of the machine. The needle, as shewn at Fig. 155, passes through the needle board at the front exactly corresponding to the surface of the card cylinder seen in Figs. 154 and in section at Fig. 155. With this exception, the perforations in the needle board (see Fig. 155) are just sufficiently large only to permit the needles working freely backwards and forwards,

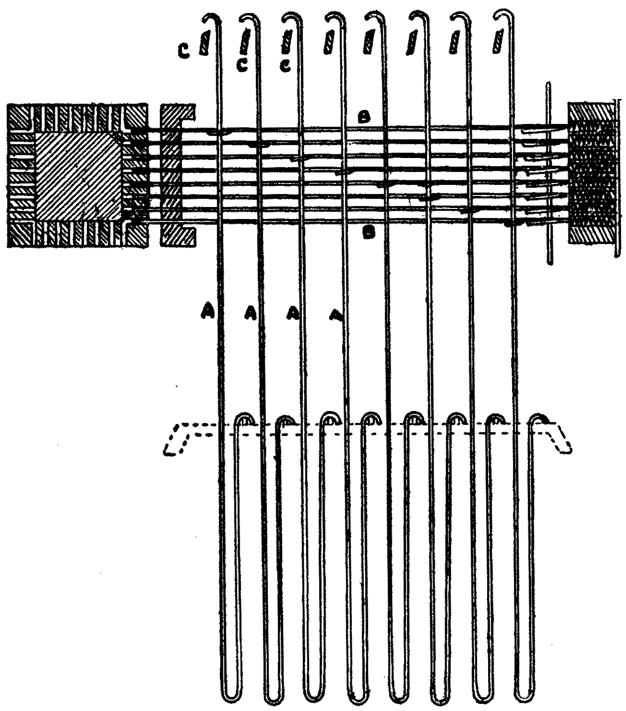


Fig. 155.

whereas the perforations in the card cylinder each have a diameter of about 1/8th of an inch, so as to permit of the needles entering them readily, even if the cylinder is not exactly accurate in its adjustment. The loop at the opposite end of the needle has a pin passed through it to keep it in position; and the spring is so arranged in a spring box that the needle, when pressed back by any card placed upon the card cylinder, will compress it, but immediately on the card being removed it will cause the needle to return to its normal position. Now we must see what the normal position of this upright hook is. A series of lifting blades shewn in section C, C, &c., (Fig. 155) are placed under the upper extremities of the upright hooks, in exactly the same manner as illustrated in the witch machine, and the hooks are always supposed to be over the lifting knives, unless struck back by means of the blank in the card, ready for being raised at each movement of the griffe or lifting knives. Suppose the machine contains 400 of those vertical hooks, they will be arranged as shewn here in rows of eight, and there would be fifty of such rows in the whole machine Now we must follow the method of numbering or the order of succession; beginning at the left and top needle we should call that No. 1, and they would be numbered consecutively from top to bottom as shewn in the illustration. The next row commencing at nine and following up to sixteen, and so each row in succession until the last hook would be numbered 400. It is imperative that this order of succession should be thoroughly understood at this stage, for although a great deal will have to be said about the mechanism required for operating the card cylinder, and raising the hooks as required, the vital part of the machine rests in this order of arrangement. Now refer to the Fig. 154 and it will be seen that near each extremity of the card cylinder there is a row of holes; those are supplementary for the purpose of working selvedges or any extra apparatus which may be introduced. Then will be seen two movable pegs the purpose of which is to serve to keep the card in position upon the cylinder. Then follow a series of rows of holes with a space in the centre, which will be explained more fully later. Suppose the face of the card cylinder, as seen in the illustration, to be really the needle board, of which it is a fac-simile, then the hole at the right-hand top will correspond with No. 1 needle, and so follow in succession downwards, the bottom will be No. 8, the next will begin at nine and end at sixteen; the next at seventeen and end at twenty-four, and so in succession until the bottom hole of the last row to the left will be No. 400: so that we have the order of succession of the needles clearly demonstrated. To prevent confusion arising here, come back to the cylinder itself. When the cards are placed upon the cylinder it is made to revolve so that the face of the card cylinder, which we see in Fig. 154, would carry its card to the top, and the next movement to the side facing the needles, so that that which is the bottom hole of the cylinder, as seen in the illustration, would become the top when the cards are brought opposite the needles or when the cylinder has made one-half of a revolution.

Before entering into the details of the mechanism of the machine it will perhaps be best to follow the methods of tying up the harness, because there are so many varieties of machine, each of which may be afterwards dealt with on its own merits, and without in any way interfering with the essential principles involved in the harness, and the method of producing patterns by its means. It will be remembered that in the witch or dobby machine each hook actuates a separate heald. For convenience we may suppose the harness really to represent a number of healds coinciding with the number of hooks in the machine, but instead of each heald having a pair of shafts the heald cords are carried direct to, what are termed, the neck cords of the machine, *i.e.* the cords which are attached to the hooks and passed through the bottom board of the machine, and seen lying upon the ground in the illustration, Fig. 154. To take the place of the heald shafts, what is known as the cumber-board is employed. The cumber-board consists of a series of holes, formed in rows in precisely the same manner as the needle board of the machine itself, but at greater or less intervals. A plan of the cumber-board is shewn at Fig. 156, which is simply a piece of solid board usually 5 to 6 inches in width and about 1 inch in thickness, with the holes bored just a sufficient

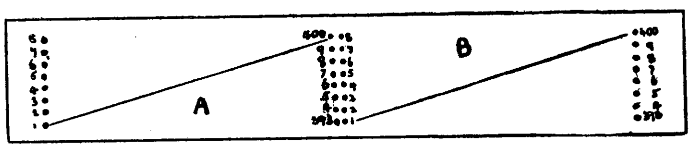


Fig. 156.

distance apart to determine the number of threads per inch. Suppose, for instance, it is desired that there should be 80 threads per inch then the 50 rows corresponding with the machine would occupy a space of exactly 5 inches or 10 rows per inch. If 100 threads per inch were desired, then the space occupied by the 50 rows would be 4 inches. It is necessary to bear this in mind as assisting us in

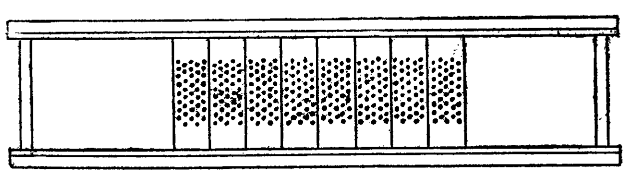


Fig. 157.

Fig. 158.

afterwards determining the question of what is termed casting out, or reducing the set or number of threads per inch.

One matter may be referred to here in reference to cumber-boards, namely, the frequency with which the cumber-boards are made in slips or loose divisions, so that they can be carried in a frame, as shewn at Fig. 157, and in sections at 158. One object of this is to enable the slips to be set out, or the harness expanded, so as to reduce the number of threads per inch, as shewn in the illustration Fig. 159. But there is obviously a limit to this power of expanding, for if the harness be made much wider than it is originally intended to be, the cords towards the edges will become too short, and instead of the mails forming a perfectly horizontal line they would form a series of steps, corresponding with each division of the harness, and increasing in depth towards the sides of the warp. A recent improvement has however been introduced and patented by Messrs. Devoge & Co., Manchester, which permits of the expansion of the harness, say from 32 inches in width to 40 inches, *i.e.* 100 ends per inch for 32 inches

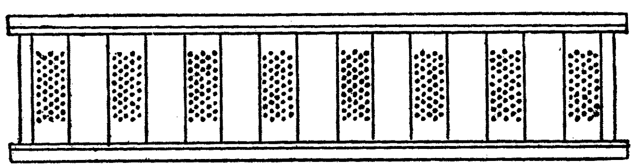


Fig. 159.

can be expanded to 80 ends per inch for 40 inches, or any intermediate stage and yet it is plain that the mails remain perfectly level. An illustration of this is given in Fig. 160, where two cumber-boards *a* and *b* are shewn, and the harness cords passing through both of them. The cumber-boards are about a foot apart, and taking the length of the harness into account the change in sett can be made without causing steps in the harness. The slips are set out, or made to occupy more space to reduce the sett, but the upper cumber-board should be carefully adjusted by setting out so as to neutralise the angle formed by the lower one; the length of the harness cord is suited to its position, and so as to enable the mails to be kept in a perfectly horizontal line. In any arrangement of this kind the slips are carried in frames as shewn in section Fig. 158, so that they may slide about freely, and small wedges of wood are put in to keep them in position.

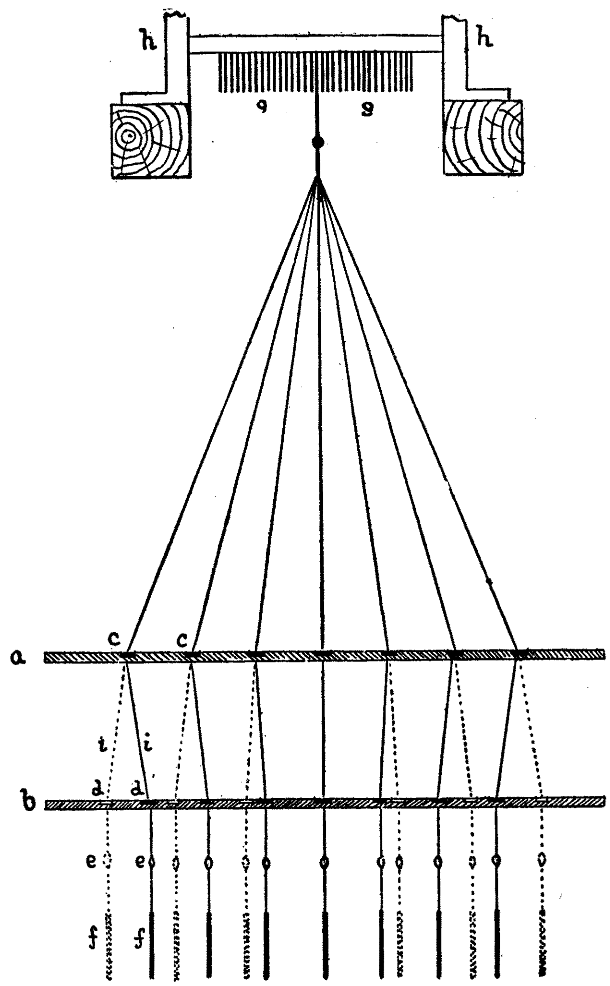


Fig. 160.

Now as to the plan of the harness, this perhaps will be best understood by making a plan of a cumber-board as shewn in Fig. 156, where a series of holes are bored in rows of 8 and carried up to 400 and then repeated as suggested. No. 1 cord or that coming from the first hook in the machine would pass through the hole No. 1 in the cumber-board and each in succession up to 400. Then a repetition occurs and these 400 would be repeated as often as necessary for the formation of the pattern or the width of the cloth. This would perhaps be best understood by the projection of two rows of hooks in the machine and the cumber-board as shewn in Fig. 161, where the harness cords can be traced direct from the hooks, each in its order of succession, and again being repeated in the second division. This division really represents the full extent of the pattern capable of being produced. The method of tying-up being what is known as the straight through tie-up, implying that as a set of healds represents the working of a continuous series of patterns in the ordinary course, so a straight through tie-up harness will represent a series of successions of the same pattern across the fabric. Now follow the cords from the neck in Fig. 161. No. 1 hook of the machine is attached to No. 1 harness cord, No. 2 hook to No. 2 harness cord, and so in order of succession up to 400, when, of course, repetition will occur.

One reference must not be omitted at this point to two distinct methods of tying-up the harness. When the machine was first introduced into England it was found difficult to operate it in the hand looms in consequence of the position in which the machine was placed in relation to the cumber-board. The machine was placed as illustrated in Fig. 161, with the short rows of hooks parallel with the short rows across the cumber-board, so that the harness would come straight down from the hooks to the cumber-board without the unnecessary crossing, but it was conceived that this was very inconvenient, so the working, and the position of the machine was altered; the rows of hooks in the machine being placed at right

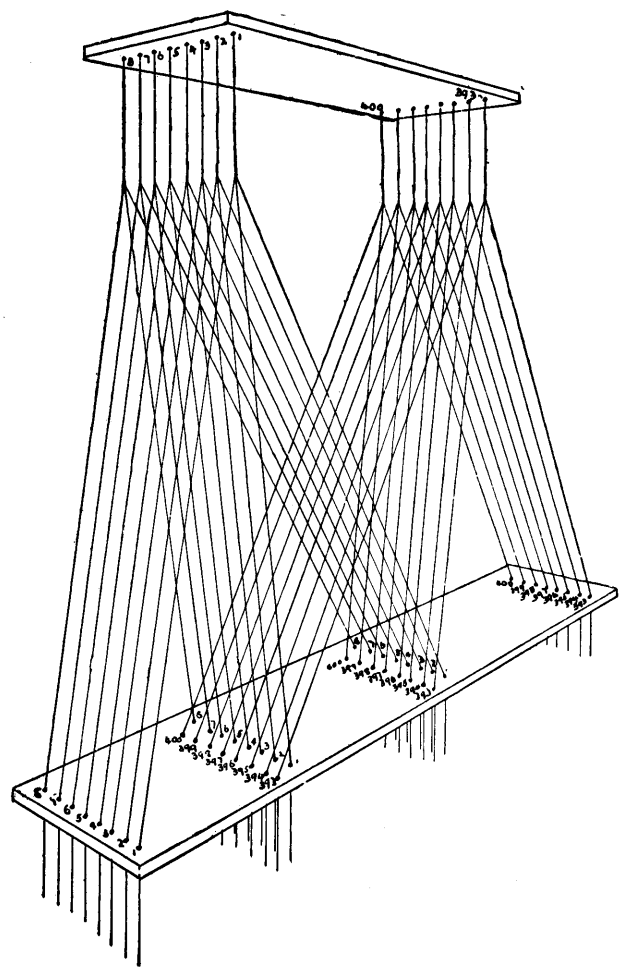


Fig. 161.

angles to those in the cumber-board, so as to permit the cards coming over the loom side and the treading lever over the weaver's head. The two methods of tying-up are known as the Norwich and London tie-ups respectively, the Norwich tie is in use in Bradford and district at the present day, but the London tie has remained in vogue in some districts, more especially where hand looms are employed, and although it has a disadvantage of considerable crossing of harness threads, and a corresponding wear and tear, is still very frequently used. With this method of tying-up the extent of the pattern is at once determined. Any figure may be made with each thread working separately and independently of the rest, to the extent of the 400 or any other number of hooks which the

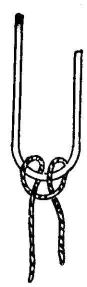
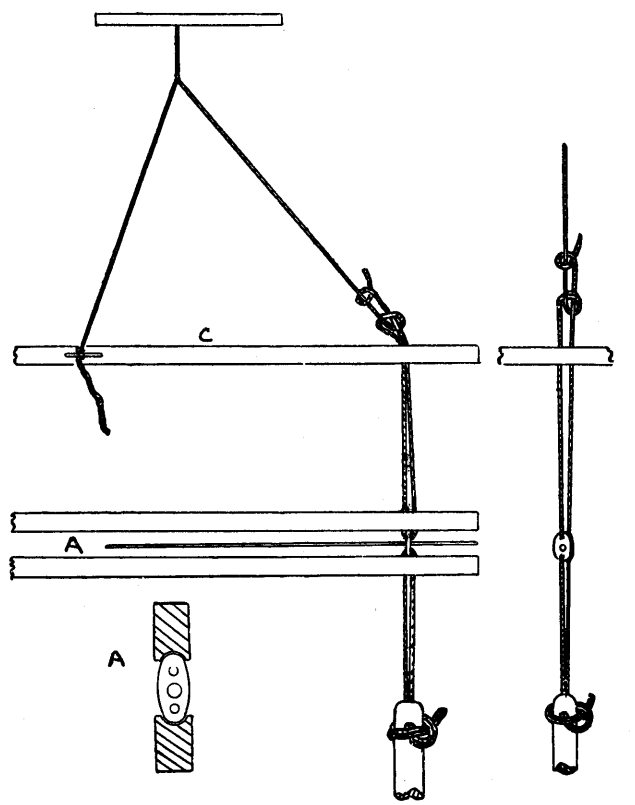


Fig. 162.

Fig. 163.

machine may contain, and would be repeated as often as necessary for the width of the fabric.

Before going further with the arrangement of the harness, something may be said upon the details of tying-up. I will endeavour to describe the method of tying as clearly as possible, because after all, a good deal hangs upon some of those trifling details. First, we have the neck cord passed over the lower part of the hook, and it should be done in such a manner as to ensure the least amount of wear and tear and the least liability to slip. The orthodox knot is shewn at Fig. 162. Then the neck cord is carried down to what is termed the neck of the harness. Here again a special knot is tied as shewn at Fig. 163, the advantage of this form of knot being in the first place that there is no liability to slip, and in the second place when a new neck cord is being put in the tension can be adjusted with at least a reasonable degree of accuracy. Then the formation of the neck itself is a matter of some importance. In reality the neck is formed by all the cords of the harness being brought together and wrapped and tied round in such a manner that no slipping can take place; and should the wrapping or tying of the thread fail it would become necessary either to make a new neck, which would be a difficult operation, or to put in a complete fresh set of threads. Now the neck having been made, consisting of a sufficient number of cords, the actual tying up of the harness commences. The machine is placed upon a frame, or gauntry, as it is termed, at the requisite height, suitable to the loom upon which it is to be worked. The cumber-board is placed in the proper position, and beneath that a rod carrying the lingoes. Now one word as to the lingoe; this consists of the mail, a length of linen thread passed through the lower eye, and attached to the weight, as shewn in Fig. 164. Again comes in a special knot in this case, rapidity of tying and freedom from slipping being factors in the matter. The knot, as it will be seen, is precisely the same as that of the neck cord and neck. Then before proceeding to tie up the harness the number of lingoes required for one row of hooks are placed upon the shaft A, in Fig. 165, and distributed as evenly as possible over the space to be occupied. Then the neck is dropped down from the cord, one end to the left say, for convenience, is made fast under a wire staple or hook driven into the front of the cumber board; the one end which is to go down to the extreme right has a loose wide knot made upon it passed down through the cumber-board, by the fingers, through the upper eye of the mail, and back through the cumber-board by means of a hook, and at the same time through the loose knot which has been formed in the harness cord. The free end is then drawn up until the whole cord is brought to the



Figs. 164, 165, 166.

requisite tension, and with the neck in a vertical position, and it is then tied with a knot, as shewn at Fig. 166, so that it will be seen that the portion of the harness cord passing through the cumber-board is double, whereas the upper portion is single; this process is repeated by each cord in succession across the cumber-board until every hook in the machine has its neck attached to it, as also the necessary number of harness cords, so that supposing there are ten divisions in the harness, or ten repetitions of the pattern, there would be ten harness cords attached to each hook, or 4,000 in the aggregate.

Now let us suppose the harness is tied up in the ordinary manner, and to a given sett, and it is desired from any cause to alter this sett; an alteration may be made, as already shewn, by means of the expanding parts, or altering the spaces occupied by slips on the cumber-board. As a general rule the alteration must take place in the direction of a coarser fabric, or fewer threads per inch. If the alteration is made either by setting out the slips of the cumber-board, or, what is the same thing, the use of the expanding harness, the full number of hooks in the machine will be available for use; but if neither of those two methods can be resorted to, then the ordinary course, casting out, must be adopted. This means that a certain number of the hooks, and the harness cords attached to them, must be left idle; suppose as in this case the machine contains 400 hooks, and the harness is tied up with 80 threads per inch, it is desired to weave a fabric 72 threads per inch; then as 80 is to 72, so is 400 to 360; or as a formula:—$\frac{72 \times 400}{80} = 360$, or 360 out of 400 would be employed and the remaining 40 cast out, or left idle. Then it would be for the designer, or weaver, to distribute the cast-out as evenly as possible over the whole machine. It is not a good practise to have all the cast-out in one place. Suppose, for instance, the first 360 hooks of the machine are employed and the last 40 left idle, that would mean a gap of blank harness cords half an inch wide; this would throw the warp threads out of the straight line and cause friction; then the better plan is to distribute the 40 idle hooks as evenly as possible over the entire length of the machine. This system of casting out, of course, may be carried to any length, but it is not desirable, at any time, to have too much of the harness idle; as, strange as it may seem, the wear and tear in the cast-out portion is much greater than in the working portion. The reason for this seems at first sight difficult to understand, but on a little consideration becomes quite obvious; the harness cords are passed through the cumber-board, which is supposed to be stationary, but as the working cords are constantly being drawn up and allowed to drop through the cumber-board considerable vibration must take place; in the working cords the friction is distributed over a length of cord equal to the depth of the shed, but in the idle portion it is confined to that over which the board vibrates; consequently the wear and tear in one case is distributed over a length anywhere from 3 to 5 inches, but in the other over a space limited to $\frac{1}{8}$th or perhaps $\frac{1}{4}$ of an inch; so that the reason for the rapid wear out of the cast-out portion is not far to seek.

The harness, tied up as described, refers to one where the machine is parallel to the cumber-board, and the cards would be working over the cloth, or over the weaver's head; but in some cases it is more convenient to have the cards passed over the warp. When tied up in this manner the order of succession appears to be reversed; in reality it is only reversed as regards each individual row of the machine, and a reversal either of the order of drawing the warp through the harness, or the position of the cards upon the cylinder will meet the difficulties. For instance, the machine is reversed in relation to the cumber-board, the order of succession is apparently still maintained, but in reality the first hook of the machine is attached to the cord going through the last row of the cumber-board, and the last hook of the machine to that of the first row of the cumber-board; so that instead of drafting the warp threads through the harness in the order of succession from front to back, which would naturally follow when the cards are placed over the weaver's head, they must be drafted from back to front, or as it is sometimes expressed, instead of from left to right, it would be drawn from right to left.

A great deal of confusion often arises when the machine is placed at right angles to the cumber-board, or what is termed the London tie is adopted. Here every cord is crossed, and the whole of the cords forming one division appear to be half twisted round each other, as shewn in the illustration of compound harness at Fig. 194. In this case No. 1 hook, or that coming to the front of the cumber-board on the left is in the front row; number 8 to the right of the machine is in the back row, and they are all apparently crossing each other from front to back, and from left to right. This follows with each succeeding row of the hooks, and also at each succeeding repetition of the pattern, or the whole of the hooks employed; hence there appears to be endless confusion caused by this crossing and recrossing. In reality if the order of tie-up is properly understood, the cords are as easy to follow from the cumber-board to the neck in this system as in the other. The one thing the weaver should practise is to follow each cord direct from the cumber-board to its hook. It is absolutely necessary that the weaver should thoroughly master this, for several reasons; harness cords are frequently wearing out, and must be replaced: then the weaver must be sufficiently conversant with the order of succession of the cords to be able to tie-up any broken one in its proper place. It may be said it is easy to find, here you have a broken thread at the cumber-board and another broken thread somewhere near the neck; if the two loose portions can be found they are simply to tie together again; but in tying together the new thread must be placed in exactly its own position, or it will be caused to wrap round a number of others, and will be constantly liable to be lifted by mere friction and thus produce a fault in the fabric. Again, occasionally, a needle or hook will go wrong in the machine; or a hole may be wrong in the cutting of the cards and a fault appears in the cloth as a consequence of this, but there is no means of tracing the fault to its source, except through the harness itself. Every thread of the warp should have its

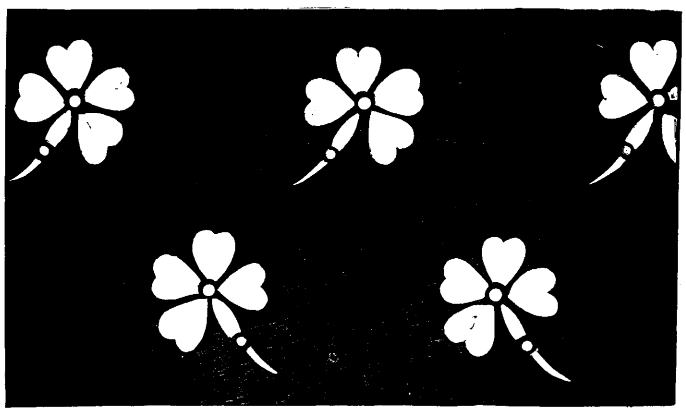


Fig. 167.

connection with the needle easily traceable, so that on the occurrence of the least fault it can be discovered. Of course it is obvious that by this method of tying-up the harness the wear and tear must be much greater than in the other methods, because of the friction of the harness cords upon each other. But it often becomes a necessity, where large numbers of cards are employed, because by bringing the cards over the loom side they can more easily be kept out of the weaver's way than when passed either over the warp or over the piece.

The use of this class of harness will be best understood by reference to Fig. 167, which shews a repeated design, the repetitions exactly coinciding with each division of the harness. Of course it must be understood that the design has been reduced to bring it within the space of a page; the pattern does not necessarily occupy the full division, or the total number of hooks contained in the machine, but it must always occupy a number which is a measure of that total. If the machine contains 400 hooks the pattern must occupy a number which will divide into that 400, otherwise some portion must be cast-out

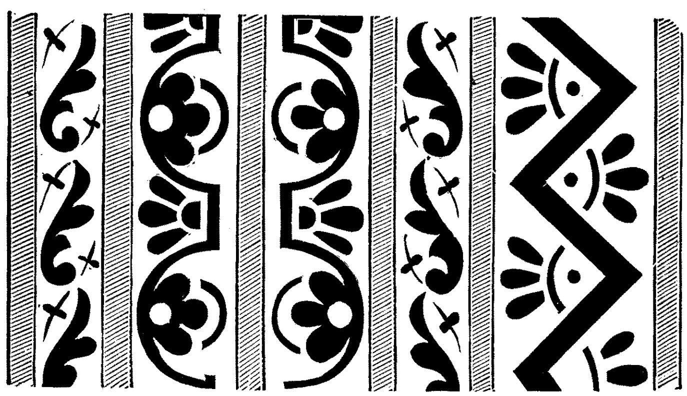


Fig. 168.

and a reduction in the number of threads per inch must follow.

The next subject for consideration is the tying-up of the harness to make what are termed repeating patterns, where three or four different effects can be combined in the same harness so as to get a wide range of pattern, apparently far beyond the range of a machine. In most cases such patterns assume a striped form, but at any rate that will be the most convenient form in which to deal with them at the outset.

The principle of this class of harness will be best understood by reference to design at Fig. 168, where we have a design or pattern, which may be broadly divided into four distinct sections. We have the section A which

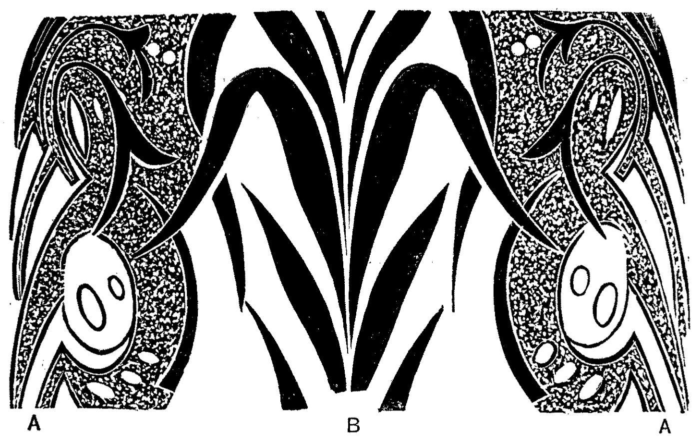


Fig. 170.

is the leading feature of the pattern; the two sections B which come next in prominence and importance; then the two sections C, and what may be termed the dividing stripes D. Perhaps it will make it more intelligible to follow the stripes D first. They are all exactly alike both in size and

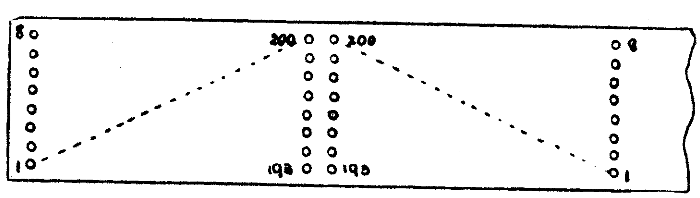


Fig. 171.

pattern and therefore, as we should say of heald work, capable of being woven with, or upon, the same healds; therefore we may say the same of jacquard work, that all the harness cords actuating the warp threads forming the stripes may be operated by the same hooks. Again the two stripes C and C are alike and may be operated from the same hooks, and in the same manner B and B. Then taking the pattern as it stands, we will suppose

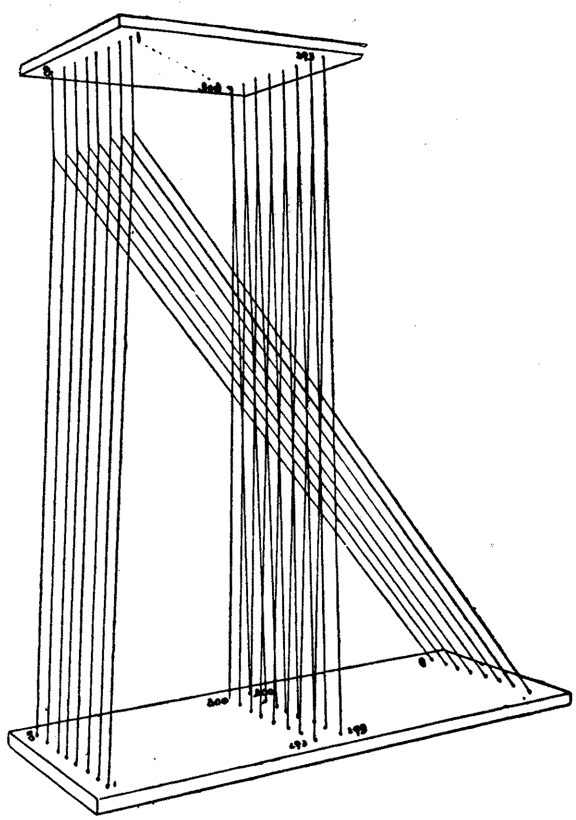


Fig. 172.

that the stripe A occupies 104 threads, one of the stripes B 32 threads, and one of C 48 threads, and one of D 16. So that we have, leaving aside repetitions, exactly 200 distinct threads, so far as their order of working goes in the whole pattern. But including repetitions we have an aggregate of 328 threads. The harness would be tied-up

Fig. 173.

for it in sections, which will be easily understood after the description of border and centre harnesses have been dealt with.

CENTRE PATTERNS.

The next form of harness calling for attention is what is termed the centre tie-up, or, as they are sometimes termed, point patterns. This will be better understood by reference to a design Fig. 170, where the pattern is represented as run into a centre and back again, so that taking the figures from the point A to B and back from B to A,

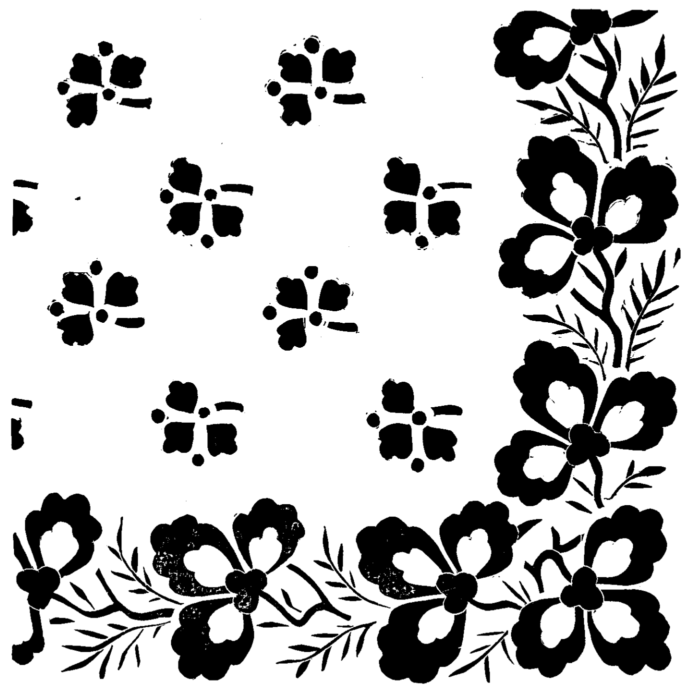


Fig. 174.

the threads on each side of B are exactly the same but in the reverse order. And again those on each side of A follow in the same manner. Now suppose this pattern to contain 400 ends, there would be 200 from A to B, and 200 back again from B to A, so that really only 200 separate hooks would be required in the aggregate.

Then for this the harness would have to be tied after the manner shewn in Fig. 171, which shews the plan of the cumber-board with the threads drawn through in their order of succession, 1 to 200 and 200 to 1, and Fig. 172 shows the actual harness corresponding with the cumber-board.

This method of tying the harness applies only to patterns of the character shewn in Fig. 170, where the figures form a centre and return again. A series of repetitions occur, each in precisely the same order across the fabric, and it necessarily follows that patterns of a continuous character could not be woven with it. The same system of tie-up is adopted for weaving rugs or other articles where a centre figure would be formed, but in such cases the harness would usually represent the full width of the article to be woven. For instance, let Fig. 173 represent the design for a rug; from the border to the centre every thread would be different, and from the centre to the opposite border there would be an exact repetition of the first half; so that the working design would be represented really by ¼ of the whole figure.

The next form of harness to be dealt with is what we commonly term border harness. This may assume several forms; first, we will suppose it to be tied up for a pattern such as shewn at Fig. 174, where the middle or body of the fabric forms figures of the continuous character, the same remark applying also to the border, but the border pattern being different from that of the middle; in this case we should divide the machine into two equal portions; say 200 hooks being allotted to the border and 200 to the middle; each of those portions would be tied up on the straight through principle, just as though they were being tied to two separate and distinct machines, and in making the design the first portion, or that for the cross border, would either have the same pattern running upon the two divisions, or one pattern may be made to form the corner of the article being woven and another the cross border. Then the side border would have its design corresponding with the cross border, and the middle only have a separate and distinct

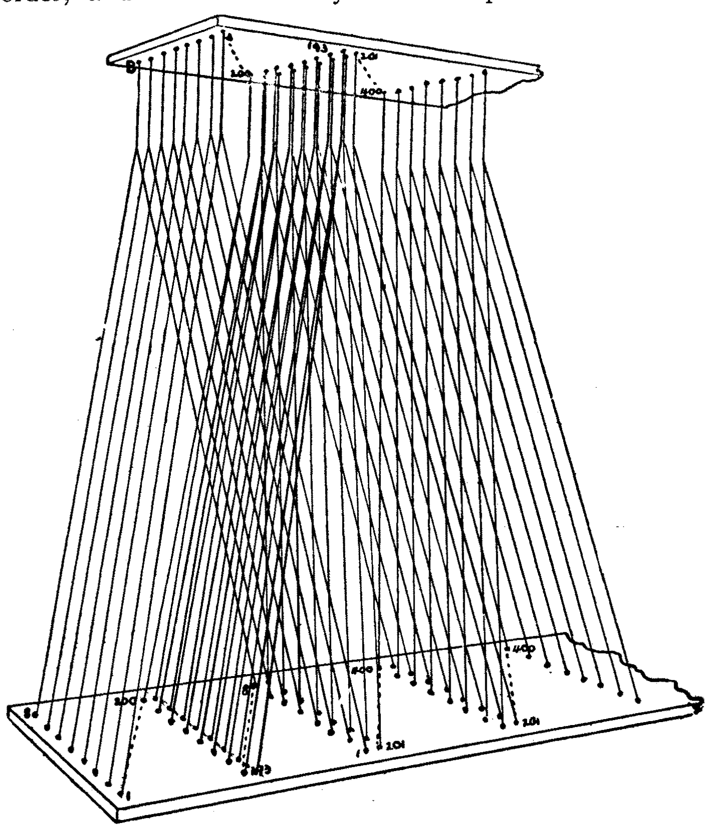


Fig. 175.

pattern as shewn in the illustration. It must however be borne in mind that if a separate figure is formed for the corner it must be so arranged that it will join and be common to both cross and side border. Fig. 175 shews method of tying the harness, the numbers indicating the order of succession of the harness cords in each division.

Sometimes ingenious contrivances are resorted to in weaving bordered articles; suppose, for example, a shawl is to be woven, and it is desired to have a border which may be figured, and that the border should be separated from the centre say by a solid line of colour, or a small figure, and again an outer border must be formed for the

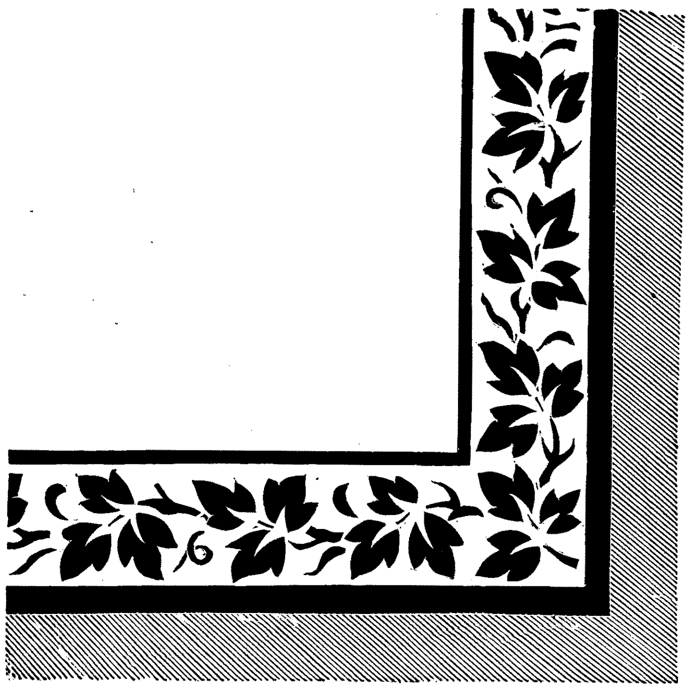


Fig. 176

purpose of giving a finished appearance to the whole; take, for example, the design shewn at Fig. 176, which may be supposed to be a representation of a figured double cloth where one figure is formed in the centre and a totally different one formed in the border, then we have a line A separating the border from the centre; another line C running outside the border; then after that, what might be termed an outer border D. The great object must be to make those lines perfect, as surrounding the centre and border respectively, and yet without interfering with the actual border itself. One thing must be made perfectly clear, the number of hooks allotted to the side border for the formation of figure must exactly correspond with the number allotted to the centre, for the simple reason that the hooks forming the centre will also have to weave a pattern on the cross border, and if the pattern on the cross border, as usually is the case, must be identical with that of the side border, then the number of hooks allotted to each must be precisely the same, although a departure may be made by allowing the picks in the cross border to correspond with the ends in the side border and *vice versa*.

Suppose the machine contains 400 hooks, and we require say 16 to form the line A, and we may suppose that we require also 16 to form the lines C and D, then we should have to take from the 200, which would otherwise be allotted to the centre, 16 hooks; and we should have to take from the 200 which would otherwise be allotted to the border 16 others; in tying up the harness we should first tie the outer border D, and occupy the hooks Nos. 1 to 8, then for the line C we should occupy Nos. 9 to 16, each of those may be repeated as often as required to form the requisite width of stripe or border; we should now take the hooks from 17 to 200 for the border itself and repeat that any number of times; now we come to the stripe A, which would occupy the hooks from 201 to 216, but here there can be no repetition, simply because those 16 threads being taken off one division of the centre must be so arranged that they can work as part of that division, and any attempt at repetition would destroy that effect. Now the first division of the centre would occupy the hooks from 217 to 400 so as to make allowance for the 16 threads which have been taken for the stripe A. But the subsequent divisions would occupy the hooks from 201 to 400. At the opposite side of the shawl, or other article being woven, we should either have to take 16 from the first division of the border or assign 16 distinct hooks which must be taken from the last division of the centre to enable us

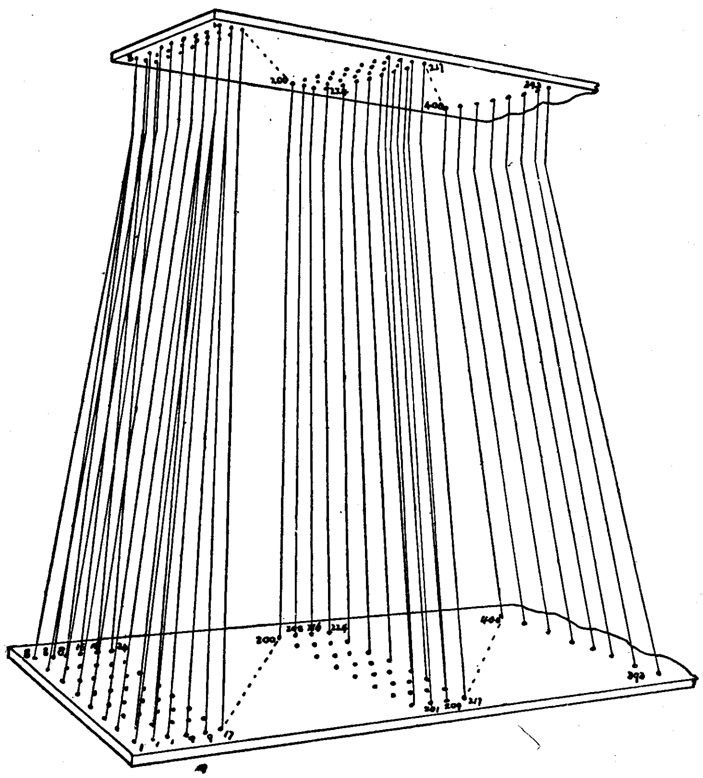


Fig. 177.

to make the pattern continuous, the latter being the proper arrangement. If the side and cross borders were always to be identical it would be more convenient to take the 16 in the one case from the centre division, and in the other from the border division, so as to leave the largest possible number of hooks available for figuring. But where the cross border and side border are not necessarily the same pattern, then, the two stripes A must be taken from the hooks forming the centre, those on the one side taking the first portion as from 1 to 16, and those on the other side taking the last portion as from 185 to 200. In cutting the cards for the cross border pattern, it would then always be understood that the hooks assigned to stripe A would have to be cut exactly in the

Fig. 178.

same manner as the first 16 of the centre division ; in other words, in the cross border pattern, hooks 1 to 16 would be working as facsimiles of hooks 17 to 32, and of course it would be understood that in weaving the cross line A that 16 picks would be taken from the first division of the pattern in the cards, in the same manner as 16 hooks are taken from the first division of the pattern in the machine. So far as lines C and D are concerned, there would be little difficulty, they simply form a perfectly straight line or a plain border and do not in any way interfere with B. Fig. 177 illustrates the method of tying up the harness.

Now another form of border harness must be alluded to, such for instance as where the centre is a straight through tie up, and the border a point, or centre tie up. We may take it in two forms, first as illustrated in Fig. 178, where we have a border on each side of the fabric, both of them being exactly alike, but the inner cords identical with each other, so that if 400 hooks are employed, the border on the left would follow from 1 to 400, and that on the right from 400 to 1. Then the centre would occupy a corresponding number, but tied in straight order, so that the pattern would be continuous as shewn in Fig. 178. In this case the whole of the border threads having separate hooks assigned to them may have a corner pattern, so as to fill in the corner and give a complete finish to the whole, but so arranged as to join perfectly to both cross and side borders. Here again in all probability a limited number of hooks would have to be assigned to a separating line, as it is not usual to allow a border to merge into the middle; generally speaking, some dividing line is necessary.

In such a case a small number of hooks would be laid off exactly as described in the previous case, and which would be taken either from the border or the centre, or both, and working as duplicates during the formation of the cross border, but afterwards quite independently. Another form now may be looked at, where the border is tied up at the point and the centre straight through; in such case we increase the power of figuring with a limited number of hooks. For instance, with 400 border hooks we could make a pattern of 800 threads, or with 200 border hooks a pattern of 400 threads, so that we should divide our machine in such a case into three equal parts, one part assigned to the border, and tied up as a centre pattern, and the other two parts assigned to the centre and tied up as straight through; then in weaving the cross border we should cut one half the cards to

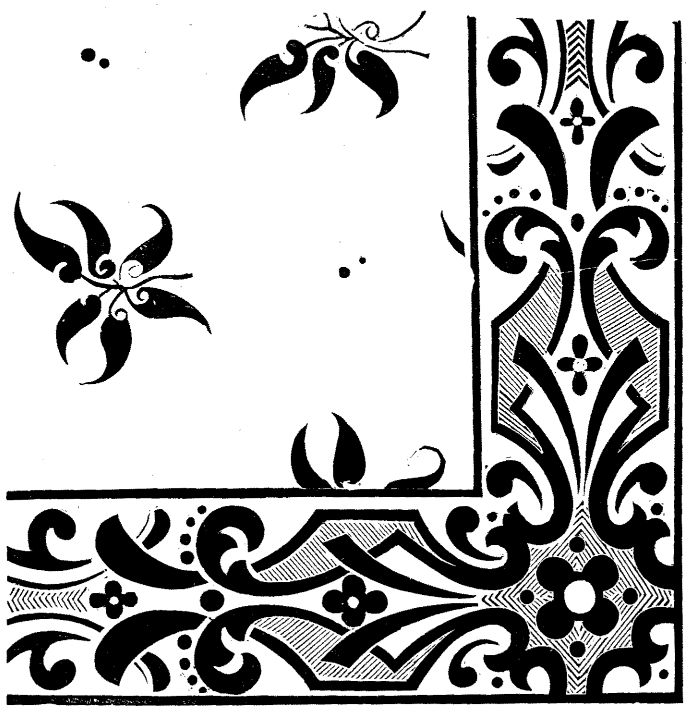
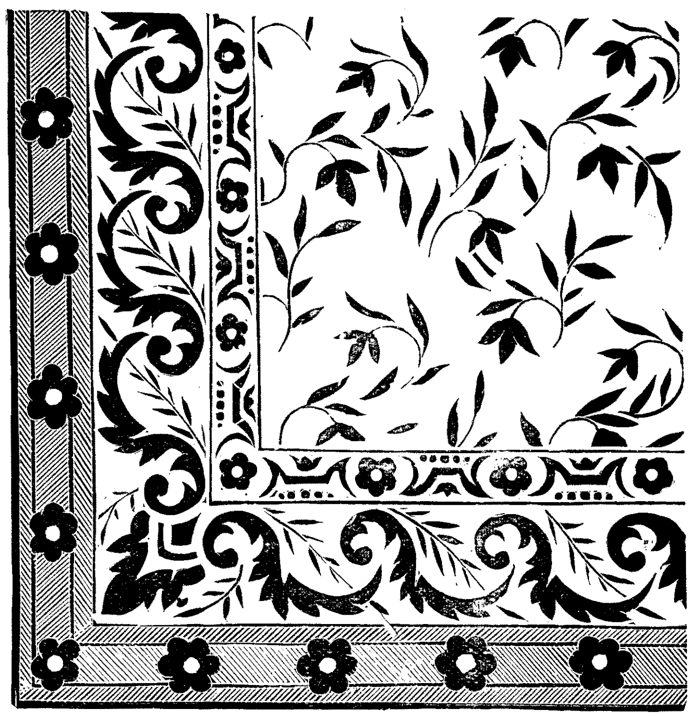


Fig. 179.

weave to the centre of the border and back again, but in the centre cards they would be continuous. A pattern is shewn at Fig. 179, and the harness will be understood from the previous explanation of centre ties.

It would be an easy matter to multiply indefinitely the various systems of tying-up for border work, but one more illustration will be sufficient; take for example, the pattern at Fig. 180, where there are no less than three borders, one running inside the other, here we assign 60 hooks for the outer border, 110 for the centre or main border, and 30 hooks for the inner border, the remainder of the machine



Figs. 180 and 182.

being assigned to the centre. What was said in illustration of border lines in Fig. 176 will apply here in precisely the same manner, the only difference being, that in Fig. 176 the narrow lines were shewn of solid colour, whereas here all the portions are figured, each differently from the other.

One more illustration will serve perhaps to elucidate the whole matter. Where we have two centre tie-ups as shewn in Fig. 181, one forming an outer and an inner border at the same time, a second forming the main border, both being centre tie-ups, and the third a straight through to form the centre or ground.

Now we may take a mixed tie of a different character, where we assign only a limited portion of the machine

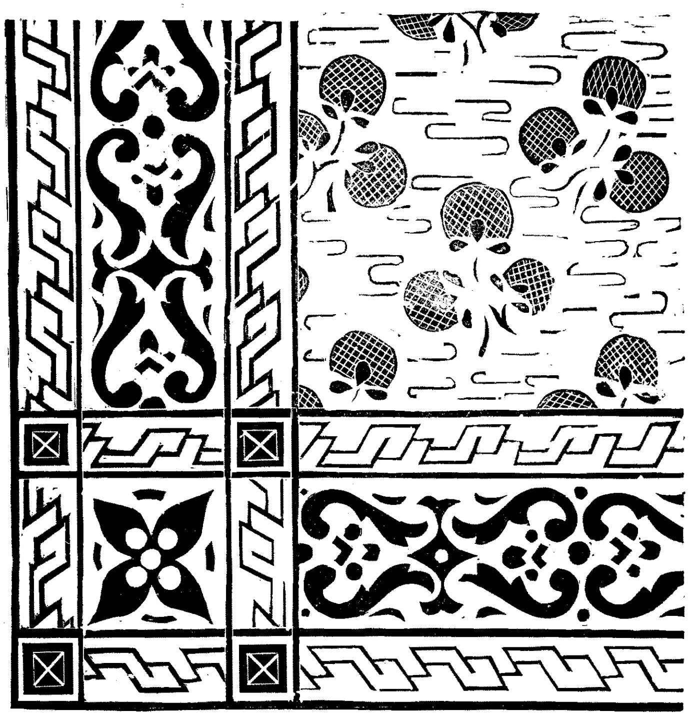


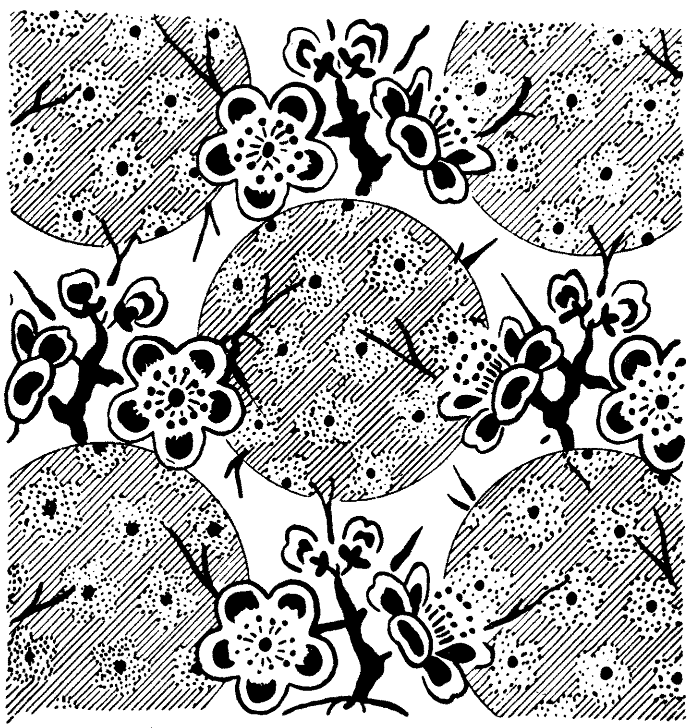
Fig. 181.

for the purpose of forming a centre figure; in this case we may divide our border into three or more sections, each section being either a continuous straight through, or a centre tie as required. For instance, we will suppose we have three divisions in the border, the outside is a straight through tie-up, the main body of the border a centre tie-up, the inside border a straight tie-up, then the main body of the middle also a straight tie-up, then a limited number of hooks to form a centre pattern and tied up as centre, the number allotted to each being as shewn in Fig. 182, which may be supposed to have a centre figure in addition to the ordinary ground figure as illustrated for the purpose of Fig. 180.

SECTIONAL HARNESS.

The class of harness to which we must now direct attention, and which I am terming sectional harness for convenience, is one in which one portion of the machine may be employed to weave the ground fabric, and another portion to weave a figure formed by extra warp. The sectional harnesses may be divided into three distinct classes, first, where the two portions, that forming the ground and that forming the figure, are equal to each other; second, where the one is not equal to the other, such for instance as where the ground may occupy, say one-third of the machine, and the figure, say two-thirds; or third, we may make a combination, and take one portion for the ground, a second portion for one extra material, and a third portion for another. And again, we may have the sectional harnesses arranged to work in stripe order, or divided and broken up in any manner we please.

The object of this system of arrangement is to lay aside that portion which forms the ground pattern, so that the design for the ground can be made in a straight forward manner, and the design for the extra figure in the material equally straight forward. Suppose, for example, that we are working upon an ordinary harness, a figure with extra warp, and we will say that we have 60 threads per inch in ground, and 60 threads per inch in the figure, making a total of 120, then we have 60 picks per inch of weft; it would be necessary to have our design paper, supposing the machine to have 8 hooks in a row, ruled 8 × 4, or otherwise the figure would be distorted, the width being double that of the length, and in painting the design upon the paper we should not only have to paint the two portions of the figure formed by the ground and the extra



Figs. 183 and 186

material respectively, in two different colours, but the card-cutter would have to bear in mind, all the way through, that he must cut the ground pattern, say, upon odd numbers only, and the figure pattern upon even numbers only. In many cases to prevent mistakes by the card-cutter, this would involve dotting out upon every individual thread of the whole pattern, the exact order of interweaving, involving an enormous amount of labour. If the pattern happened to be in three sections, as say, one ground and two figuring colours, the complication would be much greater, but it would be still greater should one of the figuring colours occur at intervals only. In that case one portion of the figure would necessarily be distorted upon the design paper, whilst another portion might be drawn in its natural proportions. I will endeavour to make this clear by an illustration presently.

Now to go back to the original two sectional harness, suppose we take the design at Fig. 183. We have there two distinct classes of figure visible, one being shewn in solid colour, and the extra material in shaded colour. This design is made to illustrate both two and three coloured sections, for two colours suppose the shaded circles to be without the dotted figures. The object of this system of pattern arrangement is to enable us to paint the design upon paper without any distortion whatever, and to enable the card-cutter to read from the design direct. Now the manner in which we accomplish this is to take one-half the machine, which we assign to the ground, and the other half to figuring material; for convenience I will take the harness as being tied up through two cumber-boards, one of which I mark "figure," and the other "ground" as in Fig. 184, where the harness is shewn as being tied up, the one-half of the machine to the one cumber-board, and the other half the machine to a second cumber-board, or two separate machines may be used. Then in carrying out our design upon the point or design paper, we should put the whole of the ground pattern, as represented in solid colours upon one-half the sheet, and the whole of the figure pattern, as represented in the shaded line upon the other half. In drawing the warp threads through the harness all the ground threads would be drawn through that portion in the cumber-board marked "ground." The figuring portion in that marked "figure," a thread of each alternately, so that the cards being cut from the design laid out in the two divisions, as already suggested, would produce each portion of the figure on the fabric perfectly in its proper place. Of course it must be clearly understood that before each portion of the design is carried out in the manner suggested, that

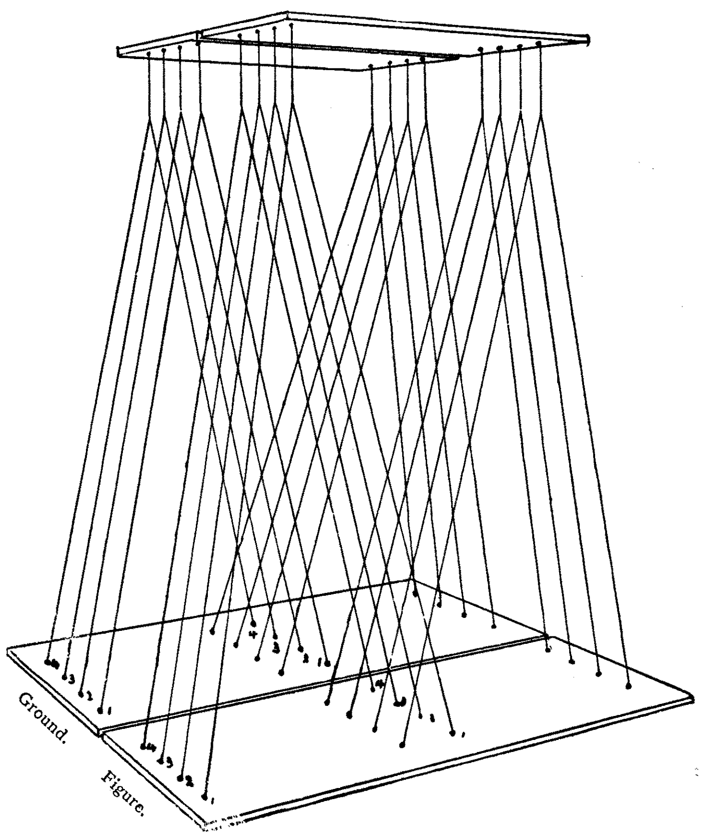


Fig. 184.

the pattern as a whole must be first drawn, and then each one re-worked out upon that portion of the machine to which it belongs. Then in this case, suppose the machine contained 400 hooks, the extent of each pattern would be virtually 200, *i.e.*, the ground hooks would take, say from 1 to 200, and the figuring hooks from 201 to 400, but they would be intermixed with each other alternately; so that the whole would occupy virtually 200 of the ground threads, and these would be arranged in the cumber-board, the ground from Nos. 1 to 4 in the first row, the figure from 201 to 204 in the same row and so up to the 400th hook.

Then another arrangement may be considered, which is closely akin to this, where, for instance, we have three sections instead of two. It will be easily understood that the arrangement of the design, to be woven with an ordinary harness, must be infinitely more difficult when there are three threads of different material or colour, each working separately and independently, as has been suggested for the two threads. The distortion would be in the proportion of 3 to 1 instead of 2 to 1, and if the harness were tied up with 8 rows of hooks we should not be able to obtain any paper ruled to exactly correspond with it. Then the figure would of necessity be distorted in form, and the reading difficult. But suppose the machine to contain 312 hooks, then we should lay off, say 104 for ground, 104 for one figuring material, and the third 104 for the second figuring material, as shewn on Fig. 185, and for convenience we should use three separate cumber-boards, one behind the other; then we might produce a pattern such as illustrated in Fig. 186, where the three different colours are represented by the solid, shaded and dotted portions respectively. Before going further into this question I would suggest to the student the great possibilities of a three section harness such as this. The ground would be of one colour and each of the two figuring materials of different colours; suppose we call the three colours A, B, C. Then we may produce on the ground of the fabric three distinct solid coloured figures; we may combine the ground weft with either of the two extra colours, and by combining with a variety of twill effects, letting either of the two colours take the place of the ground warp in interweaving with the weft, we may obtain any degree of shading we may require, or we may further alternate in any degree, or to any extent we please,

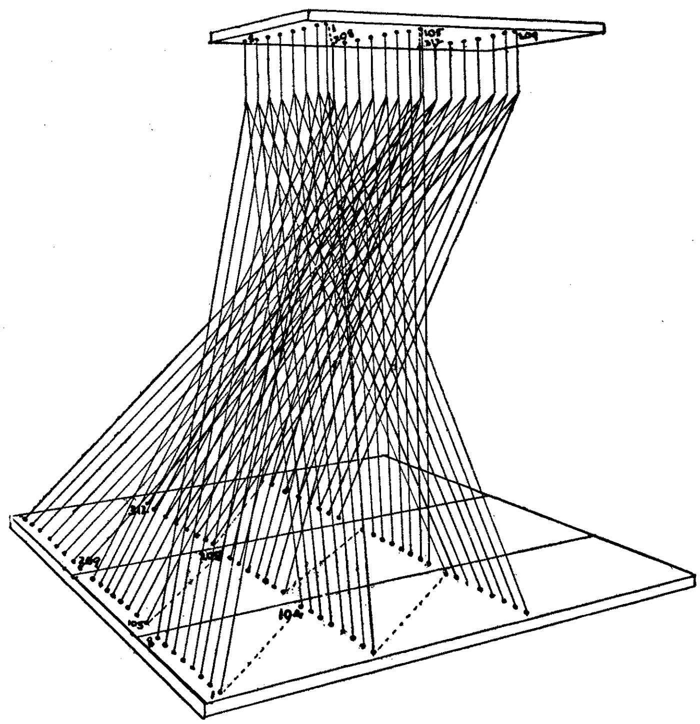


Fig. 185.

the several colours with each other and their order of interweaving with the ground weft, so that simply by the combination of the different coloured materials, and different orders of weaving, an infinite variety of colour and light and shade will be produced; one has only to look at some of the elaborate tapestries, and at some of the finest silk fabrics produced to be able to understand this. Of course I need hardly say that, in the production of large figures, instead of dividing the one machine into several portions several machines may be employed, one machine say for the ground, and one for each of the figuring materials; this being nothing more than the enlargement of the one machine. For instance, we may put one machine containing 1,200 hooks upon a loom, or we may put three separate machines, each containing 400 hooks, and we may couple the three machines together, either by placing them all within one frame, with one common card cylinder, and actuated by one lever; or we may have three separate machines, each having its own set of cards, each having its own treading lever, but all actuated from the same source. It would be purely a question of convenience, space over the loom and economy; either of the expedients might be adopted according to the necessities of the case.

Now we may look at the arrangement from another point of view. Suppose we want to make a pattern where we desire to have a small figure distributed all over the ground and made from the ground material, and a larger figure formed by extra material over it. Suppose that we desire to lay aside only 60 threads for the ground patterns and 240 threads for the figuring material, then we should divide our machine into two sections, the first sixty being laid aside for the ground, and the 240 for figure, as shewn in Fig. 187. Then assume again that the ground threads and the figuring threads are alternate, we should either divide our cumber-board into two sections or employ two cumber-boards as before, but in one complete division of the pattern we should have the 60 ground threads four times repeated to one of the 240. So that on the assumption of the previous fabric with 60 ground threads per inch and 60 figuring threads the whole pattern will occupy four inches, whereas if the machine is divided into equal portions, one-half for the ground and the other for the figuring, it would occupy one and a half inches, so it must be obvious there is an enormous advantage in tying up a harness on this principle, as giving so

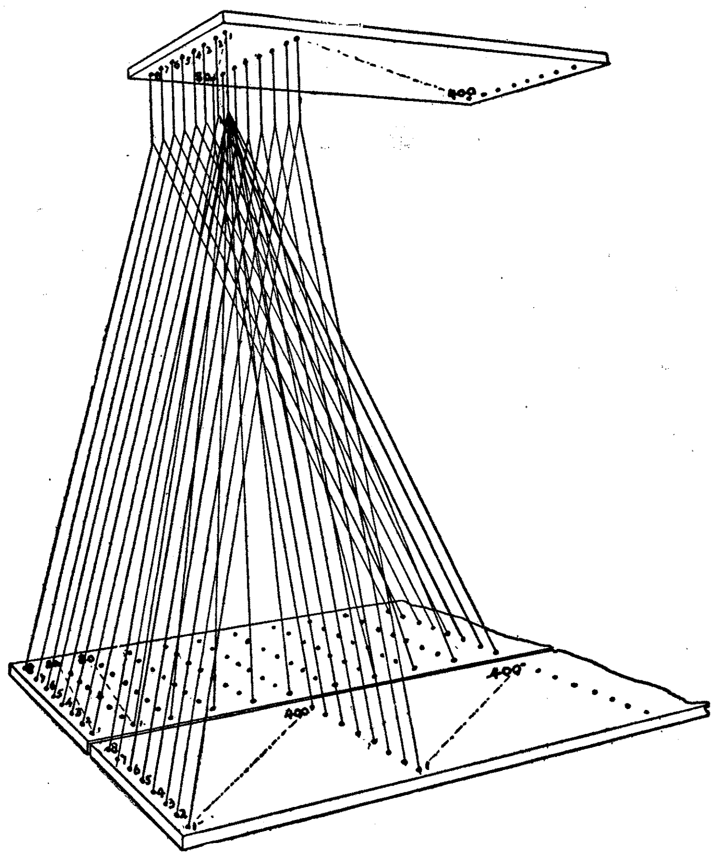


Fig. 187.

much more scope for the production of large figures. This will be understood by reference to Fig. 188, where the ground figure is shewn in comparatively small spots, but the extra, or real figuring, material distributed freely over it in large figure.

Now I must turn to another and most important division of the subject, *i.e.*, where one portion of the harness is tied up to weave with extra figuring material, either in two or more sections in stripe form, and the other

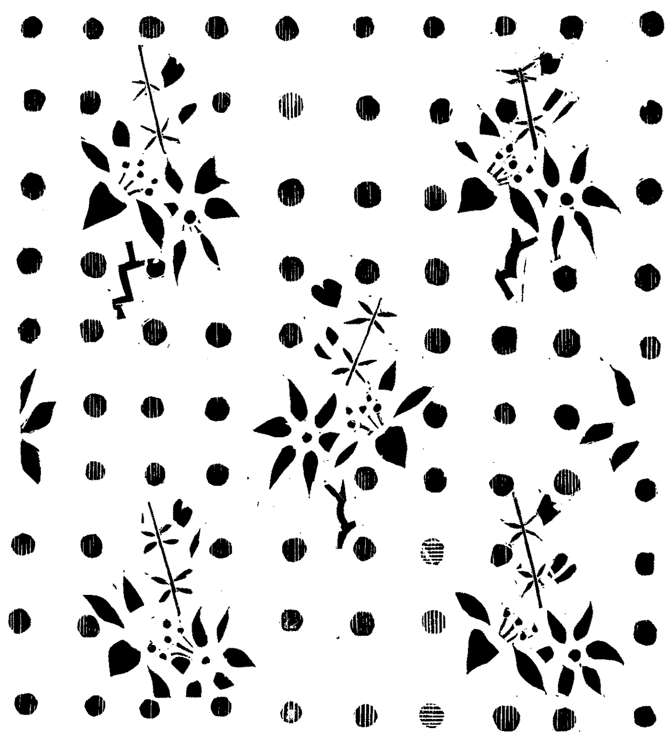


Fig. 188.

portion to work the ground. Suppose for instance that a stripe is to be formed of extra material upon an ordinary figured ground, such as illustrated in Fig. 189 where a ground pattern runs between the stripes and necessitating harness work, and a figure is formed upon the stripe itself by extra material. One of two courses may be adopted here; the first is to tie up a section of the harness with one portion of the machine allotted to the ground fabric and the other portion allotted to the stripe. Suppose 240 of the hooks are laid off for the ground portion of the fabric alone, and 60 hooks are laid off for the striped figuring material, then that 60 would be distributed in precisely the same manner as in the arrangements already dealt with, but confined to a limited space. For instance we have 240 ground threads in the total and 60 stripe threads in the total; the 60 stripe threads must be

Fig 189.

alternated with 60 of the ground threads, leaving 180 to form the solid ground between the stripes as shewn in Fig. 189. Then the harness would be tied as shewn in Fig. 190, the cumber-board again being divided into two sections, the order of tying up being indicated by the numbers upon the cumber-board itself. By this system of tying, as illustrated in this particular case, the ground pattern may be made to run over the whole of the fabric, and to combine, where desirable, with that of the stripe, but in the majority of cases this would not be desirable, the ground pattern usually being confined within the limits of the space between the stripes, and the stripe pattern to that of the stripe itself. The method

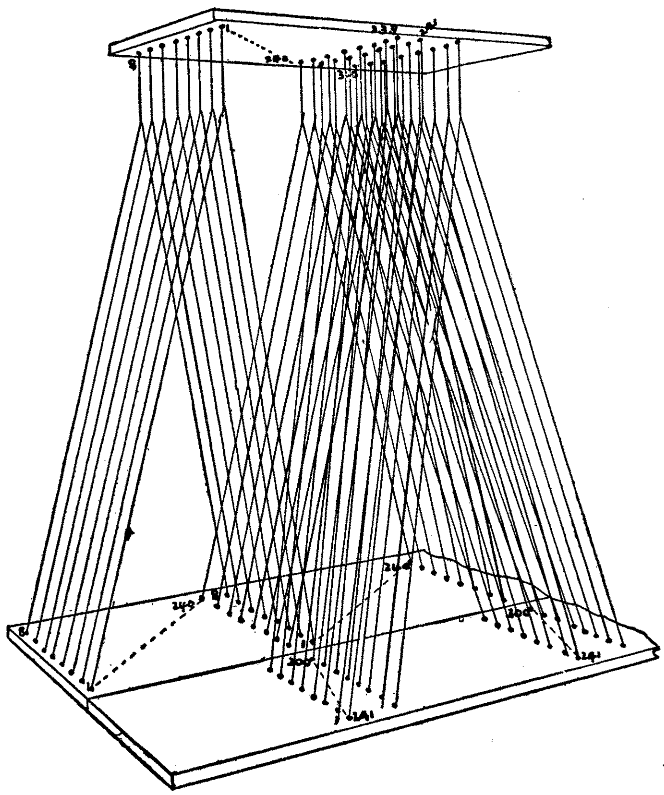


Fig. 190.

of tying the harness will be understood on reference to Fig. 190, where the divisions are laid out in precisely the same manner as in the previous illustrations. In the majority of cases the same effect which is aimed at here would be obtained by the use of what is commonly termed compound harness, *i.e.*, by employing an ordinary harness which shall form a figure over the ground, in precisely the same manner as is done in this case, and where the stripe occurs the harness will work the figuring threads, but ordinary healds will be placed in front of the harness to form the ground fabric. Suppose we had in this case

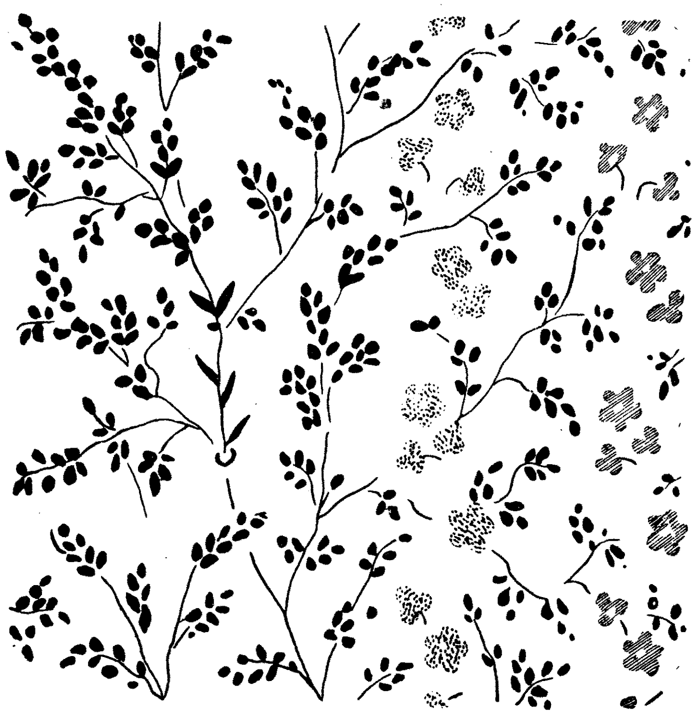


Fig. 191.

300 hooks in a machine, and 60 are required to form a figure, then we should have 240 left to form the ground instead of 180, as in the previous arrangement, and we should replace the 60 missing by passing them through a pair of healds, with their threads drawn alternately with the figuring threads of the stripe, so that the harness

would carry 300 threads and the extra healds 60, and consequently instead of having a capacity of 240 figuring threads only we should have a capacity of 300 threads from the machine, and the ground threads worked direct from healds to form the ground under the stripe. This method of working will require further explanation later on.

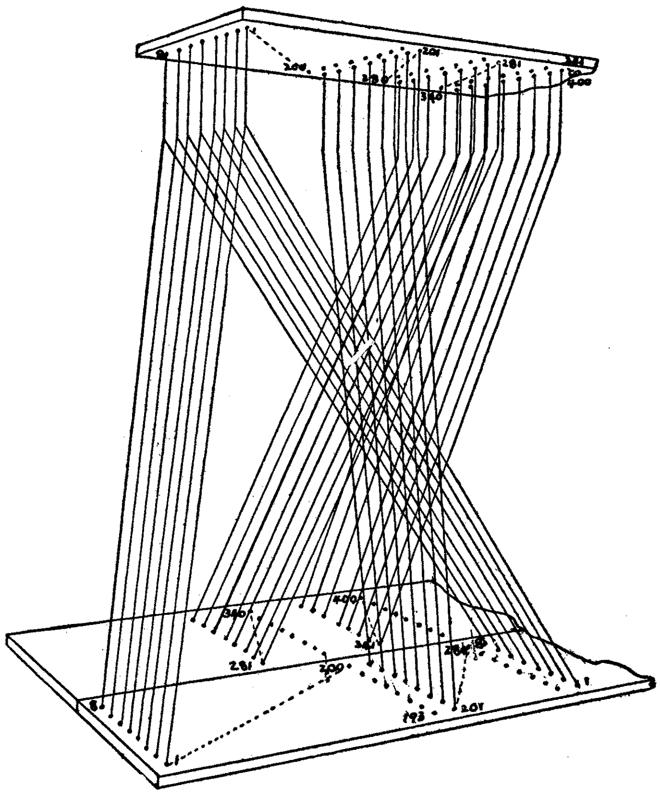


Fig. 192.

But to return to figuring where a stripe is not more than suggested, such for instance as the one illustrated in Fig. 191. We are still bound to work with the sectional harness, but our ground figure may be made to run over the fabric, and the extra figure occur only at occasional intervals, as desired, producing a class of figure which is commonly produced by what is known as a swivel arrangement, but having the advantage over the swivel of rapidity of production, but also the disadvantage of waste of material. A further advantage of this system of tying-up in stripe form would be the use of what has already been termed point tie, *i.e.*, making a centre figure in the stripes, thus enabling us to make double the size of figure with the same number of hooks. The harness is shewn at Fig. 192.

Without going too much into detail and endeavouring to explain every class of harness it may be sufficient to say that extra figuring material may be tied up in the point, or reverse order, and the ground in continuous order. The stripe may be in the continuous and the ground in the point, or reverse order, or both may be in the point order, thus giving an enormous amount of figuring space with a very limited machine. It will, of course, be easily understood that when one machine does not give sufficient figuring capacity two or more machines may be employed, and coupled together as already suggested, each taking its own part in the work.

COMPOUND HARNESS.

The compound harness may be classified under two distinct heads, first, where the harness forms the figure and the healds associated with it form the ground under a portion of the figuring, as suggested in reference to Fig. 189, and the other where what we commonly speak of as pressure harness is employed. In both cases a number of healds, varying according to the ground pattern, are placed in front of, or in the case of common compound harness, behind the harness. Suppose, for instance, in Fig. 189, the ground formed under the figure of the stripe should be a plain cloth, then two healds would be employed, those two healds carrying only the ground threads and the whole of the figure would be introduced from the machine. If it were a twill, or satin ground, then the number of healds would depend upon the twill or satin only; it is no uncommon thing in working fabrics, where it is desired to go to a much higher set than the harness is tied up for, to introduce healds in front or behind, which shall form either the whole or a portion of the ground fabric, and so devote the harness solely to the figuring portion,

S *Fig.* 193. S

and it is equally common to employ healds to form, say a close satin stripe, where the ground is figured by the harness. An illustration of the method is given at Fig. 193, where the solid stripes S shewn would be produced by healds alone, and with the threads very closely crowded, but the ground pattern would be produced by the harness alone. A general idea of the arrangement of compound harness may be obtained from Fig. 194, where the harness is shewn as one of the ordinary kind, and the healds suspended in front of it. In this case the healds are usually actuated direct from the harness, so that their movements may be in unison with the harness itself; in such case some of the spare hooks of the machine,

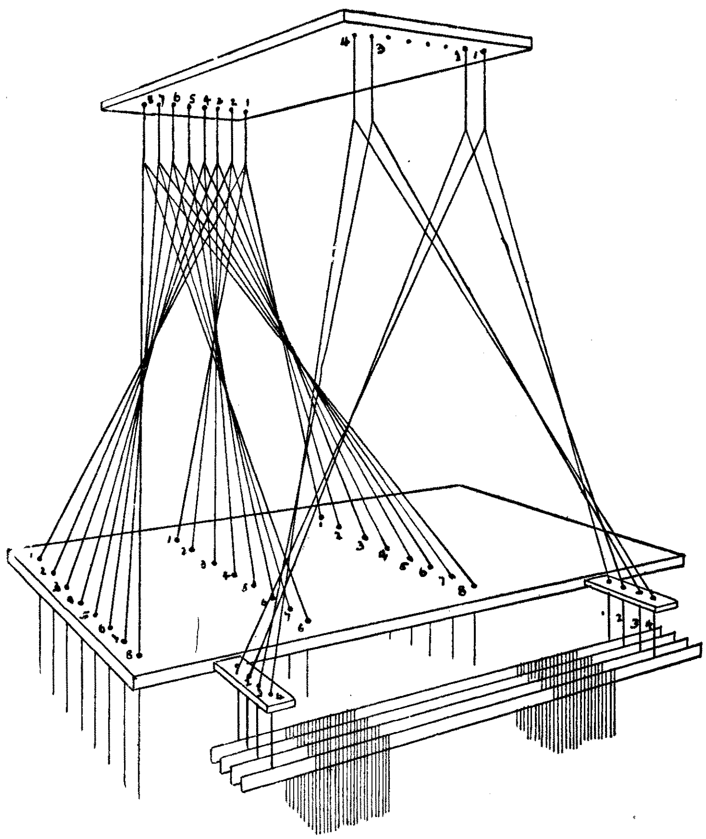


Fig. 194.

which are usually set apart for what are termed edgings, would be employed for the purpose, and the cards would be cut accordingly; but occasionally those extra healds are worked direct from tappets and independent of the harness.

Now a very nice point arises here; when the heald is operated by tappets it is almost, if not absolutely impossible, to arrange those tappets to work perfectly in unison with the harness, consequently some little difficulty arises in the adjustment. This difficulty can be overcome by a little care, or skill, on the part of the overlooker, but sometimes a totally different question arises in this connection. I will take an extreme case; suppose the ground fabric to be perfectly plain, and one in which it is absolutely necessary to have a perfect distribution of the warp threads, evenness of texture being the essential feature of the cloth; every weaver knows that this cannot be obtained in any degree of perfection with what is termed harness shedding; but we must have this perfect ground along with an extra figure upon it; then the healds must be operated by tappets, and under the same conditions as if they were weaving an ordinary plain cloth. The difficulty will then arise, how can the open tappet shedding be reconciled and made to work with the harness shedding? It can be done, but only by the most careful adjustment of all the working parts. The timing of the tappets so that the shed is fully open exactly at the same time that the harness shed is open; the adjustment of the warp line so that the figure and the ground threads are perfectly even on the under side; the exact tension of the warp beam from which the threads are drawn, and the proper adjustment of the back rail, or what is better of two back rails; the placing of the lease rods, and the general relations of the two to each other may, in skilful hands, be made to work with that perfect degree of harmony which will produce the best possible results; but unless everything is adjusted in the most perfect manner it is utterly impossible to make those two systems of shedding work together, but when they are adjusted not only is there the greatest amount of production, but the surest means of producing a good fabric.

I will deal now with a different class of compound harness, and which might be more correctly described as a compound sectional harness, and which is mostly employed in the manufacture of what are commonly known as quilt fabrics, or in the production of any fabric of a similar character. What is generally understood by a quilted fabric is one having a fine face, a coarse heavy back, with wadding inserted between the two; the face and the back cloths stitched together so as to form the fabric. In most cases the two fabrics would be perfectly plain in structure, and the pattern is formed solely by the stitching. Suppose we take Fig. 195 as a section of a quilted fabric, where

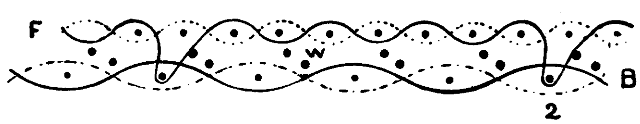


Fig. 195.

the upper surface is shewn as a perfectly plain fabric, and the lower fabric also plain, but the two cloths varying in the proportion of two threads to one; then a wadding is introduced represented by the thick dots marked W. Now we may weave the surface cloth with healds, and we may weave the back cloth with harness, or *vice versa.* Suppose we adopt the former plan, and we work the face threads through the healds 1, 2, 3, 4, in Fig. 196, and the back cloth in the harness through the cumber-boards A B, and we want to economise cards to the utmost extent. To bind the two cloths together, at the point where figure is to be formed, the warp of the back cloth must be raised at the time the face weft is being inserted, as indicated at the points 1 and 2 Fig. 195.

Now as to the method of actuating those healds and harness. Economy is the great object in this system of arrangement, first as regards the harness itself, and, second as to the number of cards employed. Then as to the manner in which this harness is tied; every thread of harness cord has a large knot immediately over the cumber-board sufficient to prevent it passing through the hole; then the cumber-boards A and B may be raised alternately, and the healds may be actuated at will, either from spare hooks in the jacquard or by independent

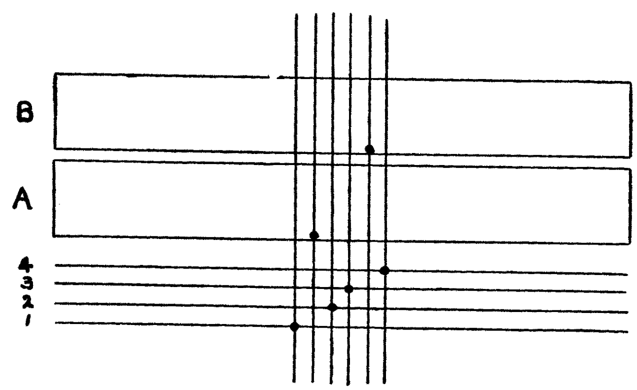


Fig. 196.

apparatus, therefore it is obvious that we can weave plain cloth by actuating the cumber-boards, raising them alternately, independently of any movement of the machine, and we can also weave plain cloth with the healds by raising 1 and 3 together for one pick and 2 and 4 together for the other; or by varying the draft we might couple 1 and 2 together and 3 and 4 together; in fact we should only employ four healds for the purpose of obtaining free distribution, as two would answer the purpose equally well otherwise. Then suppose we weave two picks of plain cloth by actuating the four healds only, then we raise all the healds and insert two wadding picks, we next raise one of the cumber-boards as well as the healds and insert a backing pick. Then if the harness has been remaining stationary, excepting so far as the cumber-board has raised it, the two cloths will be separate, with the wadding lying loosely between them, but if during the period those five picks are being inserted any portion of the harness has been raised by the machine, back threads would be lifted and the face picks would pass under them, thus binding the two fabrics together at such points, in the manner indicated at points 1 and 2 in Fig. 195. Then from this it will be seen that one card on the machine really answers for five picks, *i.e.*, two for the face cloth, two wadding picks, and one backing pick.

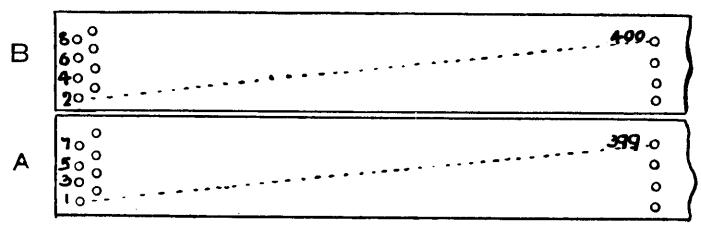


Fig. 197.

Then a change takes place, the contrary pair of healds are raised for the face picks, again the whole of the healds for the wadding picks and the whole of the healds and the reverse cumber-board B for the backing pick, so that this goes on continuously, the cards changing for every five picks only, thus it will be seen that the amount of saving in pattern cards alone will be enormous. The arrangement will be better understood so far as the harness is concerned, by reference to Fig. 197, which is a plan of cumber-board and shews the board A carrying all the threads from the rows of hooks 1, 3, 5, 7, and board B carrying those from rows 2, 4, 6, 8, and the warp threads drawn through them in the order suggested. Fig. 198, is a reproduction by photography of a piece of quilted cloth made strictly on this principle.

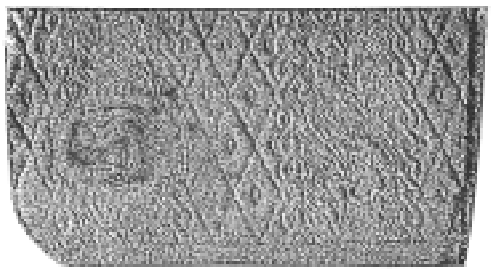


Fig. 198.

COMPOUND HARNESS FOR EQUAL CLOTHS.

Another form of compound sectional harness must be dealt with, this is for weaving reversible figured cloths, where both are plain and equal to each other, and where

Fig. 199.

the figure is produced simply by the two fabrics exchanging places as shewn in Fig. 199, which represents a dark figure upon a light ground. The principle of this harness will be best understood by a reference to Figs. 200 and 201, which are representative of four healds or harness cords arranged for the purpose of weaving double plain

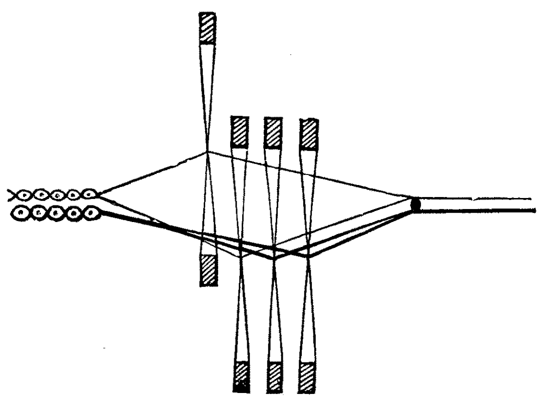


Fig. 200.

cloth ; two healds 1 and 3 carry the face warp threads and Nos. 2 and 4 carry the back warp threads, then in Fig. 200 one thread of the face warp is raised only to

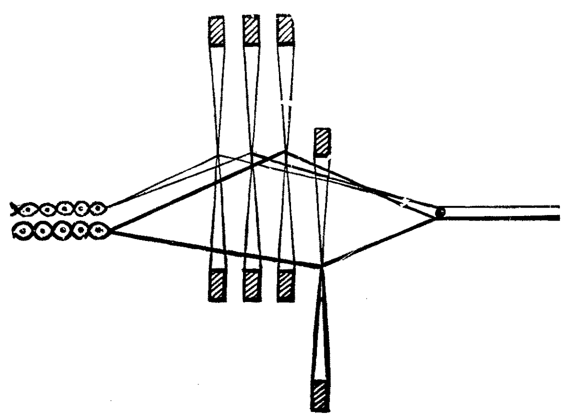


Fig. 201.

allow the pick of the weft to be passed through, and in Fig. 201 both the face warp healds and one of the back healds are raised to allow a backing pick to be inserted; then for the next pick we should raise No. 3 heald only, and for the following backing pick leave down No. 4 heald only. Instead of employing healds we now divide our cumber-board into four sections, as shewn at Fig. 202, with the harness knotted above them, in exactly the same manner as suggested in the previous combination. Then supposing the jacquard machine to remain stationary we can weave two perfectly plain cloths by raising the cumber-boards in precisely the same manner as suggested

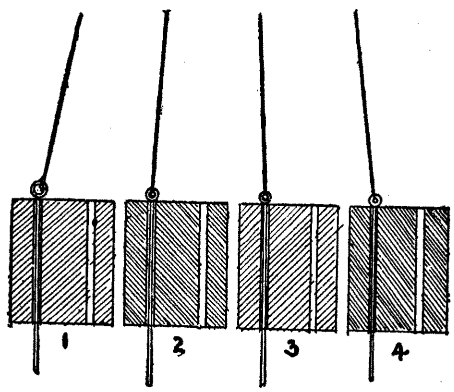


Fig. 202.

in Figs. 200 and 201. This will be understood, perhaps better, by reference to the plan of the cumber-board at Fig. 203, where we are supposed to be using a machine of 400 hooks, and where the first cumber-board carries the first and third cords of each row, the second cumber-board the second and fourth, the third cumber-board the fifth and seventh, and the fourth the sixth and the eighth, and the warp threads drawn through them, not in the order of the harness threads, but in the order of the cumber-boards, as shewn on the plan. Assuming that we can weave the two cloths perfectly plain, and separate from each other, then by bringing the jacquard machine into operation we can cause the two fabrics to reverse their position, *i.e.*, the cumber-boards rise in their regular order for the purpose of forming the two plain fabrics, but the cords on the jacquard may cause the whole of the dark warp to be raised up at any point desired when the light weft is being inserted, and at the intermediate points the whole of the light warp can be raised whilst the dark weft is being inserted, thus producing figures,

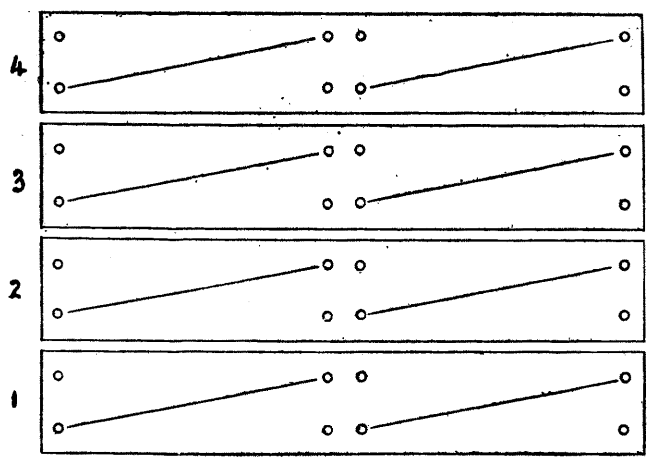


Fig. 203.

each perfectly solid in colour upon a ground equally solid; or by a judicious intermingling of the two, by bringing up a small number of threads at a place, producing any degree of shading which it may be desired to effect. Of course, by multiplying the number of cumber-boards two twilled cloths would be produced with equal facility, and a saving of cards will follow, the extent of saving being dependent upon the ground pattern and the frequency with which it is desired to change the two fabrics.

SPLIT HARNESS.

The split harness is in reality an extension of the ordinary single harness machine, and consists in tying up three or more harness cords to the same neck. Suppose for instance that we tie to each neck two or more adjacent harness cords, and we are to work in the ordinary manner, every time the harness cord lifted it would carry two threads with it. The object of this is to separate the threads, or in other words to make an extremely fine surface on the fabric by means of a coarse harness. Suppose we tie an ordinary harness up to a 400 machine, and we tie two threads to each hook, then we should have 800 separate threads in the whole pattern. Those 800 threads we split by placing a thin steel, or other rod, which becomes virtually a heald shaft, in a long loop of the harness between the warp and the cumber-board, as shewn in Fig. 204. Then suppose we have the splits in pairs the harness will work the figure, and the steel shafts taking the place of healds, will form the ground in precisely the same manner as the cumber-board in the previous case.

Suppose we are making a fabric sufficiently fine to justify us in splitting those threads into pairs, then we could weave a plain surface twice as fine as the harness was originally intended for, as represented by the number of hooks in the machine. All the way through by raising those shafts we should be making a perfectly plain surface on the body of the fabric, and by the manner in which the harness cords are raised we should be able to make a figure formed by warp threads on the surface, or by weft threads on the back. To vary the pattern we may employ any number of steel shafts which our cumber-board will permit, say 8, 12, or 16, according to the number of rows in the cumber-board. And by doing so we could vary the pattern of the ground to the same extent; and as is the case of the compound harnesses, already referred to, we effect a saving not only of jacquard power, as represented by the number of hooks in the machine, but we also effect a saving of cards in the

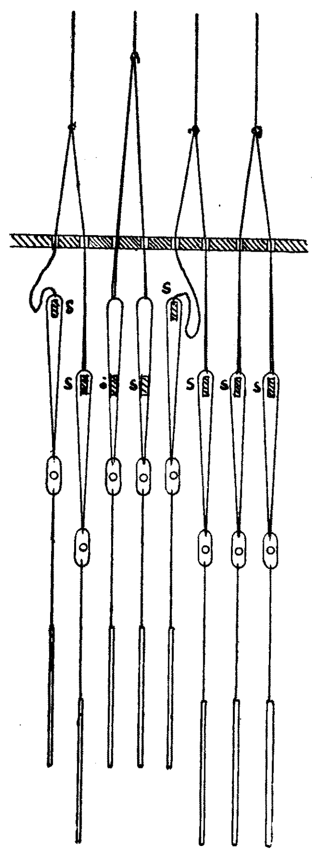


Fig. 204.

same degree. A harness tied up on this principle possesses several advantages; we cut upon the cards the pattern for the figure only, and we form the ground solely by the lifting bars or steel rods, so that we can vary the ground pattern of the figure at will, subject of course to the lifting bars being actuated independently of the figuring cards themselves; but if they are actuated by ordinary spare hooks in the machine, then the figuring cards will have to perform the double function of forming the figure and governing the ground pattern. Two disadvantages as compared with the previously mentioned compound harnesses must of necessity accompany this form of machine. The first is the necessity of forming the figure with loose material, consisting of warp on the surface or weft on the back, and the second is the necessarily ragged outline of the figure in consequence of the steps being always over a number of threads, instead of following from thread to thread as in the majority of fabrics.

PRESSURE HARNESS.

The next step from this split harness is what is commonly known as the pressure harness, which is really a compound harness of the simplest possible type, having a set of healds different from the ordinary healds, in the length of the eyes, through which the warp threads pass, and also from the fact that the number of threads which pass through one mail of the harness are divided by the healds. Briefly expressed, a pressure harness may be explained as follows:—It is desired to weave a damask fabric, or a diaper of the true type, we should pass through each mail of the harness 4 threads if the ground fabric is to be twill, 5 threads if it is to be a simple satin, or more according to the ground pattern. Now suppose we have for convenience 4 threads in each mail, and the jacquard contains 400 hooks, we should then have 1,600 threads in one complete pattern, so far as the harness is concerned; those 1,600 threads represent only 400 thick ones, then it becomes the business of the pressure healds in front of the harness to separate the threads which are carried by each individual heald and to form the twill or satin as required.

To understand perfectly clearly what is meant by damask, and in what manner the pressure harness can

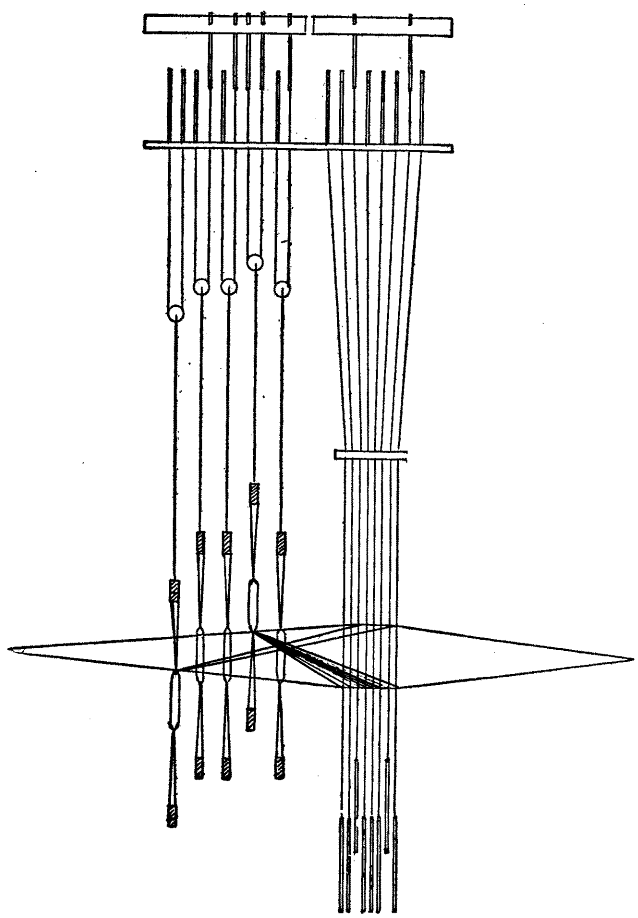


Fig. 205.

be suitably employed, it may be explained at once that the ground pattern consists, say of a warp surface of twill or satin, and the figure having a ground surface of weft twill or satin, so that whichever material predominates in the ground the reverse must predominate in the figure. Then the healds in front of the harness, as represented in Fig. 205, have a long loop, which must not be less than the depth of the actual shed required, and the threads which are passed through each mail of the harness are separated and one passed through each of the long loops of the several healds, as shewn in the draft Fig. 206. The harness now simply determines the figure, the healds determine the ground; suppose, for example, that five threads, or four threads, as contained in one mail are required to be raised to form the warp surface, then the

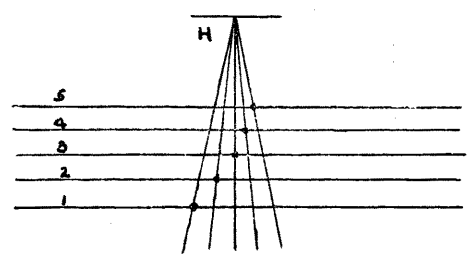


Fig. 206.

hook carrying those threads will be lifted, as indicated by the figuring cards, but one of them must be carried down for the purpose of binding the weft, otherwise no twill or satin could be formed; on the other hand supposing that five threads are required to form the weft surface then they would be left down by the harness, and the reverse of what occurred in the previous five must take place with this, *i.e.*, one of the five must be lifted for the weft to pass under so as to form the requisite ground pattern. Then this difficulty is met by raising and depressing at the same time one of the complete set of healds; for instance, if we were making a twill we may be depressing

No. 1 and raising No. 2 for one pick, for the next pick we should depress No. 2 and raise No 3 and so on. If a satin pattern they would be raised and depressed according to the order of the pattern, consequently one thread out of each group will always be at much greater tension than the rest, either by being raised or depressed, as indicated in Fig. 205, and consequently this might suggest to the mind irregularity in tension, but when it is borne in mind that this follows in regular succession through the whole series of threads no detrimental results can follow; then to ensure the raising or depressing of the pressure healds, exactly as required, each is suspended from a small pulley as shewn in Fig. 205. A cord is passed round a pulley and attached to two hooks which may be acted upon, either by the ordinary jacquard machine, or by a special machine erected for the purpose; when the healds are in what might be termed their normal position, one of the two hooks acting upon the pulley would be raised and the other depressed, or at least left at its lowest point. When the heald must be raised both the lifting hooks are carried up, when to be depressed or left at the lowest point both the hooks must be left down as shewn in Fig. 205. Consequently we have here the power of producing pattern to an unlimited extent, but subject, in some measure, to the fault which has been referred to in the split harness, of having the outline of the figure somewhat ragged. Practically the same principle is involved; if we were making a four-end twill ground we should spread the harness into four portions, so that at every pick the pattern must step in fours in the threads, or if it is five-thread satin it must spread in fives; this stepping is broken, or modified at least, not only by the fact that a change takes place in the twilling at each succeeding pick, but also that more especially in satin the warp and the weft surfaces would in some degree merge into each other, and consequently tend to soften the irregularities in the line of the figure. This is the simple principle upon which all damask figures are made.

I shall have to refer presently to special machines which dispense with the pressure harness and reduce the number of pattern cards required, but necessarily at the cost of an increased fineness in the harness and an increased number of hooks in the machine itself, and so far as the contour of the pattern is concerned merely transferring the tendency to form steps from the warp threads to the weft threads. What are the advantages or disadvantages accompanying each of those methods will require to be carefully compared and analysed at a later stage.

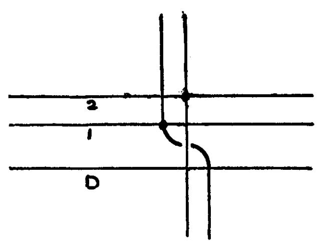


Fig. 207.

There is but one class of harness to be dealt with now, and that is for weaving gauze fabrics. In this the arrangement is different from all the others, insomuch as the threads are made to cross each other; perhaps a simple plan of a draft will explain this better than anything else. At Fig. 207 two lines 1 and 2 represent two ordinary healds, and the third line D represents a doup, then two threads, are drawn through the healds in the ordinary manner, No. 1 thread through the heald 1, and No. 2 through the heald 2; No. 1 thread is then passed under the thread 2 and through the loop of the doup, this doup loop will be best understood by reference to Fig. 208, which in an ordinary heald is really an extra loose half passed through the eye and over the top of it, but in the harness it may be passed either through two eyes in the mail, or it may be a loose slip passed through one eye as shewn in Fig. 209. In the one case the loose slip will remain in position whether there is a thread in it or not, in the other case the moment the thread breaks it will fall out and disengage itself from the harness. The object of this arrangement

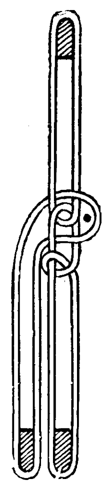


Fig. 208.

is to permit the thread No. 1 to be raised either on the right or the left of its companion thread, and so to cause crossing to occur at will. Without, at the present moment, discussing the manufacture of gauze fabric, beyond what has already been done in dealing with the dobby machine, the advantages of the doup harness may be readily pointed out. In the first place, by using jacquard hooks we have the power of causing the crossing to take place in any of the sets of threads, whether they comprise 2, 3, or more, and we may either provide each of the loose slips with a separate weight, or what is more convenient, place all the loose slips corresponding to one row of the harness upon a common heald shaft; pass each one through its own mail, and let it be held in position by the warp thread, and the moment that thread breaks allow the loop to fall clear of the harness and so prevent trouble or confusion; so that reduced to simplicity the harness for weaving gauze fabrics will consist of an ordinary harness, properly speaking, divided into two sections, the one section being detached for the purpose of becoming the standard of the doup as shewn in Fig. 209, and the other portion fulfilling the functions of a doup.

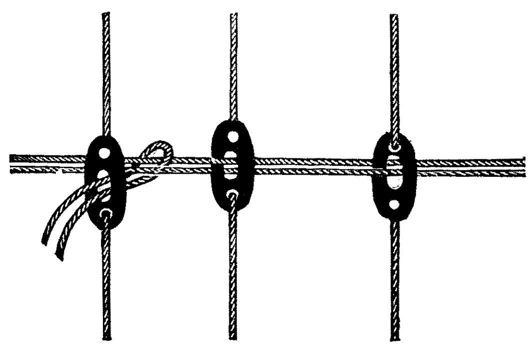


Fig. 209.

At this point attention must be called to what is a matter of necessity in gauze weaving, viz.: the slackening of the crossing threads at the moment of crossing; when working with healds, whether with tappets or dobby, the slackening is usually done by means of a lever and rod placed behind the loom, and, in the event of more than one crossing or doup heald being employed there must be a slackener for each of such doups, but in the harness there must be a slackener for each individual thread.

Without wasting time in describing the various devices which have been resorted to from time to time we may at once approach the harness of the present day, and further, without waiting for a more elaborate description of the machine in detail it will be as well to presume for the moment that the general arrangement of the jacquard is understood. A general view of the machine

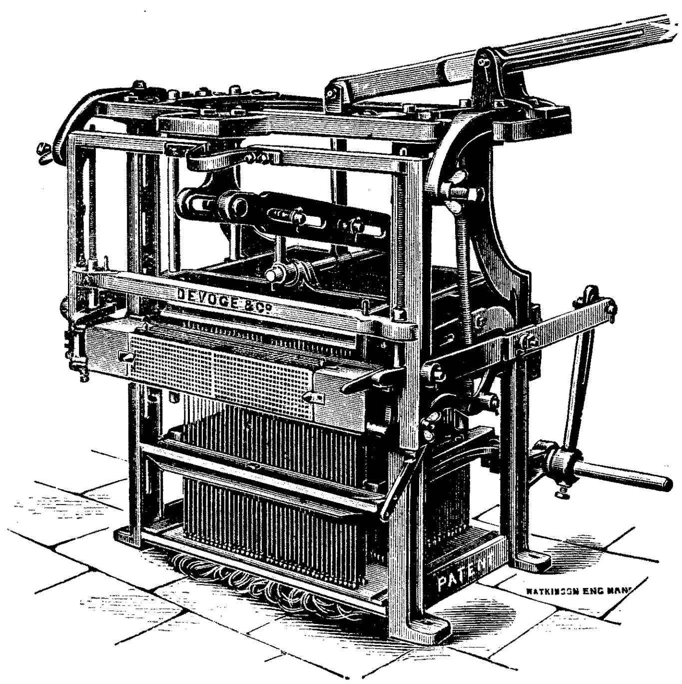


Fig. 210.

is given at Fig. 210. In this it will be seen that the two front rows of the machine are entirely detached from the rest, in reality the machine contains 600 hooks, 100 of these being detached for the doup harness, 400 for what is termed the figure harness, and 100 for the slackening harness; but although there are 600 hooks in the machine only 500 needles are employed; the needle which acts upon the doup hook acts also upon the corresponding slackening hook, thus rendering it impossible in the first place to lift the doup harness cord without at the same time lifting the corresponding slackening cord.

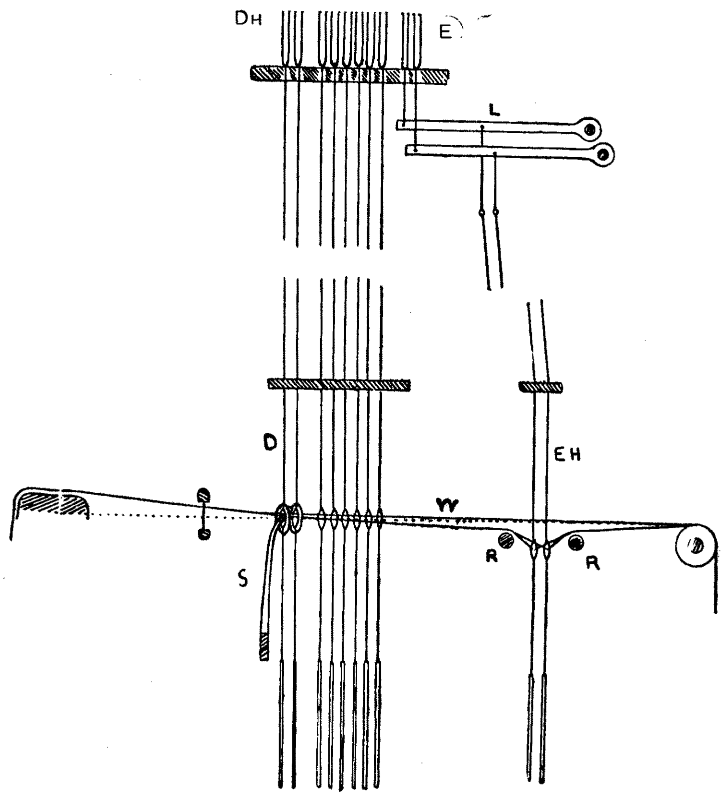


Fig. 211.

It will be necessary now to describe more fully the exact arrangement. Fig. 211 shews a section of the machine with the doup slackener and the common harness all attached, D is the doup, DH the doup hook, E the easer or slackening hook, and EH the easing harness, and S the loose slip; W represents the warp thread passing through not only the loose slip of the doup, but the first harness cord of the figuring portion, then also through the slackening, or easing, harness and over two fixed rods RR behind the harness; now it must be perfectly clear, as already demonstrated, that when the doup itself rises carrying the crossing thread, in what is sometimes termed a false position, a sufficient length of yarn must be given off by the slackener to compensate for that taken up between the figuring harness and the doup in the act of crossing; then to meet this the slackening harness is tied up with the mail below the warp line and with the fixed rods RR sufficiently close to the harness itself to give off exactly the same amount of yarn as will be taken up by the doup when lifted in crossing. The whole arrangement so far is extremely simple, but the fact remains that considerable care must be exercised in the adjustment of the rod, the doup harness and the loose slip; in the first place so as to ensure exactly the length of yarn being given off by the slackener as will be taken up by the doup, and in the second place in the lifting of the loose slip just a sufficient distance to prevent any drag upon the yarn and at the same time to avoid what is commonly termed 'knuckling.' Intermediary between the hooks E and the harness EH are placed a series of levers L for the purpose of adjusting the amount of slack given off to the warp as the doup lifts. These levers are attached to each of the easing hooks, and each carry a set of easing harness cords, so that if there are 100 easing hooks there must be 100 levers. In the machine shewn at Fig. 210 those 100 levers are dispensed with, and instead of the hooks for the easing harness being lifted by the common griffe they are lifted by a separate griffe, the stroke of which can be regulated at will. The common lifting griffe is shewn at G Fig. 212, and the supplementary one at G^1. A lever L is carried from the lifting rod R to a fulcrum at the back of the machine, and a second lifting rod R^1 is carried from this rod to the griffe G^1. Slots in the lever L permit all the adjustment necessary, so that this simple and ingenious contrivance avoids the use of the 100 levers as shewn in Fig. 211.

So far I have suggested only the arrangement of the doup for one thread crossing another, but it is equally

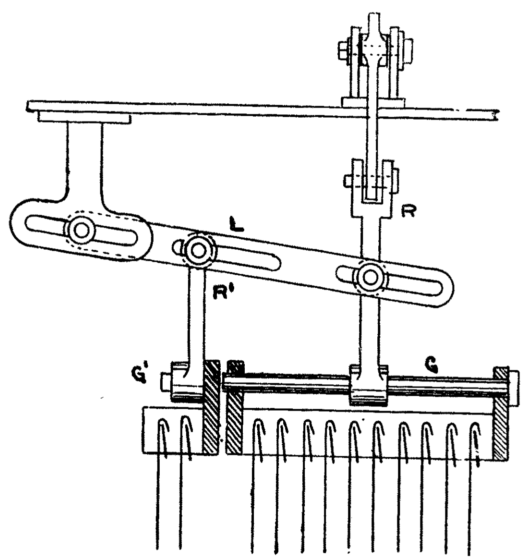


Fig. 212.

easy to make one thread cross two as shewn in Fig. 213, but what is still better and more generally practised is to have two crossing two as in Fig. 214. Without at the present moment entering too closely into the question of arrangement of design, or the practical application in weaving, both of which will be dealt with in their proper places, it will be desirable to point out generally the fact that the more threads cross each other, each working independently when the crossing does not take place, the closer the texture of a ground fabric can be made, and, proportionately, the more open in the gauze portion. There really is no limit to this, harnesses may be built

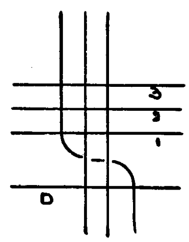


Fig. 213.

for two threads crossing two, or three, or more threads crossing each other, or in fact any combination, subject to the number of hooks in a machine being arranged and adapted to the purpose. But it must never be forgotten that the doup hooks must be detached from the ordinary

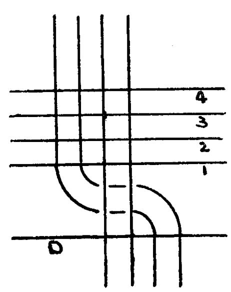


Fig. 214.

figuring hooks, and must be counted as duplicates so far as the figuring part is concerned, and must also at the same time be coupled with the slackening hooks which have no functions beyond that of giving off the amount of yarn taken up by the doup itself.

THE JACQUARD MACHINE.

A general outline of the arrangement of hooks and levers of the single-lift machine has been given in connection with Fig. 154, page 305. It now remains to give a description first of the internal arrangements of a few of the different machines, then of what might be termed the external apparatus such as the swing, or horizontal motion, for carrying the card cylinders, and of the card motions generally. I will adopt the course at first of dealing only with the interior, and of the connection of that interior with the harness, then what will have to be said afterwards of the external motions will have a general application and prevent in a great measure repetition which would otherwise of necessity occur. The general description given of the arrangement of the hooks in reference to Fig. 154, is perfectly true in its application to all single lift machines, it is only when we come to what are termed double lift machines that any considerable difference in detail arises; there may be differences in the form of hook, and the methods adopted for preventing turning, each of which will require a little notice later, but there is no difference in principle.

The double lift machines may be divided into two distinct classes, one where two cylinders are employed, one at each side of the machine, and two sets of hooks set back-to-back with each other. A full view of a two cylinder machine is given at Fig. 215, where as will be seen there are two card cylinders connected to each other by means of an arm on each side of the machine, those two cylinders carry each one half of the cards, one taking those corresponding with the odd picks as 1, 3, 5, 7, and so on, and the other carrying those corresponding with the even picks as 2, 4, 6, 8. A section of the interior of the machine is shewn at Fig. 216, where the hooks shewn must be both connected to the same neck cord. There are necessarily two lifting griffes, each acting upon their own set of hooks and rising and falling alternately, so that as one cylinder comes in contact with the needles it will operate one set of hooks, the other cylinder operating the other set, and the two griffes acting in unison with them. This machine possesses peculiar advantages, and certainly is one of the earliest forms of double hook machines in use. First the griffes acting alternately enables the speed of the machine

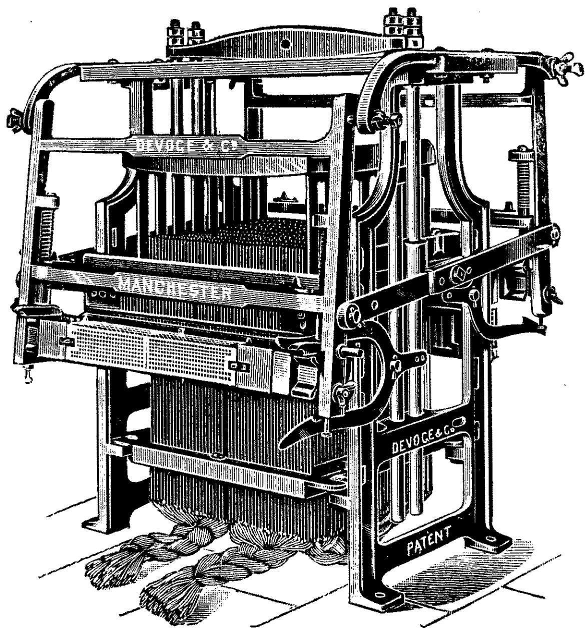


Fig. 215.

to be considerably increased; then comes in what is often termed the counterpoise principle, and suggesting what is termed the open shed; in reality there is no open shed, but exactly the same thing occurs as in the counterpoise dobby, or those already described of the type of the Keighley dobby, where it was shewn that one portion ascended and the other portion descended; a change takes place midway between the two extreme points, so that although there is not actually an open shed, in the strict sense of the term, yet the shed is never actually closed, and in any case the descending portion serves to balance the ascending portion, so assisting to give ease in working. Then again in this machine by the form of the hook, when the double hook reversed is used, there is but one neck cord and it

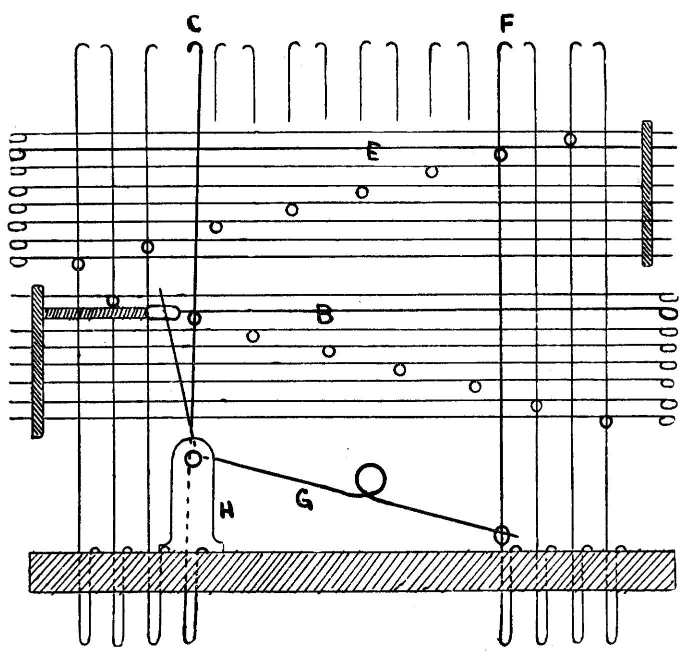


Fig. 216.

will have to be shewn in reference to other forms of machine that this is a decided advantage. Still further advantage is that each cylinder acting upon its own set of hooks there is practically the same freedom from strain upon the hooks and needle, and from pressure of the needles upon the cards, as in an ordinary single lift machine, but a slight disadvantage occurs, sometimes said to be a serious one, in the employment of two card cylinders. It is quite possible in consequence of carelessness on the part of the weaver for one cylinder to turn over its cards and get in advance of the other, when, of course, the pattern will be broken off. A tendency to mishaps in this direction has made the double cylinder machine unpopular with a great many people.

The general practice however now is to use two sets of hooks in the double cylinder machine, as shewn in Fig. 215, each set of hooks having its own set of needles, and a most important improvement has been patented by Messrs. Devoge, of Manchester, in the shape of a stop-motion, which operates in the event of one cylinder getting in front of the other. The arrangement will be understood by reference to Fig. 216. There are two card cylinders, the odd-numbered cards passing over one, and the even numbers over the other. The second needle from the top in the series opposite the lower cylinder, and at the end of the machine, acts upon a stopper hook C, and the corresponding one in the series opposite the upper cylinder, on a corresponding stopper hook F through the needle E. The two are connected by a wire lever G, which passes through a loop in the lower part of the hook F, and another in the needle B, and fulcrumed on the bracket H on the side of the machine. The end of the needle B is cut off level with the needle board when the hook is at rest or off the griffe as shewn.

Whenever the hook F is raised it must press the needle B forward by means of the lever G, which would raise the hook C by the lower griffe acting upon the hooks operated by the upper card cylinder unless B is pressed back by the card on the lower cylinder, then it follows that if the hook F is raised and there is no corresponding hole in the cards on the lower cylinder that the hook C would always be struck back and never lifted; but if a hole is cut in the cards on the lower cylinder to admit the passage of the needle B, immediately following one cut in a card for the needle E, then the hook C would be lifted.

The actual stop-motion is shewn at Fig. 217. J is the knocking-off handle of the loom, and K a small piece bolted to the back of it, L and M are species of brackets bolted to the loom frame, one on the outside and the

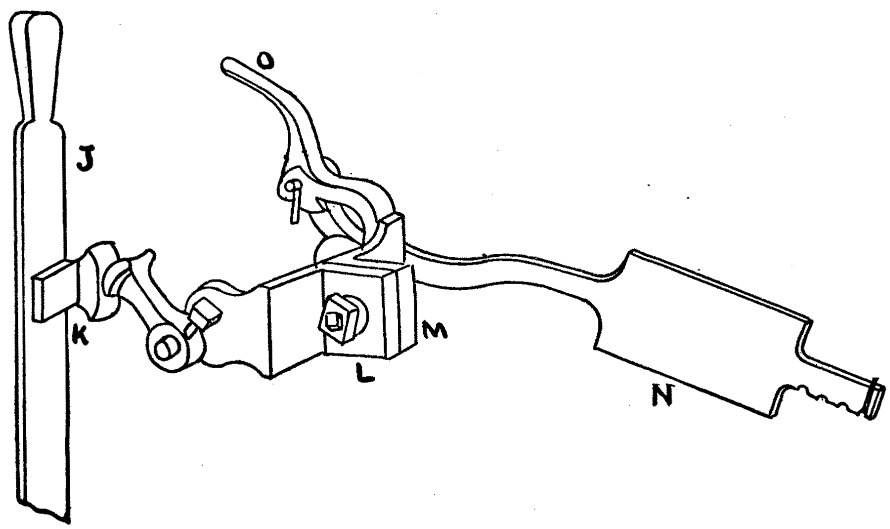


Fig. 217.

other on the inside. N is a lever connected by a string to the stopper hook C, and having upon its spindle the short lever arm P, so that whenever the stopper hook C is lifted the lever N is lifted and P depressed, at the same time pressing forward the belt fork handle J, and stopping the loom. It must then be obvious that the cards being cut for the proper order of succession prevent the contingency of a hole on the lower cylinder opposite the needle B, following one on the upper cylinder opposite the needle E. Should either of the cylinders go wrong the loom must be stopped at once. Fig. 218 shews the order of succession which may be adopted, but it follows that any other arrangement as to numbers which will prevent the conjunction referred to will be equally effective.

The dots indicate where the holes would be cut in the two sets of cards (odd and even) respectively.

To overcome this difficulty, apart from stop-motions, what is known as the single cylinder machine has been introduced, a view of which is shewn at Fig. 219. In this case there are two sets of hooks, each acted upon by the same needle and the same cylinder, there are two

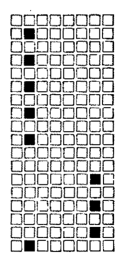


Fig. 218.

lifting griffes, just as in the previous case, each acting upon its own set of hooks; there is the same counterpoise principle, but instead of each hook being acted upon by its own card cylinder, both are being acted upon by one cylinder, therefore if the hook must be struck off the lifting griffes it must be done when one of them is carrying the whole weight of the harness attached to it, so that there must be considerable pressure of the needle upon the cards, as it is obliged to bend one of the hooks a distance corresponding with that which it presses the other hook back to strike it clear of the lifting griffe. That is one disadvantage, involving as it does great wear and tear upon the cards and upon the machine itself; accompanying this is the disadvantage of there being two separate neck cords attached to each neck as shewn in Fig. 220, so that as one hook is being lifted and the other corresponding hook being left down there is always a slack neck cord. A considerable amount of wear and tear necessarily follows this. A good deal of this has been obviated by the arrangement of the lower part of the machine, where,

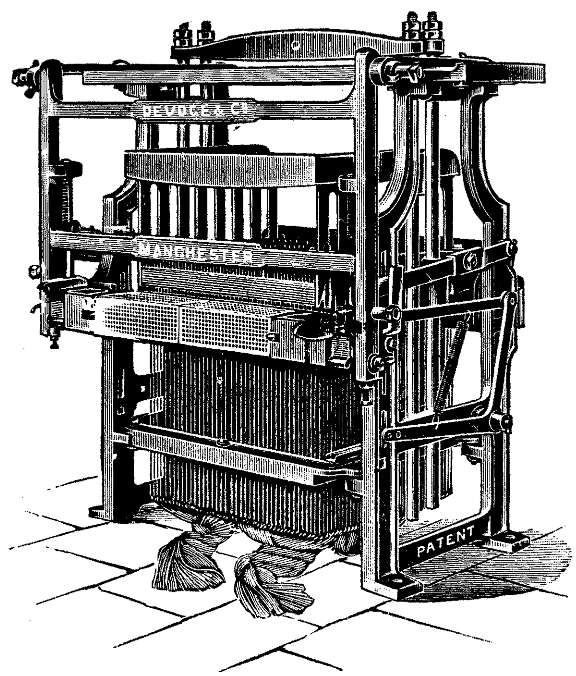


Fig. 219.

instead of the hooks resting upon the bottom board, as is the case in the ordinary single lift, they are bent over and hooked and made to rest upon cross bars, so that there is no friction upon the neck cord. Again this has been overcome recently by the introduction of a link, as shewn in Fig. 221, where the hooks are shewn both at rest in one pair, and one raised in the other—as also is Fig. 220,—which couples the two hooks together, and in

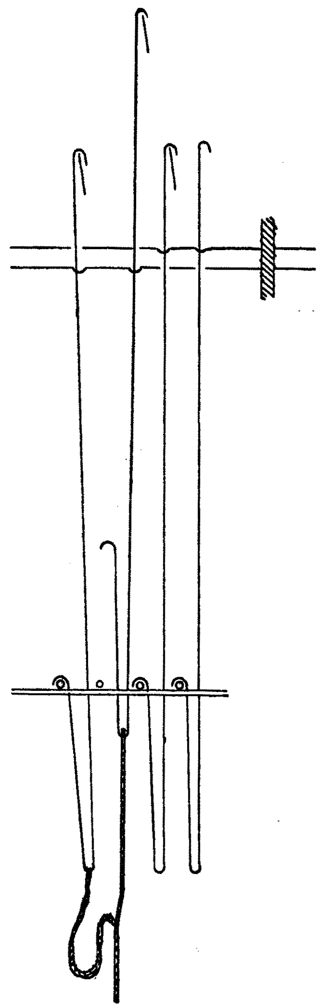


Fig. 220.

such a manner that when lifted by one hook it slides freely upon the other and one neck cord is then made common to both hooks. The contrivance is simplicity itself as will be seen in the illustration.

As against the double cylinder machine we have the disadvantages pointed out of increased wear and tear, but

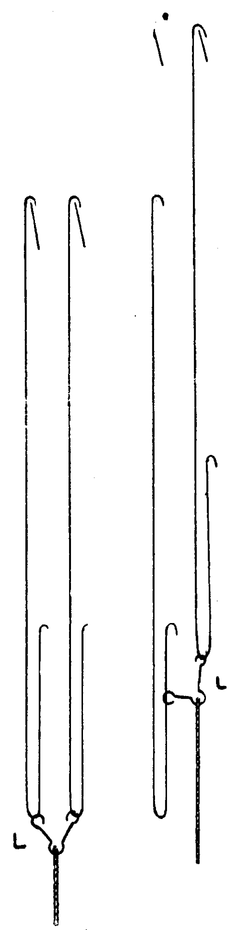


Fig. 221.

we have the advantages on the other hand of simplicity in the mechanism, one card cylinder only being required in the place of two, involving less trouble and watchfulness on the part of the weaver, and also less wear and tear in the actual mechanical parts of the machine and less driving power. It is claimed for it also that it possesses the power of running at a higher rate of speed but this claim is open to some objection.

HORIZONTAL MOTIONS.

In the machines described so far the card cylinders are carried upon arms suspended from the top of the machine, but in many cases those arms, for various reasons, are somewhat inconvenient, when what is termed the

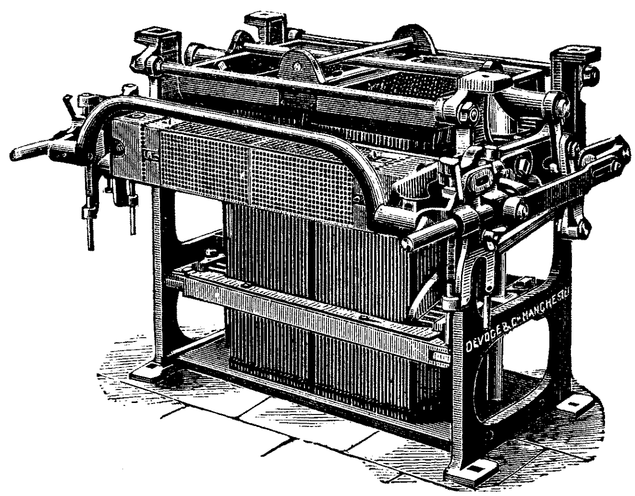


Fig. 222.

horizontal motion is resorted to. An ordinary single lift machine is illustrated at Fig. 222, which is virtually the same machine as the ordinary 400 single lift already described, but having the card cylinder carried upon horizontal bars. A similar motion is shewn at Fig. 223, and which would correspond with that at Fig. 215, the only difference in both cases being economy of space over the loom and consequently suitable for rooms, or sheds, where the roof is too low for the ordinary swing motion.

Now we must turn to another machine which is intended for what are commonly termed border patterns, *i. e.*, where two sets of cards may be dealt with separately, and each acting upon the same set of hooks. One form of machine, and which is really a compound machine, is shewn at Fig. 224, where there are two cylinders, and the two cylinders may be working alternately in the

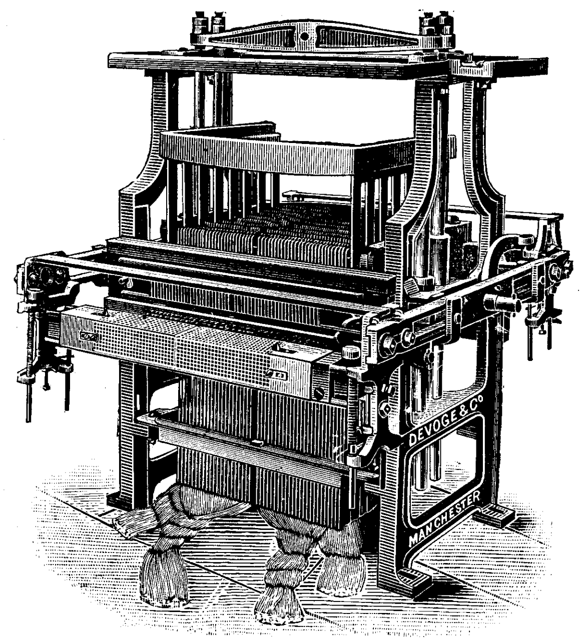


Fig. 223.

ordinary manner as in Fig. 215, or where the machine, which consists of what might be termed a double 400 machine, can be converted into an ordinary single lift 800 machine, but in that case the two cylinders must be working together instead of alternately as in Fig. 215; or again it may be converted into the cross border machine by allowing one cylinder to act with its own set of cards for the cross border, and the other cylinder with its set of cards for the middle of the handkerchief, shawl or other article. By simply pulling a cord one cylinder is disengaged and the other brought into action at will. This of course it will be seen at once dispenses with the necessity of changing cards to form the borders.

There are several other contrivances of a similar kind, such for instance as Devonport and Crossley's, where two card

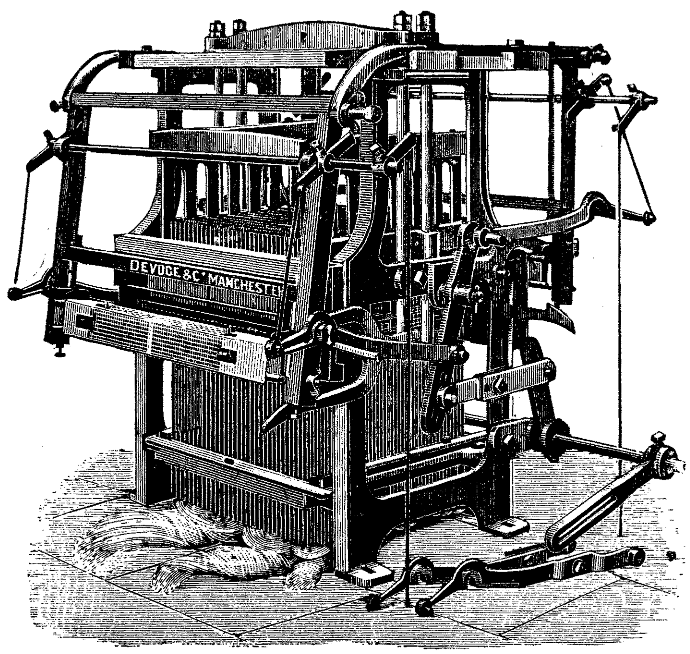


Fig. 224.

cylinders and two sets of needles are employed as shewn in Fig. 225, the lower set of needles are the ordinary needles of the machine, the upper set are supplementary, and intended to be brought into use by means of a supplementary set of cards. When the lower set of needles are in use the card cylinder operating the upper series remain stationary;

but the moment the cross border is come to, the lower cylinder is disengaged and the upper one brought into use in place of the lower one, and carrying the cross border

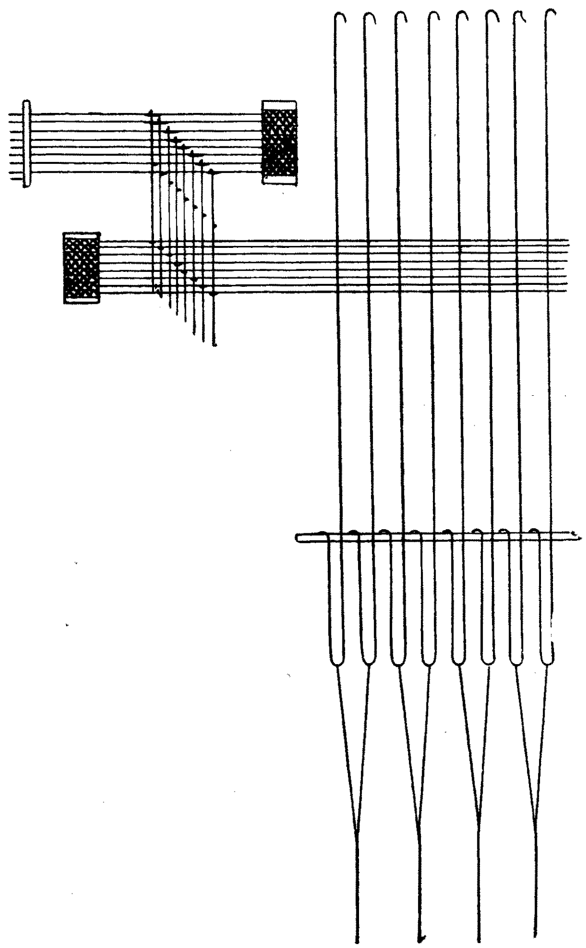


Fig. 225.

pattern. The action of the upper needles affects the lower ones by the series of vertical connecting levers as shewn in the illustration. One of two methods may be brought into use, either the supplementary needles should be placed immediately above the other ones, or they may be placed on the opposite side of the machine, and so contrived to act and serve the same purpose, and then, of course, the two sets of cards will not interfere with each other.

Another form of arrangement for answering the same purpose is illustrated in Fig. 226, the invention of Messrs. Hahlo and Liebreich, where two patterns are cut upon the same set of cards. In this case what might be termed a double cylinder is employed, *i. e.*, if there are 8 rows of hooks in the machine, the cylinder will contain 16 rows, the border pattern is put upon 1, 3, 5, 7, and the ground pattern upon 2, 4, 6, 8 rows, then by a chain or link adjustment, the cylinder can be raised or lowered, so that in weaving the cross border the odd rows of the cylinder, with the necessary pattern, are brought opposite the points of the needles, and for the middle the even rows, with the pattern for that portion, are brought into operation simply by raising or lowering the cylinder as suggested. It may be a matter for consideration whether the labour involved, the weight of paper and the attendant trouble will be sufficiently compensated for in the saving of time of card changing.

The next style of machine calling for attention is what is termed the double shed or rising and falling jacquard, which really means a machine for working upon what has been described as the centre shed motion, or a perfect counterpoise. It will be readily understood that in very heavy goods, such as shawls, where the double cloth principle comes frequently into use ; or in coatings which must be backed, or in carpets, where a very large shuttle must be used, or in fact in many very heavy goods the advantages of the counterpoise must be very great. In this arrangement the bottom board descends carrying with

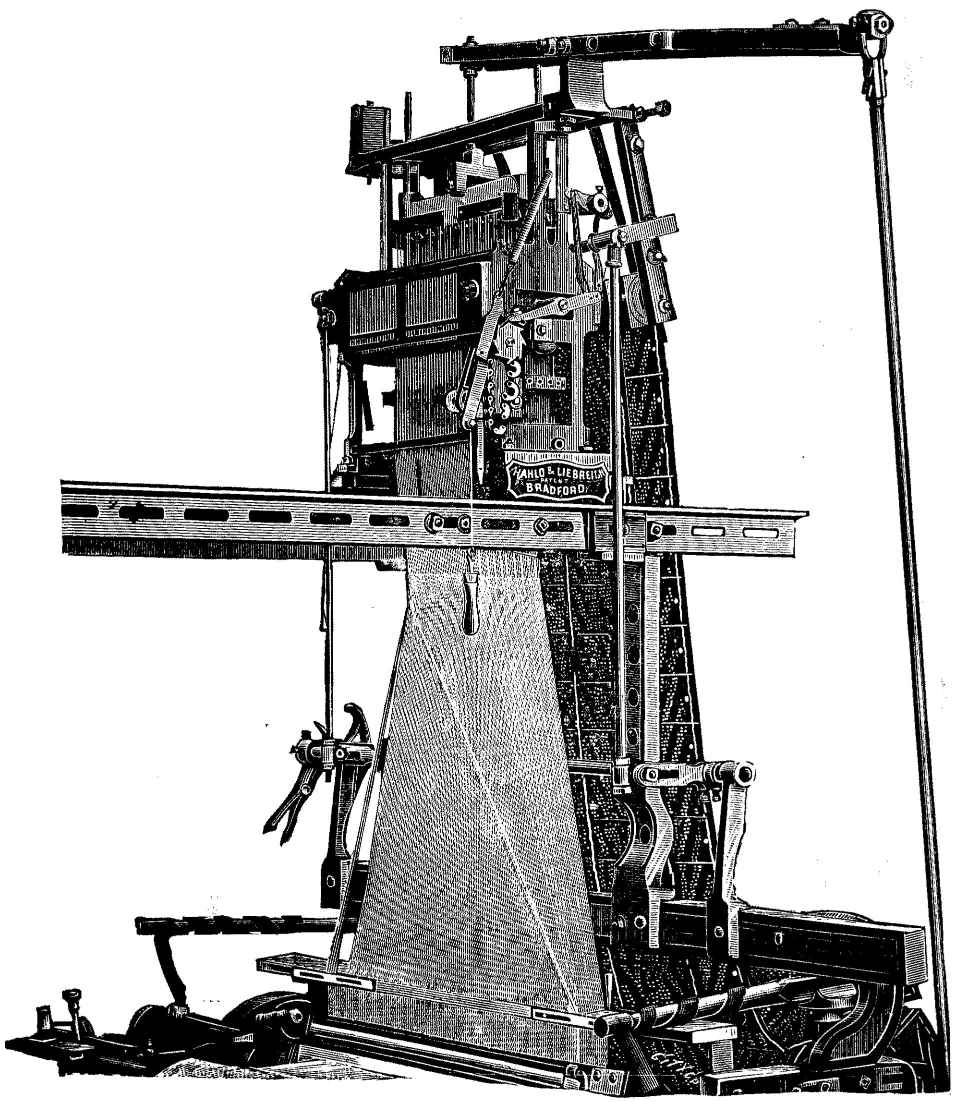


Fig. 226.

it the hooks that are not acted upon by the griffe, so that the shed is really formed always from the centre. As will be seen on reference to Fig. 227, there are four levers at the top, so arranged that they connect the griffe with the bottom board of the machine, and in such manner that as the griffe rises the bottom board descends. It is scarcely necessary to go very fully into the details of the mechanism because the whole arrangement is perfectly

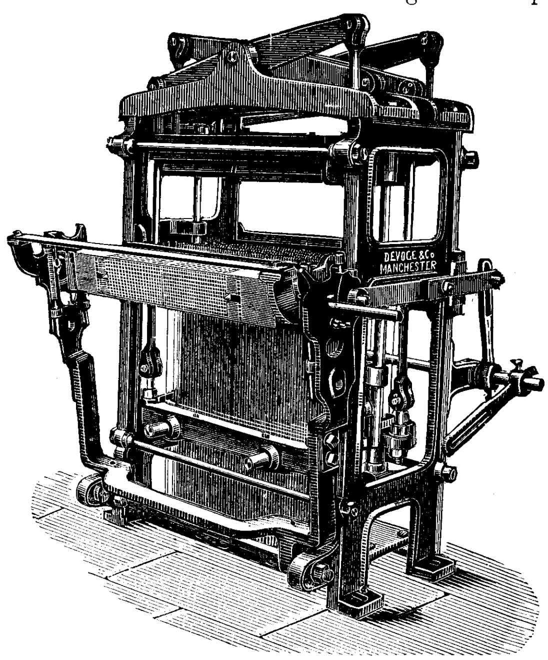


Fig. 227.

self-evident on the surface. From the very fact of the bottom board being connected to the griffe the centre shed is assured. The mechanism will however be even better understood by reference to Fig. 228, which shews a front elevation of the loom and jacquard stripped of all accessories. In this it will be seen that the lift is made, or more correctly, motion is communicated to the machine from below, by means of a lever operated from the driving shaft of the loom. As I have already said everything is so self-evident from the drawings that it would be superfluous to enter into minute detail.

Numerous attempts have been made from time to time to accomplish this object, one of the earliest being that of Sowden's some thirty years ago or more, but the first really successful one for heavy work being that of Mr. Ainley's. One of the greatest difficulties of the case has been to make the mechanism sufficiently self-contained;

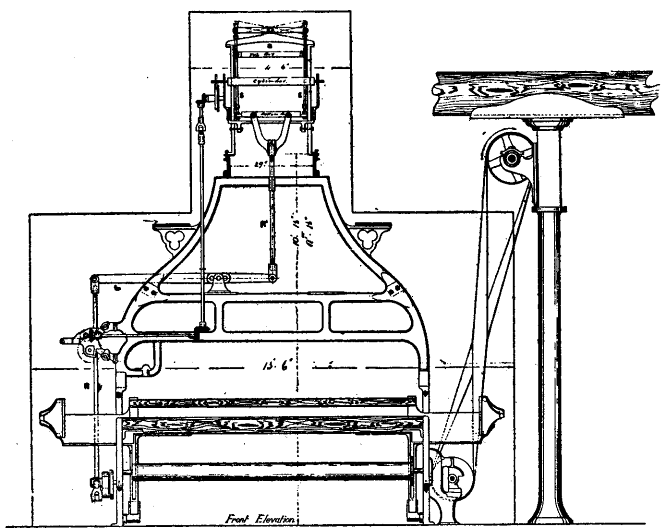


Fig. 228.

the levers being entirely outside the machine occupying a good deal of space and making the working somewhat cumbersome. But in the present instance, as will be seen, the whole of the mechanism is contained within small compass. The card cylinder arms instead of being suspended from above as in the case of the ordinary jacquard are worked from below; a lever at the back of the machine giving the necessary reciprocating motion as shewn. This is probably one of the most compact and effective machines of this kind.

The illustration in question is that of the Hollingworth and Knowles' patent fast running loom, and one feature of the machine may be examined whilst the other details are under notice, namely, the communication of motion to the card cylinder. As will be seen the card cylinder is actuated by bevelled gearing placed to the left of the loom, so that the driving is positive and independent of the machine itself. Whatever advantages may be claimed for this particular mode of driving, or whatever disadvantages may accompany the use of gearing for this purpose, one thing at least must be abundantly clear, that in this, as in all other machines, the action of the card cylinder must, for easy and good working be independent of the machine itself. In a power-loom there are two reasons for this, one, and probably the one which led to the adoption of the system, is the necessity for turning the card cylinder over so as to find the proper card in a broken pattern, or when the weft has run out, without the necessity of turning the whole loom and the jacquard at the same time. The arrangement illustrated in this instance is one which offers the facilities requisite for this purpose, but a second and more important reason for having the card cylinders motion independent of the lifting griffe, so that the cards are not pressing upon the needles until the griffe has reached its lowest point, and the lifting hooks are free of the blades of the griffe, will be better understood by reference to Fig. 229. which shews the earliest form of machine in use for hand looms, where the card cylinder was thrown out by means of a curved bar attached to what is called a swing frame, and a pulley attached to the griffe and working inside this curved bar; from the shape of the curve, as the griffe is made to rise, the cylinder arms are thrown outwards and as the griffe descends the cylinder is brought towards the point of the needles, but for the purpose of ensuring perfect working, and the proper indication of the pattern by the cards upon the needles, they were usually made to strike the needle points somewhat before the griffe had reached its lowest point. Of course there were opportunities

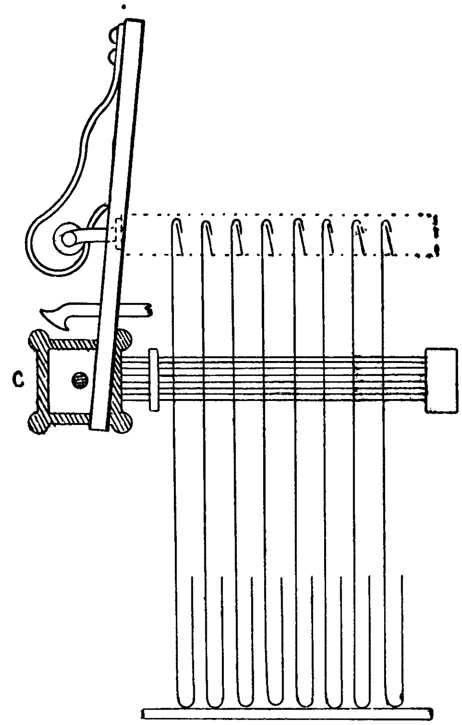


Fig. 229.

of adjustment which would enable the weaver to bring the cards in contact with the needle point exactly at the moment of releasing the hooks from the griffe, and also of keeping the card in contact with the needle until the return of the griffe had made sure of the necessary hooks being caught, and so preventing any risk of mistake in the pattern. This would involve not only careful adjustment of the bent lever arm, but also a proper adjustment of the curve itself. This however is not an extremely difficult

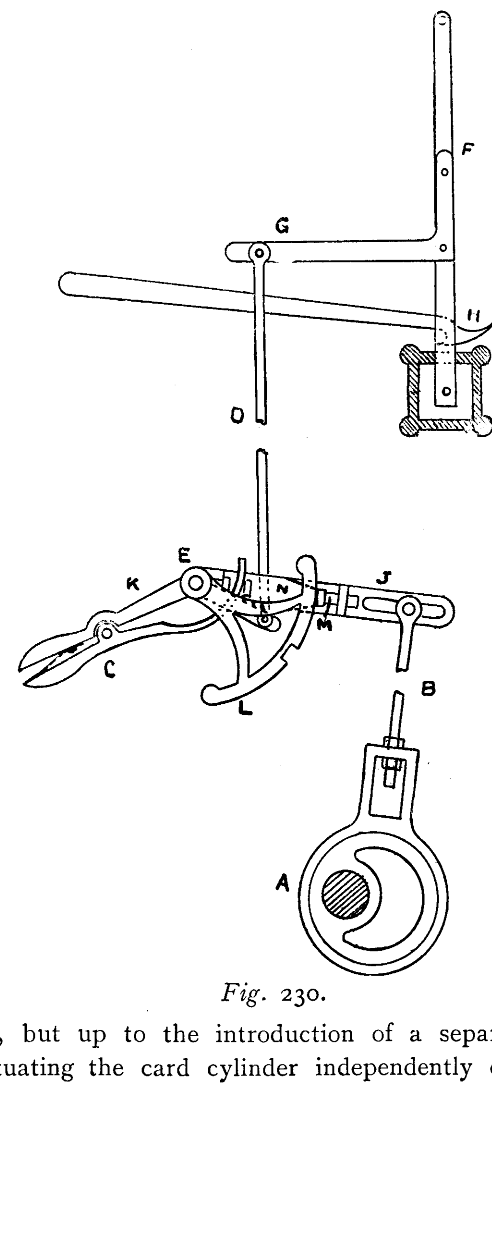


Fig. 230.

matter, but up to the introduction of a separate motion for actuating the card cylinder independently of the griffe itself there was no means of moving the card cylinder without moving the whole body of the machine.

The card motion in almost universal use will be best understood by reference to Fig. 230. An eccentric A is placed upon the driving shaft of the loom and connected by a rod to the lever B. This in turn acts upon a lever J which is made fast to a horizontal shaft E, from which another lever L K communicates motion to the swing arm F of the machine through the arm G and rod D. The lever J has adjustable slots so that the throw of the cylinder arm, or batten, as it is sometimes called, may be regulated at will; but an intermediate arrangement comes in, which really is the valuable feature of this contrivance; for instance, the eccentric would communicate motion to the card cylinder every time the loom was turned over just as the crank would communicate motion to the griffe, so that although the two motions are in a sense independent of each other they would always be acting in unison. The object of the intermediary arrangement is to enable the card cylinder motion to be detached and operated independently of the other parts of the machine and by hand. On one arm of the lever L K is an arc of circle formed at its extremity. The lever J is loose upon the shaft E, but that portion carrying the arc of a circle is made fast; a notch is formed in this arc of a circle into which a catch M sliding upon the lever J may fall; the opposite arm of the lever K is formed in such a manner as to give name to the arrangement, viz.: the "duck bill," as seen at C. One side of this duck bill is a fixture on the lever, but the other is hinged to it with a curved arm at the opposite extremity, this curved arm being so contrived that on pressing the two portions of the duck bill together it pushes the catch M, by means of the slide N, out of the notch in the arc of a circle at the opposite extremity of the lever arm, thus liberating the lever and permitting movement to be communicated to the swing arm of the card cylinder without any other portion of the loom being moved. In all probability the introduction of this arrangement has done more to popularize and render the jacquard machine a practical one as applied to power looms than any other.

BESSBROOK JACQUARD.

The Bessbrook machine is really a development of the twilling machine of Mr. Shield's, of Perth, both of which are described in my "Treatise on Weaving and Designing," and is in reality a machine for dispensing with the pressure healds already described. It has many good points to recommend it, but is only of service for weaving large damask figures, such as table cloths, &c., where great jacquard power is required, and cards can be saved by twilling arrangements in the machine.

OPEN SHED MACHINES.

A few words must be said at this point on what have been termed open shed jacquards, and although up to the present time nothing of a very positive character can be said of their success, yet of the principle and its advantages there can be no doubt. For instance, it has been pointed out in reference to centre shedding machines that the counterpoise principle is of considerable advantage, but if this can be carried out in its entirety, and produce a shedding which is practically equivalent to that obtained by tappets, an enormous advantage would arise in weaving many classes of fabrics; apart from the advantages of working with the open shed, which, of course, in some fabrics may be a doubtful quantity, there would always be the advantage of economy of power if one portion of the hooks carrying the harness threads, and the warp, could be held at the highest point as long as requisite for the formation of pattern, and another portion kept at the lowest point. Then the two portions changing from the highest to the lowest, and in the opposite direction, would tend to balance each other and so economise power. Without attempting to go into the details of each one the general principles of one or two may be referred to briefly.

We may take first that of Cheetham and Sutcliffe's, which at one time promised to fulfil all the expectations held out, but the intricacy of the mechanism and the tendency to fail at the critical moment, did much to damage its reputation.

The chief object in the machine is to keep up the lifting hook, and consequently the harness, for any length of time required for the formation of pattern, as described in the open shed dobbies. The machine is on the double lift principle, with a double hook acted upon by the same needle; that is, one piece of wire is bent round to form two hooks and receive one neck cord at the bottom, and there are two loops in the needle, and there are two lifting griffes. A series of pushing off bars are employed above the knives of the griffe, and a resting hook is formed upon the back wire of the double hook below the needles, and a resting bar placed so that this lower hook may rest upon it when required. When the hooks have been lifted and deposited upon the stationary griffe they will remain until struck off by a card, and the vibrating levers above will prevent the ascending griffe from carrying them up again until required for the pattern.

Another machine has been since introduced by Mr. Wm. Hardaker, of Great Horton, on the "dwell-up" principle, the resting griffe and double hook being employed. The hook is of a special form and held in position by the bottom board, which forms a kind of grate.

So far as can be seen this machine seems to do its work satisfactorily, and certainly it has the merit of simplicity.

An attempt has also been made upon a different principle by Wilkinson. He depended upon the use of a species of pulley block between the hook of the machine and the neck cord, *i.e.*, he took a couple of pulleys, made one end of a cord fast to one of the hooks of a double lift machine, passed it round the upper of the two pulleys, made the other end fast to the second hook, the centre of the lower pulley he made fast to the centre of the upper one. He then passed the neck cord over the lower pulley and made the other end fast to a bar, practically on the same principle as the healds are actuated as described in the pressure harness, so that when both hooks were raised the harness would be lifted, and the hooks meeting in centre of their movement they may be transferred from one griffe to the other. In other works the principle is the same as that underlying the Hattersley dobby.

Efforts in the same direction have been made by numbers of people, and, as already said, for some purposes a machine of this character is much needed, but whoever succeeds in meeting the demand, he must do it with the simplest possible mechanism. There is sufficient machinery in the ordinary Jacquard, and anything which tends to complicate it will meet with strenuous opposition both from weavers and overlookers. Once, however, the end is attained, a liberal recompense will follow to the successful inventor.

LECTURE 10.

JACQUARD, CARD-CUTTING AND PATTERN ARRANGEMENT.

Having dealt with the bulk of the systems of jacquards and harness tying-up, it is necessary for completing this portion of the work to go through the methods of arranging patterns on paper to suit all the different systems of jacquards and harnesses, the cutting of the cards and all the necessary work in connection with it. One thing however, I must make clearly understood, I have no intention of entering into all the details of pattern making, or of the system of applying twilling to jacquard figures, except in so far as it may involve a knowledge of the use of compound harnesses. The principles of designing and pattern arrangement, so far as a knowledge of the application of design to the structure of cloth is concerned, is a matter altogether outside the province of the present work. First I will take the arrangement of patterns on paper for the ordinary single jacquard. This being the simplest form of machine in use, if the subject is dealt with thoroughly, it will make it very easy to understand the preparation of designs for the more complicated harnesses. It will be remembered that in dealing with the construction of the harness for a regular tie-up as illustrated in Fig. 167, page 320, two things were pointed out, first, that the space occupied by one division of the harness, or that which represents one complete set of hooks in the machine, will be dependent upon the number of threads per inch; suppose, for instance, the machine contains 400 hooks, and the fabric contains 80 threads per inch, one complete pattern then will occupy a space of 5 inches, and this would be repeated as often as requisite for the width of the fabric. Then practically our pattern must be complete within the 5 inches, and it is repeated six times across the width of the piece, supposing that the fabric be 30 inches wide. Now take the Fig. 167, page 320, for example. There we have a small figure which we may suppose to represent either the whole division of 5 inches and repeated a given number of times across, or it may represent a fraction of the 5 inches; a complete pattern is shewn repeated, and this pattern, of course, will be continuously repeated both across the piece and lengthwise. Then we should have to arrange the pattern upon our design paper, supposing the whole of the machine to be used, so that it will occupy exactly 400 squares across, but the number lengthwise will depend upon the length of the pattern. It is not necessary that the pattern should occupy an exactly square space. The number of picks occupied in most figured designs need not necessarily bear any relation to the number of ends occupied. It is only where patterns such as diagonal or similar figures are taken into account, the angle at which they run across the fabric, or where there is some direct relation between the ends and pick in the pattern, that any attention need be paid to the relations, or to the number of picks employed. Suppose then that the pattern does not occupy the whole 400 hooks, then it must be made to occupy a number which is an exact measure of 400, or some of the hooks in the machine must remain idle; this will involve a reduction in the fineness of the cloth.

Perhaps it will be as well at this point to deal with the whole question of casting out, as, whatever applies to a plain harness will equally apply to all other harnesses. Now we will take it for granted that our jacquard contains 400 hooks, and suppose our pattern must occupy only 48 hooks, this is, of course, supposing a small pattern, but one commonly occurring; then if we divide 400 by 48 we shall find that we have 16 hooks which cannot be employed, and therefore only 384 in actual use; those 16 hooks must have no warp drawn through their mails, hence we should have 384 mails forming the pattern, which must of necessity occupy precisely the same space as the 400 did, so that we should have to reduce the number of threads per inch in the same ratio; then the calculation would stand as 400 : 384 : : 80 = $76\frac{4}{5}$, or a reduction of three ends and one-fifth per inch. This of course is very trifling in itself, and in regular practice would probably be ignored entirely, as the number of harness cords cast out in the whole width, of say 30 inches would only be equal to 80 threads, or exactly one inch in the width of the harness greater than that in the sley. This would scarcely have any detrimental effect in the working; but suppose the difference should rise to 2 or 3 inches, as is often the case, then it must be taken into account and the set in the reed reduced proportionately. Then this casting out, as it is termed, must of necessity occur where the pattern will not agree with the machine in the number of threads, but it is often resorted to for the purpose of reducing the set of the harness so as to weave cloths in a set lower than that for which the harness is tied up. Suppose the harness be tied up to weave 80 threads per inch, and it is desired to weave only 70, then the difference must be cast out, which in such a case would mean 50 hooks of a machine standing idle, or $\frac{5}{8}$ of an inch in each division. Such a number as that must be taken into consideration, as the difference between the width of the harness and the sley would, even in a narrow cloth, be so great as to preclude the possibility of good work. Then to put it as a general formula we should say as the number of harness threads per inch in the harness, is to the number required in the reduced set, so is the total number of hooks in the machine to the number that must be employed. Or as 80 is to 70 so is 400 to 350.

The difficulty attending this is in a great measure overcome by the expanding harness which has already been described. This contrivance enables us to get over all the difficulties, change of set can be made within certain prescribed limits, and which are usually sufficient for all practical purposes, and although provision is not made, ostensibly, to meet the casting out of hooks to suit the pattern, yet it must be obvious that it can be made to serve both purposes in a sufficient degree. Then to turn to the pattern shewn at Fig. 168, page 321, here we have what is termed a repeated design and with the slightest knowledge of the arrangement of patterns for small effects a designer will readily understand that there is no necessity for putting down repetitions upon his design paper. For instance, we have the pattern A repeating itself, and we have the pattern B repeating itself, but seeing that each repetition is worked from the same hooks one section of the pattern on the design paper is sufficient to represent the whole of the repetitions, so that we should simply take the sections A, B, C, put them down upon the design paper in a position corresponding to the hooks which actuate them and the whole work is complete. Precisely the same rule will apply, although the method of working appears different, in the case of the centre harness and pattern in Figs. 170 and 171, but in this we have not only one half the pattern saved, so far as the warp threads are concerned, but we have also the power of saving one half the picks, if the pattern should be worked out to form a square or parallellogram. Suppose we divide the design Fig. 170 down the centre and take the left-hand portion as representing the pattern which must be placed upon the design paper, and the right-hand half could be repeated by the harness, then if the pattern be designed for a table cover, or any fabric in which the two ends, as well as the two sides, should be alike, we should simply make a design for one quarter of the whole fabric, and having woven the cards over from the border, or from one end, to the centre we should reverse the order and weave them back again, so making the complete pattern, and effecting not only economy in the harness, but in the cards as well. Now take the centre repeated pattern as suggested, and all that has been said of the repeated design at Fig. 168, and of the centre design Fig. 170, will hold good here, excepting so far as the saving of cards is concerned, and even in some cases that might follow, but in stripes it is very seldom that the system of repetition in the weft is resorted to, as the majority of patterns would preclude this being done from the nature of the figure. With regard to the border harness the explanation would be comparatively simple, we have one set of hooks detached and tied up specially for the border and another set for the middle. Now suppose the side and the cross borders to be the same pattern; in weaving the cross border the cards would be cut for both portions of the machine alike; but in the side borders they would be different, so that two sets of cards would always be involved, and then it would simply be a question of whether these cards should be changed by hand, when required, or whether the cross border machines already described should be resorted to. In the sectional cross border harnesses, everything turns, practically, upon what has been said of the common harness, and those tied up for repeated patterns; a set of hooks is set apart for each division or section, and when weaving the cross border the several sections go to make up one complete division and the pattern forming a complete division must have its several portions repeated on its sectional hooks, but the moment the cross border is completed, then each section of hooks takes up its own duty in the formation of side border, so that in the cross borders they form really units of the whole, but in the side border each is practically independent of the other.

In making designs for the harness pattern represented in Figs. 175 and 176, we should have to treat the border pattern in precisely the same manner as the pattern Fig. 170, that is, the harness being a centre tie only one half the figure would have to occur on the design paper, and the middle being tied up in straight order would be treated in precisely the same manner as in Fig. 167 and 170, so that the harness may be compound tie, centre and common repeat patterns, and the design would be a compound one in the same sense. In all other respects the treatment would be precisely as for the common border represented in Fig. 174 Then coming to the triple border as represented in Fig. 180, the arrangement would be simply an extension of the treatment in Fig. 174, that is, in working the cross border all three sections of the harness would partake in the formation of the same figure so as to make it continuous; in the second or middle cross border the outer section would be detached and begin to form the side border; then in the third cross border both the outer ones would be detached, and when we reach the middle of the fabric each of the border sections would be forming its pattern independently of the others. Then the next arrangement is that represented in Fig. 182, where the outside border and the inside border are both straight ties, but the middle border is a centre tie, as well as the middle of the fabric itself; then for the first cross border in this case the pattern would have to be so arranged that the presence of the centre tie is not made visible, *i.e.*, the borders must be of such a character that although there are two centre ties the pattern appears to be a continuous running one. For instance, refer to Fig. 181, and it will be seen that is the case, that although the middle of the three borders is a centre tie there is nothing in the cross border to suggest it, or should there be anything of that kind; the pattern must be so contrived as to make the cross and side borders join in such a manner as to produce the effect which will hide the suggestion of a repeat from the centre. In some cases this is difficult to accomplish without making the pattern appear too much in squares and too stiff in form. In other respects, of course, it will be understood the working is a combination of Figs. 176 and 178.

Now we must look to the sectional harnesses where one portion is intended, we will suppose, to weave the ground pattern and the second portion to weave the figure which may be formed by extra material. Then if we refer to Fig. 183, where the two patterns, ground and figure, as they are termed, respectively, are shewn differently, we see at once which portion must be worked by each section of the harness. It will perhaps make the value of this principle of harness tying more clear if it be compared with the ordinary harness as shewn at Fig. 167. If a pattern such as this had to be woven on a harness such as Fig. 167 each alternate hook of the machine would take the ground and figuring threads respectively, then the figure would either have to be distorted, supposing the ground picks to be equal to the ground threads in number, to double the width, because of the figuring threads intervening; or paper having twice as many squares in one direction as the other would have to be employed; not only that, but supposing the pattern to be painted upon the paper in two colours the card-cutter would always have to bear in mind that one colour represented the ground threads and the other the figuring threads, so that he would have to cut odd numbers for one and even numbers for the other.

In the event of any elaborate variety of twilling being necessary, as is often the case, in the production of such patterns, the operation is rendered very difficult, and in most cases will involve carrying out the twills by the designer over the entire surface of the paper, which of course involves an enormous amount of time, and even then the card-cutter's work will be difficult; but with the sectional harness one pattern would simply be put upon the hooks assigned to it and the other upon the opposite set, so that in reality the two sections of the machine are treated as though they were two separate machines, and the card-cutter would practically treat them as though they were designs for two separate fabrics. The same conditions apply exactly to Fig. 186, where there are three sections; each section carries its own pattern or figuring material, and the design for each is made separately and to all intents and purposes, so far as the card-cutter is concerned, independent of each other. Of course it will be understood that the designers business is to so arrange the patterns upon the paper, that when they come into the cloth they fall into the proper relations with each other, as it would be absurd were the figures to begin to overlap or fall into any accidental position. And it follows equally that the designer would be compelled to consider the nature of the twilling given to each section for the production of special effects, and more especially when working any two or more of the sections together for the purpose of producing, either variety of colour or light and shade. Of course the same rules will hold good with regard to the Figs. 188 and 189, where the two sections are not of the same size. It simply means in that case that the pattern upon the smaller section of the ground may be much less than that on the larger section. But one thing must always be perfectly clear, viz.:—that the two patterns must be complete at the same time. Little need be said now of the stripe section shewn in Fig. 189 or of those in Figs. 190 and 191, because the principle of application of patterns to sections, whether of the character described in reference to Fig. 183 or the more elaborate ones remain the same and it must only be a matter of application. In Fig. 191 perhaps there might appear to be some difference as compared with the others, but in reality we are taking the healds placed in front of the harness as representing one section of the harness, as represented in Fig. 183.

The compound harness with which we have next to deal differs from the others inasmuch as the jacquard machine itself takes no part in the formation of the ground pattern, but only in the production of figure by causing the two fabrics, of which the whole is composed, either to combine together or exchange places as shewn in section at Fig. 196. The cumber-boards are arranged in such a manner as to form the ground pattern, each pair of boards for its own fabric; then as the several picks of the face weft are inserted the harness lifts in such a manner as to cause the two cloths to exchange places and intersect each other as required by the pattern, so that really the general principle upon which the patterns are laid upon the design paper is simply laying on a wash of colour to represent the form of the figure, and then the cards are cut so as to lift the fabrics separate from each other.

In the use of the split harness practically the same thing may be said. The machine forms the figure and the shafts which lift the harness cords form the ground pattern, therefore the method of laying the design on paper is simply that of laying a wash, or washes, of colour to represent the pattern, and operating the shafts to form the ground. With reference to the pressure harness, the principle of twilling with the healds has already been fully explained in reference to Fig. 191, consequently again here there is little to say as to the arrangement of pattern, if the whole fabric consists simply of a warp and weft satin, or warp and weft twill, then the design is simply laid on with a wash of colour; the cards are cut as though it were a solid figure, and all the twilling is done by the pressure healds, and it is only where special twilling would be introduced in combination with the ground twill that any variation need be made in the pattern upon paper; but when there is any variation it must be laid on very carefully, and in such a manner as not to interfere with the working of the ground healds, and the card cutter must carry out his instructions in their entirety.

Only few words now need be said with reference to the gauze harness. The arrangement of the design differs in this machine from all others; here we have a certain section of the machine set apart for actuating the doup; we have a certain section set apart for actuating the slackening portion; each of these is supplementary and cannot be treated as the sections in the previous harness. For instance, one thread passes through the slackening harness, then through one of the common harnesses, and then through the doup; the arrangement of the pattern upon paper must, so far as the extent of the hooks in the machine is concerned, apply to those only which form the actual plain harness; again the hooks forming the doup and slackening portions have their needles placed in rows as in the plain harness. Consequently, although the design paper may represent only eight rows of hooks there may be in reality twelve rows in the machine; usually, however, the same needles which actuate the doup actuate the slackening harness, simply by having two loops or eyes, so that that would make ten rows of needles for the ten rows of hooks, and twelve rows of holes in the cards. The pattern would be painted on in the usual manner, and where no gauze is being formed the harness would be treated in every respect as an ordinary plain harness, but the moment gauze is formed, then the gauze hooks must have holes cut for them, and consequently some representation must appear upon the design paper to indicate the order of cutting. This will be best understood by reference to Fig. 231, which shews a design of a portion of a small figure. The figure itself is laid on in the usual manner as for plain harness, and the gauze portion is represented by working in a different colour upon the first, or first and second threads of each row

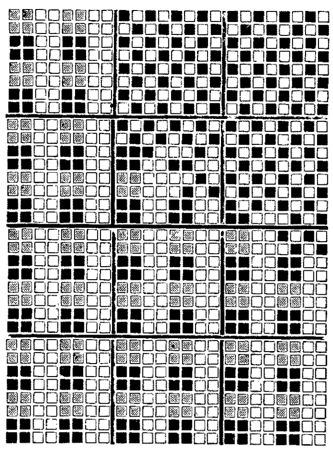


Fig. 231.

thus indicating that the extra hooks which operate the doups must have holes cut for them in the place of the ordinary hooks of the figuring harness. A comparison of this design with the harness Fig. 212 or 213 will make this quite intelligible.

CARD CUTTING.

It will be necessary now to explain the exact process of card cutting. Suppose we take the card cylinder as represented on the machine at Fig. 154, and place it before us on the table with the cylinder head to the left we have then on the outsides, or towards the extreme ends, to make provision for the lacing or linking together of the cards, for that purpose two holes are usually cut as shewn in the laced cards at Fig. 232. Then a larger hole is cut for the peg upon the cylinder to pass through, and hold the card in position. Then come four hooks, two on each side of the peg hole, for working selvedges or any extra apparatus which may be attached; then the first hole nearest to us represents the first hook of the machine, and going across the first row of eight hooks on the cylinder they would follow each other in order of

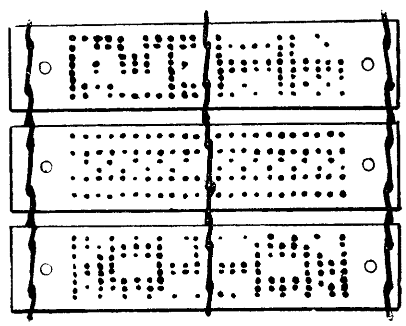


Fig. 232.

succession from 1 to 8, the second row would follow from 9 to 16, exactly as indicated on the cumber-board at Fig. 156, page 309, then referring to the small piece of design paper Fig. 233, we may compare it with the cylinder. The first row of little squares across the paper represents one pick of weft, and each card represents also one pick of weft, so that if we place a dot upon the design paper to indicate that the warp thread must be lifted to permit of the weft thread being passed under we must cut a hole in the card exactly corresponding to that thread. Suppose we are cutting cards, for instance, for a plain cloth and we wish to lift, for the first pick, the 1st, 3rd, 5th, 7th, and so on throughout, we should make a plan upon our design paper corresponding to that, and we should commence cutting the cards from the left by making holes in each row exactly corresponding to the dots upon the design paper. Then for the next card we should cut the 2nd, 4th, 6th, and 8th holes in each row, and by bringing such cards upon the cylinder, and pressing them upon the needles alternately, we should weave a perfectly plain cloth, and so with any other pattern. If we are cutting cards with the ordinary plate machine, and inserting the punches in the plate with our

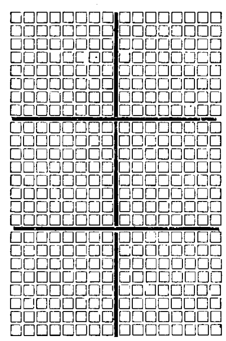


Fig. 233.

fingers, we should place the plate in front of us, in precisely the same manner as we have placed the card cylinder, and so by inserting punches in each of the holes corresponding with the dots upon our paper, taking each square of paper in succession, and the row of holes in the plate corresponding to the squares, until we have read all across the design; then the plate would be placed upon the carriage of the stamping machine, the punches pressed through the card and the operation repeated, card by card, until the whole design is gone over.

It will be necessary now to describe the various types of card stamping machines in use. I have spoken of reading direct from the design to the stamping plate; this plate then is usually placed upon the carriage of what is known as a railway press as illustrated in Fig. 234. The press is pushed forward and the roller revolved, and as the press passes under the roller the punches are pressed down and perforate the card which has already been placed between the plates in the carriage. There

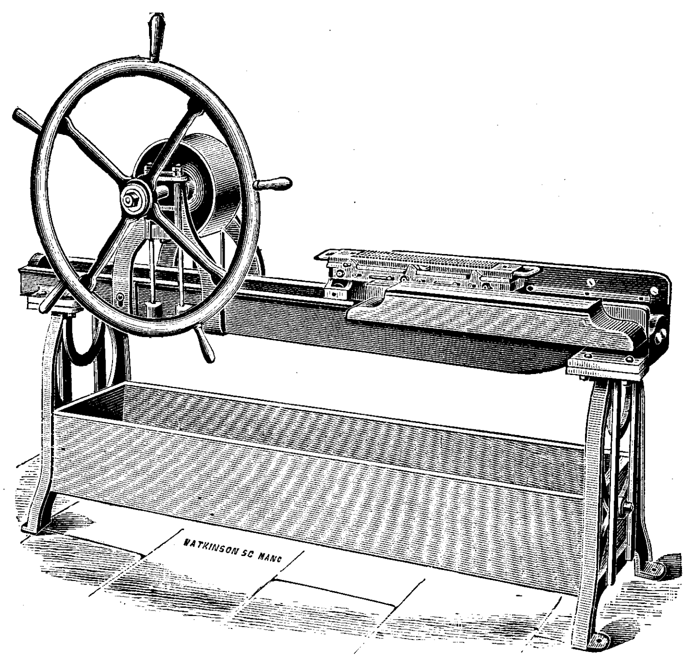


Fig. 234.

are two forms of machine, broadly speaking, of the railway press type used; one where the roller is covered with buffalo hide, so that the pressure upon the rollers may not be too hard, and the other where the roller is a smooth iron surface and a sheet of buffalo hide is placed upon hinges over the plate on the carriage, something like the lid of a box, so that it can be lifted free of the plate and laid down upon it at will. Again there is a difference in the construction of the carriage. In some machines the loose plate must be lifted off and the upper of the box plates raised for the purpose of changing the cards; in others the two box plates are fixtures with a contrivance for sliding the card in between them, so that

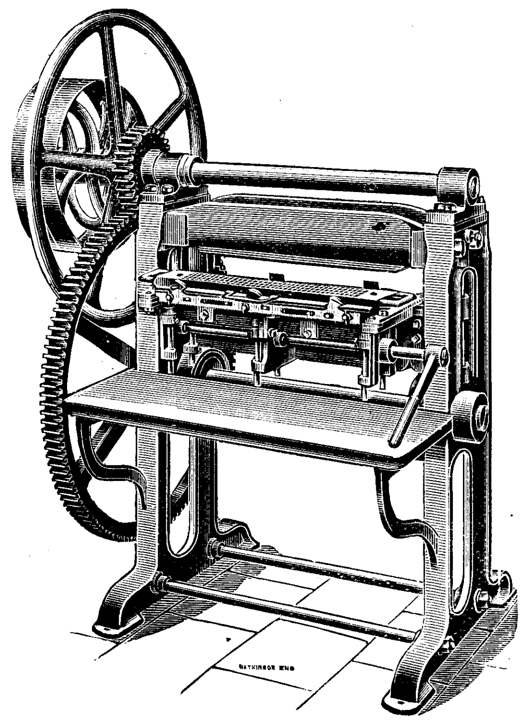


Fig. 235.

the change can be made without the removal of the punch plate. For rapid work, where a number of cards have to be cut from the same plate, as for instance in the old system of repeating, the latter machine has considerable advantages, as far less time is consumed in changing the card and less exertion required on the part of the operator. These machines are usually made to be driven by power or by hand at will. Another form of machine is illustrated in Fig. 235, but instead of working on rails as the previous one, the press moves vertically. The punch plate is placed upon box plates in precisely the same manner as in the previous case, but instead of the box plate moving upon a carriage, and passing under a roller, it is moved into the press by a slight movement horizontally, and then vertically, thus causing the punches to pierce the cards in the same manner as in the railway press. It is not necessary to enter into the details of either of these two machines beyond general description. For instance, in the railway press the moment the carriage has passed under the roller it strikes a lever, which, moving the axis of a species of roller, upon which the rails along which the carriage slides rest, causes it to move about one-eighth of a revolution. A flat has been filed or formed upon the surface of the discs, so that the carriage is allowed to drop somewhat and is relieved from the pressure of the roller, so that it can be withdrawn without the movement of the roller being arrested. Then as the carriage is drawn back by hand it strikes a corresponding lever, bringing the eccentrics, or discs back to their normal position. At the same time a lever underneath the carriage itself and connected with a series of vertical pins passing through the box plates is made to slide under a bar at the back of the machine, causing the pins to risc, at the same moment pushing up the punch plate and releasing the punches from the card they have just perforated. So that the plate may be easily removed or the card may be removed and replaced by a fresh one. Where a number of sets of cards have to be cut this system is very convenient, but in many cases must be worked in conjunction with the repeater, which will have to be described presently.

Before dealing with the repeating of cards, a glance may be permitted of other kinds of machines for reading in as it is termed. One of the most generally used machines is that one known as the piano, and which is represented in Fig. 236. In this machine, as will be seen by the illustration, the design is placed upon a reading

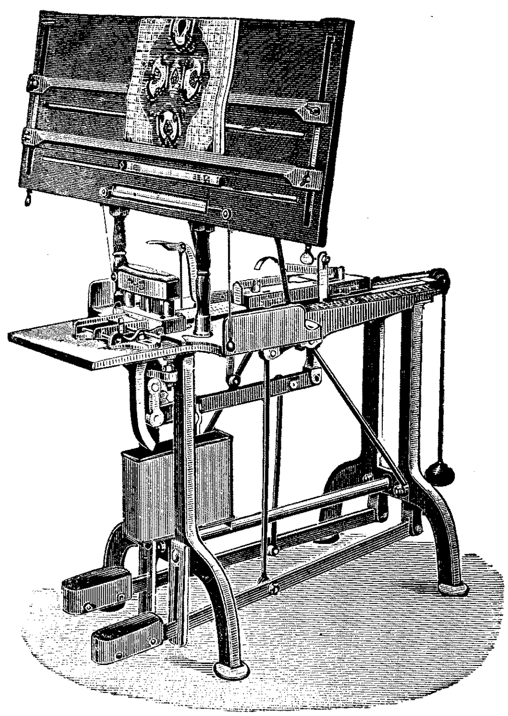


Fig. 236

board over the machine, the operator sits upon a stool in front of the reading board, the card is inserted in a species of slide in the front of the machine, and under a series of vertical punches, under the keyboard as it might be termed. A carriage is placed upon a slide behind those punches with a gripping jaw in front which takes hold of the fore end of the card. This carriage has a cord attached to it passing over a pulley at the back of the machine and to which a weight is attached. On the left is a rack, and immediately to one side of the slide on which the carriage moves is placed a sort of rack head, or catch, having a movable portion; beneath this a treadle is placed and so connected with the rack head as to lift it on the treadle being depressed. Every time the rack head is raised the fixed catch is freed from the rack upon the carriage and the movable catch,

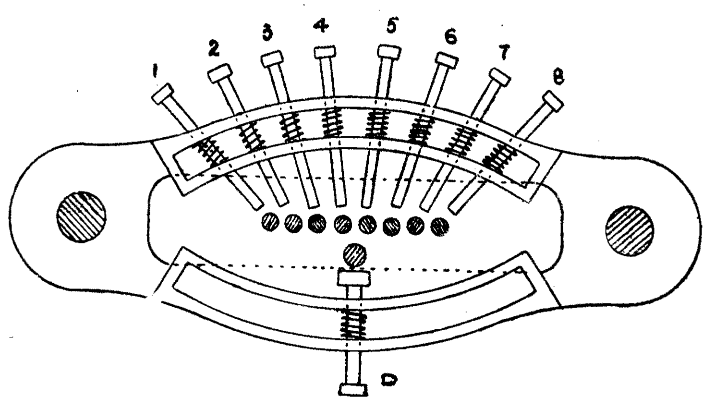


Fig. 237.

which is always one tooth in advance of it, takes its place and allows the carriage to recede a distance equal to one tooth. A second treadle is employed which brings down the keyboard—this keyboard, which is shewn in section at Fig. 237—has in front of it, usually, one key for acting upon the large punch for cutting the peg hole, frequently also two keys for acting upon the punches cutting the the lace holes, and on the back of it are eight keys corresponding to eight punches for cutting the ordinary figuring holes in the card. For 600 machine four extra punches would be on the front to make up a row of twelve. In reading from the design the operator presses the keys corresponding to the dots on his paper, and which really represent the punches which he would insert in the plate already described; as the keys are pressed when they come over the heads of the vertical punches, and on the right foot of the operator being depressed, the punches are forced through the card. The moment that is done the left foot is depressed and the two being connected by the levers, seen under the machine, the right treadle is raised, the carriage allowed to move one notch, carrying with it the cards and bringing it into position for the next row of holes to be cut. This is repeated continuously from end to end of the card, so that a rapid operator, and who can read quickly from the design, can on this machine cut a card in an incredibly short space of time.

I must briefly describe another machine illustrated in Figs. 238 and 239—one showing the front elevation and the other a cross section of the machine—although it has virtually gone out of existence, but it is one which did, in its day, good service; my object here being not so much to give a sort of historic sketch as to shew the application of old principles to new machines. This machine was purely and simply a reading-in machine. A series of cords *a* are carried round the machine, and on the one side being leased through a pair of rods *f f*, and those answering to each row of hooks being passed over separate rollers *b* at the head of the machine. The whole mass previous to passing through these rods *f* which are seen in front, and under the design, were divided in 8's or 12's, according to the size of the machine, by a comb *g*, and then the whole mass passed under a roller, or rather a pair of rollers, b^1 and b^2 at the foot of the machine. Then up through a set of needles *i*, corresponding with the needles of a jacquard machine, over another roller at the head, down through rings attached to lingoes *d*, which pass through the cumber-board *c*, exactly the same as the

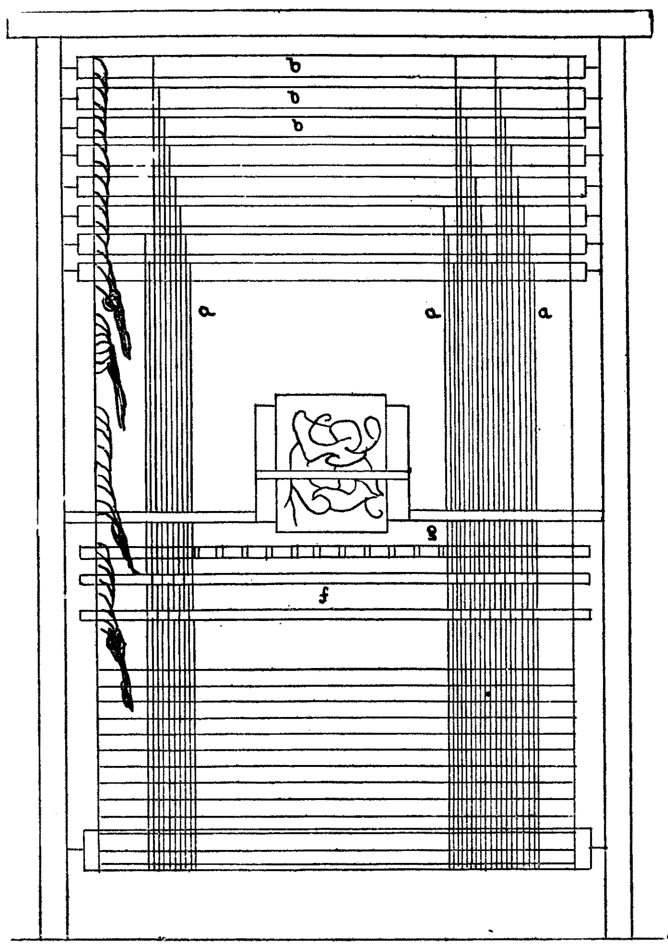


Fig. 238.

harness of the jacquard, and forward to the dividing rollers already described. So that each lingoe in the cumber-board had a species of harness cord attached to it which consisted of an endless band passing round the machine. The card reader would then insert cords which correspond really with the picks of weft in the fabric, or in other words he would weave into those endless bands

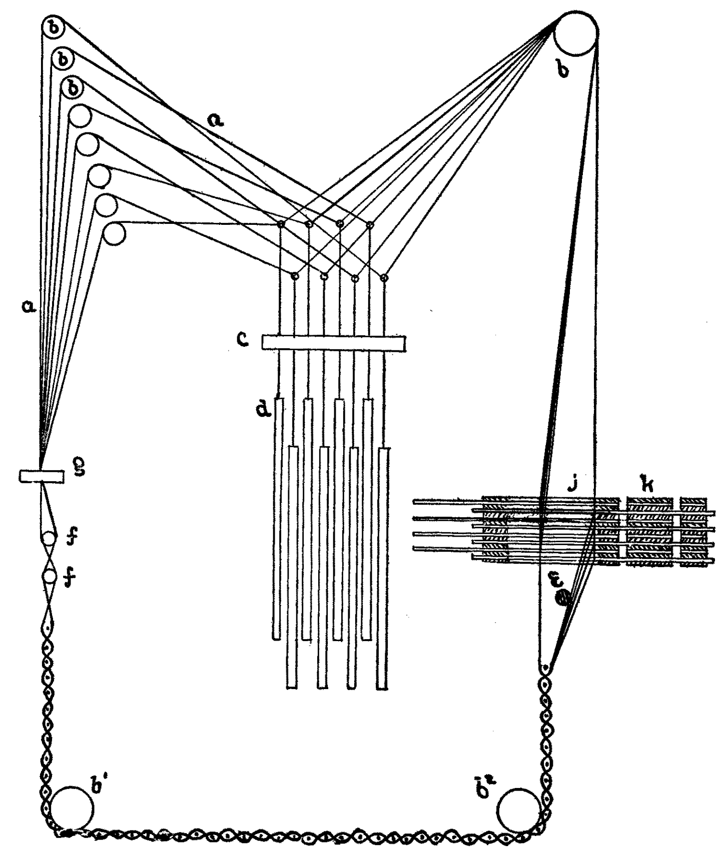


Fig. 239.

as warp threads a series of weft threads, producing precisely the same pattern as was intended to be produced in the cloth, as seen in both the section and elevation.

Those who have any recollection of the old draw loom or who have read the description of it in my "Treatise on Weaving and Designing," will recognise at once that the endless cords correspond with the tail cords of the draw loom, and that what I have here described as the picks of weft correspond with the draw cords. As a matter of fact this machine is based upon the draw loom; the pattern having been read in the cords are drawn round to the opposite side and immediately under the needles *i*. In front of this series of needles, each of which are passed through a needle board exactly corresponding to the needle board of a jacquard machine, is placed a punch plate *k*, containing a punch corresponding with every needle in the machine. In front of that a second punch plate may be placed for the purpose of receiving such punches as are drawn from what might be termed the magazine plate. Then a roller *e* is inserted in the place of the first cord which has been woven in to form the pattern and placed upon the arms of the sliding carriage which may be operated by a lever. The carriage is drawn forward causing the cords to exert pressure and move the needles in the direction of the punches, thus forcing out of the magazine plate punches corresponding to the needles acted upon, and pressing them into the punch plate which has been placed in front of it. This punch plate was then removed to the carriage of the railway machine, passed under the roller and the card is punched. I need not dwell upon the advantages of this machine for rapidity of execution in several classes of work, as it has, practically, become obsolete and many of the special qualifications it possessed have been replaced by the method of harness tying, which I have already described, more especially for the production of double cloth figured goods; but we shall see presently when the machine for self-acting repeating is described the principle still has some existence.

CARD REPEATERS.

I may turn attention now to what are termed repeating machines. One of tbe simplest forms is illustrated in Fig. 240, here a set of cards is seen passed over a cylinder corresponding in form with the cylinder of the machine. It is then brought down between the magazine plate containing

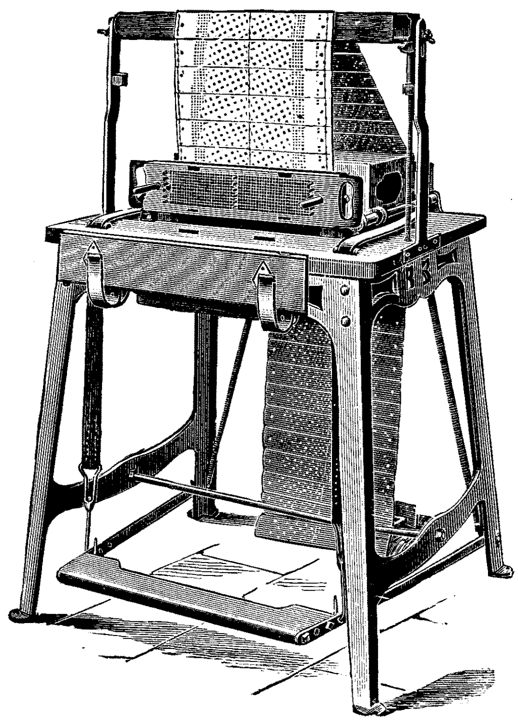


Fig. 240.

the punches, and similar to that described in the reading-in machines, and a series of needles carried in a box and corresponding to the needles of the jacquard. Each of those needles has upon it a helical spring, some eight or ten inches in length, in reality the needle box is a species of carriage; in front of the magazine plate is placed the stamping plate as seen in the illustration; a treadle connected by straps causes the needle box to move forward upon the slides. Wherever there is a hole in the card, the needles pass through it, force the punches out of the magazine plate into the stamping plate; the stamping plate is then taken and placed upon the railway press and the card punched. The plate is then returned to its position upon the repeater, and a comb which is seen resting on the hooks in front, is put upon the slides and the punches forced back out of the stamping plate into the magazine plate. And so the operation is repeated continuously. Here it will be seen that three movements have to be executed; first the drawing of the punches into the plate; second, the stamping which really takes place upon a second machine—and third, the return of the punches into the magazine plate. In machines of more recent construction although it may be noted that this particular machine is in regular use at the present time, the first and last operations are performed simultaneously, or at least by one movement of the treadle, thus economising in some measure the time occupied.

A self-acting repeater is illustrated in Fig. 241, which will be seen to embody the principles involved in the reading-in machine which I have just described. The cards to be repeated or copied, are passed over a cylinder at one side of the machine and act upon the draw cords, in a manner very similar to that of the roller in the reading-in machine, and actuate needles at the other side which in turn cause punches to be pressed through the card. The advantages of this machine over the ordinary repeater must be obvious, the machine itself being self-acting and capable of cutting, as alleged, from sixty to seventy cards per minute, although the makers, Messrs. Devoge and Co., Manchester, say that forty per minute is recommended for good work.

Another machine for answering the same purpose is shewn at Fig. 242, made by Messrs. Wm. Ayrton & Co., of Manchester. Here the pattern cards to be copied are put upon one side of the machine and over a card cylinder, just as it would go into the jacquard, as seen on the left; the card cylinder revolving and bringing the cards against a series of needles in precisely the same manner as the

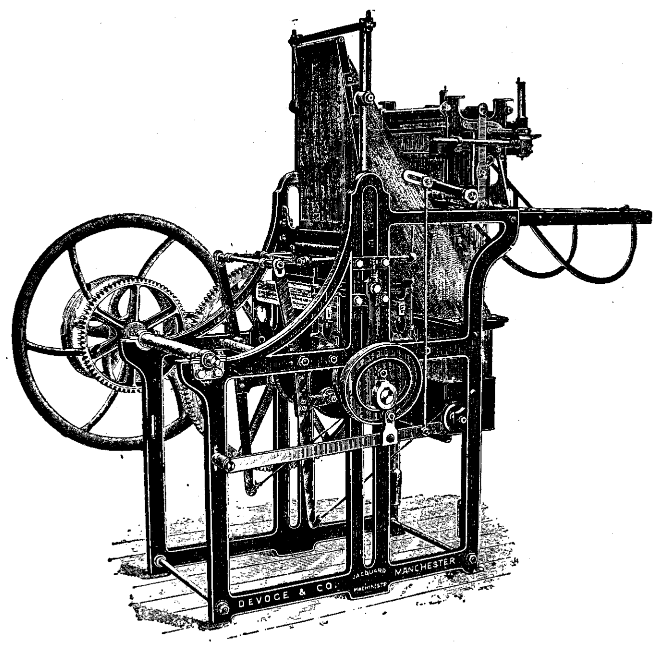


Fig. 241.

ordinary jacquard. When there is a hole in the card, the needle of course passes through it and remains stationary. The needle is connected to a rod, which will act upon the punch by means of an abutment bar, so that if the needle remains stationary, a hole will be cut in the new card corresponding to that being copied, but if the needle is pressed back by the pattern card, the vertical rod is moved off the bar, and the punch, having nothing to hold it in position, simply rises with the blank card which is placed in position to be punched, and consequently is not perforated. The cards to be cut are laced in a long chain and stacked under the machine as seen in the illustration. They are

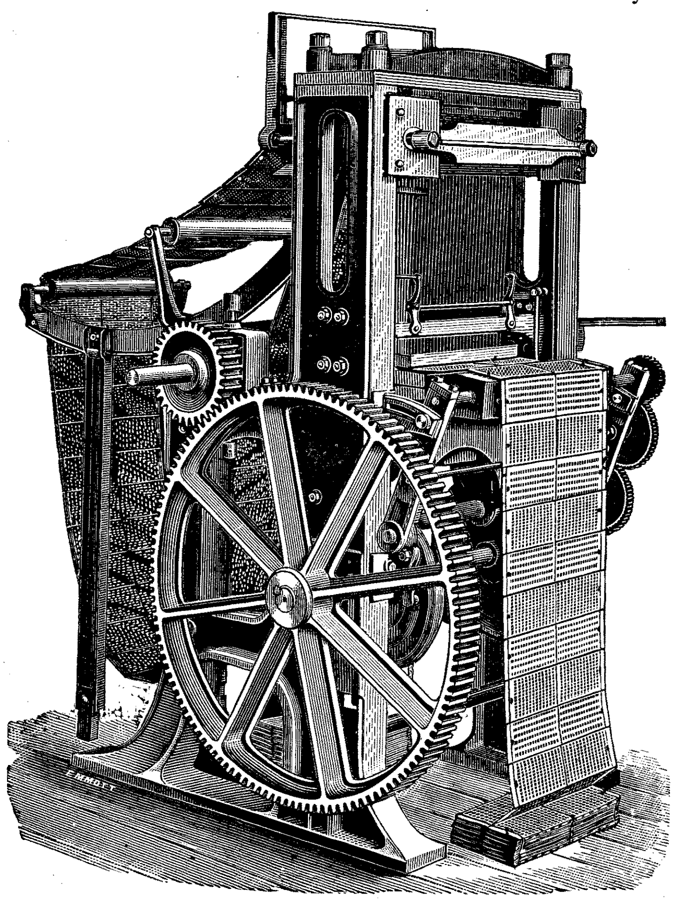


Fig. 242.

brought over an ordinary jacquard cylinder as seen on the right for the purpose of being moved forward at a rate corresponding with the movement of the pattern cards being copied. The cards pass between two die plates which rise simultaneously, the upper plate really being the magazine plate, having a punch in every hole, and each punch being placed vertically in the magazine plate has a vertical pin placed above, and subject to the action of the selecting needle as already described, so that when the machine is set in operation the cards being copied are brought in contact with the needles, the selection of

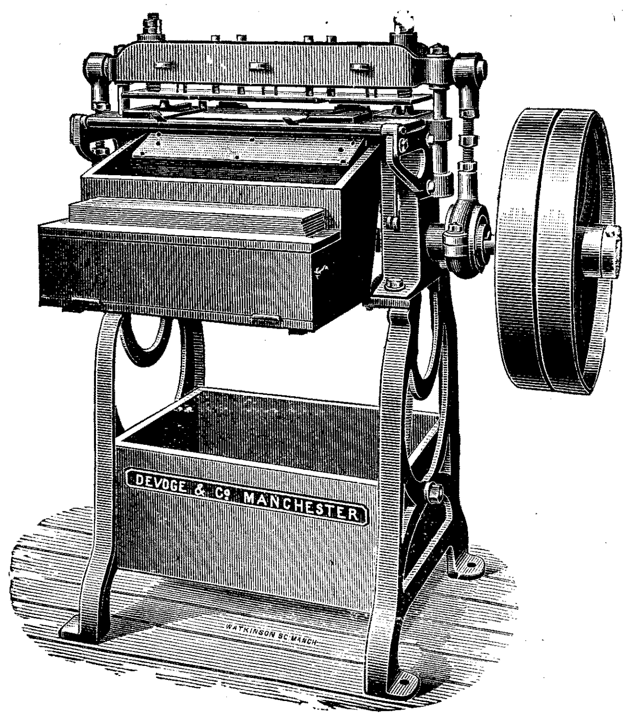


Fig. 243.

punches being made simultaneously with this movement, the die plates are raised and the plain cards perforated; so that the work can be carried on almost at any rate of speed desired. It will be seen that the cards to be cut must be laced together before being placed upon the machine, instead of placed in separately as in the ordinary machine. Then two machines are required to prepare the cards for this, the one being a machine for cutting, what are termed, the peg and lace holes, and the other a lacing machine itself. In the ordinary way the cards are laced by hand, but for the rapid preparation of a large number of sets of cards this operation is too slow. One of the machines is shewn in the illustration Fig. 243. Here a bar, carrying the necessary pegs is caused to rise and fall by eccentrics on the driving shaft, the cards are fed in by a boy or a girl and drawn automatically between the plates and punched and dropped into a box, the details of the machine are so simple that further explanation is unnecessary.

Another machine of a similar kind is illustrated in Fig. 244. Here again the cards are placed by the attendant between adjustable guide plates and carried under the punches by two double oscillating levers mounted on a short counter shaft under the machine, each being connected at their upper extremities by curved plates, which form a kind of support for the cards to rest upon temporarily, projections being formed at equal distances apart, and sufficient to allow of the cards to rest between them. A combination of levers actuated by cams on the driving shaft are so arranged that immediately the cards are carried under the punches there is a dwell sufficiently long to permit of the punching operation. This is effected by means of a centre plate lifted by two eccentrics and bringing the cards immediately under the punches with sufficient force to perforate them; while the punching operation is being performed the oscillation of the curved plate continues and returns to its original position for receiving another card. After punching the first card the centre plates recede from the punches, still allowing the card to rest upon the curved plates, but move beyond the first stops and ready for delivery, the operation is carried on continuously in this manner.

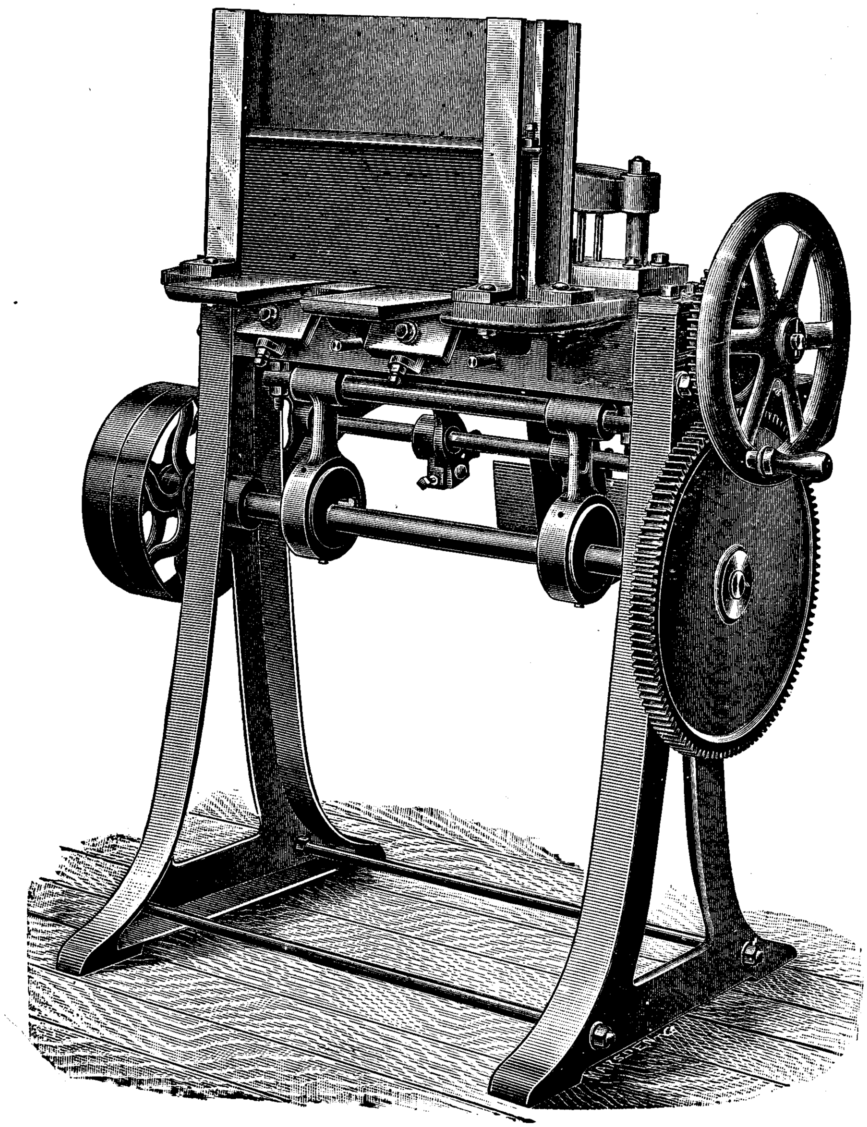


Fig. 244.

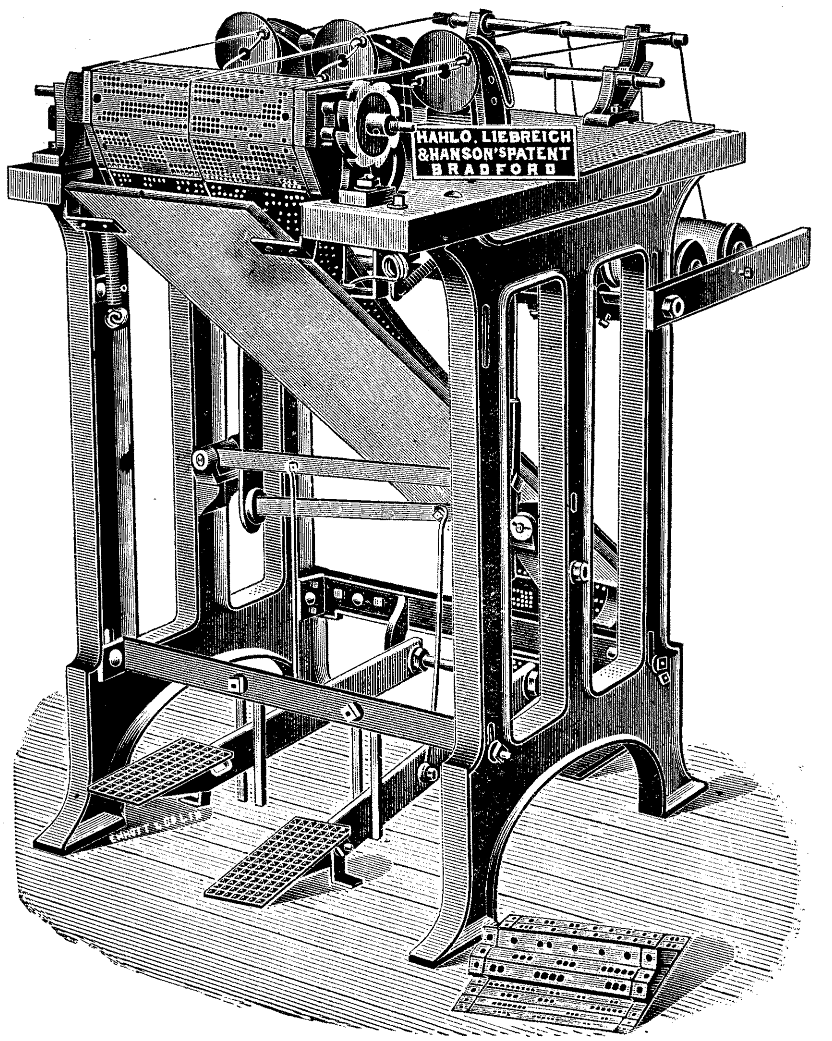


Fig. 245.

LACING.

The next operation is the lacing of the cards and for this various devices have been invented. As seen in the illustration already referred to, the usual practice is to thread cords through the holes at each end and in the centre of the cards, and to cross them between the cards themselves so as not only to form a continuous chain, but also the space between each one to permit of its passing round the corner of the card cylinder. Sewing machines have been introduced to perform this work, and other machines where the cord or lacing band, as it is commonly termed, instead of passing through holes in the card simply fall into notches, of the form of semi-circles, cut in each side, and twisted round each other between the cards so as to hold them in position.

The machine illustrated in Fig. 245, of Messrs. Hahlo and Liebreich, of Bradford, is one of the most ingenious for this purpose. As will be seen at the back of the machine are spindles carrying bobbins or balls of the lacing band, and the band is made to revolve with a face plate, the end being brought through holes in the face plate to the front of the machine, a boy sitting in front of the machine places a card upon the resting plate and between the two sets of cord, and by a simple movement of a wheel, or treadle, the face plates are made to revolve, giving a twist to the cord which presses up to the card. Another card is inserted between the cords, placed upon the pegs of the receiving plate, or bar, the previous one having been moved forward, and the operation is complete, and so this goes on until a long chain is made. The speed is only determined by the rate at which the operator can feed the cards to the machine.

LECTURE 11.

ADJUNCTS TO THE LOOM.

In the previous lectures the principal movements involved in the operation of weaving have been fully dealt with. It now remains to deal with the various additions to the looms for the purpose of ensuring not only continuous working, but all the freedom from accident, either to the machinery or material, which can be introduced. The most important are those for protecting the warp, or bringing the loom to a stand in the event of a shuttle not having reached its destination, because accidents arising from this are most disastrous to the material, and cause greater loss of time than from any other cause. Following that then we must have the apparatus which have been introduced for bringing the loom to a stand when the weft breaks or the shuttle becomes empty. In this case, of course, there is no serious injury to the material; it is only really a contrivance for assisting the weaver to prevent irregularities in the cloth which would occur if the loom was allowed to run without any weft. Then I will take those motions in their order of merit.

In the ordinary plain loom what is known as the stop-rod motion is most generally in use. This consists of a lever and a swell, which have been already referred to in Lectures 4 and 5, placed in the back of the box, but the details will be more readily understood by reference to Fig. 246, which shews an end elevation of that portion of the loom with which we are immediately concerned. This swell is hinged at one end and really becomes a lever to be pressed back by the shuttle as it enters the box. Behind the box is a bent finger of the lever A. The opposite arm of the lever L being nearly at right angles to it, the fulcrum being on the stop-rod at the point R. This rod is carried across the loom so that the levers placed at each box will be actuated at the same time. On the loom frame and in front of the lever arm L is placed what is termed a frog F, and in such a position that when the shuttle is in the box the point of the lever arm L will be lifted sufficiently high just to pass over it, but if the

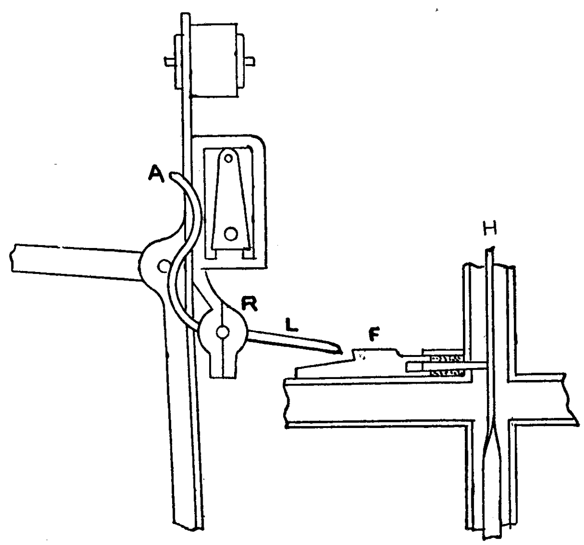


Fig. 246.

shuttle is not in the box then the lever L will strike it and arrest the forward movement of the going part. In the earliest form of loom, the loom was stopped practically by the force of the concussion, but now several contrivances tend to minimise this, and, in fact, to bring the loom to a stand as gently as possible. The frog F for instance is made to slide upon the loom frame and a pin projecting from it strikes the belt fork handle H and throws the belt from the fast to the loose pulley. At the same moment a brake, which is also attached to it, and seen in the illustration Fig. 247, is allowed to drop and so soften the force of the impact. Consequently the loom is brought to a stop with comparatively little risk of breakage. The arrangement of the mechanism is simplicity itself and really the only questions for careful consideration are the placing of the fulcrum R and the balance of the several parts.

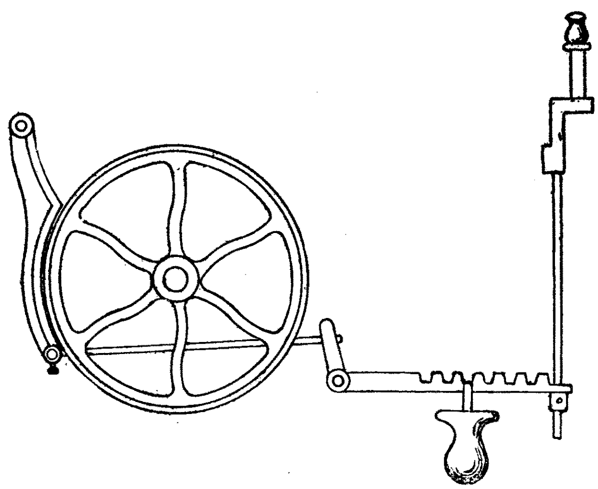


Fig. 247.

Perhaps we had better examine the question first by considering the amount of work we should have to give the shuttle to do. The point of the lever L must be raised clear of the frog, so that the heavier it is, or the greater the distance we have to raise it, the more work we throw upon the shuttle; and consequently the greater amount of work required to send it into the box, and also the greater amount required to send it out of the box. Again the position in which we have placed the fulcrum R will have a material effect upon the liability to injury as the lever strikes the frog. Suppose the lever L forms a very obtuse angle with the sword of the going part, then it is liable to be bent every time it strikes the frog, and the slightest bend in it has the effect of preventing the shuttle raising it sufficiently to clear the frog, and consequently the liability to touch the frog in passing and to stop the loom, even although it does not actually come into full contact, becomes a source of constant irritation. Then, of course, it will be understood also, that the lower this lever points from the horizontal line the greater the weight, or more correctly speaking, the power required to raise it by means of the finger A. So that for a perfect balance, as well as for certainty in working, the nearer L approaches the horizontal line and the better; so that the frog upon the loom frame must be placed sufficiently high to admit of this horizontal line being maintained as nearly as possible.

Now another thing arises in connection with the position of the fulcrum R, that is the tendency to break the sword of the going part. The nearer this fulcrum can be placed on a line with the connection of the sword with the crank arm the better. Suppose it to be placed considerably below that point of connection, then the liability to breakage, in consequence of the amount of leverage given to the sword arm is very great; so that taking the matter generally we may say that the loom frame which has the frog sliding upon it should be so built as to bring the frog, not only in the position for striking the belt fork lever, and also of throwing the brake into action at the moment of striking, but also for maintaining the best position for the delivery of the blow by the stop-rod finger whenever it should come into use. Every good overlooker will, of course, recognise that the less the stop-rod comes into use and the better; generally speaking, it may be said that with a good working loom, with the picking arrangements properly adjusted, and the shedding properly timed, the stop-rods should never come into use except through some accident, such as the "feltering" of broken threads, or broken healds in the warp, which would either retard the shuttle in its progress or throw it out of the loom altogether. Such a thing as "knocking off" by the stop-rod ought never to occur in a well managed room. As a matter of fact this, along with the other stop-motions, is a contrivance which only should, as it is intended, come into use in the event of unforeseen accidents occurring and should not be relied upon to cover bad workmanship on the part of the overlooker.

LOOSE REEDS.

The stop rod of the loom is invariably connected not only with fast going looms, but looms built for heavy work; and it is either associated with the ordinary plain looms or the rising box. In the circular box loom it is impossible to make use of the stop rod, at least in its ordinary form, for the simple reason that we cannot have a swell in the box which can act upon the stop rod finger; in a plain loom or rising box this is quite easy. Then in the circular box we have to resort to what is known as the loose reed, that is, the upper part of the reed is held in the hand rail of the loom in the usual manner, but the lower part instead of being placed in a groove, is held in position by a lath as shewn in Fig. 248. In one sense this lath, and the lever to which it is attached, may be compared in its movement to the stop rod, but that is only as to the nature of the movement imparted to it, its functions are entirely different. The stop rod brings the loom to a dead stop in the event of the shuttle not having reached the box, but in this case the lath gives way and allows the reed to fly out so as to prevent injury to the warp. This in itself is extremely simple, but it must be obvious that one of two conditions must attend the working of this arrangement. In the first place a spring A must hold the reed in position, and that spring, although it may be strong enough to hold the reed in position during the time the shuttle is passing, would not be strong enough to hold it for the beating of the weft up to the fabric,

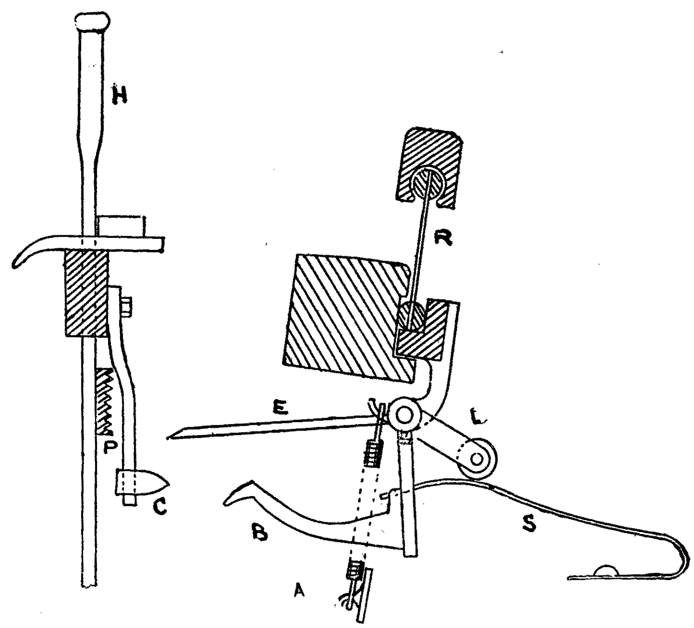


Fig. 248.

otherwise it could be no safeguard against breakage of the warp threads. Then as seen in the illustration Fig. 248, other provisions are made; as the reed comes up to the cloth a finger B somewhat similar to the stop-rod finger in character, but different in shape, is allowed to pass under a V shaped frog C attached to the loom frame. So that at the moment the reed comes into contact with the cloth it is held almost as firmly as an ordinary fast reed. On the other hand there is a lever D projecting in the opposite direction and having a roller at its end, and under this roller is a peculiarly bent spring S, and so placed that as the shuttle is passing across the loom it presses the reed close up and holds it in position, but as it goes forward the pressure is released until the frog takes hold of the opposite finger; so that the spring A which nominally holds the reed in place need not be a very strong one. The object of this is to prevent damage in the event of the shuttle being caught; for instance the shuttle could never be caught when the reed is at the back extremity of its stroke, nor could it occur at the extreme front, but it must be at a point about midway during the passage of the reed when the shuttle would begin to press upon it. That is, the moment when there is the least pressure on the reed neither the frog at the front nor the strong spring at the back have any hold upon it, consequently there is little danger of damage even to the most tender warp. In addition to the arms B and D another arm E is attached to the same fulcrum, and so that it will be raised or depressed with B. On the front of the belt fork handle H is a projection P, having a sort of toothed surface. When the reed R is held properly in position, that is, when the shuttle is not in the shed the finger E passes clear of P, and everything goes forward, but should the shuttle have remained in the shed the reed will be struck back as shewn in Fig. 248a, the finger B will be thrown on the top of the frog C, E will be brought in contact with P, the belt fork handle will be struck back, the belt thrown on the loose pulley at the same time, the brake will be brought into use as in the stop-rod loom and the loom brought to a stand. This contrivance works very well for light goods but it has always been one of the drawbacks of circular box looms, that, in spite of the apparent perfection of the frog and lever for giving firmness to the reed in delivering its blow, it has never been sufficiently rigid to enable a blow to be given suitable for heavy work. Numbers of contrivances have been invented for the purpose of overcoming this difficulty, but without attempting to detail them the general principle may be illustrated in what is known by the paradoxical name of a fast loose reed. This contrivance consists in a

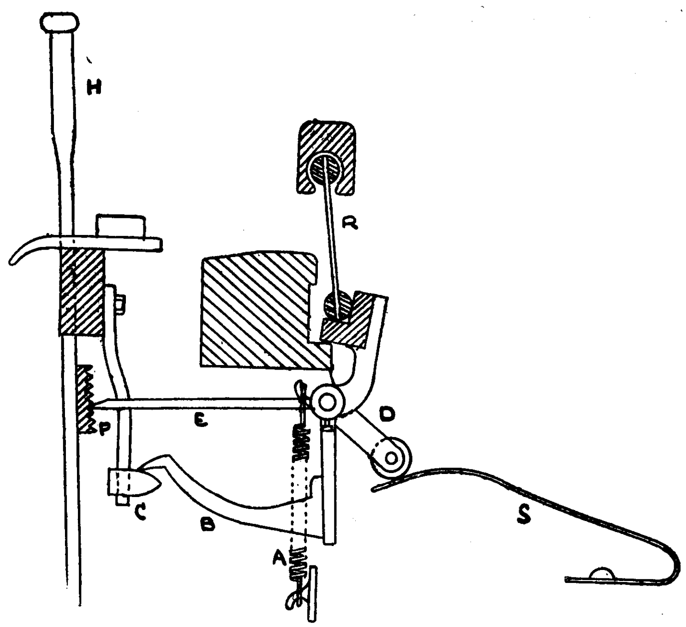


Fig. 248A.

series of levers which lock the reed in a perfectly rigid position the moment it has passed the centre of its stroke towards the cloth, and holds it there until it has returned to the corresponding point, when the locking arrangement is released and from that moment it becomes a loose reed. So that from the moment the shuttle is in danger of being trapped until the reed has delivered its blow it may be described as a fast reed loom, but after the blow is delivered it becomes an ordinary loose reed loom. The advantage of the system will be evident at a glance and of course can be applied to any ordinary existing loose reed loom. The attachment of the additional levers being all that is requisite to effect the transformation.

SHUTTLES.

As explained in the second lecture the function of the shuttle is to carry the weft across the loom, but as explained there it must do this in a particular manner. It not only must carry the bobbin, or cop of weft, but it must carry it so as to prevent any interference with, or damage to the warp; and also in such a manner that the weft leaves the cop or bobbin exactly at the rate of speed desired, and as the shuttle delivers it to the cloth there must be as nearly as possible an even tension upon the thread. Then at least two things are implied here, first, a ready means of placing the bobbin in the shuttle and holding it firmly in position when so placed, and, secondly, a ready means of regulating the tension upon the thread. In the great majority of shuttles the weft issues, as already described, through an eye near one end, and various methods are adopted for regulating the tension. If only one shuttle eye is used then a series of brushes, rollers, or tension pins are contrived inside the shuttle to keep the yarn from running off too quickly, or failing that two or three eyes are used through which the thread is passed to give the increased tension. The various means resorted to will depend in a great measure upon the nature and strength of the yarn. Silk threads for example may be treated with a series of delicate springs, or springs and rollers combined; or in some cases as already suggested, brushes in the shuttle, not only to keep the thread at a steady even tension, but also in keeping the yarn from flying off the bobbin or cop. In cotton yarns practically the same means are resorted to. In woollen or worsted the brushes, or tension pins, may be stronger, but in all these contrivances there is a tendency to increase the tension as the bobbin becomes empty; and although in a great proportion of goods this variation in tension may not have a seriously detrimental effect in light goods it is always liable to produce unevenness. It may seem singular that the same effect is produced in extreme cases, for instance, very heavy goods are liable to be affected by irregularity in the tension in precisely the same manner as light goods, whilst medium weighted fabrics may absolutely escape. This may be due to the fact that in the very lightest goods it is necessary to have the least possible amount of tension upon the thread, consistently with keeping it straight, as it passes into the cloth, whereas in heavy goods it is necessary to have a great amount of tension upon the thread for the purpose of compelling it to lie straight, so that the variation of tension upon the delicately weighted fine thread has practically the same effect as the variation in the heavily weighted strong thread. A recent contrivance goes a long way to fulfil the necessary conditions in weaving heavy goods. For instance, in jute or linen yarns the cop is placed in the shuttle without being put upon the peg or tongue and the thread is drawn from the inside. In this arrangement the drag is obtained by means of a spring, the pressure of which is adjusted by means of a set screw 4 in the illustration Fig. 249. This spring is in contact with the small hinged drag lever 1, over the upper end of which the yarn passes, being bent round it as it leaves the cloth, and from there it is passed forward through the shuttle eye in the usual manner; so that there is very little of mechanism, the whole of the details being visible in the two figures, one of which shews a section of the shuttle with the thread as it comes from the cop, and the other the elevation or plan. The arrangement is so open and free that there is no danger of locking by waste or fly from the yarn, and once the tension is adjusted it cannot be altered by the weaver. It is claimed also for this arrangement that it is suitable either for heavy or light jute or linen yarns. The inventor and maker is Mr. Ireland, of Dundee.

Apart from the question of tension on the weft thread as it is drawn from the shuttle the next in importance is the shuttle tongue. In the hand loom, where the shuttle was thrown at a comparatively slow rate of speed,

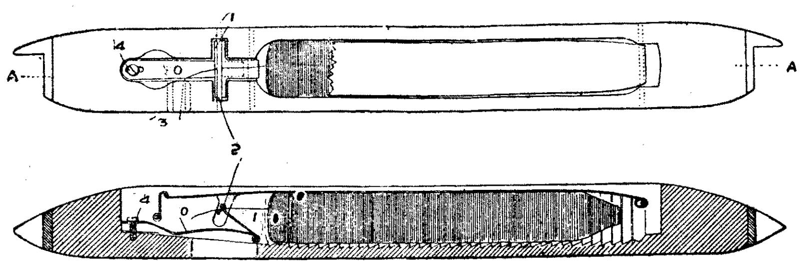


Fig. 249.

this was not a matter of such vital importance; any simple contrivance that would hold the bobbin in place would be sufficient for the purpose, but in fast running looms, or looms weaving heavy goods, accompanied by the various forms of bobbin or cop upon which the yarn is spun, and the liability not only to throw the yarn from the bobbin, but to breakages in both bobbin and shuttle renders this part of the mechanism most important. Without attempting to go through the various forms of shuttle, or to point out all their various advantages and disadvantages, it will be sufficient to call attention to the leading features of those in most general use. Fig. 250 shews a series of shuttle tongues of different form, and Fig. 251 shews a section of a shuttle with the tongue and tongue rest.

Now first refer to the tongue No. 6 in Fig. 250. In this we have simply a straight spindle passing through a holder which could be hinged within the shuttle. A spring on the upper side of the peg is designed to keep the bobbin, or cop, in position; in the ordinary shuttle the whole arrangement is held rigid when the bobbin is placed upon the peg and returned to the inside of the shuttle, and consequently there is liability, in the event of the spring on the peg becoming weakened, for the shuttle or cop to fly off, and on the other hand there

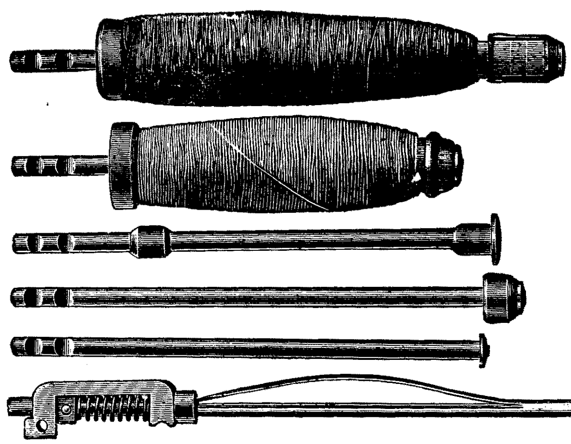


Fig. 250.

is liability if the bobbin is held too rigid when the loom is picking very harshly for the weft to fly from the bobbin. It will be obvious at a glance that the bobbin, or cop, only being held on by the strength of the spring that the arrangement could only be suitable for light running looms, where the pick is of the smoothest possible, and the speed not excessive; but in the arrangement shewn here, where a spring is placed on the tongue, and inside the head, the vibration will occur in the tongue in consequence of any severe shock and will prevent, in a great measure at least, the shock being communicated to the bobbin, thus reducing the tendency of the weft to fly from it to the lowest point. A tongue of a different form is shewn in Fig. 251, where a spring is placed on the under side for holding the bobbin, and a notch is formed at the extreme end to prevent any possibility of the bobbin coming off in the process of weaving. This tongue it will be seen is hinged at the back, and beneath it is placed a strong steel spring to keep it in position; the whole arrangement having, first, for its object the holding of the tongue and bobbin in the proper position during the weaving, and permitting of the tongue being raised to enable the weaver to change the bobbins.

Now it would be as well to examine from every point of view possibilities of damage, either to the bobbins, to the shuttle, or to the warp; as also the probable interference with the regular tension of the weft. In the first place a glance at this tongue will shew that in putting the bobbins on and taking them off what is termed the bobbin nose is always liable to injury, and any crack or injury to the bobbin is liable to catch the weft as it is drawn from it, to break it and bring the loom to a stop. This, if of frequent occurrence, is not only irritating to the weaver and causes a loss of time, but it is practically impossible to weave the fabric without imperfection either in the form of broken picks or thin places.

Then again the shuttle tongue must be held in a perfectly horizontal position, so that the weft can come straight from the bobbin to the shuttle eye. Should it point either upwards or downwards there must be considerable drag upon the weft, and that would be increased as the bobbin becomes empty. Again should there be any vibration in the bobbin, either by the spring at the back not holding it sufficiently rigid, or the peg passing through

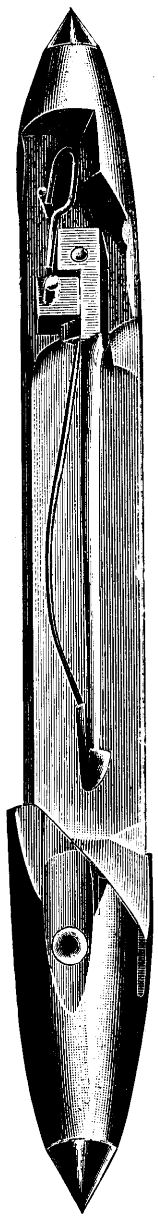


Fig. 251.

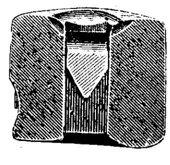


Fig. 252.

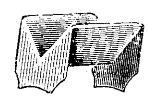


Fig. 253.

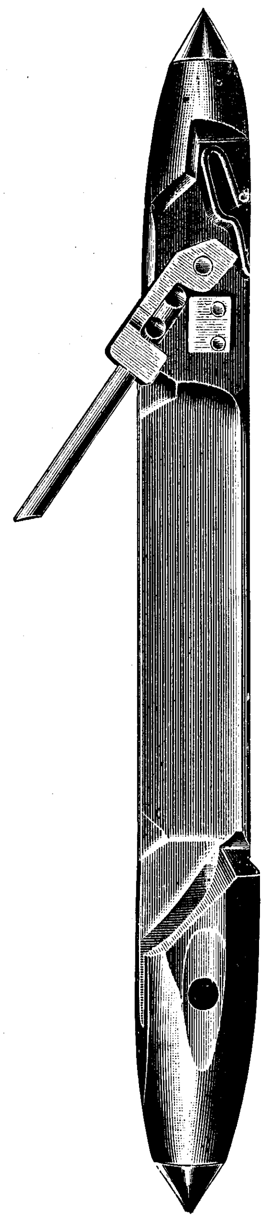


Fig. 254.

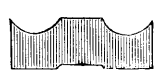


Fig. 255.

the tongue head becoming loose and permitting it to vibrate sideways the same fault will occur, but in an irregular manner. Sometimes too, the tongue will permit the nose of the bobbin to rise above the level of the shuttle when it will be liable to catch the warp.

Another fault is of more frequent occurrence even than that. In the usual form of shuttle the tongue rests upon a pin which is put through from side to side, or it may rest upon ledges of wood, left for the purpose; where it rests upon the pin there is a constant tendency to split the shuttle, and everyone knows that this is the most vulnerable point, because at the point where the pin is put through the sides of the shuttle have been weakened by being cut away, partly to permit the ready insertion of the tongue, and partly to facilitate the raising of it for changing bobbins. To dispense with the pin through the shuttle, and prevent splitting, various devices have been resorted to; one where a small peg is passed through the shoulder of the tongue and rests upon solid wood at each side. Theoretically this seems perfect, but in practice it is not quite so, for, with the constant raising and depressing of the tongue in changing bobbins and from other causes, apparently of a trivial character, the wood at the side gradually gets worn and allows the bobbin nose to point downwards until it reaches a point where weaving becomes practically impossible. The only way to meet this difficulty, it is said sometimes, is to build the shuttle so that the tongue, when new, shall point slightly upwards and so allow for a certain amount of wear and tear. This then reduces it to the proposition that the shuttles shall be in perfect working order when half worn, because there must be some irregular tension upon the weft when the shuttle is new by reason of the tongue pointing slightly upwards, and a corresponding tension when the shuttle is getting worn out, by reason of the tongue pointing downwards. There is no remedy for this but constant packing at the sides as wearing takes place. This is not only difficult, involving time and labour, but is a very unsafe mode of procedure. Metal bearings certainly offer the most ready solution and the illustration given here is one which apparently will meet the requirements. Instead of the tongue resting upon wood, or upon a pin passed through wood, it is made to rest in a V shaped metal groove which is inserted under the tongue, the tongue itself being formed to correspond with it. Fig. 252 represents a cross section of the shuttle with the tongue in position, and Fig. 253 represents a metal packing which may be inserted in the tongue rest in the event of the tongue getting too low. The change is easily accomplished and all being of exactly the same form they assure the fitting and cause no trouble. This contrivance is patented by Mr. James Waddington, of Bradford.

Now attention may be directed to one or two other forms of tongue designed specially for the protection of the bobbin and preventing the yarn slipping off, as well as ensuring even tension. In No. 1 of the Fig. 250 an arrangement is shewn where the end of the tongue is provided with combined cushion spring and cover, against which the end of the bobbin is pressed in weaving. Here a difficulty presents itself, apparently, in the use of an arrangement of this kind, in consequence of the tongue having to be removed from the shuttle every time a bobbin is changed. This is got over by a very simple arrangement in this case, and there are numbers of others of a somewhat similar character, by having a couple of notches cut in the end of the tongue; the tongue is inserted in the shoulder or head after the manner shewn in Fig. 254, and as the tongue is dropped into its place with the bobbin the two notches engage with two pins passed through the tongue rest as shewn at Fig. 255, which indicates the rest. Thus it will be obvious that when the tongue is raised for the purpose of changing a bobbin it is perfectly free and can be drawn out readily, but the moment it is dropped back into the shuttle it is securely locked into position. Then to come back to the shuttle peg No. 1, shewn at Fig. 250. The end of the bobbin pressing against the flexible spring not only prevents the yarn being thrown off by force of concussion, but it acts as a shield, and anti-vibrator as well. Other forms of the same contrivance are shewn in Nos. 2 and 4 of the same figure. Nos. 3 and 5 are simply plain tongues for different sized bobbins, all of them being interchangeable so that they may be used for the same shuttle and readily adapted for different kinds of bobbin or cop.

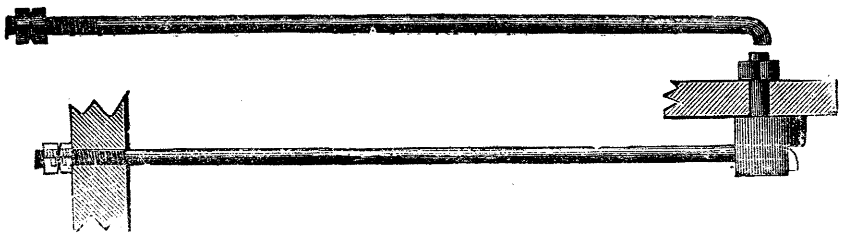


Fig 256.

Whilst dealing with shuttles perhaps one word may be said in reference to the picker spindles. The general arrangement has been already referred to in dealing with shuttle boxes, but a contrivance has recently been patented by Messrs. Bentley and Ramsden, of Bradford, which is said to be an improvement upon the existing system. An illustration is given at Fig. 256, where the spindle itself is shewn and also placed in position. One end of the spindle is slightly bent, the other is provided with lock nuts, so that when placed in position and the nuts screwed up tight it is held perfectly rigid. Two things in special are claimed for it, the first of importance is, that the shortening of the picking strap by the weaver would not have the usual dangerous effects in consequence of the rigidity of the spindle itself; and a second is, that in the event of the spindle breaking no portion of it could fly, as sometimes happens, and consequently no liability of injury to the weaver. Of course it is also claimed that from the rigidity of the spindle the liability of the shuttle flying out is also reduced.

SHUTTLE GUARDS.

There is probably no subject connected with looms which, during the last few years has attracted so much attention as that of shuttle guards. In fast running looms, more especially in weaving heavy work, or with rough fibrous material, the tendency to fly out is very great and also the consequent risk to the weaver. The various causes have been already dealt with, so that it is only necessary at the present moment to refer to means of prevention. Broadly speaking, it may be said that the best shuttle guard is a competent overlooker, a man who will look to his loom always being in good working condition; the great majority of shuttle accidents undoubtedly arise either from incompetence or carelessness. To arrive at a conclusion as to what is the best form of guard, leaving aside all questions of automatic arrangement, we have only to consider what are the probable causes of a shuttle leaving the loom. If it is from any fault in the picking arrangement we can determine almost immediately at what point it would leave the loom, and the probable direction it would take; on the other hand if the shuttle is thrown out merely by an obstruction in the warp we could only determine the direction it would take by a knowledge of the position of the obstruction. Suppose, for example, that the loom is picking in the best possible manner and the shuttle is being propelled from side to side with just sufficient pressure upon the reed to ensure good running; we are weaving a heavy yarn and one which requires great force in picking; then an obstruction occurs, either by the warp threads having broken or become entangled, or from any one of the numerous causes so well known to the weavers, and a bar is offered to the passage of the shuttle. If the shuttle point is thrown upwards it will in all probability be thrown outwards at the same time; if the upper half of the shed is a very light one the shuttle will then leave the loom in an oblique direction and probably in the direction of the weaver's head at the next loom; then serious danger exists, but should the upper half of the shed be heavy the shuttle, in forcing its way through the threads, will not only be retarded, but also somewhat diverted, and it would in many cases drop quietly on the floor a yard or two from the point where it leaves the warp, and there is, comparatively speaking, little risk of injury either to the weaver at the loom from which the shuttle flies or the one at the neighbouring loom. The greatest danger always arises from the shuttle flying nearest the side from which it has been picked, as it would then, not only rise higher, but travel considerably further, in consequence of only a small amount of the force of propulsion having been exhausted before it leaves the warp; but if we add to the causes of shuttle flying the more probable ones of having a bad picking arrangement, misdirection of force, or the reed and the back of the box not forming a perfectly straight line, any bulging of the reed, or any of those apparently trivial causes, then the danger is increased considerably.

Now the question arises, assuming any or all of these conditions to prevail, as to the best methods of prevention. To attempt to enumerate all the shuttle guards that have been invented during the past eight or ten years would be not merely an act of folly but perfectly useless. The first and simplest shuttle guard ever applied contains, so far as protection, all the requisite elements; this simply consists of a couple of small brackets attached to the handrail of the loom and extending forward over the shuttle race; these brackets carried one or more light iron or wire rods across the width of the fabric; but two objections were raised to their use, the first and the most vital one was the interference with the weaver, not only in taking up the threads, but also in interfering with the seeing of the fabric as it was being made. The latter objection is not of so much importance as the former as the rods might be made so light as to offer practically no interference with the vision, but the interference with access to the reed is certainly an important one. The next objection is as to the insecurity, as the shuttle could often fly out between the shuttle box and the guard itself; a system of flying which is not only in itself most dangerous, but in all probability it would strike the guard and have its course averted, to the imminent danger of any one in the immediate neighbourhood, for if it did strike anyone it would certainly strike high. This could be met by extending the shuttle guard closer to the box, but in doing so security is gained at the cost of the weaver not being able to take out the shuttle to change it as the weft is run out, without considerable difficulty and loss of time. Then recognising these objections the next movement was to form a species of grate which could be turned up and out of the weaver's way to permit of ready access to the reed.

Here again objection arises on the part of the weaver; this grate must be thrown back by the hand, and however simply contrived it usually involves two movements; when the guard is in position it must be held down firmly, so that the bracket on the handrail to which the guard is hinged, is usually provided with a sort of incline and a notch, and a spring upon the spindle of the guard itself presses a small catch into this notch, so that to raise it the guard must be moved to one side and lifted upwards. Then the most acceptable arrangement is after that for the guard to fall down simply from the vibration of the going part on the loom being started. To this there would seem to be little objection, and absolute security may be obtained by having a guard sufficiently long, and projecting sufficiently far forward; yet the weaver's object to the time occupied, and the trouble involved.

Numbers of so-called automatic shuttle guards have been invented, and it will be absolutely impossible to deal with them in detail. One of the earliest and most effective ones consists of a rail running across the front of the going part, and actuated by means of a lever direct from the belt fork handle, so that the moment the loom is started the rail is thrown out from the hand-rail into position, as suggested by the preceding remarks, and there it remains so long as the loom is running; but the moment the loom stops, from any cause, it is thrown back under the handrail out of the way of the weaver. The mechanism is so simple that it needs no explanation, the method of connecting to the belt fork handle being the only matter of moment. Many others have been made having practically the same principles involved, in some cases the rail being formed of wood and moving either vertically or diagonally, sometimes falling back under the handrail, sometimes in front and sometimes on the top of it; but seeing there is no real principle involved it would be unnecessary to go into the details of any number. Many objections have been made to these so-called automatic ones, sometimes on the ground of the mechanism involved, and sometimes on the ground of the trouble caused by having to detach them whenever the sley has to be taken off, and at other times on account of the liability to failure to act at the proper moment, and as a consequence attention is directed by many inventors to the production of a shuttle guard which would fulfil all the conditions of safety with the least possible amount of mechanism and the least liability to go wrong. It will only be necessary here to mention one or two for the purpose of shewing the direction in which inventors have been working. One of those is the invention of Messrs. Raper, Pitts and Noble, and is illustrated in Figs. 257, 258 and 259. It consists simply in a series of

A

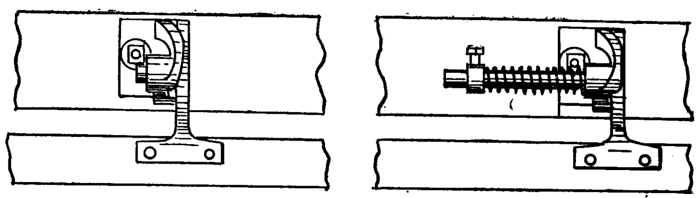


Fig. 257.

B

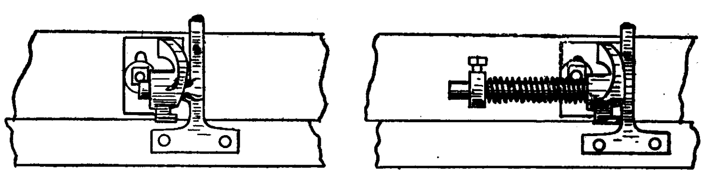


Fig. 258.

brackets attached to a handrail, one at least of which is formed after the nature of a cam; these brackets are made to carry lever arms, to the lower end of which either a wood rod or a series of wires are attached, and they are so arranged that when the loom is in motion they are held in such a position over the warp and shuttle race as to effectually prevent the shutttle from flying out as shewn at A. Whenever the weaver desires to remove the shuttle guard it is only necessary to turn it inwards or upwards and the rod will lay close under the handrail as shewn at B. To facilitate this, and to keep the guard in either of the desired positions, the cam-shaped bracket has a swell upon it in the direction of the sley, and the arm carrying the rods is produced beyond the fulcrum so as to slide upon the surface of the bracket as shewn in Figs. 258 and 259. Then upon the spindle carrying the lever arms a helical spring is placed and held in position by a screw-collar so as to always keep the lever arm in contact with the cam-shaped bracket. By this arrangement when the loom is at rest a slight pressure of the finger will bring the guard up to the handrail and out of the way of the weaver, but the moment the loom is started the vibration of the going part is sufficient to throw the guard

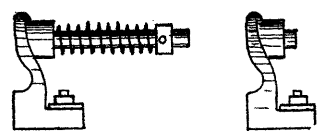


Fig. 259.

out into the position for protecting the shuttle; so that the apparatus is automatic in one sense, that the moment the loom is started it falls into its proper position and only requires the pressure of the finger of the weaver to remove it when desired.

Another apparatus of a similar character is the invention of Messrs. Redman and Sons, of Haworth. In this case there are brackets employed somewhat after the same manner as in the previous one, but the movable arm assumes a cam shape instead of the bracket itself, and instead of the spring being placed upon the spindle, so as to keep the arm and bracket in contact, it is placed within the bracket, or in other words the conditions are simply reversed with some slight modifications in detail, that which exists in the bracket in the one case exists in the lever arm in the other; the effect is precisely the same, and the efficiency of the two are about equal, so that as between the two inventions it is simply a matter of economy of production.

The three illustrated here may be taken as sufficiently typical of all the inventions and amongst the most efficient. It remains then only to describe one of the fixed arrangements, which not only differs from those previously described, but possesses special merits as a fixed guard. This is the invention of Mr. Jonas Hey, of Bradford. In this case a bracket is fixed to a handrail projecting in the usual manner towards the cloth, but made from flat steel, and in such a manner as to partake of the nature of a spring, and to these brackets bars are fixed in position parallel to the sley or handrail, these also are made of flat steel, or charcoal wire, so as to be very elastic, and they are placed at such a distance from each other as to make an absolute cover for the shuttle race, at the same time in their very lightness and elasticity they offer no interference to the weaver, and also not only prevent the shuttle flying out, but should it rise from the warp they readily force it back again. As a fixed guard this certainly possesses more merit than any other from the very elasticity of the material and the small amount of interference with the weaver's work.

TEMPLES.

There is probably no accessory to the loom which is of such importance in the production of good fabric as a good temple, and although at the present time there are scores of forms in use they may all be reducible to three practical forms. The object of the temple is simply to keep the cloth distended in front of the reed in such a manner as to keep the fabric the full width occupied by the warp threads in the reed, so that as the weft is being beaten up there can be no interference either from the pressure of the threads upon the reed itself or by friction of the reed upon the threads. To make this clear it will be perhaps necessary to explain what actually takes place in the process of weaving. As cloth is formed and carried away from the reed a considerable contraction usually takes place in the width, the amount of this contraction being dependent upon two things; first, the amount of warp or the bulk of the threads forming the fabric; second, upon the nature and elasticity of the weft, and those two conditions may also be influenced by the character of the pattern. Suppose, for instance, that the warp is very thick or very closely set in the reed, then very little contraction will take place, simply because the weft can exercise very little influence over it; if on the other hand the warp threads are fine, or very openly set, then contraction will take place in consequence of the weft bending round the warp threads after being beaten up by the reed and they are left at liberty to assume corrugations, which in many cases are leading characteristics of the fabric. If the weft is very strong, or made from very stiff fibres, or twisted threads, then their flexibility is lost and very little bending takes place; consequently the contraction is limited, whilst, on the other hand, should the weft be of a very soft and flexible character the contraction will be great. The influence of pattern follows practically upon the same lines. The frequency with which the weft and warp intersect each other may give opportunities for increased bending which will generally imply a tendency to contraction. This, of course, will also be dependent upon the relative bulk and quality of the two materials.

One thing may seem difficult of explanation, after what has been said of the manner in which the weft is thrown across, and the length of yarn actually employed in forming one pick. It will be remembered that in dealing with the tension upon the weft the thread forms a diagonal line across a parallelogram represented by the width of the sley on one side and the length of the shed, from the fell of the cloth to the front of the shuttle, on the other; so that the length of the yarn thrown across the piece, and beaten up to the fabric by the reed, must of necessity be somewhat

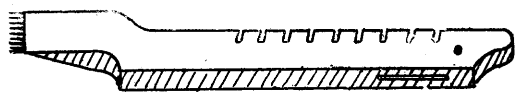


Fig. 260.

greater than the actual width of the threads in the reed itself, consequently it would seem that this increased length would be sufficient to allow for the corrugations formed by the weft threads after leaving the reed. But as a matter of fact, in very fine material, the contraction in width, due to the causes already mentioned, may be anything from 1 to 15%, and as this contraction increases

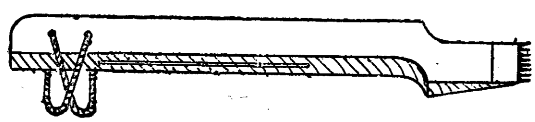


Fig. 260A.

the difficulty of weaving a good fabric becomes intensified. In the first place the friction upon the outer threads will become so great as to be absolutely cutting; in addition to that the resistance offered to the reed in its progress towards the cloth will prevent the requisite number of picks per inch being beaten in, and there is also a tendency to cause what is termed curling in the weft at the same time. In fact the defects in the cloth are such as in most cases, especially fine fabrics, to render them absolutely unsaleable.

The earliest forms of temple in use for hand looms consisted simply of bars of wood with pin points projecting from the extremeties, and coupled together in such a manner as to form a sort of hinge in the centre, so that on the insertion of the pins in the two selvedges and the downward pressure upon the two levers the cloth would

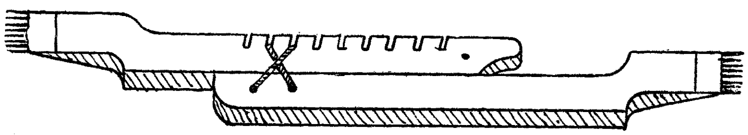


Fig. 261.

be distended. Figs. 260 and 260A shew the two separate parts of an ordinary temple, Fig. 261 shews them joined together as in use. The weaver had simply to place the teeth through the selvedge within a very short distance of the fell of the cloth, press them down, and make a notch in one of the arms to drop into a groove in the other one, which combined with the pressure on the pin points would cause it to be held firmly in position.

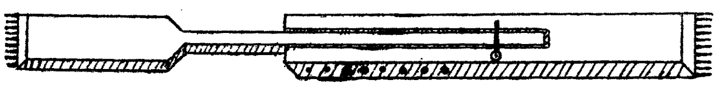


Fig. 262.

Another form is shewn at Fig. 262, where instead of the parts being joined together by a piece of string they are joined by a pin passed through them and when pressed down are held in position by a small button. The form shewn at Fig. 261 was, however, preferred by most weavers on account of the exact nicety of adjustment which could be obtained by the use of the string. Where the two parts were hinged together with a pin the width at which they could be set could only be varied as the distances apart of the holes through which the pins passed, but with the string it could be set to the exact width of the warp in the reed with the utmost nicety. This form of temple, however, possesses two serious disadvantages, especially for power loom work. In the first place some time is occupied in moving the temples up to the fell of the cloth periodically; and in the second place, the tendency to irregularity in the fabric if the temples are not moved with sufficient frequency. It was a recognised maxim with hand loom weavers that the temples should never be woven more than an inch, or inch and a half, from the fell before being moved, but a careless weaver might allow them to run 3 or 4 inches, or even more, with the result that, in fine goods at any rate, a marked unevenness in the cloth was visible. In the power loom, of course, this is an impossible position especially in fast running looms, for not only would it take up too much of the weaver's time to keep moving the temples forward, but it would be necessary to stop the loom every time to permit the operation, so that a continuous temple becomes an absolute necessity.

I shall not attempt to deal with every form of temple in use or to say much as to their relative merits as it would not only occupy too much time, but involve entering into a vast amount of unnecessary detail. There are two principles directly involved and all the various forms of temples belong either to one or the other, or are in some measure a combination of the two.

In Fig. 263 we have what is commonly known as the star temple. This is simply a roller placed horizontally with teeth upon its rim and surrounded by a shield plate, with grooves cut so as not only to permit the cloth to embrace a section of the circumference, but also to hold it in position there. This temple is placed under the cloth with its circumference in a line with the warp as it leaves the reed. The selvedge of the cloth is pressed under the shield plate and engaged with the teeth of the roller, and as near the fell of the cloth as possible, without being in the way of the shuttle race. Once being properly adjusted, and the cloth placed upon the teeth so as to engage a sufficient depth into the fabric to have a good hold, the cloth will always remain held by them and distended equally in front of the reed to the requisite width. For a large proportion of fabrics this temple is all that could be desired, but there are cases where it scarcely fulfils the conditions; for instance in fine fabrics, and especially those made from very shrinkable material, the tendency to contraction after passing the temple is so

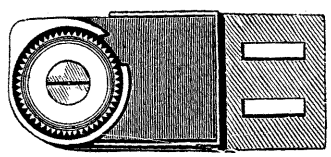


Fig. 263.

great as to cause injury to the selvedge; to mitigate this sometimes the double star is used, one being placed behind the other, and the position of the second star relieves, in some measure, the strain upon the first. In other cases however it has been found necessary to get a much greater hold upon the cloth than could be had by merely taking hold of the selvedge; then what is known as the segment temple is brought into use. Since its first introduction the segment temple has not only undergone a vast variety of changes and been used in various forms, but it is also used in combination with the star. The Fig. 264 represents one of the most improved forms of segment temple; this consists of a series of rings revolving upon a horizontal spindle. In the earliest form of segment temple the rings were placed in a sort of diagonal position, but exactly parallel with each other, so that they would all take hold of the cloth to the extent of say 3 to 6 inches, according to the strength or width of the fabric, and as the cloth is carried forward they would gradually stretch it out. To ensure the work being done satisfactorily the rollers are covered with a shield plate which compels the cloth to embrace about one-third of the periphery, so that sufficient hold will be had to ensure its being kept extended. In some cases, especially where the fabrics are of a light character, all the rollers dragging with the same amount of tension will be liable to cause a little damage by displacing the threads in the cloth. This was sought to be overcome by placing the rings in the position shewn in the illustration Fig. 264, where the angle is gradually varied so that the greatest amount of pull is on the extreme edge of the fabric, and gradually decreasing towards the centre; that is the rings A^1 are nearly at right angles to the axis, and have very little pull upon the cloth, whilst from A^2 to A^4 and forward, the angle is constantly increasing. Of course those rings would vary not only in size, but in the strength and number of the teeth on their circumference according to the weight of the cloth.

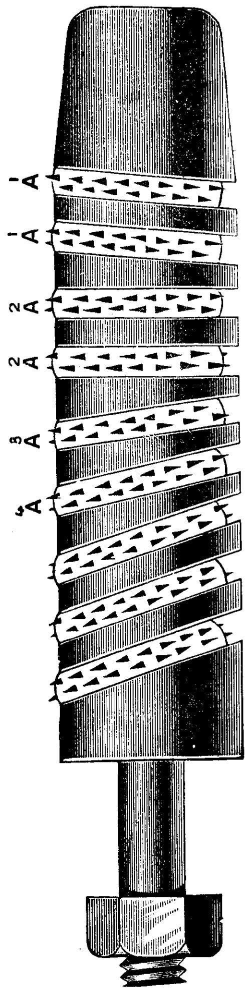


Fig. 264.

In addition to segment temples there are many in use commonly known as roller temples, which consist simply of a roller with teeth on its surface taking the place of the segment rings; these of course are cheaper and for many purposes sufficiently good but not suitable for the finest woollen or worsted fabrics. Then a compound of the two principles comes in, and numbers are employed in fine worsted goods, such as cashmeres or merinos, where one roller, or a double roller, somewhat after the segment is used, but being rather more rounded off so as to get full hold of the whole of the selvedge, without going too deeply into the body of the fabric; or again one of these rollers may be used in conjunction with the star. But whatever may be the form of temple adopted two things only must be looked to, the first is that involved primarily in the use of the temple to keep the cloth distended so that the reed can be brought up to the fell without undue pressure upon the threads at, or near, the selvedge; and to do this without any risk of injury to the fabric by displacing the threads. In some cases instead of these temples being held rigidly springs are placed behind them so as to give some elasticity of movement and allow them to travel forward with the cloth a little as the reed is striking the weft up, and then to return on the pressure on the reed being released, but those are details which must always be considered in connection with the class of work to which they are applied.

THE WEFT FORK.

One of the most important additions to the power loom is that for stopping the loom in the case of the weft breaking or the shuttle becoming empty. The contrivance is simplicity itself and only requires a very brief explanation. Fig. 265 gives a representation of the weft fork detached from the other parts of the loom. F is the fork in the form of an L lever, having three prongs at one extremity and a hook at the other, and as seen in perspective in the illustration. In the going part, and alongside the sley, is placed a small grate through which the prongs of the fork can pass as the reed is brought up to the fabric; under the hooked end of the fork is placed a lever L, with what is termed a hammer head, that is, a flat cross head with a notch upon it and hinged near its centre,

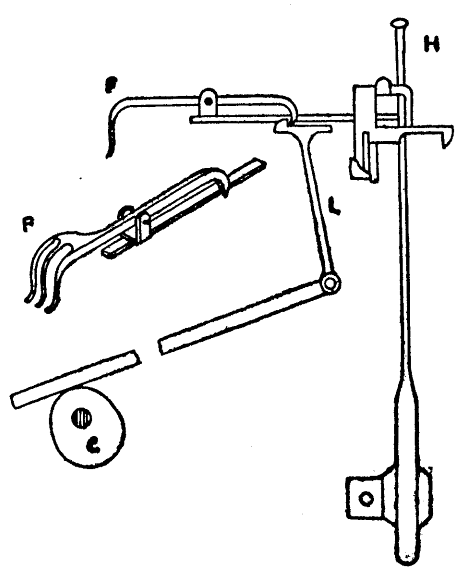


Fig. 265.

the lower end resting upon the tappet of the loom; upon the tappet shaft is placed a cam C, which will lift the lever L at each revolution; as the lever is lifted the hammer head will be thrown back and in the event of the hook of the fork resting upon it will pull it backwards towards the belt fork handle H. The spindle upon which the fork is hinged is carried to a lever resting upon the breast beam, and in such a manner that on being pulled back by the lever H it would strike the handle and throw it out of the notch in which it usually rests when the belt is on the driving pulley, and so throw the belt on to the loose pulley and stop the loom. Very little need be said of this contrivance, everything depends simply upon the careful balancing and adjustment of the parts; the fork must be placed exactly opposite the grate at the end of the reed so that it will pass readily through it; it must be carefully balanced so that as the weft strikes the lower part of the prongs it can raise the hook clear of the hammer head, and this being done the timing of the movement need only be adjusted, so that the hammer head begins to recede exactly as the reed comes up to the fell of the cloth, which requires only a moment's consideration to see that in the event of the weft being in its usual place the prongs of the fork will be pressed back and the hook raised to the highest point just when the reed is in contact with the cloth, and that before the hook is allowed to descend the hammer head must have moved sufficiently far to prevent the hook dropping into the notch for it, and so permitting the loom to run; but if the weft is absent the prongs of the fork pass clear through the grate allowing the hook to remain immediately over the hammer head, when it will be caught and the belt thrown off, so that very little is required on the part of the weaver or overlooker to ensure good working on the part of the weft fork.

CENTRE WEFT FORK.

The weft fork just described is only really useful at one side of the loom. For plain looms, or for box looms, where the boxes are at one side only, and consequently where the pattern can only be in "double picks" it is, both for simplicity and efficiency, no doubt the best; but