*.

The doup is attached to a "dead" leash *d* as shown, and this dead leash is attached to a whip leash at *e*. The whip thread *x* not only passes through the mail or eye in it at *c*, but through the doup also. See Fig. 211, *a* and *c*.

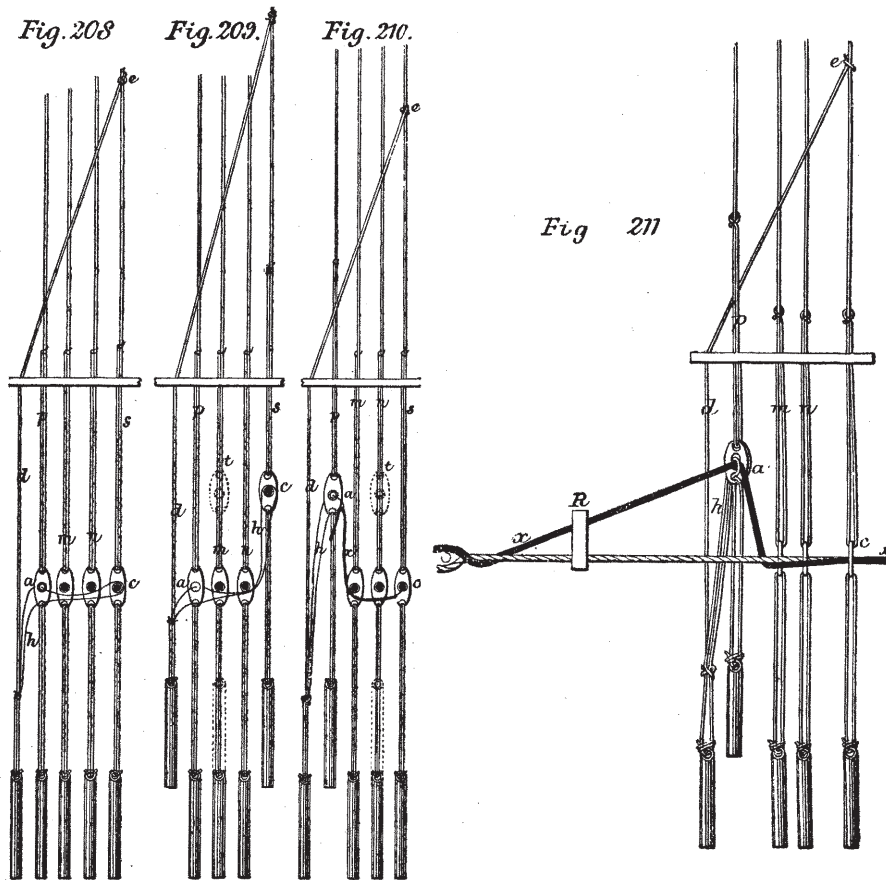
The leash *p* corresponds to the additional headle previously alluded to, to support the doups, and it will be seen in the figures that the doups pass through the mail in a similar manner to that described in Figs. 204 and 205.

Now Fig. 208 shows the three warp threads in their normal position, governed by the leashes *m n* and *s*. These leashes can be raised in any order required for plain or figured weaving; but whenever the leash *p* is raised, it draws with it the whip thread as shown at *x* Fig. 210.

The mails *a* and *c* are employed much closer together than we show them, consequently the effect of the dead leash *d* is not so apparent. But it will be seen that it effectually holds the doup in position, and by being connected to the standard leash at *e* whenever the standard is raised, the dead leash is raised also, otherwise the whip thread would be strained by the tension of the doup. See Figs. 209 and 211.

In plan 207 the warp threads are numbered in consecutive order from 1 to 21: every third thread is a whip thread, and is passed

first through the mails *c c*, and thence through the doups *h¹⁻⁷*. The doup *h¹* is shown drawing with it the whip thread underneath the threads 11 and 12, represented also at Fig. 211, by which means a



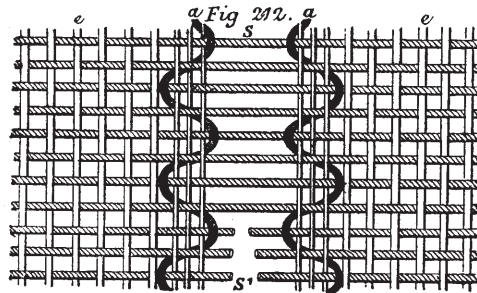
gauze spot is formed. Now, by referring to the numbers at the margin of the cloth they show the numbers of those warp threads, &c., that have been raised to produce the effect. For instance, *h¹⁻⁷* means that the mails *h¹⁻⁷* have been raised to form the twistings or gauze spots shown at that position.

The diagrams will better explain the process than any written description, especially as each motion has been represented in them. It may be mentioned that the reed *R R*, Fig. 207, shows the set of three threads passing through each space, otherwise, as before observed, they could not be twisted round each other. The whip

thread is usually made stronger than the other threads, or used doubled, so as to counteract the strain of the threads round which it is twisted. When four or six threads are used then the strain becomes far greater, and requires considerable judgment in their use.

The application of gauze to the formation of selvages may now be readily understood. When the cloth is being woven the place where it is intended to be cut has had no threads passed through the reed; in other words, one of the dents, or spaces, has been left empty. On each side of this empty dent gauze threads are used to form the selvages, by means of a doup, as at *D*, Fig. 198.

Fig. 212 represents a portion of plain cloth woven, showing the gauze selvages, with the whip threads *a a*. At *S* a portion of the cloth is shown cut, and it may be readily imagined that when the threads are entwined firmly and compactly together, that a very

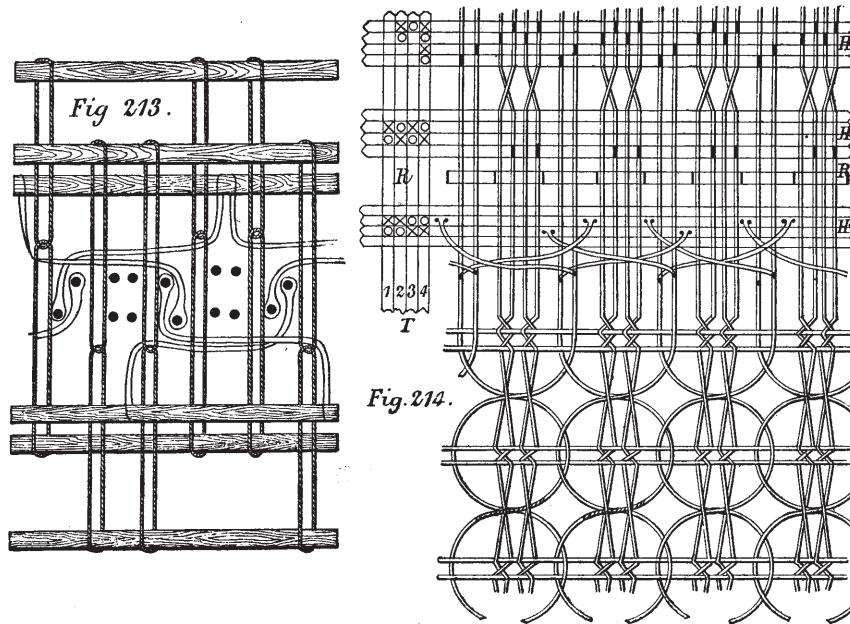


serviceable substitute for a genuine selvage can be made, and by this means narrow strips, such as velvet ribbons and scarves, can be woven at much less expense than where they have to be woven in separate pieces. Contrivances for producing the same effect by the use of small bobbins are often used, but it does not appear that there is any special advantage over the above plan.

Net weaving is an extension of the same kind as gauze weaving, and therefore more complicated. In fact the whip thread is made to pass over much wider distances than in gauze weaving, where it is confined to the space of one dent only. To accomplish this effect the whip douples are placed in front of the reed, and not at the back, as in gauze, consequently they form a mass of complicated harness apparently impossible to use. To give an idea of this class of work, which is now perhaps completely superseded by lace-work, Figs. 213 and 214 show an elevation and plan of a fair specimen of net-

work. The reed *R R* is shown in front of the gauze harness *H¹* and *H²*, and at the back of the whip threads forming the figure. The tying up of the harness is shown at *T*, where the connexions between the treadles and headles may be seen represented in the usual manner. The Figs. 213 and 214 are taken from Murphy's excellent treatise on weaving.

In all figured gauze weaving it is evident that those threads



which are twisted round the others must be used in greater or less lengths according to the amount of twisting. In arranging the loom, therefore, means must be provided accordingly for separate bobbins or small warp beams to be used. This matter was alluded to in the description of the damask loom, Fig. 126, and we shall now show how these small warp bobbins or beams are weighted so as to throw a constant tension upon the threads, and allow of various lengths of thread being used.

There are several ways in which this can be effected, but we give three, viz., Figs. 215, 216, and 217. In each figure a front and an end view is shown.

Fig. 215 shows the plan adopted in the loom Fig. 126, where each bobbin is provided with a groove, round which is wound a cord to which a weight *w* is attached. When the warp thread *c* is

unwound it draws the weight w upwards, until it falls over the top of the pulley and resumes its former position, which is shown at w

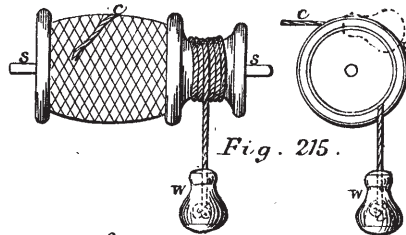


Fig. 215.

and w' . The weight thereby always causes a strain upon the warp thread, and the plan is a very effectual one. The bobbin is supported on the spindle s , which is of wire and is passed through the bobbin.

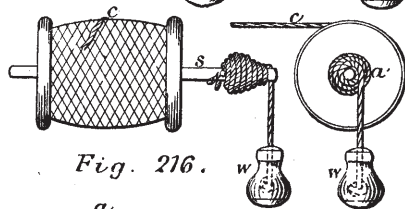


Fig. 216.

In Fig. 216 the cord is coiled on the spindle, and instead of being carried over the top of a pulley the cord slips off the end of the spindle, as at a . This plan also causes a constant tension upon the thread c .

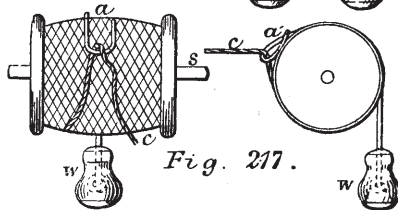


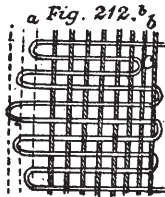
Fig. 217.

The plan Fig. 217 is more adapted for coarse or stronger threads, such as are used in carpet weaving. In this case the weight is attached to a

hook which rests upon the bobbin at a' , and the warp thread c being passed over it cannot be unwound without a constant friction and back-strain to take up the slack after each movement of the harness.

In recapitulation it may be said that gauze weaving merely consists in the employment of additional leashes to the ordinary leashes of the loom, and these leashes, which may be used in any required number, have the power to draw one or more warp threads across the path of one or more of the adjoining threads.

The selvages of ribbons are sometimes formed with loops either in a straight line or variegated. They are called "pearl edges," and are effected by means of temporary warp threads, of horse hair or of wire. Fig. 212 b shows a portion of a selvage so woven; at b the permanent warp threads are shown as woven into the cloth, but at a the warp threads are of short lengths, in fact horse

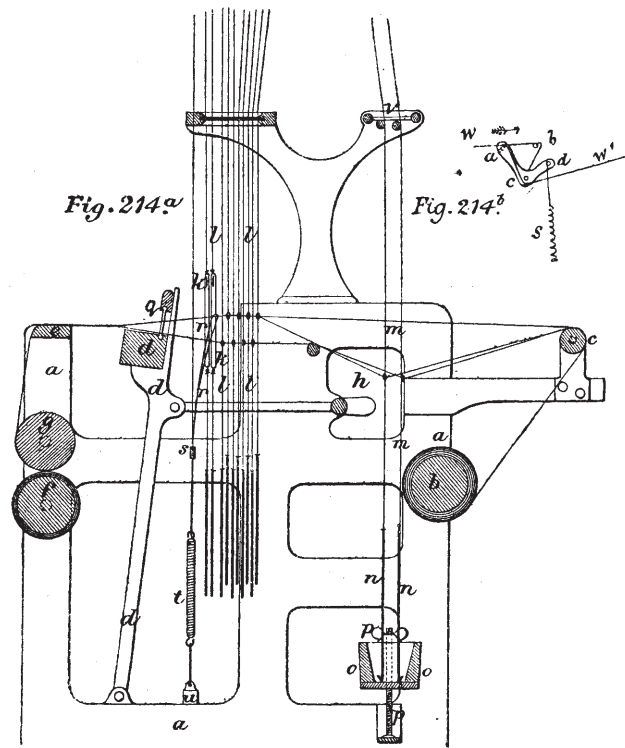


hairs. They are raised to intercept the weft in any way desired, and as one end (at the back of the headles of course) of the hair is

made fast, the cloth draws itself away from the other end as it is woven—the hair merely being held in the cloth for a few inches only. It will be evident that many uses may be made of false or temporary warp threads, as in fringe weaving.

In the description of the Levers Lace Frame another variety of temporary warp thread is shown, called a “lacing thread.”

As an example of the application of cross weaving to the power loom, Fig. 214 *a* represents a harness for fancy weaving, patented



December, 1876, by Mr. Aldred, of Macclesfield, and is for “a special style of fancy weaving by which three or more fabrics may be produced by one operation, viz. plain, leno, float, or twill in geometrical or other patterns, or figures.”

In the section of the loom shown, *a* represents the framework of the loom; *b*, the warp beam; *c*, the back bearer; *d*, the batten; *e*, the breast beam; *f*, the cloth beam; *g*, the take-up roller; *h*, the crank shaft. A single or double lift Jacquard machine may be used, the front row of hooks being attached to wire couplings *k*, and the

middle runs attached to the cords *l*, to work the brocade portion of the harness. The back rows are attached to work the cords *m*, connected to the mails of the elastic cords or tensors *n*, fastened to the frame *o*, which is adjusted by the screw *p*.

Only one warp beam *b* is used for the whole warp, and vibrators are dispensed with, as well as compensating shaft, &c. The warp is drawn through the Jacquard harness singly, and through the reed *q*, two or more threads in each dent. Half of the warp is drawn singly through the mails of the tensors *n*, and through a portion of the brocade harness, and the other half is drawn through the other portion of the brocade harness. This portion works freely between the other mails, the ends passing through the mails of the tensors, and also through the slip healds *r* of the fine wire couplings *k*, one or more in a group; so that when leno is made, one or more of the elastic cords are raised, and one or more of the corresponding wire couplings, and so reverse the crossing from right to left by lifting the next end or ends, which pass freely between the mails.

The slip healds *r* are connected to the shaft *s*, which is lifted at every pick of the loom to ease the warp, and is again tightened by springs *t*, connected to the shaft *s*, and fastened to a rod *u*. The groups of threads are drawn in through the slip healds (doups), as in ordinary cross weaving, so that any number of leno threads may be crossed to the right or left of the ground thread next to it, so as to form leno or open lace fabric.

The fine wire couplings through which the double or single loops of the slip healds are passed are used instead of the ordinary mails, thus saving any sticking of the leno threads, and so preventing the breakage of the warp.

To keep the leno threads at a proper tension, whether crossing or not, they are passed through mails attached to the cords *m*, which pass through the horizontal reed *v*, and connected to the elastic cords *n*, thus giving a direct action, and doing away with cranks and even compensating bars and weights.

Mr. Aldred claims: 1st, the fine wire couplings in connexion with the slip healds; 2nd, the elastic cord tensors; and 3rd, the general arrangement, &c.

It will be evident that in many cases the whip thread, as in lappet work, will be used in greater lengths than the warp threads round which it is drawn, therefore not only has a greater supply of thread to be given, but the slackness must be taken up, or a proper elastic

tension put upon it to suit the various motions. This is done in other ways besides those shown in Figs. 191, 192, 215, &c., the most common, when a number of threads are used, being the vibrator shown in Fig. 162 *b*, which is simply a shaft provided with arms at each end to carry a rod. The threads are passed under the shaft *e*, and over the rod *a*, so that by means of the spring *s*, a constant tension to take up any slackness is thrown on the threads, as shown by the direction of the arrow and dotted lines, showing the threads to be moved from *a* to *b*.

CHAPTER XVIII.

PILE FABRICS—VELVETS—CARPETS—CHENILLE, ETC.

THIS class of weaving includes velvets, Brussels carpets, fustians, &c. It consists in the formation of loops on the surface of the cloth, and if the loops are cut through they form a brush-like surface to the cloth known as velvet. If the loops are left uncut, similar to the loops on Brussels carpets, then it is known as terry velvet.

The loops may be formed either by means of the warp threads or the weft threads, and they are called the pile.

The richest description of velvet made, with the exception of Dutch, Genoese, and specially made velvets, is known as "collar" velvet, for gentlemen's coats. The pile threads are of silk, but the weft is often of cotton, and velvets so woven are said to have cotton backs. Cotton makes the body of the cloth firm and suitable for the purpose, so that the inferior material is not used on the score of economy alone.

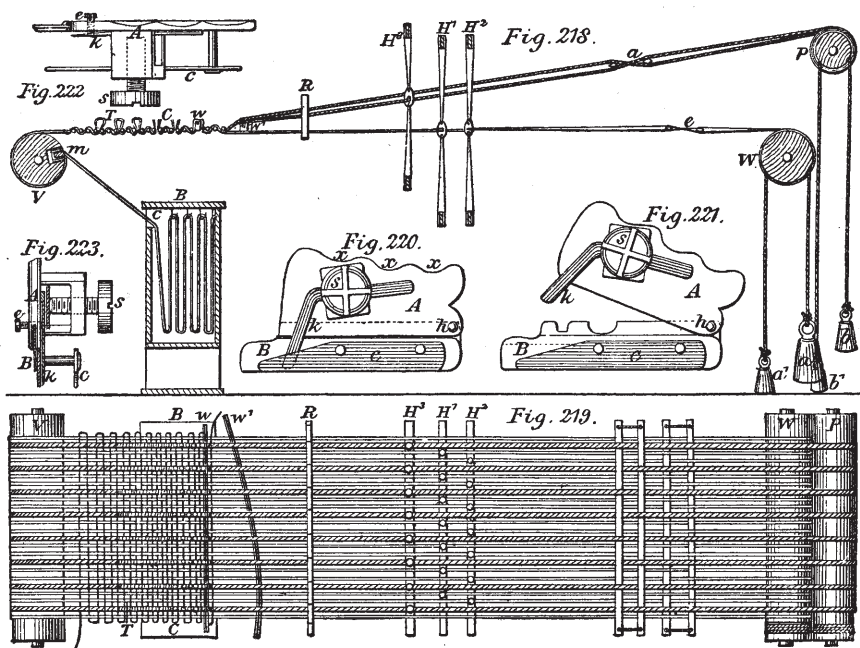
Of velvet nothing is known as to its origin. The oldest is the beautiful crimson cape embroidered by English hands in the 14th century, and now kept in the College of Mount St. Mary, Chesterfield. It is attributed as well as satin to Central Asia or China, the earliest place to weave it in Europe being the south of Spain. Yet the name "Velluto" is said to point out Italy as the market through which it was got from the east.¹

Velvets of this kind are woven in hand looms of the ordinary description, as far as concerns the harness of the loom. But it provided with two warp beams, one for the pile threads and one for the ground. The cloth beam is provided with a peculiar contrivance, for the velvet as it is woven must not be wound like ordinary cloth upon the beam or it would "lay" or crush the brush or pile threads. Consequently when the velvet has nearly completed one revolution of the beam the cloth is unfastened and again attached to the beam.

¹ Rev. Daniel Rock.

As it is a very slow and tedious class of weaving, only about a yard a day being made, this unfastening of the cloth does not consume so much time as it would do if repeated often.

Let Fig. 218 represent a section of a velvet loom, showing all



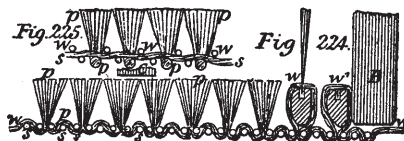
the working parts necessary, but omitting the framing. *W* is the ordinary warp beam supplying the threads for the body of the cloth. *P* is the "pole" (corruption of pile) or the pile beam, which contains the pile threads. *V* is the cloth beam, showing that it has made three-quarters of a revolution, and *B* is a closed box to contain the velvet as it is unwound from the beam. At *T* will be seen loops rising from the surface of the cloth, and at *C* the loops are shown cut through at their upper surface. These loops are made by inserting thin wires into the shed, which are beaten up with the cloth similar to ordinary weft threads. One of these wires is shown thus woven in the cloth at *w*, and at *w*¹ another wire is being inserted.

Now between each insertion of the wires three shoots of weft are thrown into the cloth, and well beaten together, otherwise the pile threads after they were cut would draw out. Fig. 219 shows a plan of Fig. 218, and the same letters and numbers refer to each. In the plan the wire *w*¹ is shown placed in the shed of the warp, and will be

driven up by the reed *R* in the same manner as the wire *w* has been. When both wires have been firmly bound into the cloth by the weft threads, the first one is cut out by means of a knife fixed into a frame and called a "trevette," and it is again inserted. Thus only two wires are used, and they are cut out alternately by means of the trevette. The instrument is well suited for the purpose, and when it is considered that the wires are inserted from 50 to 60 times, and upwards, per inch in length of velvet woven, and three times that number of weft threads, it will be evident that great exactness of the operation is necessary, or the slightest error or carelessness would cut the warp threads out of the loom—a circumstance by no means unknown to most velvet weavers. The wires, which are made with a fine groove for the point of the knife to enter, are very truly made, and the blade of the trevette must be "as right as a trevette," or such beautiful work as velvet could not be produced.

Figs. 220 to 223 show the trevette. The knife *k* is fixed into a frame *A*. This frame is hinged to another frame *B* at the point *h*, so that the weaver can open and sharpen the knife easily. The knife is held firmly by the screw *s*, and at the back of the frame a small adjusting screw *e* is placed to regulate the distance of the knife from the steel frame *B* against which it is placed. See Figs. 222 and 223. The frame *A* is of brass, but all the rest is of steel. The indentions *x x x* are for the fingers to fit in, a requisite precaution to insure accurate hold of the instrument.

The use of the trevette is shown in the enlarged sketch, Fig. 224,



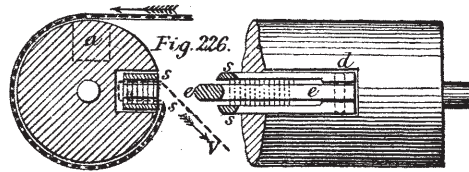
in which the knife edge is seen entering the wire *w*. *B* and *C* are the bottom portions of the trevette, and rest upon the warp and cloth as shown. The trevette is held in the right hand, and drawn from the left to right. It is pressed against the flat side of the outside wire *w'*, which forms the guide or fence, and the knife is regulated to fall into the groove of the inside wire *w*. When upwards of sixty insertions of the wires per inch are made, an idea of the perfection of workmanship required for the purpose may be realized.

About six times in length of the pile threads are used to what are

required for the "back," which, of course, arises from the formation of the loops. Much less strain is also put upon the pile threads by the use of smaller weights, as shown at *b* and *b'*.

The wires, see *w'*, Fig. 219, are slightly curved, for they are better in this form for the weaver to insert, for he glides them upon the convex side through the shed, and being curved also insures that the right side of the wire—the grooved edge—is always uppermost. The wires being only about $\frac{1}{30}$ in. deep, are easily driven straight by the reed. They are made of brass wire about the size of an ordinary pin, and recover their curvature after being driven straight by the reed.

Fig. 226 shows the cloth beam with one of the many contrivances



for holding the velvet. A large slot is cut in the beam, and three strong laths are placed into it. The middle lath *e* has a number of needle-points, about $\frac{1}{4}$ in. apart, fixed through it, these points extending to the side laths *s s*, as shown in the figures. Now the velvet is pierced by these needle-points and held fast, as may be noticed by tracing its course shown by the dotted lines. The side laths are hollowed out to allow space for the velvet.

After leaving the beam the velvet is hung up by means of pin hooks in the box *B*, Fig. 218, which keeps it free from injury. The warp and pile threads may be traced in the figures as well as the weft. The headles, Figs. 218 and 219, shown at *H*¹ and *H*², work the ground or warp threads by raising each half of the threads alternately as in plain weaving. The headle *H*³ raises the pile threads at every fourth change.

Singular as it may appear, when the work is taken from the loom the weaver frequently places it upon a table, and by means of a sharp common razor literally shaves or mows the whole surface of the pile, in order to remove any stray filaments of extra length and improve the face of the cloth. Or it may be shaved in the loom.

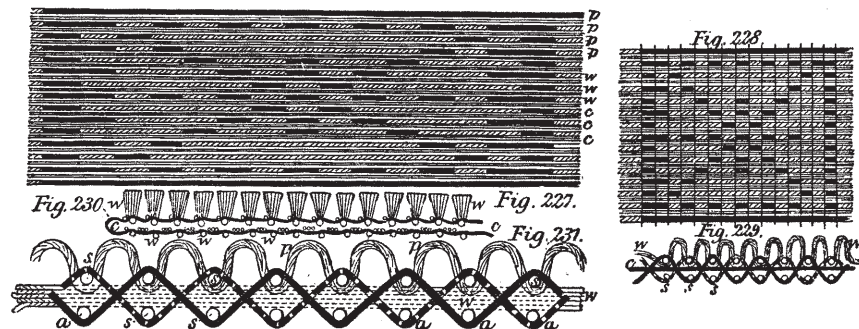
Fig. 225 shows a section of the velvet through the line of warp threads, in which *s s* is the weft, *w w* the ground or warp threads, and *p p* the pile. Fig. 224 is a section at the side of the cloth, and

the letters refer to the same parts. In these figures the actual formation of the cloth is represented, excepting that the pile threads are usually made thicker or doubled.

Brussels and other pile carpets are made upon the same principle as the velvet above described, but generally the pile is not cut, consequently round wires are used instead of grooved ones, and they are drawn out from the side of the cloth.

There are two descriptions of Brussels, one in which the pile threads have had the pattern printed upon them previous to weaving, and the other in which the threads are used dyed in separate colours.

The first kind is known as tapestry carpets, patented in 1832, by Mr. Whytock, of Edinburgh, and forms a comparatively simple and cheap manufacture when compared to Brussels carpets. Let Fig. 227 represent the warp and pile threads with the pattern printed



upon the pile threads. The pile threads are marked *p p* and the ground threads *w w*, these lying between and under the pile threads. About five of these warp or ground threads are used to each strand of the pile, which may be seen in section Fig. 230. Now when the threads are woven together the pile is contracted to nearly one-third of its length in consequence of the loops, and the distorted figure, as printed, becomes of the intended proportion. Thus Fig. 227 becomes, when woven, Fig. 228.

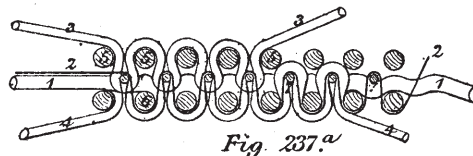
A section of the cloth is shown in Fig. 229, and in all the figures 227 to 230 the same letters refer to the same parts. The threads *c c* do not intersect with the weft, but merely lie between the warp threads *w w*, and form a bed or ground for the pile to rest upon. The wires used are generally six or more in number, for if only two were used the loops would scarcely resist the strain of drawing the wire, the greater number causing greater firmness to the cloth to

resist the strain. Brussels carpet is a very different affair. A great variety of threads of different colours are required, and they are selected by the action of the Jacquard machine to form the pattern. They are wound upon separate bobbins, for each colour is used in various lengths. See Fig. 217.

Let Fig. 231 represent a section of a Brussels carpet. The threads *a a* are the warp threads, and *s s* the weft. Where there is only one thread in the tapestry carpet there are five or six in the Brussels; thus the five threads are shown at *w w*, and as the various colours are required they are drawn to the surface to form the loops whilst four-fifths of them remain in the body of the cloth. The great number of pile threads, and being made of wool and not of hemp, as the warp and weft are, causes the Brussels carpet to be much thicker and softer, the colours brighter, and altogether a superior fabric to the less costly tapestry, as the difference in price attests.

In Cochrane's carpet loom (1874) the wires are inserted and withdrawn from opposite sides of the loom simultaneously, and increased speed is claimed for this invention.

Various combinations of the warp and weft for the production of new kinds of fabrics are frequently patented. Fig. 237*a* is a section of a double faced carpet patented by Mr. Webster and Mr. C. Meserole,



of New York. The wires shown at 5, 5, are for forming the pile on one side of the cloth, and 6, 6, is the thick filling on the other side. The coarse warp is shown at 1, 1, and the fine at 2, 2. The top worsted warp is shown at 3, 3, and the bottom at 4, 4. The fine weft or filling is shown at 7, 7.

The body of the Wilton carpets is made similar to a Brussels, but the pile is cut as in velvet weaving. "Kidderminster" or "Scotch" carpets are not pile fabrics, but are made similar in principle to that of double cloth.

Mr. C. Dresser, in his treatise on carpets,¹ observes that "the Egyptians made their carpets by picking out from a piece of coarse linen, which was already woven, certain weft threads, and by sewing

¹ Published by Mr. Stanford, 1877.

tufts of coloured worsteds to the warp threads, sufficient of the weft threads being allowed to remain to knit the warp threads together. Some of the simple kinds of cotton carpets of India are formed in the most primitive way, but these are without 'pile' of any description. Warp threads are placed horizontally, and the loom is without treadles or reed. The weft threads are thrown across by the weaver, and are brought together by a small hand comb. A similar loom, only placed vertically, is employed for the production of certain Indian carpets which have a looped surface, and some of the richly figured cotton carpets from Wurringal, Deccan, are wrought in this simple manner, every loop of the variously coloured cottons being brought up by the hand of the weaver. In such cases he has the drawing of the pattern by his side; but by much practice he is enabled to form the designs without reference to it. Persian carpets, whether wrought in Persia, India, or elsewhere, are formed upon a vertical frame, on which warp threads are arranged. Upon these tufts of woollen yarns are knotted, and over each row of these tufts a wool thread is passed to bind them. Turkey carpets are made in the same manner, and so are French tapestries; only in the latter a 'shuttle needle' is used in attaching the woollen threads to the warp. The manufacture of Axminster carpets is a mere modification of the Persian method, for the worsteds are only knotted to the warp threads. They derive their name from a town in Devonshire, but the seat of manufacture has long been removed to Wilton. The first seat of the Brussels carpet manufacture in England was at Wilton, where it was introduced from Belgium about a century ago. Kidderminster now supplies the great majority of such carpets, although they are made at various other places. Wilton carpets are similar to Brussels, except that the pile is cut as in velvet weaving. Brussels may be made of five or six threads or frames, but it frequently happens that portions of the threads are cut out and not bound in the body of the cloth, in which case the carpet is reduced in substance and quality."

Both cut and terry velvets are now woven in power looms, and the various methods adopted for the purpose may be best understood by the following diagrams.

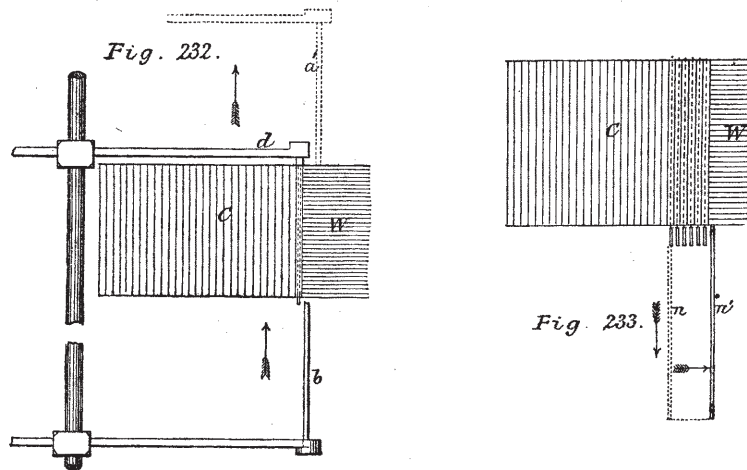
Fig. 232 shows one of the first attempts at weaving terry ribbons by power, patented by Mr. Thompson, of Coventry, in 1842, but only one ribbon is represented, that being sufficient for the purpose. In this instance two wires or "tags" are used. They are fixed into side levers, and are regulated and moved to follow the motion of the

cloth. In the diagram *W* is the warp, *C* the cloth, and *a* and *b* the velvet wires. The wire *b* has been withdrawn, and advanced to the front of the wire *a*, ready to be inserted again into the shed. The wire *a* is then withdrawn, and moved in a corresponding manner, as shown by the dotted lines *a'*. Thus the wires are woven into the cloth and withdrawn alternately.

But this plan was found defective from the circumstances before alluded to, namely, that two wires are not sufficient for weaving terry velvet fabrics. Many attempts were, therefore, made to use several wires, and at last with success. Fig 233 shows the plan patented by Mr. Collier, of Halifax. In the diagram *W* and *C* represent the warp and cloth, into which a number of wires are placed. The outside wire has been withdrawn from the cloth and moved to the front, to be again used, as may be traced by the dotted lines and arrows at *n* and *n'*

This motion really follows the action of the weaver in the process when the hand loom is used for the purpose.

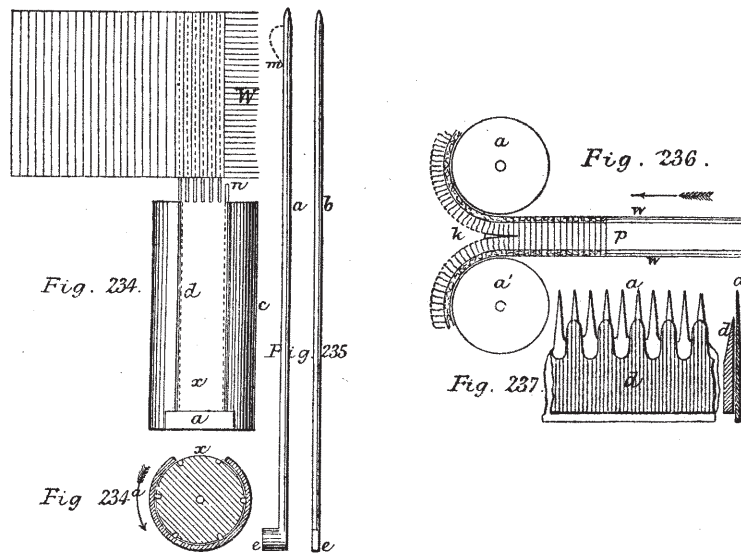
In 1855, Mr. Weild, of Manchester, took out a patent for an in-



genious and effective plan for inserting and withdrawing the wires, which is somewhat similar in its action to the circular shuttle boxes used in power looms. Mr. Weild places a cylinder at the side of the loom, upon the surface of which several grooves are cut for the reception of the wires. Now the distance between any two of the grooves corresponds to the distance between the first and the last wire in the cloth, consequently by means of catches and a slide the wires are

inserted and withdrawn at each intermittent motion of the cylinder. This will be understood better by reference to diagram Fig 234, which is a plan, and Fig. 234 *a*, an end section of the cylinder. It will be seen the cylinder is enclosed in a tube, the upper surface *x* of which is left open, so that the wires can drop into the grooves, and then be carried round to the front of the cloth as required. A carrier or slide *a* provided with catches, &c., pushes and draws the wires at the appointed times.

Fig. 235 shows one of the wires in two positions *a* and *b*. They have, as in Mr. Collier's loom, a flat wedge-shaped head at one end,



for the purpose of holding it in position and for the catches to take hold of during the various movements.

In both cases, Figs. 233 and 234, the wires are for weaving terry velvet; but wires are used with a thin knife-edge fixed upon the end, as shown in dotted lines at *m*, Fig. 235, when the velvet is intended to be cut. On withdrawing wires of this kind the knife cuts the loop. This plan of cutting the pile is an old French invention, used for cutting the pile of coach lace, and making rugs.

Another class of velvet and plush weaving very often used is to weave two pieces of cloth one above the other, and the pile threads, passing from one piece to the other, connect them together. If these threads are cut, then two pieces of cloth with velvet surfaces

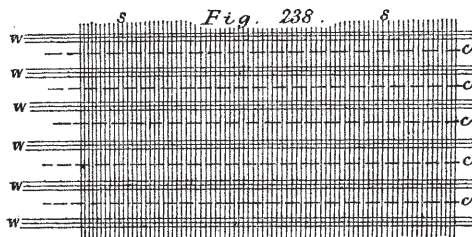
will be produced. Fig. 236 shows two warps w and w' , with the pile threads p passing from one to the other.

At k there is a thin knife-blade, which is made to move rapidly between two beams a and a' , and as the cloth is woven and advances, the pile threads are cut and the two separate pieces are wound upon the beams. Mr. Lister, of Bradford, has done much to bring this kind of loom to its present perfection. Instead of a knife or blade being used, a plan of burning the pieces asunder by means of a platina wire heated by electricity has been patented.

In double velvet weaving there has been one great difficulty to contend against, namely, to keep the two pieces of cloth at an equal distance apart. To do this an exact supply of pile thread, and of one given tension, must be supplied at each shed of pile threads, otherwise any additional strains would draw the two pieces nearer together, and the pile would be irregular. To prevent this sometimes wires are inserted at short intervals, which act as distant pieces, but their use is evidently undesirable.

The cutting-knives are of various kinds, and are sharpened on stones as they pass over the sides of the loom in their rapid movement. A knife similar to the serrated blades of a mowing machine has been patented by Messrs. Shaw, Ditchfield, and Knowes, the long teeth of which enter between the two pieces, whilst the lateral movement of the top blade cuts the pile threads. See Fig. 237, which shows the movable blade d upon the fixed blade a .

A modification of pile weaving is made by using chenille weft. Chenille is a fringed thread, and when used as weft, the filaments of fringe protrude through the interstices of the cloth, and produce a



fur-like surface on the cloth. Fig. 238 shows a simple method of making chenille, which is weaving a piece of cloth with a small number of warp threads, and then cutting into strips as at c . The warp threads w , best woven as gauze, bind the weft threads s together, and when twisted form a cord, as at Fig. 239, which, when

woven in the cloth, appears as at Fig. 240; but it is woven in conjunction with ordinary weft according to the cloth required.

Messrs. Tomkinson and Adam, of Kidderminster, obtained a patent in October, 1876, for an improved chenille loom, in which they use two treadles only instead of six, as previously used. By this means they open three sheds at one time, consequently there is much less friction on the warp.

Fig. 240*a* represents a section of their loom, in which there are four warp beams. Now, the warp threads shown in dotted lines remain stationary, and are not moved by the treadles, for they pass through the headles secured to the brackets *E*, excepting at the completion of the rug or piece, when the plain cloth forming the hem of the fabric is woven, when the upper warp threads are lowered to the level of the lower warp shown in dotted lines.

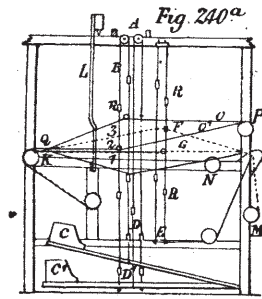
By this means three sheds, 1, 2, 3, can be opened, and the different warps may be made to intersect each other in various ways by means of two treadles *c* and *c'* only. The two uppermost warps, *o o*, are the pile binding warps, and *h* the ground warp; *q*, the spike roll; *L*, the batten; and *k*, the chenille fabric.

The system of forming two sheds and using stationary warps has long been applied, and three sheds are used in elastic web looms, where they are of great advantage. See Figs. 264, 331 to 333, and 344 to 350.

Two or three tiers of shuttles can be thrown simultaneously in narrow looms without difficulty through two or three sheds, and in hand looms they may be thrown separately. In power looms for carpet weaving, &c., with two sheds, it becomes a more difficult question, for a temporary race must be made for the upper shed or sheds.

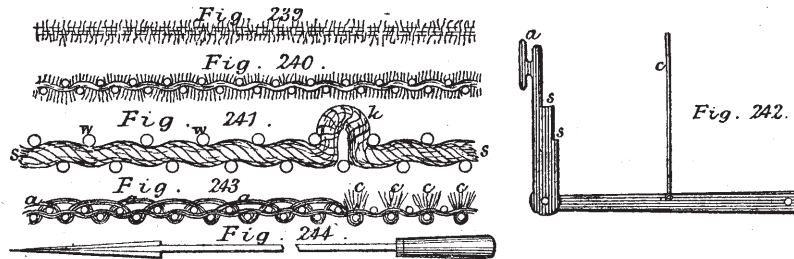
In Webster's loom (1872) a temporary race is formed by means of "fingers," inserted and withdrawn at proper times, and two shuttles may be thrown separately or simultaneously.

Fig. 241 shows one method of raising the loops or "knobs," as they are called, on counterpanes, in which *k* represents one of the knobs. It is formed by means of small levers with slots in them to raise the weft thread. Fig. 242 shows the notch or slot at *a*, and *c* is the cord attached to the Jacquard to raise the thread where



required. A number of these levers are used, but they are only raised at long intervals. The plan shown was patented by Mr. Myerscough in 1840. The steps *s s* are stops to regulate the height of the loop to be raised.

Figs. 243 and 244 show the method of fustian weaving. It was

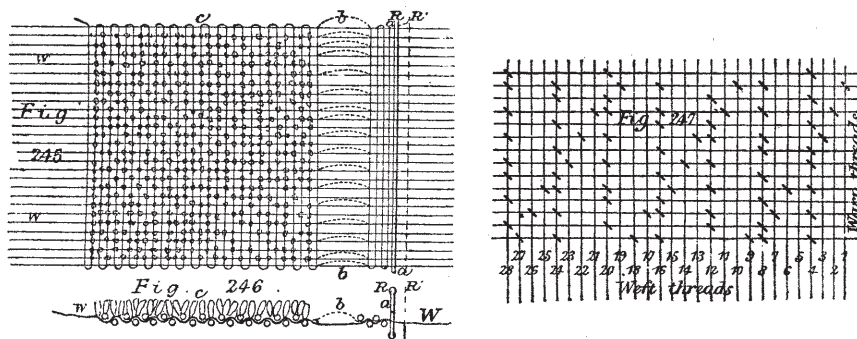


woven so early as the thirteenth century, and was made for under sheets for bed-clothes. The pile is merely the floating weft threads *a a a* woven to form loops parallel to the warp threads. After the cloth is woven it is placed upon a table, and by means of a long rod, at the end of which is a sharp blade, the loops are cut by inserting the point under the loops, and pushing the blade rapidly forward by hand. The loops are shown cut at *c c c*. There is a guard placed on the lower side of the knife to prevent it piercing the cloth. See Fig. 244. Many attempts have been made to cut fustian by machinery, but it is attended with many difficulties, and is still done by hand, the work being carried on in the small towns and villages in the neighbourhood of the manufactories.

The system of cutting fustian was invented nearly four centuries ago, for in 1494 an improvement was introduced in the manufacture of fustians, which at that time were brought in the rough state from abroad and finished here. An Act says, "fustians brought from beyond sea should be the most profitable cloth for doublets and other wearing cloths used by the common people of this realm, and formerly they were truly wrought and shorn by the broad shear and no other deceitful means. Now, diverse persons have with undue sleights and means imagined and contrived instruments of iron, with which irons, in the highest and most secret parts of their houses, they strike and draw the said irons over the said fustians unshorn, by which means they pluck off both the nap and cotton of the said fustians, and break commonly both the grounds and thread asunder; and after by crafty sleeking they make the same fustians appear to the common people fine, whole, and sound. And also

they raise up the cotton of such fustians, and then take a lighted candle and set it in the fustian burning, which singeth and burneth away the cotton from the said fustian from the one end to the other down to the hard threads, instead of shearing; and after that they put them in colvers, and so subtly dress them, that their false work cannot be espied without it be by workmen shearers, or by weavers of the same; and so by such subtleties, whereas fustians made into doublets were wont and might endure by the space of two years and more, will not endure now whole by the space of four months, to the great hurt of the poor commons and serving men." Shearing only was to be practised.

A system of raising pile threads without the aid of wires is also adopted for weaving towels, &c. See Figs. 245 and 246, showing a plan and section of this kind of weaving. *W* is the warp, *C* the



cloth, *R* the reed. There is seen at *a* next the reed a few insertions of weft at little distance from the body of the cloth. Now, by slackening the pile beam, and forcing the batten forwards, loops will be formed, as shown at *b*, where the reed has moved from *R'* to *R* in its progress towards the cloth.

Thus a few shoots are woven in to bind the pile threads, and then by carrying the batten forward, the pile threads are carried forwards, but not the warp threads, which remain intact.

In order to raise the pile threads for the production of particular kinds of fabrics, numberless plans are used for the purpose, and the tie-up or draughting of the pattern is sometimes patented. Thus, Mr. Smith, of Ripponden, patented in 1873, amongst other designs, "a pile produced by the weft firmly secured, so that the cutting and dressing does not loosen the pile, and the fabric will be equal to seal-skin." Fig. 247 is a copy of that portion of Mr. Smith's design.

CHAPTER XIX.

THE DUTCH LOOM—THE BAR LOOM.

THE common hand loom for weaving ribbons was formerly known as the Dutch engine loom, and it was also called the swivel loom. Before it was invented, ribbons were woven in small looms, and only one ribbon was woven at once. But by means of the swivel loom from 8 to 10 or 30 to 40 ribbons, according to their width, could be woven, consequently it was an invention of great importance, and its introduction caused a considerable amount of trouble, as will be presently seen.

More than a century ago, and long before Dr. Cartwright's time, the swivel loom had been made self-acting, for all the principal operations of the loom were made automatic. The shedding of the warp, throwing the shuttle, and beating the weft together were effectually accomplished by means of cranks, tappets, &c., almost in the same manner as used at the present time.

These improvements appear to have been carried out both in France and England, at about the same time. They really formed the first successful application of power to work the loom instead of the usual operations of the weaver. In fact, the history of the swivel loom, and the application of the bar, &c., to it, is the history of the first successful attempts at power-loom weaving, and on that account it deserves more than usual attention.

The "bar" loom, or the "a la bar" as weavers often call it, was introduced in the following manner, according to the evidence of Dr. Bowring before a select committee on the silk trade in 1831—1832. The question asked was, "Whether the bar loom had been introduced subsequently to the Jacquard loom, and if its introduction had met with similar difficulties?" His reply was, "Yes; that it was a Swiss invention, and it was taken into the neighbourhood of St. Etienne by two brothers, who were themselves persecuted and abandoned to extreme misery; the last of them died not long ago,

in a hospital, in consequence of the obloquy and neglect to which he was subjected. Since then the use of the bar loom has become nearly universal in the immediate neighbourhood of St. Etienne."

According to this evidence the loom was introduced in the early part of the present century, or since the introduction of the Jacquard loom. But both of the great French Encyclopædias, Diderot and D'Alembert's, and the "Encyclopédie Méthodique," give detail drawings of the loom thirty years before that time. Therefore Sir John (then Dr. Bowring) must have been misinformed on the subject.

It will be preferable to give the history of the Dutch loom first, and then refer to what is known concerning the improvements made in it. For this purpose Beckmann's account is more than usually clear and interesting, from which it appears "that it is probable the ribbon loom had its rise in the Netherlands or Germany, either about the end of the 16th or the beginning of the 17th century, although Mr. Jacobson believes the Swiss invented such looms. The oldest account with which he was acquainted seems to be in favour of Germany and the 16th century.

"Lancellotti, in a work published at Venice in 1636, says, Anthony Möller, of Dantzic, relates that he saw in that city about fifty years before a very ingenious machine, on which from four to six pieces could be wove at the same time; but as the council were afraid that by this invention a great many workmen might be reduced to beggary they suppressed it, and caused the inventor to be privately strangled or drowned. Who this Anthony Möller was I do not know; but that he saw a ribbon loom at Dantzic is beyond all doubt. If the date of the printing of the book be taken as the time in which Lancellotti wrote, there is reason to believe that there was a ribbon loom at Dantzic about 1586; but it appears to me that the book was written in 1629, which would bring us to the year 1579."

"The next oldest information," continues Beckmann, "with which I am acquainted is that given by Boxhorn, who says, 'About twenty years ago some persons in this city (Leyden) invented a weaving machine, on which one workman could with ease make more cloth than several others in the same space of time. This gave rise to rioting amongst the weavers, and to such loud complaints that the use of the machine was at length prohibited by the magistrates.' According to this account Leyden was the place of its invention;