it is necessary to commence from the opposite side—*i.e.* the right-hand side. But in some dobbies—as, for instance, Parker's centre-shed dobby, Figs. 103 to 107—the cards for a right-hand dobby are at the right side; therefore the cutting must be commenced at the left. Then, again, some dobbies have two sets of cards or lags, one set on each side, in which case one set of lags commences from the right-hand side and the other set from the left. The different positions of the lags are such as to cause confusion,

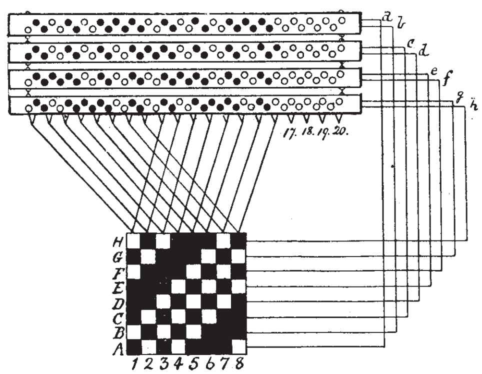


Fig. 112.

but a simple rule to observe in pegging is first to notice on which side of the dobby the lags hang, and then to commence pegging from the opposite hand. Thus, if lags hang at the right side of the dobby, commence pegging from the left-hand side; if lags hang at the left side of the dobby, commence pegging from the right-hand side; or, what is equivalent, commence at the left side with the last lag instead of the first.

As already stated, dobbies of the type of that described above are very suitable for most classes of light and

medium work, but in many cases, and for all heavy fabrics, it is advisable, if not essential, that the shedding motion should be of a positive nature. Figs. 113 and 114 are illustrative of the positive open-shedding dobby made by Messrs. George Hattersley and Sons, Limited, Keighley. In general the principle is the same as in the original dobby, while the main differences in detail are due to the changes necessary for a positive tread. Motion, as before, is imparted by a crank on the bottom or wyper shaft through a suitable rod to the ⊣ lever A fulcrumed at B, each arm C and D of this lever being connected near its extremity to two blades or knives EF, E^1F^1, by means of the connecting rods G and the eyebolts H. From the arm D, rod I, lever J, and pulling catch K, the octagonal lag barrel L is rotated as before: the rollers M serve to guide the lags clear of the arms of the levers which connect with the underside of the camb leaves, these levers (N, Fig. 114) being double bell-cranked and fulcrumed at O. As in the negative dobby, these levers (usually notched at their extremities to permit of a graduated shed) are connected at P to the swing baulk or beam lever Q, on the arms of which drawing knives R and R^1 are connected. Each arm of Q has its corresponding fulcrum S and S^1. The weighted levers T and T^1 act as already described to lower the drawing hooks R and R^1 over the knives E and E^1, which serve as pulling or lifting knives; whereas F and F^1 serve as pushing or depressing blades. It will be observed that both hooks R and R^1 are raised clear of the pulling knives, which in the figure are shown at the extremity of their stroke. Assuming that the hook R is dropped for the next outward movement of the knife E, the lower arm of Q will move outwards, and the lever N will thus be raised at U, and lowered at V. Since the latter point of N is connected by wires and levers, or jacks, to the under side of the camb leaf, and the former point

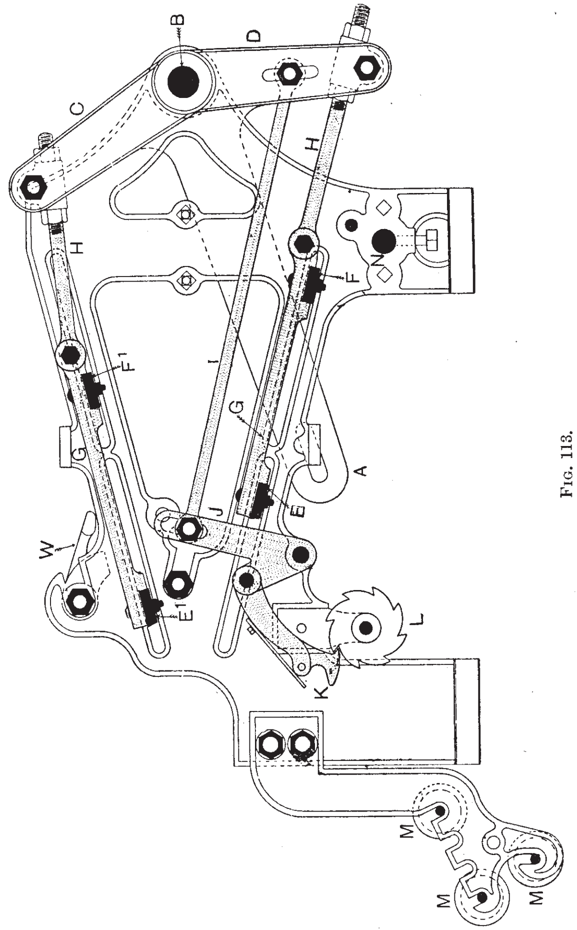


Fig. 113.

to the upper side, it follows that the leaf connected will rise. The blades E and F being connected together by a

rigid bar G (Fig. 113), always retain their relative positions, and, at the outward extremity of the assumed stroke, F will still be in close proximity to the lower end of the

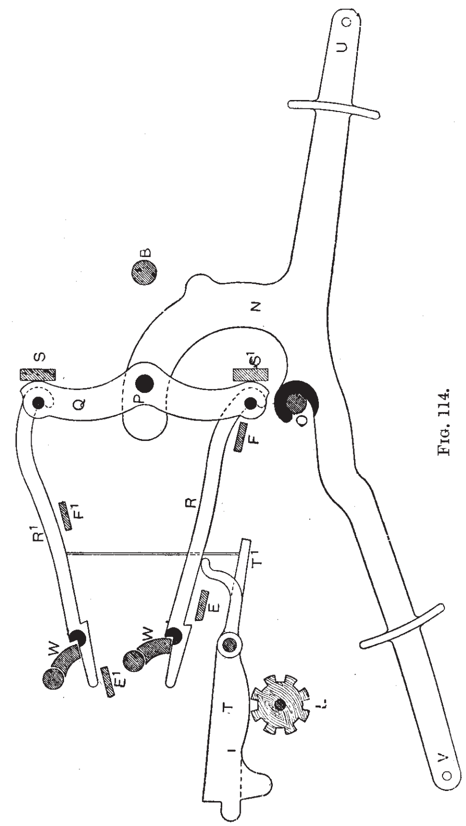


Fig. 114.

lever Q. If the leaf in question, now raised, requires to be lowered for the next succeeding pick, the blade F will press upon and positively return the lower arm of the lever Q to its former position—that shown in Fig. 114,—and the leaf attached will be depressed. If, on the other hand, the leaf were required to be up instead of down for the following pick, the hook R^1 would have been allowed to drop over the knife E^1, and lever Q would simply swing about P as a centre (this point being practically stationary during the stroke), and the leaf would be retained in its raised position. In order to ensure that the blades F and F^1 will keep in close proximity to the extremities of the arms of Q when the latter are removed from their respective fulcra S and S^1, but more particularly to reduce friction to a minimum, they are arranged to move practically in the same radius as the lever Q. Weights W rest upon and therefore keep the hooks R and R^1 in contact with their respective lifting knives. For wide looms suitable connections are made to ensure a vertical and graduated lift.

The lag or pattern cylinders in the Keighley dobbies represented in Figs. 108 to 114 are shown as being driven negatively, but arrangements may be made in both cases for a positive drive if necessary. Figs. 115 and 116 show the arrangement for a positive drive to the lag cylinder of one type of loom supplied by Messrs. G. Hattersley and Sons, Limited. Keyed to the crankshaft A is a spur pinion B of twenty-two teeth, gearing with a spur wheel C of forty-four teeth, supported on a suitable stud D. Compounded with C is a bevel pinion E of twenty-eight teeth, gearing with the bevel pinion F of equal teeth, supported at the lower end of the vertical shaft G, about which it may revolve freely. It is, however, prevented from so doing when in action by a Λ-shaped projection from its upper side taking into a corresponding groove in the under side of the part H. In the event of the lag chain becoming locked, the projection from F forces H clear of the

pinion, and permits the latter to revolve without imparting motion to the shaft G. A helical spring between the collar I and the part H serves to keep the latter in contact

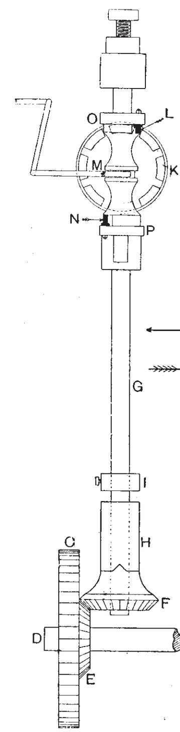


FIG. 115.

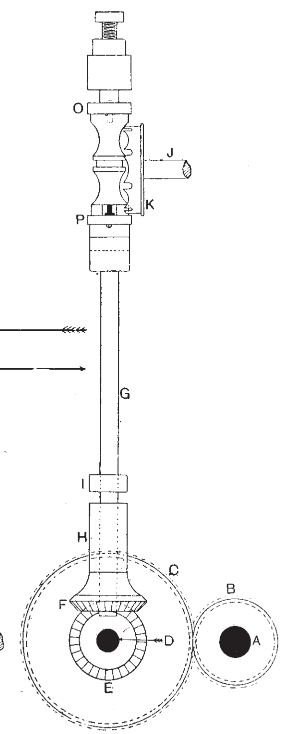


FIG. 116.

with F, and yet allow, when necessary, the disconnection mentioned. On the end of the lag cylinder shaft J a crown star wheel K is set-screwed, which is turned one-eighth of a revolution by the pin L every revolution of the shaft G. In order to reverse the direction of motion of the shaft J, the pin L (by means of suitable levers and the fork M) is lifted out of gear with K, and at the same time the pin N is lifted into gear—as shown in Fig. 116, —causing K, and therefore J, to move in the opposite direction. Due to the relative values of B and C, it is evident that the shaft G revolves only once for two picks, and that therefore one lag on the lag cylinder must also serve the same number. Occasionally lags are introduced which only serve for one pick, in which case each disc O and P contains two pins set diametrically opposite to each other. The shaft J will thus be moved every pick.

When this arrangement of positive driving obtains it is usual to drive the ⊣ lever of the dobby from a crank on the end of stud D, or from a pin or stud near the periphery of the wheel C, the former being the more modern method. The positive cylinder motion supplied by Messrs. Ward Brothers consists of a somewhat similar star wheel actuated by a pin and disc on a short horizontal shaft. This shaft is driven from the crankshaft by means of a pitch chain and pinions, the relative value of the latter being as two to one. Positive driving of the lag cylinder assists in keeping the box and pattern chains in unison with each other.

Those dobbies already described may be considered as shedding mechanisms which may be mounted on almost any loom for the single purpose of governing the shedding of the warp yarn. But in fancy work of any kind where different coloured wefts are used, and where the same are required to keep in unison with a prearranged order of shedding and picking, experience has determined that if at all possible these three actions should be so governed by some simple arrangement that it will be impossible for any one of the motions to get out of harmony with the others. The fact that it is a machine that will accomplish the object desiderated is our reason for introducing Hollingworth and Knowles' dobby, which, although not employed in the linen trade, nor yet extensively in the fancy part of the jute trade, is well worthy the closest attention of manufacturers engaged in the latter branch of weaving. Besides controlling the shedding, picking, box, and up-take motions from one direct source, the mechanism is so arranged that all parts may be reversed by hand; and to facilitate mending broken ends a levelling bar is provided which in connection with the ordinary mechanism can bring all leaves to the same level at any desired moment. The loom is made in various widths, and to actuate from 16 leaves upwards, as required. All parts subjected to much wear are casehardened, or chilled in casting, and all parts are interchangeable for the same hand of loom. The driving of the loom also is such that a variation in speed may be obtained without change of pulleys or drum.

In Fig. 117 the essential parts of the mechanism of the dobby are shown. A and B are two fluted or toothed driving cylinders, which continually revolve in opposite directions, as indicated by the arrows. Each camb leaf is attached, from the top and bottom respectively, to C and D, the two arms of a bell-crank lever fulcrumed at E; each lever is provided with a separate short connecter F, vibrator lever wheel G, and vibrator lever H, the latter being fulcrumed at I. One end of the connecter F is hooked at J to the bell-crank lever, the other end being attached to the vibrator wheel G by a pin K, the wheel G being supported at its centre by a suitable pin in H. The arrangement of the three parts F, G, and H is shown in detail (plan and elevation) in Fig. 118, one-sixth the actual size. F and H are each composed of two flat wrought-iron bars, riveted together at suitable points; F is forked at one end 2 to connect with the bell-crank lever CD at J (Fig. 117), and at the other end 3 to take in the lever wheel G, to which it is connected by a pin K; while H is also forked at 4 to take in the same lever wheel, supporting it at its centre by the pin 5. The lever wheel G is provided with

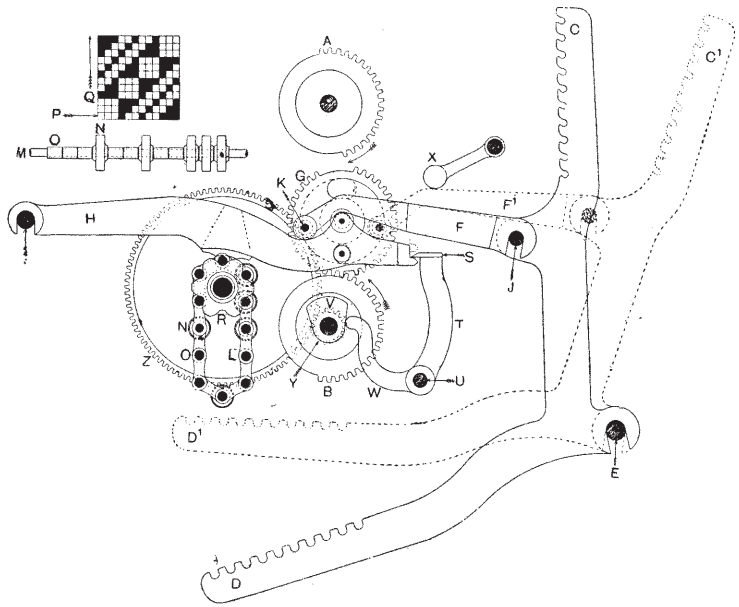


Fig. 117.

a concentric slot 6, extending fully halfway round, through which a pin 7, carrying an anti-friction roller, passes to prevent excessive travel in the wheel. The continuity of the teeth of the wheel is broken at 8 by the omission of one tooth to facilitate engaging with the toothed cylinders A and B; and at the point 9 (diametrically opposite 8) is again broken by the omission of four teeth to enable it to

remain at rest for any number of successive picks, as may be determined by the weave. In the position shown in Fig. 117 it will be observed that the rotation of the cylinder B will cause the lever wheel G to revolve clockwise, and thus place the connecter F and the bell-crank lever CD in the positions represented by F¹, C¹, and D¹ respectively. This movement will result in the lowering of a leaf, and will bring that part of the wheel G with the four teeth missing opposite the cylinder B, which will thus be prevented from rotating G any further, so long as G remains in this position. It will be seen that the motion imparts a harmonic movement to the leaves—very similar to that obtained with wypers. Lever H, which supports the wheel G and determines the cylinder with which it shall be in contact, rests upon the pattern chain L, which is composed of rods M, with bowls N and bushes O, according to the pattern, and of which one link is shown detached for the first pick P of the weave. The pattern chain L (which shows the arrangement of bowls

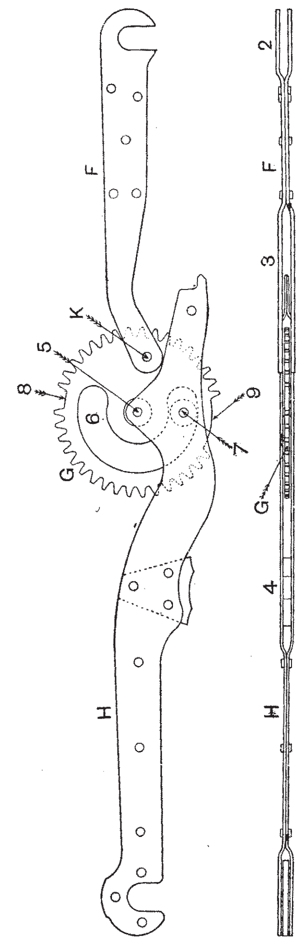


Fig. 118.

and bushes for the first thread of the weave in the direction of the arrow Q) is carried round continuously by the chain cylinder R, and according as a bush or a bowl be under the lever H, the lever wheel G will be in contact with the cylinder B or the cylinder A. As already shown, the movement of the cylinder B from the position represented in the figures will result in the large gap in the wheel G occupying the low position, and thus preventing further rotation until the bowl N in the pattern chain L lifts the lever H, thus placing G in contact with the top cylinder A, which will again raise the leaf. It will thus be seen that the mechanism is on the open-shed principle.

The lock-knife S (which serves to keep the gear wheels G in contact with the cylinder B during action) is supported by two arms T, set-screwed on the shaft U. Motion to the lock-knife is imparted by a cam V (fixed on the shaft of the cylinder B), through the finger W (also set-screwed on the shaft U). The finger W is kept in close contact with the cam V by the action of a flat spring; the cam V is timed to act upon the finger W so that the lock-knife S will be withdrawn immediately the pin K has reached its opposite dead centre, and of course before the pattern chain L attempts to lift the lever H and wheel G into contact with the top cylinder A; its timing also permits of S being in the position shown a little before the cylinder B can produce any movement in the wheel G. A steadying weight X rests on all the lifted connectors F. Originally the hexagonal chain cylinder R was driven as represented in the figure from the shaft of cylinder B by a pinion Y of 16 teeth and the wheel Z of 96 teeth, but it is now driven from cylinder A.

The levelling apparatus shown in Fig. 119 consists of a grate A, bolted to the framework in such a position that

the ends of all the vibrator levers H (Fig. 117) project through it and over the part B. The latter is a flat bar, provided with inclined slots C, through which pins D are passed and fixed in A. When in work, the pins D occupy a position at the top of the slots, but by drawing a handle E (which projects outside the front of the dobby) the part B is raised into the position shown, raising with it all the vibrators H and the wheels G which are in the low position into contact with the top cylinder A; half a revolution of the cylinder A will then place all leaves level in the top position. A newer form of levelling apparatus is illustrated in Fig. 120. The top figure represents the position of the

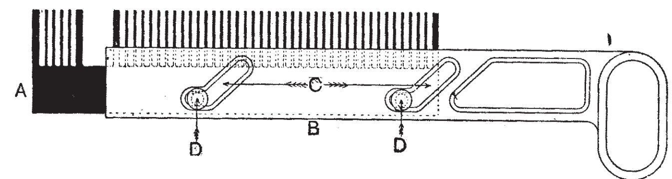


FIG. 119.

levelling bar A when the loom is working; the ends of the vibrator levers, shown in black, indicate that Nos. 1, 2, 3 and 7 are up, and Nos. 4, 5, 6 and 8 are down according to the pick line B at the top of the figure. In the lower figure the lever C has been moved partly round, with the result that all vibrator levers have been raised to the same level, much the same as indicated in Fig. 119. The end views in Fig. 120 also show the respective positions of the levers when in work, and when lifted for the purpose of bringing all leaves to the same level.

The method of driving this loom differs from that of the great majority of others in that the motion, instead of being taken to the crankshaft direct, is first imparted, as shown in Fig. 121, to a short cross-driving shaft A placed at right angles to the line of the crank and wyper shafts B

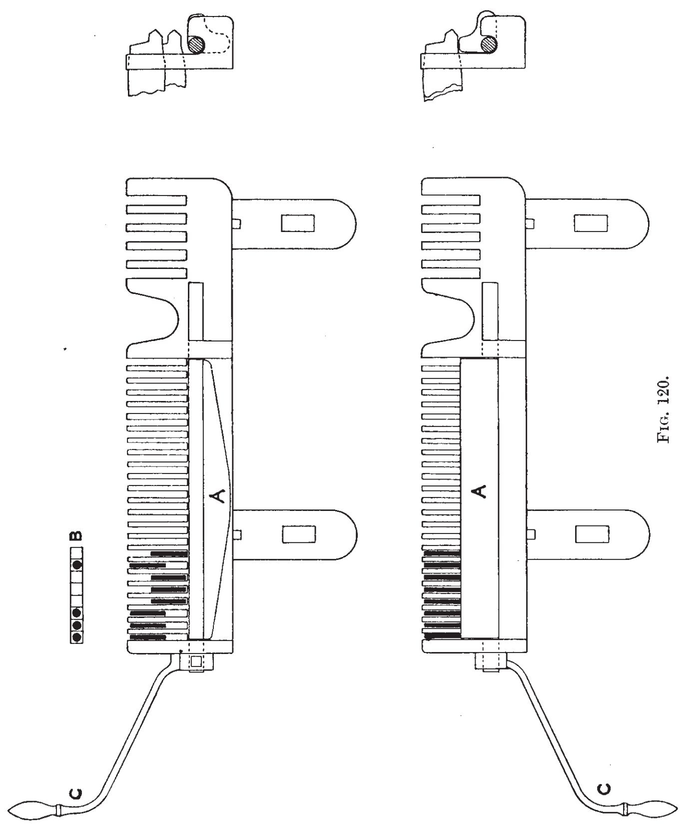


Fig. 120.

and C. The shaft A is supported at two points near the fast and loose pulleys D and bevel pinion E, in a suitable sliding bracket, which enables driving pinions of different values to be placed at E, thus securing a ready method of

altering the speed of the loom without change of pulleys or drums, and therefore without breaking the belt. Three pinions are supplied, which permit of a variation in speed of about 20 per cent. The bevel pinion E gears with the compound bevel and spur wheels F and G on the low shaft C, the crankshaft B being driven by gearing of spur wheels G and H of equal teeth. In wide looms G and H are slightly elliptical and eccentrically set in order to increase

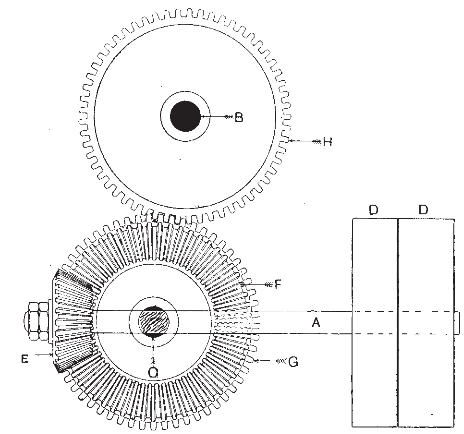


Fig. 121.

the dwell of the lay when the crank is rounding the back centre. Because of this latter gearing, the shaft C, on which the picking tappet is placed, will revolve at the same speed as the crankshaft. A decided advantage is thus gained in picking, as the action is imparted from a shaft which has twice the speed it would have under the usual conditions which obtain when picking from the low shaft. Due to the respective values of the bevels E and F (approximately as 1 is to 5), the shaft A will run at about five times the speed of the crankshaft. This high speed of the driving shaft ensures a much steadier movement in the loom than if driven direct from the crankshaft B.

The driving of the mechanism of the dobby is shown in

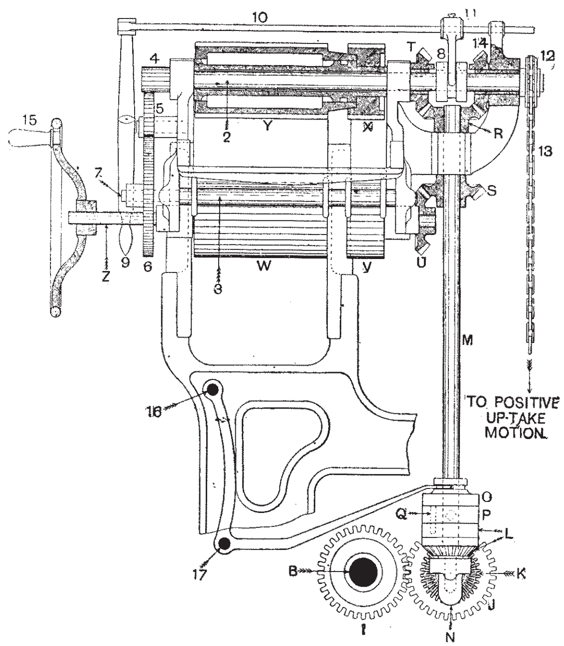


Fig. 122.

Figs. 122 and 123. On the end of the crankshaft B (opposite to that of the driving) a spur wheel I gears with a stud wheel J of an equal number of teeth. Compounded with the latter is the bevel pinion K, gearing with the clutch bevel pinion L of equal teeth, which revolves loosely round the vertical shaft M supported in the footstep N.

Part of this clutch arrangement O is also loose on the shaft M, while the part P is set-screwed on the same shaft; the clutch is completed when in action by a pin Q fixed in O, passing through a hole in P and entering partly into L. Keyed on the shaft M are two bevel pinions R and S which gear with and drive equal bevel pinions T and U;

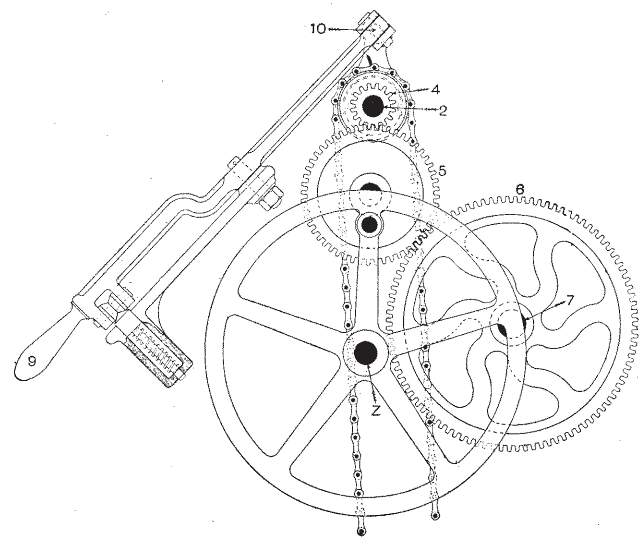


Fig. 123.

the latter pinion, as well as the low cylinders V and W, is keyed on the shaft Z. The pinion T, however, and the cylinder X are keyed on a sleeve which may revolve freely round the shaft 2. To this sleeve cylinder Y is set-screwed. The cylinders W and Y are those represented by B and A in Fig. 117, and therefore control the shedding; cylinders V and X similarly control the levers for the box and picking motions. Since the pinion R drives the pinion

T from below, and the pinion S drives the pinion U from above, it follows that the cylinders Y X and W V will revolve in opposite directions.

As already stated, the chain cylinder 3 was originally driven from the shaft Z, but the motion is now imparted from the shaft 2 through pinions 4 of 16 teeth keyed on the end of this shaft, carrier wheel 5, and wheel 6 of 96 teeth on the end of shaft 7 of chain cylinder. This arrangement will be better seen in the front elevation in Fig. 123. When the loom is working forward, the clutch 8, Fig. 122, which is fixed to the shaft 2 by a sliding key, is brought into contact with the pinion T by means of a handle 9, rod 10, and fork 11, when the shaft 2 and the cylinder Y rotate in the same direction. On the end of the shaft 2 a chain pinion 12 is keyed, which through the pitch chain 13 conveys movement to the positive uptake mechanism. When it is desired to reverse the loom in the case of a broken shot or other defect, the dobby mechanism is liberated from the driving of the loom by the action of lever 16, fulcrumed at 17, withdrawing parts O and Q from the part L of the clutch arrangement at the bottom of the shaft M; then by placing the clutch 8 into gear with the bevel pinion 14 (which also revolves freely on shaft 2, but in the opposite direction to pinion T), and by rotating the hand wheel 15 in the normal direction, the chain cylinder 3 and the uptake chain 13 will be rotated in the backward direction, while the cylinders V, W, X, and Y will revolve in the normal or forward directions, and will actuate the shedding, box, and picking levers just as if the loom were going. The arrangement of the uptake motion is such that when "picking back" the cloth beam gives off the cloth in exact proportion as the shedding is reversed.

Fig. 124 is an isometrical view of the top shaft, cylinders, etc., removed from the framework. C is the shaft; B the driving pinion for the chain cylinder; A the toothed cylinder for operating the camb leaves; E the toothed cylinder for operating the box and picking levers; F the bevel pinion for the forward driving of the shaft C; D the sleeve on which the parts A, E, and F are fixed; G the bevel pinion for reverse driving of the shaft C; J the clutch; K the projections on the pinions F and G for engaging with the clutch J as desired; and H the chain pinion for the uptake motion. Parts B, J, and H always rotate with and in the same direction as shaft C. Parts A and E are fixed on the sleeve D independently of each other, with the view of placing the shedding cylinder A in advance of the picking and box cylinder E. This may be done to the extent of seven teeth, or approximately one-fifth of a revolution of the crankshaft. In the figure, A is four teeth in advance, a position which is found to be suitable for most classes of work. The box, picking, and other motions of this loom will be considered under these respective heads.

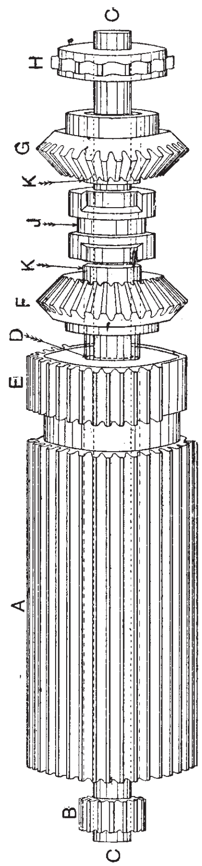


Fig. 124.

For cross-border, and other similar work, special dobbies are provided, or special parts are added to existing machines, by which two sets of cards or lags, each set cut or pegged to produce a different effect, may be brought alternately into play on the indicating or needle part of the dobby. These machines are usually arranged to be either semi-automatic or fully automatic; that is, they are arranged so that the change from one set of lags to the other may be made by hand at any desired moment, or so that the change will be made by the machine automatically after a pre-determined number of repeats of either chain of lags has been woven. The latter is the more desirable machine as it can generally be worked in either way at will.

Simple changes, such as closing the sides or the ends of a seamless bag, may be and frequently are produced by tappets only; but where the repeat of the weave exceeds about four picks, a cross-border dobby is desirable if not absolutely necessary. In some cases a two-cylinder dobby is arranged to give three different weaves on two sets of lags. For example, an ordinary huck towel is desired with a cross-border made up of $\frac{1}{\ \ }\!\!{}_{1}$ plain cloth and another fancy weave other than huck. Alternate lags, say odd numbers, of the border set are pegged for the plain weave while the even numbered lags are pegged for the fancy weave. The ratchet wheel on the border cylinder is provided with 12 teeth, and the cylinder with 12 divisions for the lags, but when in action the ratchet wheel is moved two teeth at a time, so that only odd numbered lags, *i.e.* those pegged for the plain weave, act upon the needles. When even numbered lags are required, a simple movement raises the pawl which has been in action, and releases a second pawl arranged to act upon the intermediate teeth of the ratchet, and so present the even numbered lags to the needles. Take a case where a four-inch border is wanted on a cloth containing 60 picks per inch. It might require $\frac{4 \times 60}{2} = 120$ lags to peg this fully; but if the fancy weave repeated on 40 picks, then 20 lags would be required for it, and other 20 for the alternate lags for the plain weave, or only 40 lags in all.

Generally speaking, however, the machines are of the usual two-change type, and in Fig. 125 we illustrate one of this kind as made by Messrs. Ward Brothers, Blackburn. The dobby is fully automatic, and the change from one set of lags to the other is perfect. The repeat and border cards are carried respectively by cylinders A and B; these are rotated in the same direction — clockwise — by two ordinary pushing pawls which act upon corresponding ratchet wheels at the other end of the cylinders, that is, at the weaver's side of the machine. Cylinders A and B are supported by a two-armed rocking lever C, but on opposite sides of the fulcrum shaft D, so that when either cylinder is raised into working contact with the needles of the dobby, the other cylinder is naturally lowered and so removed from working contact. At the same time, parts on the other side of the machine, which it is not necessary to show, drop one pawl into gear and raise the other one out of gear with their respective ratchet wheels, so that one cylinder begins to rotate while the other one ceases. The rocking lever C is extended and forked at its inner end to carry on suitable studs the antifriction rollers E and F, between which a six-sided tappet G is made to revolve. From the formation of the tappet ($\frac{1}{\ \ }\!{}_{1}\frac{1}{\ \ }\!{}_{1}\frac{1}{\ \ }\!{}_{1}$), and the position of the rollers E and F, it is evident that rotation of the tappet G will bring the cylinders A and B into action alternately; but the further arrangements are such that either set of lags may make any desired number of complete revolutions, or repeats of the pattern, before the other set is brought into play. This number is, of course, determined by the length of the cloth to be woven, the

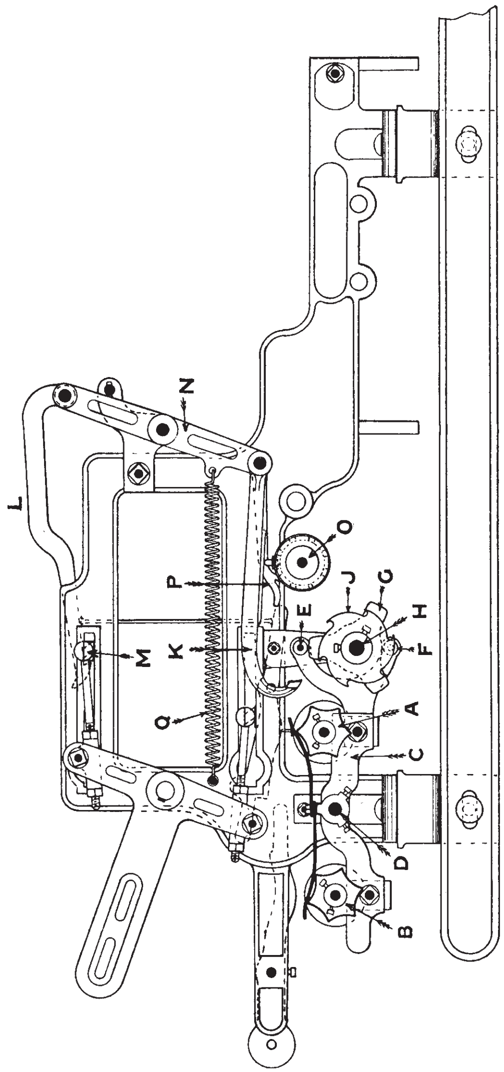


Fig. 125.

picks per inch, and the repeat of the weave. Set-screwed on stud H, and thus compounded with tappet G, is a six-toothed ratchet wheel J, which may or may not be moved one tooth by pawl K at the end of each complete revolution of the lags on either cylinder A or cylinder B. The last lag of each set is so pegged that on the last pick of the pattern the draw hook L is caused to drop, engage with, and be withdrawn by the top draw knife M as the latter recedes. Through lever N this motion is imparted, but in the reverse direction, to pawl K, which, in the position shown in the drawing, would clearly pass over ratchet J. If, however, the peg shown on cylinder O were withdrawn, or a lag without a peg were in position, the pawl K would drop, engage with, and rotate ratchet J, and therefore tappet G, and thus change the positions of cylinders A and B. Cylinder O is advanced one tooth or one lag in a counter-clockwise direction by means of pawl P and spring Q with every forward movement of pawl K, and therefore for every repeat of the lags on either of the cylinders A and B. Consequently, the order of pegging for the pilot set of lags on cylinder O determines the order in which the change of cylinders A and B will be effected. Thus, all blanks would mean that each cylinder would act for one complete repeat of the lags alternately, while all pegs would mean that one cylinder would act continuously. One blank followed by nine pegs, one blank, three pegs, would give ten repeats of one set of lags, followed by four repeats of the other set, and these repeats could be either ten of those on cylinder A followed by four of those on cylinder B, or ten repeats of B, followed by four of A according as they were arranged to begin. It will be evident that any arrangement of this kind deducts from the dobby one shaft from the total of those available for ordinary shedding purposes.

Fig. 126 illustrates another type of automatic dobby, made by Messrs. Lupton and Place, Ltd., Burnley. A special jack at the back of the dobby is provided, and which may be brought into action by the lower pulling knife only. As the latter moves to the right it draws forward the lower end of lever A, and thus, through the action of pushing bar B, rotates pilot cylinder C one-sixth of a revolution. This action takes place every revolution of each of the patterns, and is brought about by pegging the lags as mentioned in connection with the dobby shown in Fig. 125. The two sets of lags for operating the levers, and therefore the leaves of the camb, according to the two different patterns, are placed over cylinders D and E respectively. These are mounted on opposite ends of lever F, and are capable of being placed into and out of position by oscillating the lever F on its centre G. A pushing pawl operates cylinder D, and a pulling pawl operates cylinder E, the direction of motion being indicated by the two arrows; both pawls are at the front of the loom, and when either is in action the other is kept clear of its corresponding ratchet wheel. Cylinder E is at present in gear, and the lever F is kept steady by means of spring H, which is exerting its pressure on the under side of the > shaped end J. The change from one cylinder to the other always takes place when the lower arm of ⊢ lever K is moving to the left; this is necessary in order that the two patterns may join perfectly — if arranged otherwise, a pick is lost and the pattern broken. The illustration shows that during the last movement of ⊢ lever K to the left, the < shaped piece L has acted on the upper sloping surface of short arm M, and forced down rod N, one end of which is guided vertically by a slot in bracket O, while the other end encircles shaft P of lag cylinder D. A down-

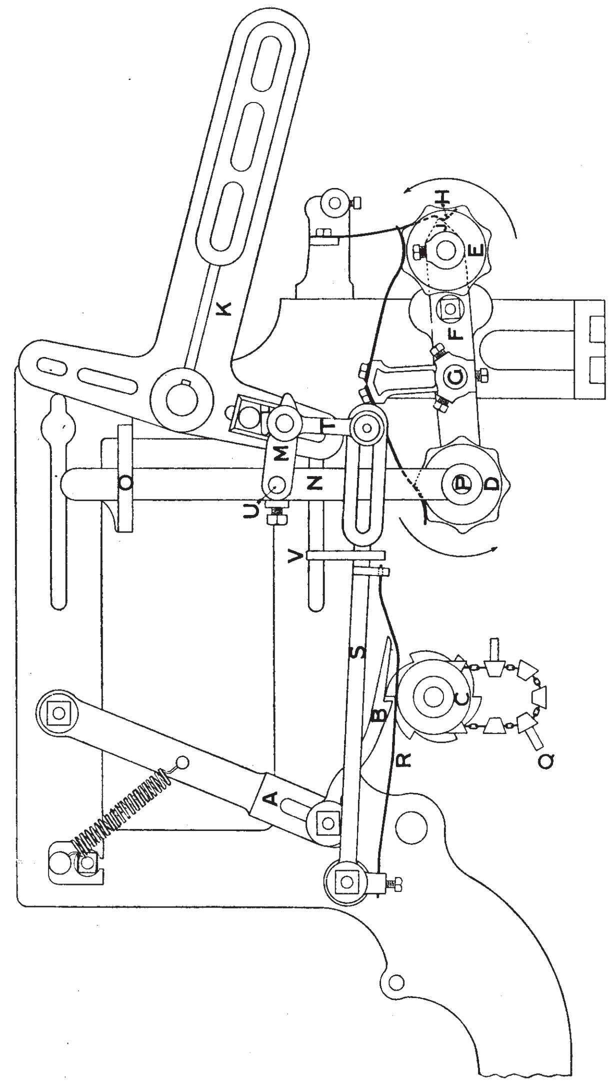


Fig. 126.

ward movement of rod N necessarily places lag cylinder D out of action, and correspondingly raises cylinder E into action. The lags on pilot cylinder C show that, after four revolutions of the lags on cylinder E, the peg Q will be placed under spring R simultaneously with the movement to the right of the lower arm of ⊢ lever K. Peg Q will thus raise spring R, and the latter will in turn raise lever S, connecting link T, and short arm M, which turns freely on stud U. This action will raise the end of arm M so that the < shaped piece L, in its next movement to the left, will act upon the under inclined surface of M, and thus raise rod N and cylinder D, at the same time lowering cylinder E out of action. When this takes place the bent part of spring H presses on the upper surface of J, and keeps lever F and both cylinders steady.

CHAPTER XII

JACQUARDS: SHEDDING, MOUNTING, ETC.

For patterns of a geometrical nature which are beyond the easy compass of a dobby, and for all patterns of a floral or elaborate character, it is advisable, if not necessary, to use a jacquard machine. Many types of this machine are in every-day use, from the ordinary single-lift jacquard to the specially-constructed, and in most cases complex machines introduced for the production of certain special fabrics. The introduction of the latter class of machines has been resorted to for various economical reasons, but it is generally admitted that any gain in this direction has been obtained at the expense of the delicacy of the outline

and the detail of the pattern, and in some cases, of the perfect structure of the cloth. The size or denomination of a jacquard machine, and its capacity for producing large and varied figures, are determined by the number of hooks or threads which it is capable of lifting independently of each other. For example, a 600^s jacquard, sometimes termed a 60-design machine, is one containing at least 600 hooks, any one of which or any section of which can be lifted at will. Jacquards are made in many sizes from 100 hooks upwards, and the following list indicates the capacities of machines which are in daily use:—

Nominal Capacity.	Number of Rows.	Number of Hooks per Row.	Total Number of Hooks.
100	26	4	104
200	26	8	208
300	38	8	304
400	51	8	408
500	51	10	510
600	51	12	612
600	76	8	608
880	{48 {8	16} 14}	880
900	56	16	896
900	76	12	912
900	57	16	912
1200	76	16	1216
1320	{72 {12	16} 14}	1320
1344	84	16	1344

Any odd capacity may be obtained by compounding any two or more of the above sizes. Occasionally three machines, all different in capacity, may be mounted on one loom, although it is usual, when compounding, to have all the machines of the same size; thus, two 400^s to give a capacity of 800, and so on. Most machines, although not all, are provided with a few extra or spare hooks beyond their normal capacity for the control of selvages, or for other work outside the pattern proper.

Ordinary jacquard machines may be divided into three well-defined kinds—single-lift single or double cylinder, double-lift single-cylinder, and double-lift double-cylinder. Figs. 127 and 128 are sectional views of the first-mentioned kind (single-lift), the action of which is the basis of action of all jacquards. The principal parts are hooks A, cross wires or needles B, cylinder C, springs D, and lifting knives E, these latter being fixed in an iron frame F. The knives and frame together form what is commonly termed the "griffe," or "brander." The griffe is raised and lowered (by means of suitable connections) every revolution of the crankshaft, and therefore once every pick.

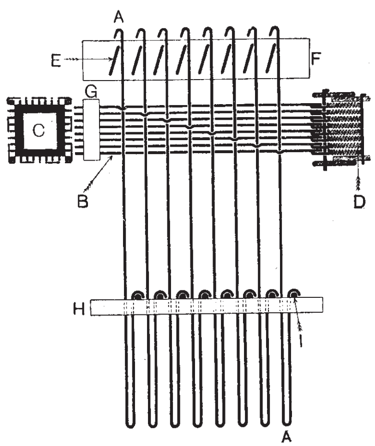


FIG. 127.

The normal position of the hooks A is directly over the knives E, as shown in Fig. 127; the hooks are retained in this position by the action of the springs D on the rear end of the needles B, and a suitable bend in the latter passing partially or wholly round the hook. Any hook allowed to remain in this vertical position will be taken up by its respective knife when the griffe is raised. The cylinder C is a square wooden prism made from a solid piece of wood, or else built of four separate pieces; in both cases each side is perforated to correspond with the

number and the pitch of the needles in the machine. It moves to and from needles B approximately in unison with the falling and rising of the griffe, makes a quarter of a revolution each time, and thus presents its four sides to the needles in regular succession. The looped ends of the needles B are supported by horizontal wires passing between them, while their straight ends are supported in the needle board G, and, provided no obstruction is placed in the way, they will all enter the perforations in the cylinder C when the latter advances to the needle board, and all hooks will be lifted. To form a shed it is necessary that part of the warp, and consequently some of the hooks, must remain down, and to attain this end stiff paper cards, perforated or cut according to the pattern to be woven, are used. These are laced in an endless chain, are passed round the cylinder, and revolve with it. The size of each card and the pitch of its perforations correspond with every side of the cylinder, and therefore with the needles. As cylinder C advances, the needles B enter all perforations in the card presented; but where the card is uncut the needles are pushed back and their corresponding hooks placed out of the reach of the lifting knives. This action should take place when the griffe is in its lowest

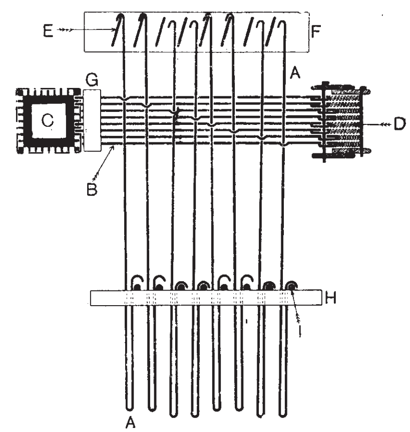


FIG. 128.

position, but as a matter of fact it takes place some time before this in looms where the cylinder receives its motion from a swan-neck, or is directly controlled by the movement of the griffe. In Fig. 127 the griffe has reached its lowest point, but the cylinder C is shown advancing towards the needles B. In actual work, however, the cylinder would be close in at this time. The present position is taken to show the action of the cylinder on the ends of the needles. In the card facing the needle board it will be seen that needles 1, 2, 5, 6, counting from the top, will enter the cylinder, but needles 3, 4, 7, 8 will be pushed back, as the card is uncut at these points.

Fig. 128 shows the result of this action. Here the cylinder is close to the needle board, and the griffe has begun to rise, taking with it hooks 1, 2, 5, 6, and leaving down hooks 3, 4, 7, 8 as selected. Immediately the cylinder recedes, the compressed springs D compel their corresponding hooks to resume the normal vertical position, but the cylinder must not leave the needle board until the knives have come into contact with the hooks which are to be lifted. Further examination of the hooks A will show that their lower ends are bent upwards from 5 to 6 ins., and hooked partly round an iron rod attached to, or bead cast upon, the grate H. Rods or beads I support all hooks in their lowest position, and prevent them resting on the knives E when the griffe is down and the new selection is being made. It is obvious that unless hooks were supported clear of the knives the action of the needle would only tend to bend the hook at its point of connection with the needle. The slots in the grate H, through which the hooks pass, keep the hooks facing the knives, and cause them to rise and fall perpendicularly. Harness cords to which the heddles or mails are

attached, are connected to the lower end or bend of the hooks.

Fig. 129 shows various types of hooks and needles

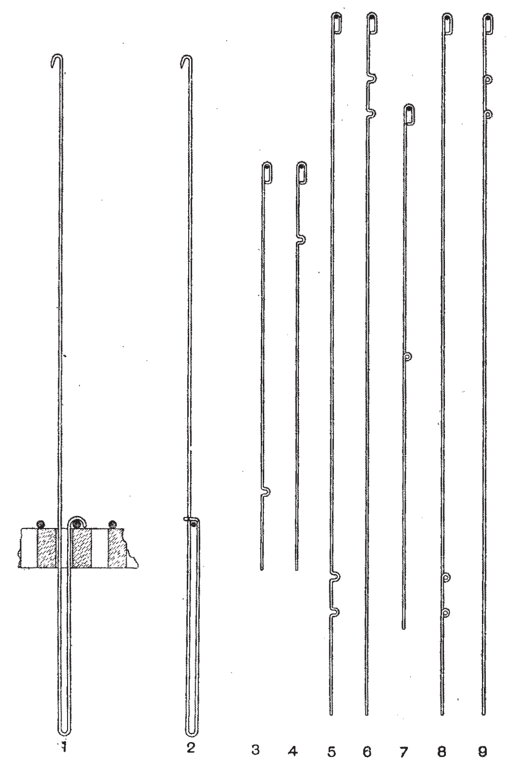


FIG. 129.

utilised in jacquard machines. They are represented exactly one-fifth their full size. Nos. 1 and 2 are the two kinds of hooks in general use for single-lift machines. Nos. 3 and 4 are the top and bottom needles of a 400 single-lift machine, and may be used with either type of hook, although generally used in conjunction with No. 1. The needle for No. 2 hook usually passes completely round it, as shown in No. 7, which is a needle for a 600 machine. Nos. 5, 6, 8, and 9 show the top and bottom needles of each kind for a 400 double-lift single-cylinder machine.

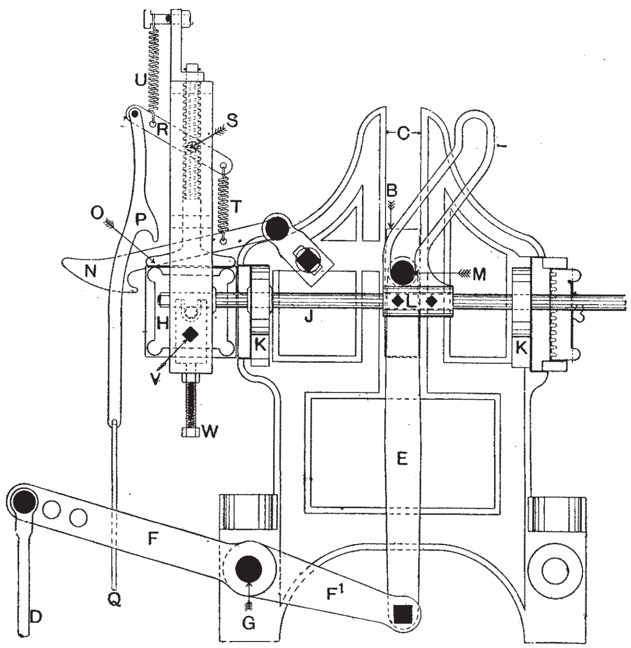


FIG. 130.

Figs. 130 and 131 show in elevation and plan the framework of a single-lift jacquard machine of a Scotch type. Projecting from each side of the frame of the griffe A is a lifting block B, part of which is planed to move freely in the vertical slide or guideway C of the framework. Motion is imparted to the block B by means of a crank or

an eccentric on the crankshaft of the loom, through the

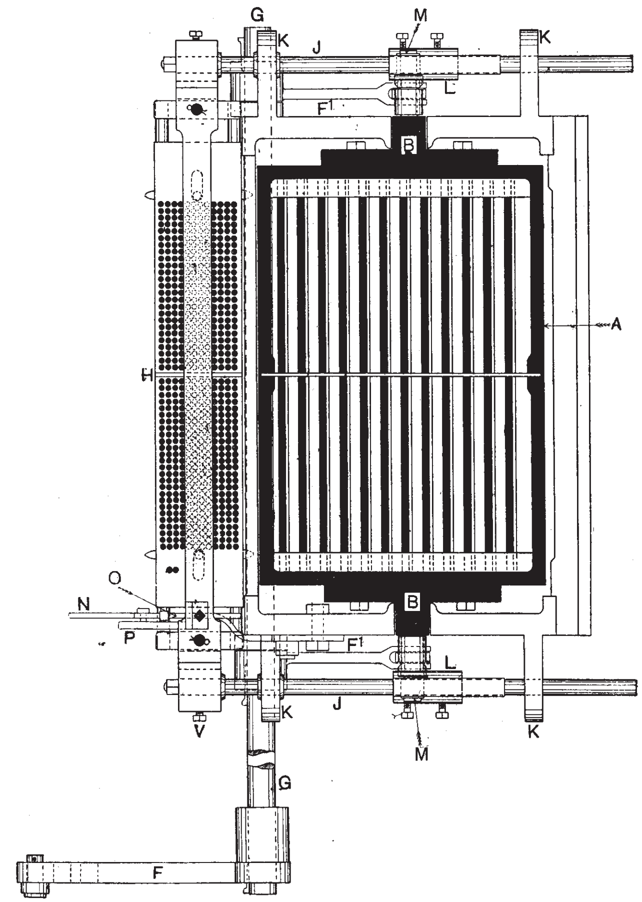


FIG. 131.

connecting rods D and E, and the lever F F^1 keyed on the shaft G, which is supported in, and extends across, the framework, carrying at its farther end corresponding parts to F^1 and E. A horizontal movement is imparted to the cylinder H by means of "swan-necks" L set-screwed on the rods J. These latter are carried by, and slide freely in, the brackets K. The studs M project from the lifting block B on each side of the machine into the swan-necks L, and at that point carry anti-friction rollers. As the block B rises, the studs M force forward the swan-necks L and the rods J, the latter carrying with them the cylinder H. Fixed at each end of the cylinder is an iron head or lantern, rounded at the corners, and slightly cut away between them as shown. When the cylinder H is clear of the needles in its outward movement, one corner of the lantern takes into, or is arrested by, the catch N, and is rotated thereby as the cylinder still further recedes. The spring hammer O serves to keep the cylinder perfectly level by pressure on the two corners of the lantern when the latter is not being acted upon by the catch N. Immediately the cylinder begins to rotate, O is gradually raised by the corner of the lantern until the latter in its turning begins to fall, when the pressure of O aids the turning movement, ultimately levels the cylinder, and checks all vibration of the cylinder before it again reaches the needles. In catch P provision is made for turning the cylinder in the opposite direction when necessary. This must, however, be done when the cylinder is out and clear of the needles; then, by pulling the cord Q, the catch P takes hold of the corner of the lantern, while at the same time, by means of the lever R, fulcrumed at S, and connecting spring T, the catch N is lifted clear of the lantern, allowing the cylinder H to turn. The spring U keeps the catch P in its normal position clear of the lantern. As it is absolutely necessary that the ends of the needles should be

directly opposite the holes in the cylinder H, the latter may be adjusted vertically by the screws V and W, and laterally by shifting the position of the cylinder frame or batten on the slide rods J. It will be observed that the jacquard described is a 60-design or 600^s machine.

An end elevation of a slightly different type from that just described is shown in Fig. 132. In this view the griffe A is partially raised (the ends of the lifting knives being shown at E) while the cylinder H is turning by the action of the catch N. The griffe A is supported at either end by two spindles C; these pass through and slide freely in the guide bushes D, supported on brackets inside the framework, and thus ensure a vertical motion to the griffe. The spindles C, near their upper ends, pass through and are rigidly fixed in the lifting blocks B, which are attached to the griffe A. Bolted on the upper ends of C, and passing across the griffe, is a crossbar Z. This is attached at the centre by a pendant connecting rod to an overhead lever, which is actuated in the usual manner by means of a crank or an eccentric on the crankshaft of the loom.

A horizontal movement is imparted to the cylinder H in a manner exactly similar to that already described, the cylinder in this case, however, being supported by slides J instead of spindles, adjustment being provided for by means of the screws W on the brackets K. The spring hammer O, while serving the same purpose as that already mentioned, is of an entirely different kind. To reverse the motion of the cylinder H it is only necessary to pull the cord Q when the catch P is brought into gear with the cylinder, the catch N being at the same time lifted clear by means of the wire X. This reversing motion, when used alone, is, however, suitable for hand looms only when the cylinder is actuated by a swan-neck. Y is a spring arranged

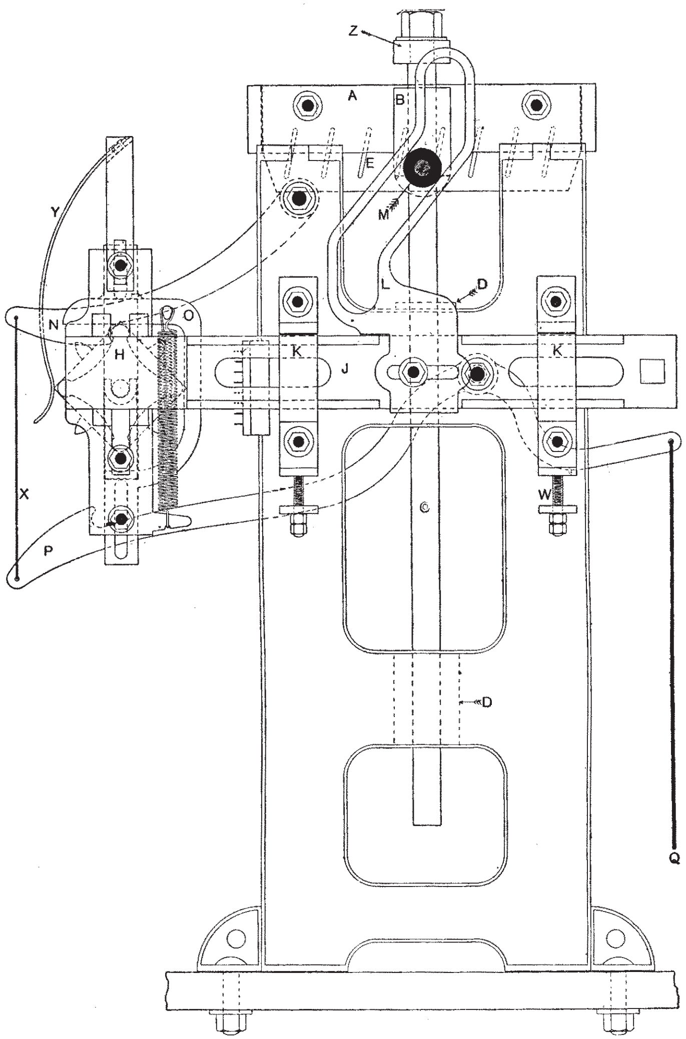


Fig. 132.

to keep the cards on the cylinder where sufficient tension is not obtained by the weight or drag of the cards themselves.

Most single-lift jacquards have the card cylinder driven by a swan-neck, or some other means which is dependent upon the rising and falling of the griffe. All those machines which are of the usual type have, however, the common defect that the cylinder must be full in, and pressing back the needles and hooks before the griffe has reached the lowest point in its movement, and before the griffe blades have cleared the hooks. This defect undoubtedly puts an undesirable stress upon, and reduces the life of, the needles, hooks, and cards, besides serrating the upper edges of the griffe blades. For these reasons it is often desirable, and ultimately more economical, to fit up an independent drive for the cylinder, at a greater initial cost, in order that the movement of the cylinder may be timed properly with regard to the motion of the griffe.

It is possible, however, to obtain the chief advantages of an independent drive to the cylinder, coupled with the low initial cost and the simplicity of a griffe controlled cylinder motion, and Fig. 133 shows a part sectional elevation of a machine, perhaps the only kind of this particular type. The machine is of continental make, and is extensively used. The griffe may be raised and lowered, and the cylinder supported and reciprocated in any well-known manner, although special methods are adopted in the machine under notice; these methods, however, do not affect the principle involved. Each hook or upright A is controlled by a corresponding needle B, the bend of which passes only behind the hooked part of the upright A, and which can therefore control the latter in only one direction, *i.e.*, forwards or towards the needle board C. All the needles are supported by the needle board C at the front,

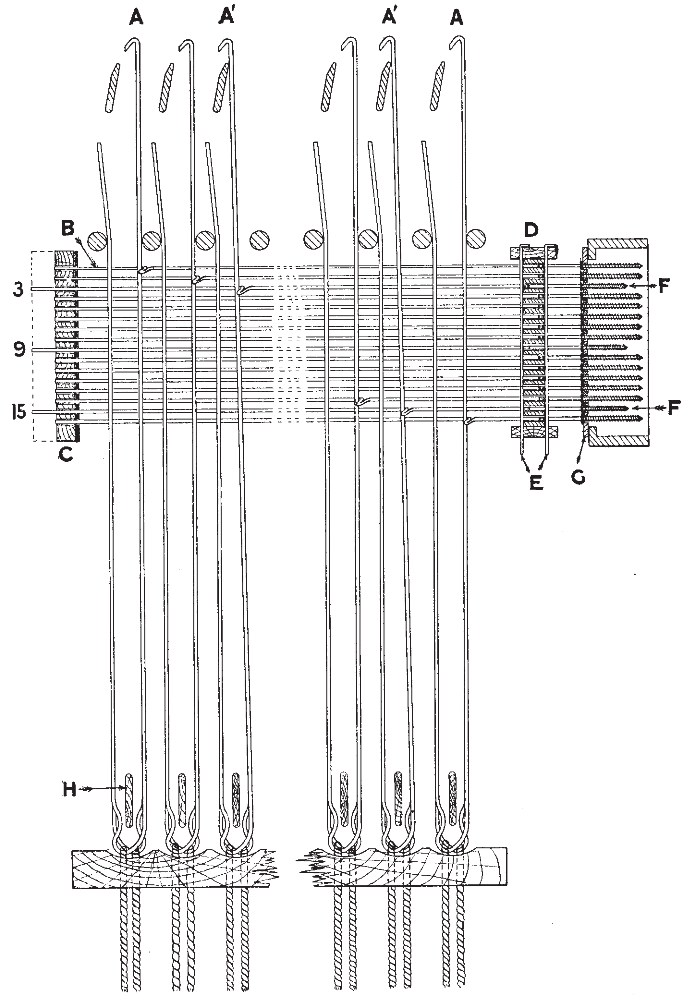


FIG. 133.

and by the heck or grate D at the back, and have their travel limited in both directions by the pins E in the heck, and a suitable bend formed on the needle at this point. Each needle extends about $1\frac{5}{8}$ inches beyond this bend, and has a very fine spiral spring F threaded upon it—the head of the spring being enlarged so that it is retained by the plate G, while the other end is tapered and closed to prevent the end of the needle from passing through. Each hook is a spring in itself, and always tends to open to the position shown at A, A, where the two hooks are clear of the corresponding griffe blades; but the spiral spring F is of sufficient strength normally to neutralise the spring of the hook, and to place the latter, by means of the needle, over the griffe blade—see hooks A′, A′, and needles 3, 9, and 15. The needle board C of this machine is so arranged that it is free to move forward by spring action as the cylinder recedes until it is practically flush with the needle tips; it thus protects the tips from the action of the cylinder, and also prevents them from tearing the cards. As the cylinder advances it pushes back the needle board, and also those needles which correspond with the uncut portions of the card, but no hooks are pushed back positively; those hooks which are falling with the griffe, and which require to go back for the next pick, only do so when the griffe, near its lowest position, releases them. The laths H are fixed in a light framework which rises and falls with the griffe; they assist in preventing the hooks from turning, and also steady them when in action. This machine is made with the comparatively fine pitch of 4 mm., or rather more than 6 needles per inch, and in multiples of 440 needles; 880 and 1320 are the usual capacities of the machine. Purely structural defects—the result chiefly of the demand for a cheap jacquard—and the difficulty of cutting cards of the exact pitch upon an ordinary "piano" cutting machine, militate against the very wide adoption of the machine.

Double-lift Single-cylinder Jacquard.—In all single-lift machines the movement of the warp must necessarily be of that type described as bottom shedding, in which the warp in motion travels twice the depth of the shed for each pick. This fact, coupled with the consideration that the machine is mechanically unbalanced, practically prohibits high speeds in all looms so mounted, and has led to the introduction of the double-lift jacquard. This machine gives a shed of the semi-open type, in the formation of which some of the moving threads travel through only half the distance covered by those actuated in a single-lift machine. The shed may thus be formed in theoretically half the time, and the strain and friction on the yarn greatly reduced from this point of view. Fig. 134 is a sectional elevation of a double-lift jacquard. All double-lifts differ from single-lifts, in the fact that they contain double the number of hooks for the same capacity of machine. Thus a 408 machine has 816 hooks. Each needle B governs two hooks A and A^1, which may be actuated alternately and respectively by the griffes F and F^1. To each pair of hooks is attached one tail cord J by means of neck cords K and L. It will thus be seen that each pair of hooks governed by one needle actuates the same thread or threads in the warp. The griffe F is now in its highest position, supporting all threads through the medium of hooks A and cords K; while the griffe F^1 is in its lowest position with all hooks A^1 resting on the grate H, and all cords L slack. As both griffes are driven by a double-throw crank, it follows that as F descends, F^1 will rise in a corresponding degree. As F descends, the hooks A and

cords K will fall, while a corresponding upward movement will be given to the hooks A^1 and the cords L until F and

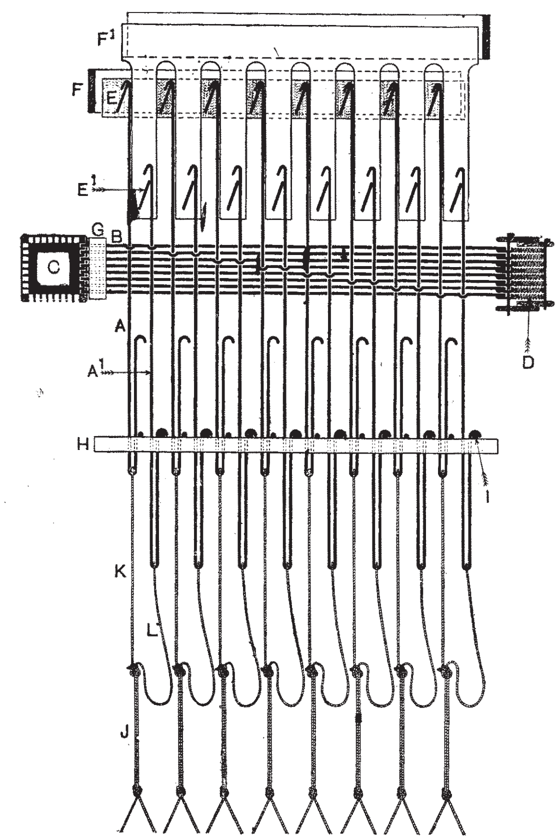


Fig. 134.

F^1 are level, when the cords K and L will both be in equal tension, and all threads in motion will be at the centre of the shed. From this point the cords K will slacken until

F reaches the lowest position, while the cords L, through the hooks A^1 and griffe F^1, will carry the threads to the top. The amount of lifting to be done by each cord will vary according to the weave employed. Thus, in a perfectly plain cloth, all the work would be thrown on one or other of the cords and hooks, but where a thread requires to be up for two or more successive picks, the weight will be borne alternately by cords K and L.

Fig. 135 gives a general view of one method of driving a double-lift single-cylinder machine. The griffes F and F^1 are shown in sectional elevation, and also in plan. In the elevation the framework only is shown with the lifting knives removed, but in the plan the knives are in position. The construction of the griffe F is in all respects similar to that of a griffe of a single-lift machine, consisting of a cast-iron frame to which is bolted two wrought-iron or cast-iron plates, slotted as shown to receive the lifting knives, or else provided with short pendant arms to which the knives are bolted. A similar cast-iron frame is used in the griffe F^1, but the wrought-iron or cast-iron plates have pendant arms about $6\frac{1}{2}$ ins. long, slotted near their lower ends to receive the ends of the knives. The griffe F^1 occupies the inside position, and the pendant arms move up and down between the knives of griffe F, these latter moving vertically in the spaces between the arms. Connections between the griffes F and F^1 and the spindles C and C^1 to the pendant connecting rods G and G^1 are similar to those already described for the single-lift machine, Fig. 132. The levers H and H^1 and the connecting rods J and J^1 are shown completing the connection to the double throw crank fixed on the bottom or wyper shaft L. As will be seen, the throws of the crank are diametrically opposite to each other at K and K^1; they will therefore

impart an equal and opposite movement to the griffes F and F^1. The levers H and H^1 are fulcrumed in a bracket

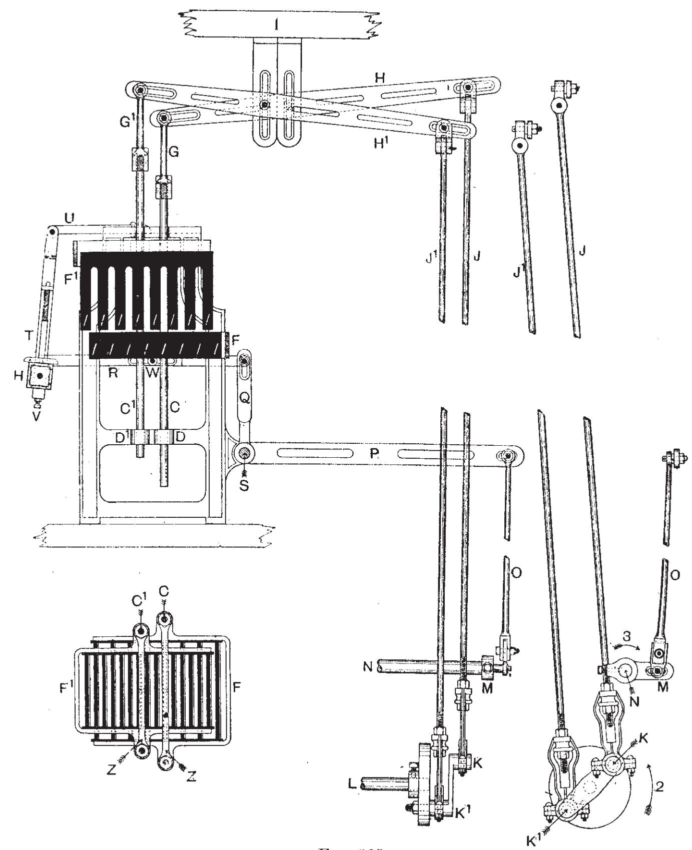


FIG. 135.

bolted to the beam I about the roof of the weaving shed, or supported by a standard from the beams supporting the jacquard, to ensure freedom from vibration; and for the same reason it is advisable to support the jacquard machine independently of the loom framework. This may be done by means of wooden beams or light iron or steel girders which are carried on brackets cast upon or bolted to the columns supporting the roof of the weaving shed.

The chief advantages obtained through the use of the double-lift machine over that of the single-lift lies in the fact that for the same number of picks per minute the griffes travel at only half the speed. In the double-lift a shed is formed by the rising of one griffe and the falling of the other, while in the single-lift a shed is formed by the falling and rising of the same griffe. It is, however, not to be deduced from these statements that a double-lift machine may be driven at twice the speed of a similar single-lift machine, as other considerations, such as the speed of the cylinder and the speed of the loom itself, prevent this. It must also be remembered that no advantage is obtained in the double-lift with respect to the speed of the cylinder, as in all single-cylinder machines the cylinder must strike for every pick. Any increase of speed will therefore be accompanied by a corresponding increased tendency to puncture the cards and to cause them to leave the cylinder.

All independent single-cylinder motions are driven by means of a crank or an eccentric on the crankshaft. In Fig. 135, motion to the cylinder H is imparted by the crank M on the crankshaft N, through the connecting rod O, levers P and Q, and the adjustable connecting rod R. The rocking shaft S extends from side to side of the machine, and carries a duplicate lever Q and an adjustable connecting rod R at the other side. The cylinder H is supported in suitable bearings at the lower end of the batten T, which swings freely on a screwed centre stud in

the bracket U. Lateral adjustment of the cylinder may be obtained by means of this centre stud, and vertical adjustment by screw V. The pressure of the cylinder H upon the needles is regulated by the slot W in the adjustable connecting rod R. The arrows 2 and 3 in the end elevation indicate the direction of movement of the cranks on the wyper and crankshafts respectively. The benefit of an independent drive being imparted to the cylinder lies in the fact that it can be timed to strike the needles at the most convenient moment in the rising of the griffe, whereas with a "swan-neck" movement no variation of the time of striking is possible.

One of the latest and perhaps best methods of connecting and supporting the cylinders of a double-lift, double-cylinder machine in a slide motion is illustrated in Fig. 136. Many practical men prefer slide motions to swing motions because of their greater rigidity, and because the cylinders come perfectly square on to the needles instead of moving in the arc of a circle. The cylinders A and B are supported at each end of heavy slide rods C, which in most cases slide in simple bushed bearings bolted to or cast on the machine frames D—see K in Figs. 130, 131, and 132. In the present case, however, the slide rods C are supported near each end by grooved steel pulleys E, the small centres of which roll upon the chilled edges of the cast-iron brackets F. Steel plates G are fixed to the front of each bracket F, and are bored for the passage of the slide rod, so that it cannot by any means leave the grooves of the pulleys E. The arrangement forms a very satisfactory application of a well-known anti-friction principle.

The driving of the cylinders is obtained from an eccentric on the wyper or low shaft of the loom; the eccentric is connected to rod H, and acts through it and levers J and K, fulcrumed on shaft L, on the connecting rod M, which is attached as shown to the slide rod C.

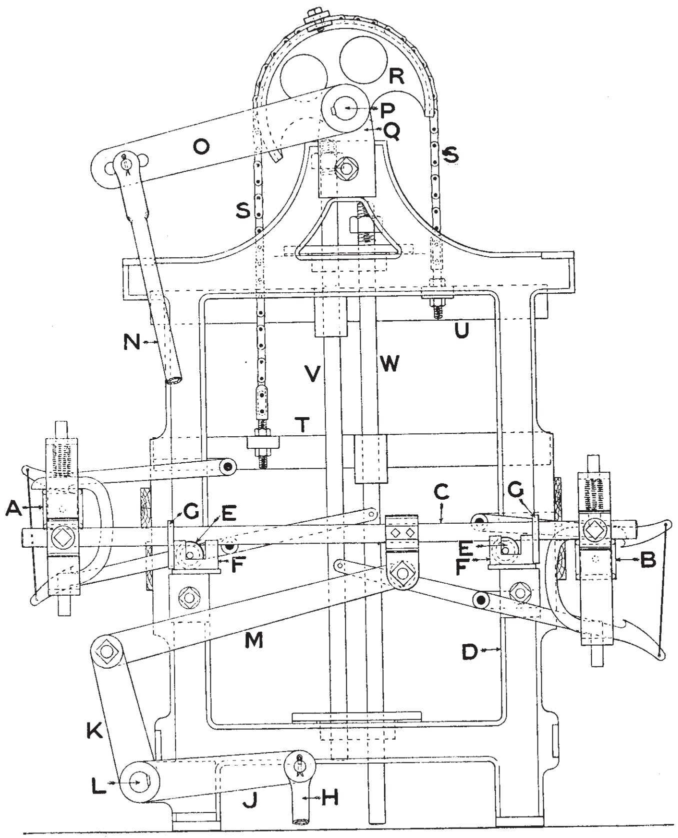


FIG. 136.

Shaft L extends across the machine, and lever K and rod M are duplicated at the other side. The figure also shows what is perhaps the simplest method of lifting the two

griffes of double-lift machines. The method illustrated in Fig. 135 is quite satisfactory when only one machine is required for one loom, but when two or more jacquards are necessary for one loom, the method is not so convenient. The method illustrated in Fig. 136 is suitable for, and is applied to, one or any practicable number of machines, and acts as follows: A connecting rod N, circular in section, and either solid or tubular, or made of rectangular wrought-iron, is carried from a crank of suitable throw on the wyper shaft of the loom, and is connected as shown to the lever O, which is keyed on the rocking shaft P. This shaft is sup-

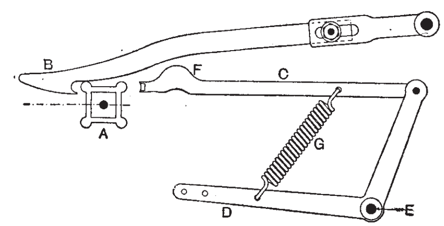


FIG. 137.

ported in suitable brackets Q bolted to the side frames of the machine, and extends over all the machines which are employed on the same loom. Set-screwed at suitable intervals on shaft P are flanged half moons R, to which the steel chains S are fixed. Opposite ends of the chains depend and are fixed as shown, one in a lug cast upon the frame of griffe T, and one in a similar lug on the frame of griffe U. Similar connections at the other side of the griffe frames, together with the action of the usual guide spindles V and W, ensure a perfectly balanced lift, and a vertical travel of the griffes as the wyper shaft revolves.

Reversing Motions.—Messrs. Devoge and Co.'s reversing motion for the card cylinder is shown in Figs. 137 and

138. The former shows the position of all parts when the cylinder A is being rotated in the normal direction by catch B. When it is necessary to reverse the direction of motion, the cylinder A is thrown out clear of the needles, and the pushing bar C is (by means of a cord attached to bell-crank lever D, fulcrumed at E) caused to act upon the corner of the cylinder and rotate it in the reverse direction. The elevation F on the bar C raises the catch B, Fig. 138, clear of the cylinder during this action. The spring G returns the bar C and lever D to their normal positions.

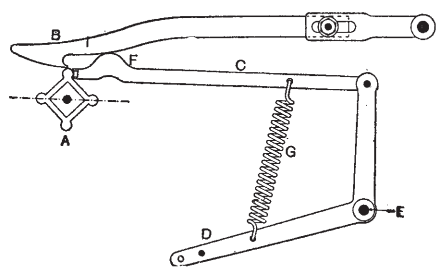


Fig. 138.

Another well-known cylinder driving and reversing arrangement termed the "duck-bill" motion is illustrated in Figs. 139 to 142 inclusive. In a single-cylinder machine, motion is imparted from an eccentric K on the crankshaft L, Fig. 141, to lever A, which is centred loosely on shaft B. Shaft B is mounted on the top rail of the loom, and extends at least to the other side of the jacquard. Keyed to the shaft B are two levers C, one for each side of the jacquard, and about 32 inches apart. Two rods D, one from each lever C, are connected to two arms M, which are bolted to the batten arms N on each side of the jacquard; while the cylinder O is supported and carried

by the battens N. Set screwed or keyed at the extremity

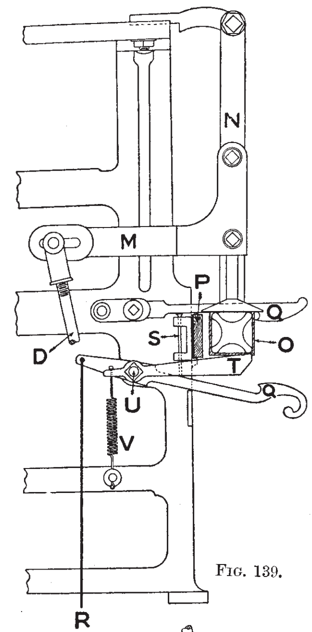


Fig. 139.

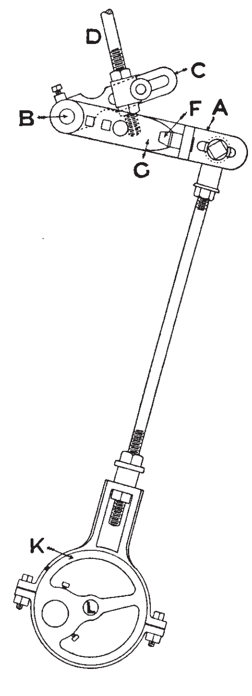


Fig. 141.

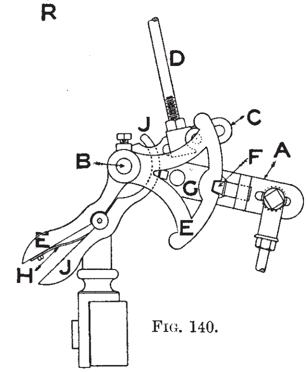


Fig. 140.

of shaft B is the peculiarly shaped lever E, which, through the recess in the sector portion of this lever, and the

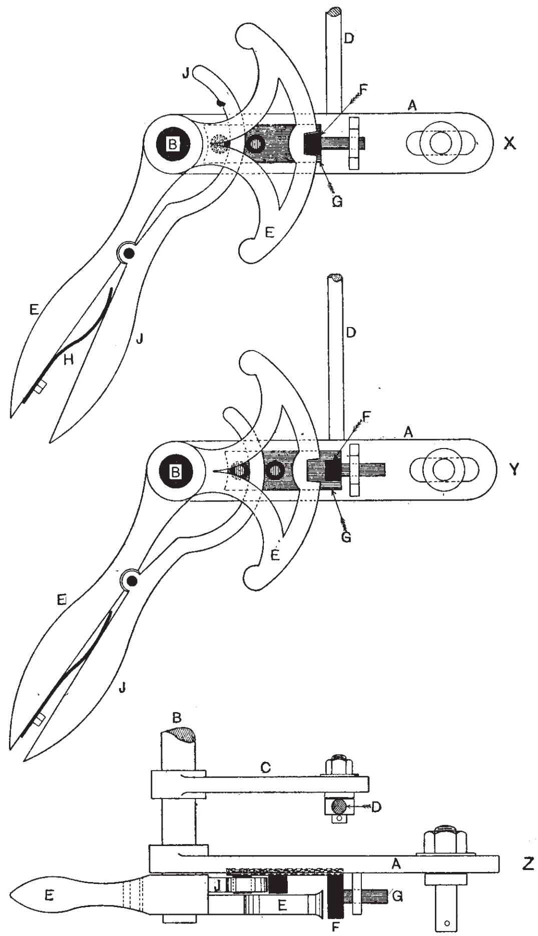


FIG. 142.

projection F of the sliding bar G of the lever A, completes

the driving connection between the eccentric K and the shaft B. The various parts are shown in this position in Figs. 140 and 141, and in X, Fig. 142. The up and down movements of rods D will bring the cylinder O to, and withdraw it from, the needle board P.

To reverse the cylinder with this motion, a double catch Q is used (see also Figs. 132 and 136). The top catch Q rests by gravitation on the head of the cylinder O, but when reversing is necessary, the bottom catch Q is brought into action with the underside of the cylinder O by pulling cord R downwards; the top catch is lifted clear of the cylinder by the same movement, since the lower catch raises pin S, the head of which lifts the top catch clear. The position of the other parts when reversing is necessary is shown in elevation Y, Fig. 142, where it will be observed that the projection F has been pushed out of contact with the recess in the lever E. This being so, it is obvious that the shaft B, the levers C, and further connections to the cylinder, may be actuated manually by the lever E independently of the lever A. The projection F is kept fixed in the recess of lever E by the action of the spring H on the lower arm of the lever J, and the curved portion of this lever passing between the two studs on sliding part G; the disconnection of the levers E and A is accomplished by pressing together the lower arms of E and J, when the curved arm of the latter lever forces forward the part G as shown in elevation Y and in plan Z, Fig. 142. Other methods of reversing are noted incidentally in Figs. 130, 155, 170, and 171.

A simple yet effective means of preventing the corner of the cylinder from coming into contact with the needles is also illustrated in Fig. 139. A short arm T, centred at U, is kept in its present position by spring V and a part of the framework against which the upper surface of T abuts. The cylinder, if properly turned as shown, can pass and repass the point of T without touching; but if the cylinder fails to turn properly, and remains with two opposite corners in the vertical position, the lower corner will come in contact with the end of arm T as the cylinder advances, and the latter will therefore be placed in its proper position before it can reach the needles.

Double-lift Double-cylinder Machine.—The principal defect of the single-cylinder is of course the high speed at which the cylinder must be driven if much benefit is to be derived by a double-lift machine over that of a single-lift machine of the same capacity. This defect, however, has been overcome by the introduction of a second cylinder. The two cylinders, acting alternately, present the pattern cards to two distinct sets of needles and hooks. A 400-machine of this type (a sectional elevation of which is shown in Fig. 143) contains 816 hooks and 816 needles. The griffes F and F^1 are driven as shown in Fig. 135, from the low shaft, and the knives E and E^1 are inclined in opposite directions as indicated. The two sets of hooks A and A^1, governed by their needles B and B^1, naturally face their respective cylinders C and C^1. These cylinders are supported at opposite ends of a suitable bar or rod, see Fig. 136, which is actuated by an eccentric on the low shaft, and therefore advances the cylinders C and C^1 alternately to their respective needles. This being so, the cards for the design are laced in two separate portions—one containing all odd picks carried as shown by cylinder C, the other containing all even picks laced in the opposite direction or backwards and carried by cylinder C^1, the two sets forming the simple weave M. Since each adjacent pair of hooks is connected by neck-cords K and L to the

same tailcord J, it follows that the top needle of one set

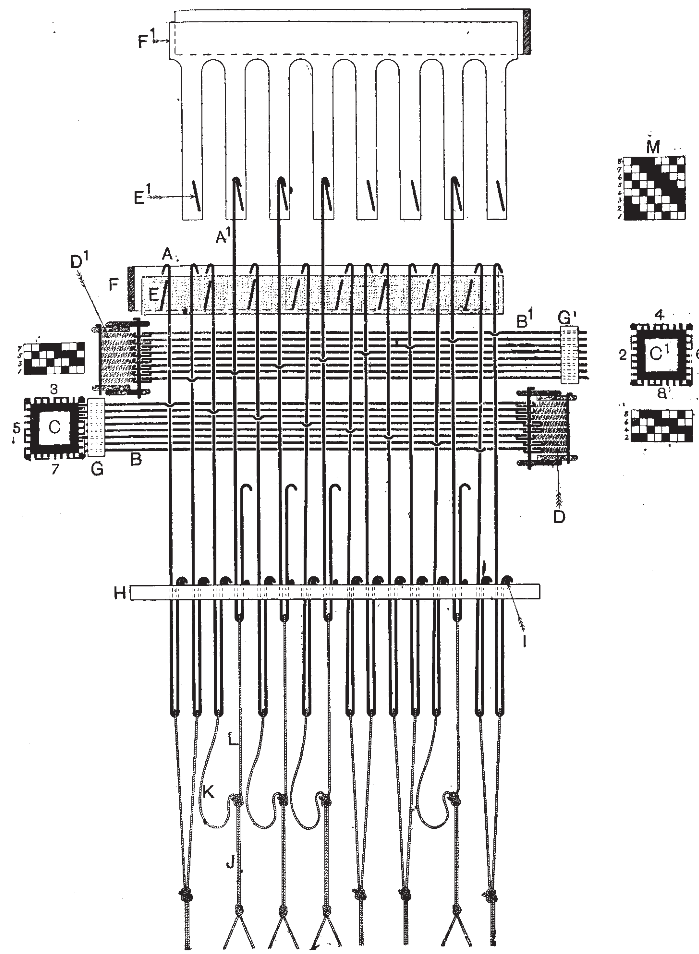


FIG. 143.

and the bottom needle of the other, and so on, will govern the same thread or threads in the warp. In this machine, as in all others described, the cylinders must be so timed that the knives E, in their upward movement, must be in contact with the hooks A before the cylinder leaves the needles, otherwise those hooks which should remain down might, in consequence of the action of the springs D, be lifted by the ascending knives. It is evident that if both sets of needles B and B^1 were to receive equal movement from their respective cylinders, the hooks A, actuated by the needles B, would be moved at the top through a greater distance than the hooks A^1. Indeed, a variation of movement will take place throughout an entire set of needles from top to bottom. It is, however, minimised in the two sets by adjusting the cylinder C so that it does not advance quite so close to the needle board G as does cylinder C^1 to needle board G^1. For similar reasons it is also a common practice to adjust the spring hammers, which act upon the ends of the cylinder, in such a manner that the cylinders will not advance so close to the bottom edge of the needle board as they do to the top edge. This practice, besides graduating the travel given to the needles from the top to the bottom rows, has the advantage of bringing the pressure of the cylinder on the needles gradually instead of suddenly as would be the case were the cylinder to come against the needles perfectly square. Fig. 143 shows the griffes F and F^1 in their highest and lowest positions respectively; while in Fig. 144 the central position is shown. Here the cylinder C is receding from the needles, being turned meanwhile by the usual catch, while the cylinder C^1 is advancing towards the needles, both of course being about the centre of their travel.

In double-lift machines where a considerable number of harness cords or threads in the warp fall to be actuated by

each pair of hooks, and where the threads require to be up for two or more picks in succession, it is evident that a

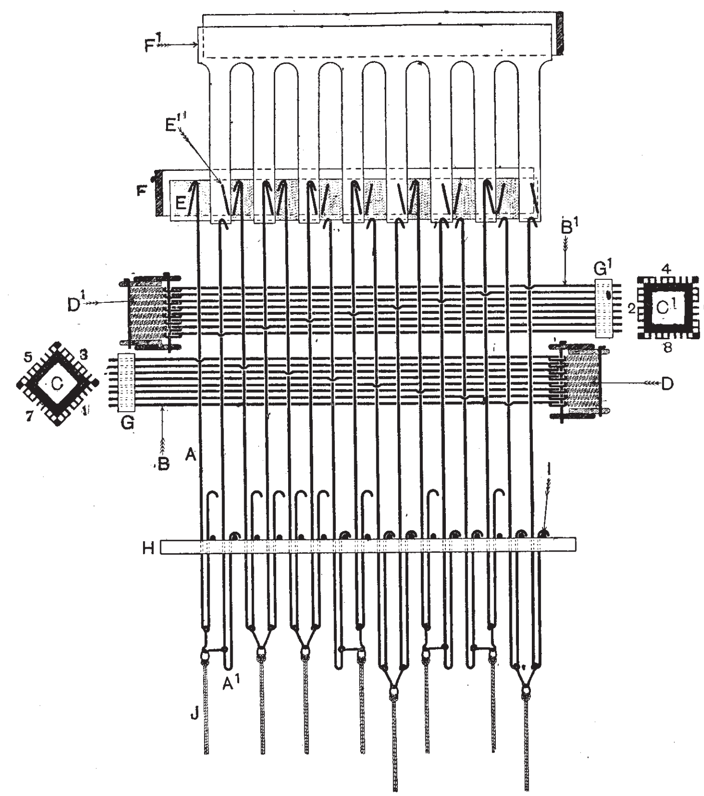


Fig. 144.

great stress will be thrown on the neck-cords K and L, when, in passing the level position, the load is suddenly transferred from the one to the other. This sudden jerk results in frequent breakages of these cords. When both break, the fault is readily observed in the cloth, but when only one is broken the loom may in some cases run a considerable time before the defect is detected. A link connection, which almost entirely does away with the above source of annoyance, and which has largely superseded the neck cords K and L, Fig. 143, is also shown in Fig. 144. Its form and action will be readily understood from its various positions in the figure. In Figs. 143 and 144 similar letters refer to parts of a similar nature.

In double-lift double-cylinder machines the main disadvantage is the liability of the cards on the two cylinders to get out of their proper rotation; especially is this the case with inexperienced weavers. This fault has led to the introduction of various stop motions, the purpose of which is to bring the loom to a stop when the cards get out of order. One of the simplest and most widely adopted is that of Messrs. Devoge and Co., illustrated in Fig. 145. It consists of two special hooks A and B controlled by special needles C and D, and of spring wire E fulcrumed on a pin G in a special bracket H. One end of the wire E passes through a coil formed on the hook B, and is therefore controlled by this hook; the other end of E is bent upwards and passes, as shown, through a loop on the needle C. All these parts are arranged on the machine at the driving side of the loom, and hook A is attached in a suitable manner to the set-on handle. Since the needle D is provided with a spring at its rear end (as usual), the normal position of hook B is on the knife. The spring J of the needle C, however, is at its forward end acting between the needle board K and a collar L on the needle, consequently the normal position of hook A is off the knife of the opposite griffe. When in this position—that of rest—the end of the needle C is flush or level with the face of

the needle board K, as shown. It is obvious that if the hook B be lifted, the needle C will, by the action of spring

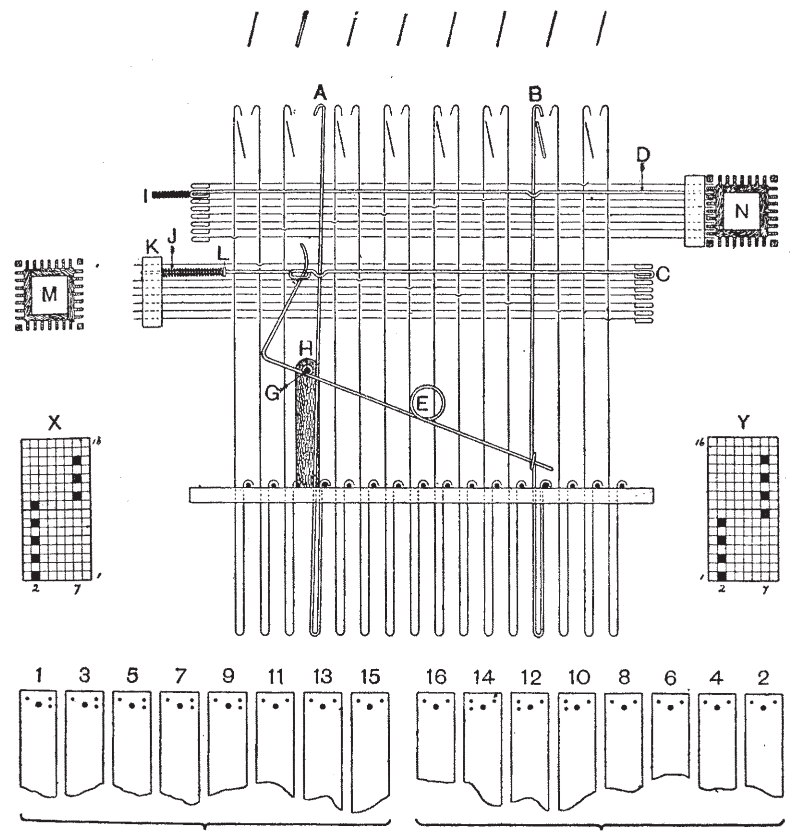


FIG. 145.

wire E, be pressed forward until its point projects beyond the face of the needle board, at the same time placing the hook A on the knife. It is therefore evident that to prevent the hook A being lifted and the loom set off, the card on the cylinder M next presented to the needles must be uncut or blank opposite the needle C. Clearly, then, a hole in the card on cylinder N must always be followed by a blank in the card on cylinder M, if the loom is to continue running. The simplest order of cutting to obtain this is, of course, all holes on N and all blanks on M. This order, however, would be ineffectual for stopping the loom where one set of cards was any even number in advance of its proper time, and would therefore never be adopted. A suitable order of cutting the cards is shown at the bottom of Fig. 145, the odd-numbered cards being for the cylinder M and the even-numbered cards for the cylinder N. The lacing and peg holes are cut in each card, while the holes cut in approximately the same line as the peg hole are those which are intended for the needles C and D. These are in the second row for cylinder M, reading from the top needle; and the seventh row for cylinder N, reading from the bottom.

Any suitable order of cutting may be adopted, but the cards in the repeat should, if possible, be a measure of the total number employed, although this is not absolutely essential. If the cards shown in the figure followed each other consecutively the hook A would never be lifted, as it depends for lifting on a cut on the cylinder N being followed by a cut on the cylinder M. It is also obvious that if either set of cards gets 8, 16, 24, etc., places in advance of the other set, the same order of cutting would obtain and the loom would still run. This may seem an argument in favour of increasing the number of cards in a repeat of the arrangement; but it must be remembered that the loom will not always stop immediately the cards get wrong, for in the arrangement given the loom may run a maximum number of 14 picks before being stopped, and as the cards in a repeat are increased this maximum number is also increased.

The order of cutting is indicated alongside the design proper, or on a detached piece of point paper (as shown at X and Y), which the card cutter may adjust to the design as he or she proceeds with the cutting. The order shown at X is that cut on the cards in the figure; the alternative order of cutting shown at Y for the same number of picks is probably the better of the two, since where there is an equal number of cuts to each cylinder in the repeat, it is evident that the number of opportunities for the action of the stop motion will be at a maximum, seeing that the conditions for stoppage are that a cut on N is followed by a cut on M.

Fig. 146 is a front view of the single-lift jacquard machine shown in Figs. 130 and 131. It is introduced principally to show the position of the heck and its necessity where jacquard shedding is applied in wide looms, as well as to illustrate a few minor details. The heck consists of a suitable number of steel wires A supported in and kept equi-distant by a flat wooden frame B, the dimensions of which must be somewhat greater than the area occupied by the hooks. The heck may be supported in position in various ways, but in this instance it is fixed between the parts C and D, the former of which are fixtures to the beam E supporting the machine, while the parts D are screwed to the part C and kept in position by snibs F as shown. This arrangement enables the supported parts D to be withdrawn from under the heck so that the latter may be lowered in order to facilitate the mending of broken harness cords. The position of the heck, through which all harness cords

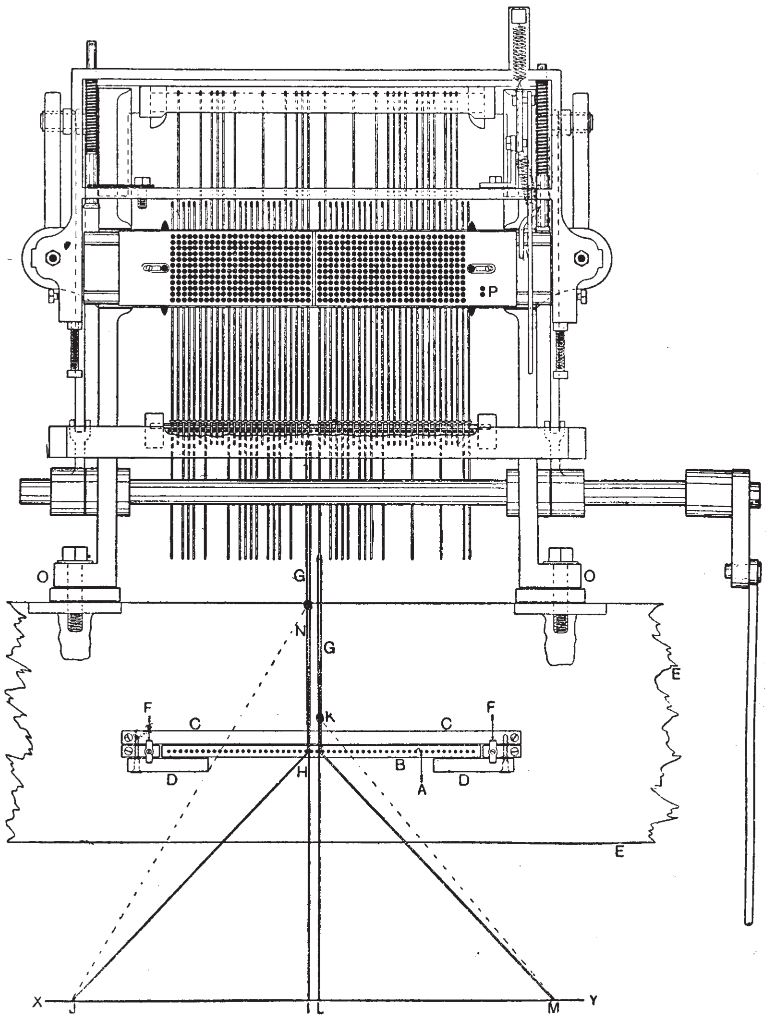


FIG. 146.

must pass, is a little below the point of connection of the latter to the neck bands G when in their lowest position. The purpose for which it is introduced is to enable an equal lift or level shed to be obtained from selvage to selvage of the cloth, as well as to ensure that the pull of the harness cords will be in the same vertical line as the hook to which they are connected.

Suppose X Y to represent the comberboard through which all harness cords pass: it is obvious that when a heck is used the distance from J to H will remain constant, and therefore the lift at J and at M, or at any intermediate point in the comberboard, will be the same as that given to the hook. The dotted lines K M and N J represent the positions which these harness cords would assume in their lowest and highest positions were no heck used. The right-angled triangle K L M may be assumed as of the following dimensions:—

Length of cord K L, say 64 ins.

Length of comberboard between cords L and M, say 60 ins.

$$\begin{aligned} \therefore KM &= \sqrt{KL^2 + LM^2} \\ &= \sqrt{64^2 + 60^2} \\ &= \sqrt{7696} \\ &= 87{\cdot}7 \text{ ins.} \end{aligned}$$

Suppose the lift to be 4 ins.: the lifted cord K L now represented by N I will be $64 + 4 = 68$ ins. $IJ = LM = 60$ ins., and

$$\begin{aligned} NJ &= \sqrt{NI^2 + IJ^2} \\ &= \sqrt{68^2 + 60^2} \\ &= 90{\cdot}7 \text{ ins.} \end{aligned}$$

But $90{\cdot}7 - 87{\cdot}7 = 3$ ins. of a lift on harness cord N J as compared with the above-mentioned lift of 4 ins. on harness cord N I, showing a faulty lift of 1 in. at a point 60 ins. from the vertical, in this case the centre of the cloth. This difference of lift gradually diminishes as the vertical point is approached, but the minimum lift obviously occurs at the two selvages, just where the maximum lift would be of the greatest advantage.

One disadvantage of the heck—which, however, cannot be avoided—is the excessive friction generated between the harness cords and the steel rods of the heck, even although the rods are highly polished and free to rotate with the moving cords. To minimise this friction as much as possible, the jacquard, especially in wide looms, should be placed as high above the comberboard or harness reed as circumstances will permit. When the machine is set so that the cards hang over the end of the loom, the rods (9 for a 400-machine and 13 for a 600-machine) pass between the long rows of the harness cords, and consequently may be much greater in diameter than those represented in the figure.

Due to atmospheric and other changes, the harness cords sometimes vary in length, and so produce a faulty shed. To meet these changes, and to ensure that the warp threads shall occupy their proper positions on the race board of the lay, a method of adjustment frequently adopted is shown at O. This consists of adding thin wedges of wood or paper under the feet of the machine to increase the thickness of the support O between the beam E and the feet, or of removing the necessary amount to decrease the thickness of the support. As an alternative the distance of the feet of the machine from the supporting beams may be regulated by means of set screws. Another

method often adopted is that of making the sword of the lay in two portions, so that it may be increased or decreased in length, and the lay lifted or lowered to suit the level of the warp threads. In some extreme cases the loom itself may be raised bodily from the weaving shed floor.

To dispense with the necessity of punching every card of the design for a selvage, extra hooks actuated by bent needles are introduced into this and other machines. At a point P, on each face of the cylinder, and clear of the end of the card, extra holes are drilled for these bent needles to work into independently of the cards. It is evident that with this arrangement, and the cylinder drilled to suit, any type of selvage, repeating on two or four picks, may be obtained.

Cross-border Jacquards.—In by far the greater majority of woven figured jute fabrics (with the possible exception of Brussels and Wilton carpeting) no cross-border or other similar effect is ever introduced. In the particular exception mentioned, the carpet or "square" is made up to the requisite size from a number of widths of 27 ins. each and equal in length, cards being cut to cover this length, which rarely exceeds four yards; the width of the square in all cases is, therefore, a multiple of three-quarters of a yard. On the other hand, however, considerable quantities of figured linen fabrics are made in bordered cloths, such as table damasks, napkins, etc., necessitating two distinct sets of cards for the alternate working of the border and of the centre of the cloth. Where each design (border and centre) is of such an extent that only one repeat of the centre is necessary to complete the cloth (see Figs. 130 to 133, Textile Design: Pure and Applied), the cards may be, and sometimes are, in one continuous chain—*i.e.* two repeats of the border on end, but laced in opposite directions with one repeat of the centre cards. This is, of course, practically one-half more cards than actually represented by the two designs, but the introduction of the extra border set is necessary in order that the pattern of the cloth may be developed in proper sequence. In the great majority of cases, however, the design of the cloth is such that the centre pattern is repeated two or more times between the cross borders, as well as between the side borders. For this character of design it is usual to have the cards for the centre and the cards for the cross border laced in two distinct sets, and each set brought into operation on the machine when necessary. The simplest method of bringing about this change of cards, and that which is yet widely practised, is where the change is made manually by the loom attendant or other operative specially employed for that duty. Where this practice obtains no special machine is necessary, and probably this is the main reason why it is still so extensively adhered to. The time lost, however, by this method of changing has led to the introduction of various devices and of special machines peculiarly adapted for cross-border or other similar work where two sets of cards are required to act at different times on the same threads of the warp.

One of the simplest of these devices is that developed by Messrs. Devoge and Co., who can arrange their double-lift, double-cylinder jacquards so that they may be actuated as two separate single-lift, single-cylinder machines; one griffe, with its corresponding cylinder, hooks, and needles, acting for one set of cards, the other griffe, etc., acting for the other set. Where this is the case each griffe is actuated as required by its separate

connection from the crankshaft, the method of driving and of bringing the different cylinders into action being

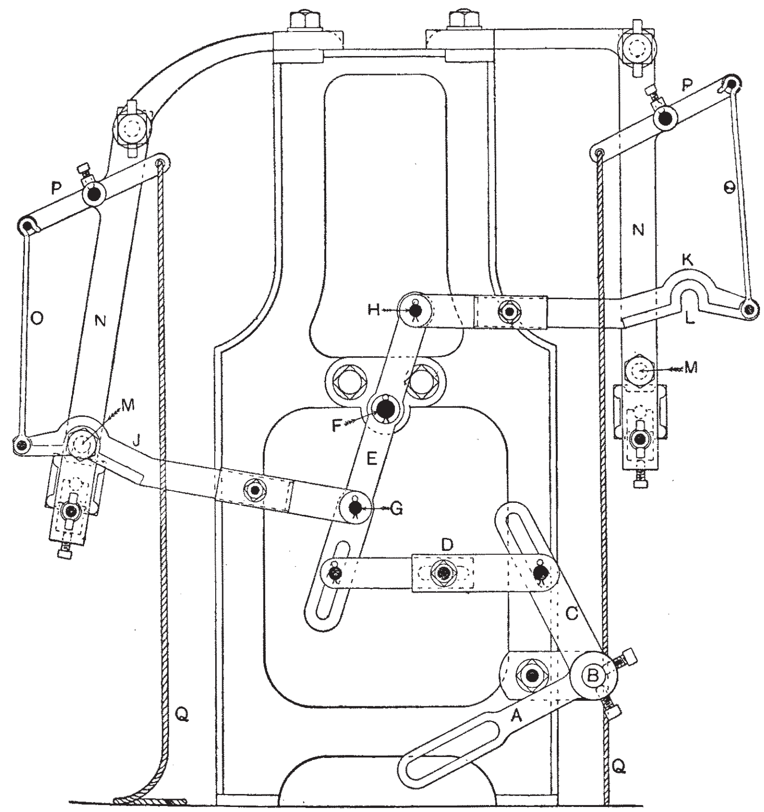


Fig. 147.

shown in Fig. 147. Motion is taken, as is usual for single-cylinder machines, from the crankshaft by a connecting rod to lever A, set-screwed on shaft B, which extends across the machine, and carries (set-screwed near each side of the frame-work of the machine) a lever C, which by link D imparts motion to a double-armed lever E fulcrumed at F. At two points equi-distant from F on lever E, two studs G and H are fixed, which carry the connecting arms J and K. Each of the latter arms near its extremity is provided with a recess L, which when required takes hold of the body of a stud M, which projects from the side of each swing batten N. Arms J and K are under the control of the weaver by means of links O, levers P, and cords Q. If both arms J and K were in connection with their respective studs M, it is evident that both cylinders would approach the needles simultaneously. On this account the makers claim that a 400's machine of this type may be used as the equivalent of an 800's single-lift, single-cylinder machine. When used as a cross-border machine it is of course obvious that only one link, J or K, will be in connection at one time, as shown.

Another device, introduced by Messrs. Davenport and Crossley, which practically constitutes a special machine, is shown in Fig. 148. It consists of an ordinary double-lift, single-cylinder machine, the needles A of which are made longer than the ordinary needles between the hooks B and the spring-box C. Each needle (besides controlling two hooks B as in an ordinary double-lift, single-cylinder machine) is cranked between the last hook and the spring-box to receive the lower end of a vertical lever or wire D, the upper end of which passes through and is controlled by an eye in its corresponding supplementary needle E. Behind each row of vertical levers D a rod F passes to serve as a fulcrum against which levers D can act. Supplementary needles E have no spring-box, as the springs on the ends of needles A

serve to return both sets of needles to their normal positions. It is evident that a blank in the card acting on either cylinder would move the corresponding hooks in the same direction—that is, off the knife. The action of cylinder G, which usually carries the centre cards, is

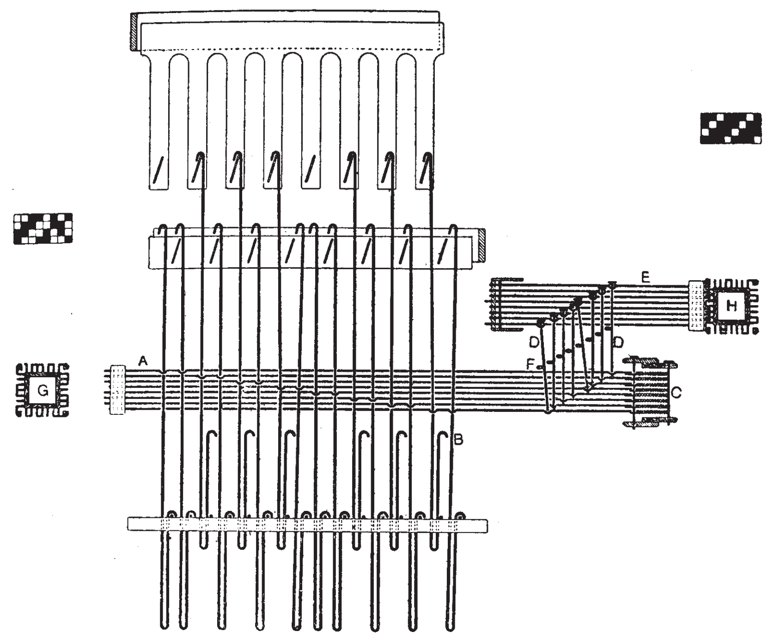


Fig. 148.

already well understood; and the action of cylinder H, which in general carries the cross-border cards, is shown in the figure where blanks in the card opposite the fourth and eighth needles have caused the said needles through levers D to pull back the corresponding long needles A just as if cylinder G had acted directly. The cards for cylinder G are laced and wired in the usual manner, but the cards for cylinder H, while cut and laced in the usual way, are wired on the opposite side in order that the reverse side or back of the card may be presented to the needles E.

The method of bringing each cylinder into operation

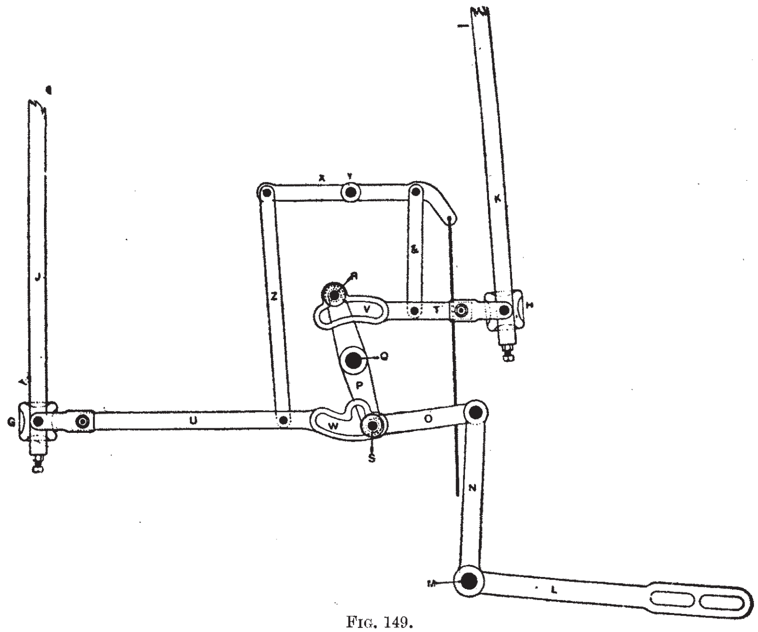


FIG. 149.

as required is illustrated in Fig. 149. Cylinders G and H are suspended as usual by their respective battens J and K, and receive motion from the crankshaft through an ordinary connecting rod attached to the lever L fulcrumed on shaft M, which extends across the machine. From M, connections to the cylinders are as follows, and are duplicated at the other side of the jacquard:—Lever

N and link O impart motion to an equal armed lever P centred upon stud Q. P carries near its ends projecting studs R and S, which, when desired, may actuate spanners T and U respectively, and through them the cylinders H and G. Spanners T and U are provided with concentric slots V and W, which are recessed at a suitable point to receive the studs R and S. Stud R is in the recess of V, while stud S is in the concentric slot of W. It is therefore evident that any movement imparted to lever P, through parts L, N, and O, will cause stud R to transfer a similar movement to the cylinder H, while at the same time stud S will simply move backwards and forwards in the concentric slot W. Spanners T and U are so connected by lever X fulcrumed at Y and links Z and &, that by pulling on the cord attached to the extremity of lever X they are brought into the positions shown; but by releasing the said cord, T is raised and U lowered until stud R can move in the concentric slot V, while stud S is placed in the recess of slot W. Cylinder H is thus placed out of action and cylinder G brought into action. The principle of this machine may be, and sometimes is, applied to a single-lift jacquard.

An alternative and possibly simpler method of driving the card cylinders G and H in the cross-border machine illustrated in Fig. 149 is shown in Fig. 150. Motion is taken as usual from a crank or eccentric on the crankshaft through the rod A, lever B, and shaft C, to a short lever D which is set-screwed on shaft C. Attached to the end of the lever D is a short connecting rod E, which carries, bolted to its upper end, a peculiar headpiece F. This latter is cast with a recess or notch in each edge for the purpose of engaging at will with either of the studs J or K bolted respectively near the ends of the levers L and

M. These latter are set-screwed respectively on shafts N and O, which stretch across the machine and carry at each

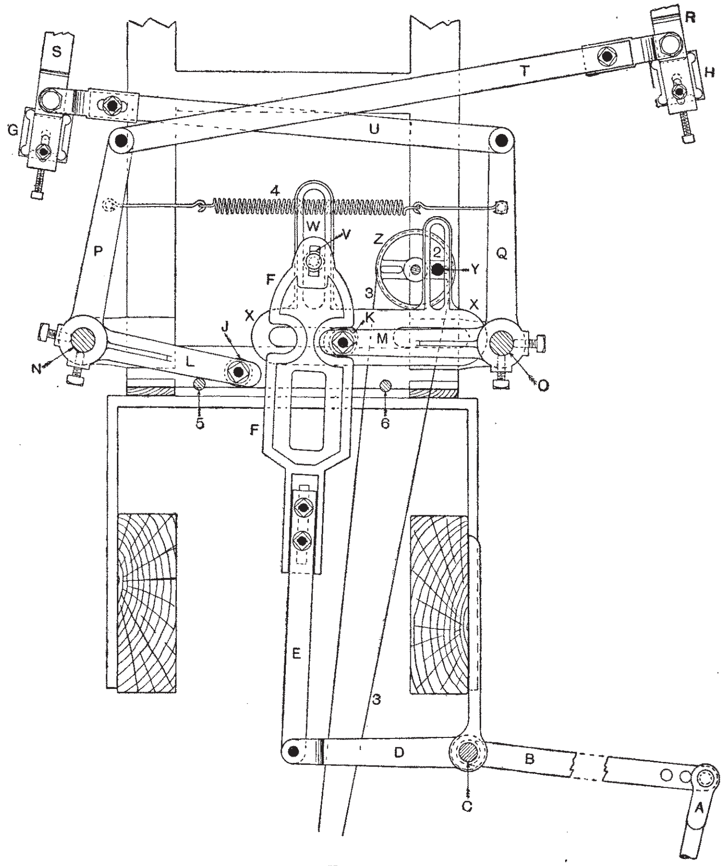


FIG. 150.

side the further levers P and Q, to which the swing-battens R and S are connected by means of the links or spanners T and U. In the figure the recess on the right of F is

represented as being engaged with the stud K of the lever M; the cylinder G will therefore be actuated, through the medium of the lever Q and link U, as the headpiece F rises and falls. The latter is supported approximately vertically, and is guided in its upward movement by means of a stud V which is bolted to F near its upper end and projects into the slot W of the sliding piece X. So long as it is required to work the cylinder G, this sliding piece X is retained in its present position; but when the cylinder H is required in action, X is moved to the left of its present position by rotating the crankpin Y through 180°. This crankpin is fixed in the pulley Z, and moves in the slot 2 of the sliding piece X. The change is accomplished from the weaver's position by a strap or chain 3 passing over and fixed to the flange pulley Z. In this manner the headpiece F is caused to release the stud K of the lever M, while the recess on the left is made to engage with the stud J of the lever L, and so actuate the cylinder H. It is obvious, as well as desirable, that this change can only be effected when the headpiece F is in its lowest position with both cylinders full out. The cylinder, which for the time being is at rest, is of course held in this position by the action of the spiral spring 4, which connects the levers P and Q. Adjustable stops 5 and 6 are suitably supported to retain the levers L and M in the most convenient position for effecting the changes, while suitable studs—not shown—support and guide the sliding piece.

A special machine introduced some few years ago by Mr. Robert Hutchison, Dunfermline, and now extensively used in and around that centre of damask weaving, is that shown in Figs. 151 and 152. It is a single-lift machine, and has the advantage of having only one set of needles A. Each needle is cranked or looped round a double upright or hook B, the heads of which face in opposite directions to cylinders C and D. The needles

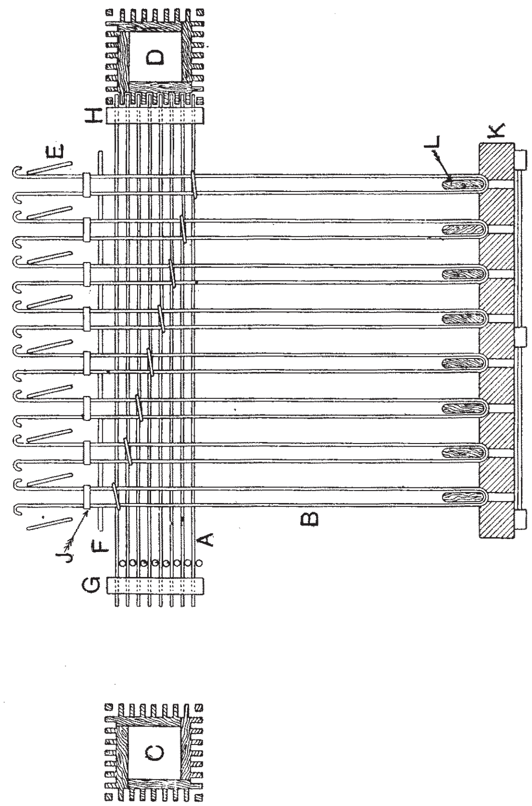


Fig. 151.

A have no springs, as each double hook is a spring in itself and returns to the normal position when the needle is released by the cylinder in action. Between each pair of uprights B and under the knives E a flat bar F is fixed,

which assists in retaining the hooks in a vertical position, regulates the extent to which the needles may project

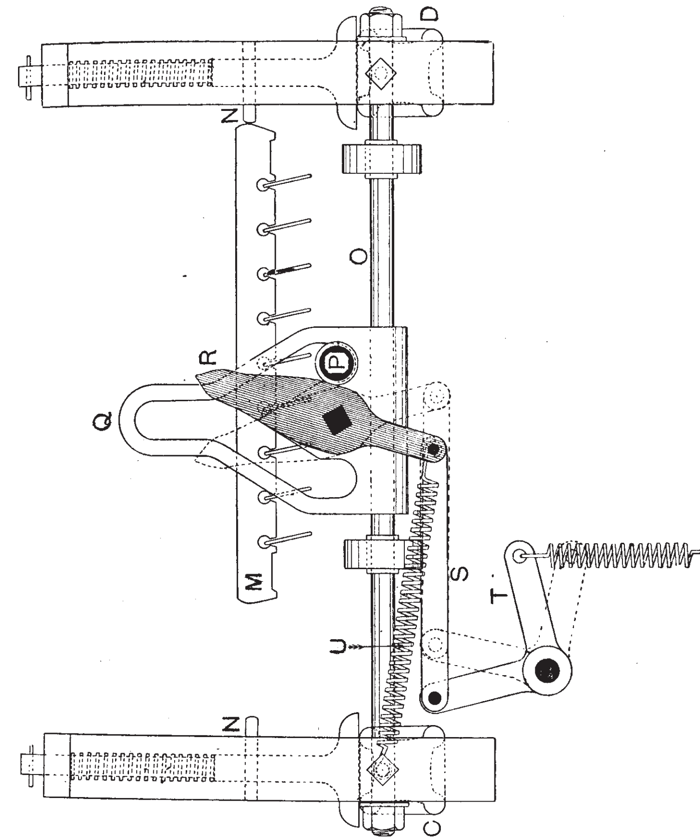


Fig. 152.

beyond the face of the needle boards G and H, and at the same time serves as a fulcrum for, and virtually creates the spring in, the hooks. Excessive friction between uprights B and bars F is prevented by a stop-band of tin J, which is soldered to one upright and encircles both. The uprights rest, as shown, on a grooved board K, while a flat wooden bar L serves to keep them facing the cylinders.

When cylinder D is in action the threads in the warp will be lifted by the action of the knives E on the right-hand hook of each double upright B; but when cylinder C is in action the shedding is performed by the action of the same knives on the left-hand hook of each double upright. Clearly, then, an alteration in the position of the knives from that shown in the figure must be effected. Each knife rests in a V-shaped slot, and is capable of being rocked in the said slot by two bars M, which are moved into position by a projection N on the side of the batten as either cylinder is brought into play. This action of course takes place when the knives (nine in a 400's and thirteen in a 600's) are in the lowest position, and therefore clear of all hooks.

The cylinders C and D are supported at opposite ends of the slide rod O, and are actuated from the griffe through stud P and double swan neck Q. Either neck may be opened or closed at will by a switch R through the medium of link S, bell-crank lever T, and spring U. When cylinder D is in action, the switch R occupies the dotted position, and although both cylinders are moving together, that which is considered out of action approaches the needles only half-way. With the switch R in the position shown, it is obvious that stud P will next descend into the left-hand groove of the swan neck. Cylinder C will thus be brought into contact with the needles, and bar M will, by the action of projection N, cause the knives E to incline to the right.

A newer form of double upright for the machine just

described is shown in Fig. 153, while a part plan of the

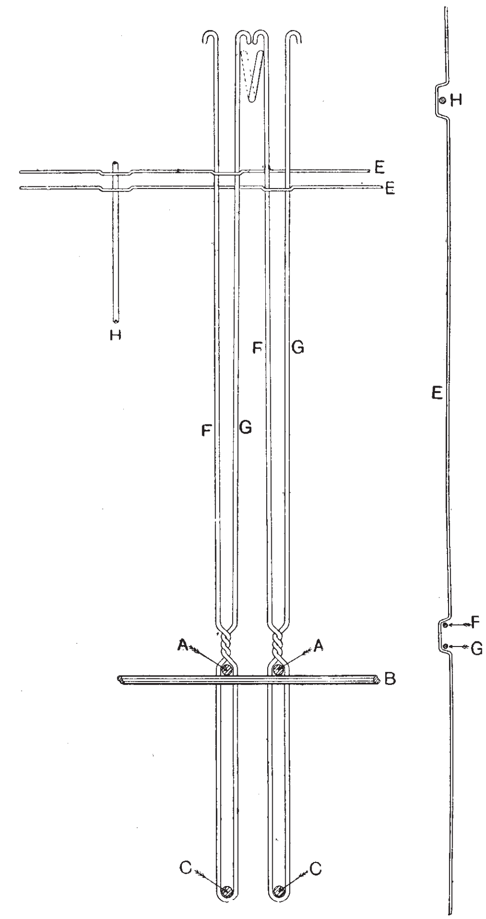


FIG. 153.

lower rods is shown in Fig. 154. Its form will be readily understood from the illustration, and it is supported when in its lowest position by rods A immediately under the twisted portion of the upright. Transverse rods B support rods A, and keep the hooks facing the cylinder. Rods C at the bottom of the uprights are fixed in a framework D which is connected to and moves with the griffe. Rods A and C serve as resisting points to the action of the needle E upon the upright, preventing it moving bodily in the direction of the thrust, and of course confining the needle's action to one or other of the arms or hooks F or G. Each hook is thus constituted a spring in itself, and returns to the normal position immediately the cylinder recedes.

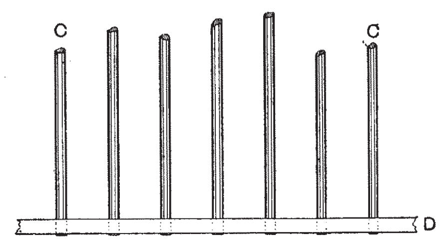


FIG. 154.

Wire H limits the movements of the needle in both directions.

Another device introduced for expediting the change of border and centre cards, and one which is also largely used in the Dunfermline district, is illustrated in Fig. 155. The cross-border portion is simply an addition to the ordinary single-lift machine illustrated in Figs. 130, 131, and 146. All parts to the left of the framework are supported by spindles A, and are moved to and from the needles by the action of a common swan neck. The arrangement consists principally of two cylinders B and C, set approximately at right angles to each other, and carried by the two arms D and E of an L-shaped bracket,

which is centred on a shaft F at the junction of the two arms. Keyed to the same shaft is a lever G, by means of which, through cords H or I, either cylinder with its respective cards may be brought into position opposite

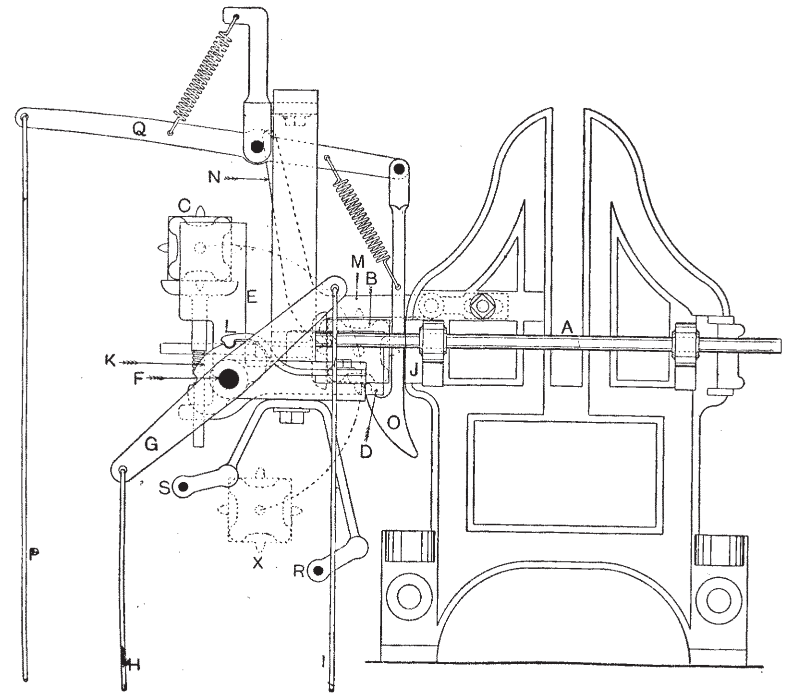


FIG. 155.

the needle board J. The extent of movement from the one position to the other is restricted by a sector piece K having two recesses in its periphery, into either of which, as the case may be, the head of the spring L can rest. When cylinder C faces the needle board, cylinder B occupies the dotted position X. The normal or forward pulling catch M is provided with an arm N which projects over the cylinder C while the latter is being moved into position opposite the needles. The reversing of the cylinder is brought about by catch O through cord P and lever Q. In the case of the cards being required to work in the backward direction (that is, for patterns symmetrical in the way of the weft) a second catch will be necessary to act upon the underside of the cylinder. Rollers R and S guide the cards to and from their respective cylinders B and C. A recent improvement in this motion consists in placing the cylinders B and C nearer each other so that the two arms of the bracket L make an angle of considerably less than 90°. The result of this alteration is that when cylinder C is moved into action, cylinder B does not move so far out as indicated by the dotted position X, consequently a better fall is obtained for the cards from cylinder C. Moreover, since when in this position the face of the cylinder B is held in a diagonal position instead of in a horizontal one as shown at X, there is not the same tendency for the cards to catch the corner of the cylinder, nor to collect on its upper surface. Further minor improvements have been effected with the view of simplifying the operation of changing and of imparting greater steadiness to the cylinder in action.

Verdol Fine Index Machine. In linen damask factories and in other factories where jacquards are extensively used for the production of elaborately figured fabrics, the question of the lighting of the factory, or perhaps the excessive obstruction of the light by the cards, as well as the question of the storage of the cards not in actual use, becomes a very serious matter indeed, even if the initial cost of the cards be left entirely out of

consideration. With a view of mitigating the above defects which always accompany the use of the standard size of jacquards, machine makers have from time to time introduced jacquards of finer pitch, both direct acting, and indirect acting. What is perhaps the finest pitch direct acting jacquard has already been referred to, see Fig. 133, page 216, and although there are many pitches intermediate between 4 mm. and the standard British pitch, it has been considered unnecessary to refer to them as no new principle is involved. Of indirect acting jacquards there are one or two types, but only one, the Verdol patent, has been extensively adopted. In this machine card-saving seems to have reached its limit, since a card of 896 needles capacity measures only $12\frac{3}{4}$ ins. by $1\frac{1}{12}$ ins., or say an area of 14 square inches as compared with $16\frac{1}{4}$ ins. $\times$ $3\frac{1}{2}$ ins., or say 56 square inches for an ordinary 600's standard British pitch card; this means a saving in area alone of about 83%. Since the thickness of the new card is only that of good note-paper, a considerable saving in weight is also effected. Against these advantages must be set the consideration that the very smallness of the card necessitates a very fine pitch of the indicating needles—3 mm. from centre to centre—a pitch which demands fine and delicate wire, accurate workmanship, and careful fitting of the moving parts of the machine; in addition, such a fine pitch permits of no latitude for the fluctuation of the size of the card due to changing atmospheric conditions. It is true that the makers claim to have solved this difficulty by means of specially prepared paper, but notwithstanding this improvement considerable difficulty is often experienced due to expansion of the cards during a wet week end.

In Fig. 156 parts of 3 cards for an 896 needle machine are shown along with a part sectional elevation of the jacquard. From A to B shows one half of the cards cut for the pattern, while the lower or incomplete portion is fully cut to show the zig-zag or hexagonal arrangement of the holes—an arrangement which utilises to the utmost the space of the card, in addition to retaining the maximum strength of the paper. The ordinary paper is strengthened at each end and in the centre of the card—which is in the form of a continuous strip—by the addition of an extra layer of stout paper so that it may better withstand the action of the pegs or studs C of the card wheels D, by which the cards or rather the continuous strip of paper E is rotated when in position. These extra layers of paper are represented by the criss-cross marking at A and B. Three large holes are shown in the end and the centre of each card, but the pegs C naturally work into only one hole at a time; should this hole, say the centre one of the three, get unduly worn, a simple change is provided by means of which the pegs C may be set to take either one or other of the outer holes, and so counteract faulty placing of the card due to worn peg holes.

To the right of the needle board F the jacquard is of an ordinary type but springless. Each hook G is a spring in itself, and all are retained in the normal or upright position over the griffe blades H by the resistance of the rods J, unless the corresponding needle K is pushed backwards. The full jacquard has 16 hooks and needles per row, and two rows of 8 holes each on the card correspond with one row of 16 needles and hooks. The board L is moved outwards positively as the griffe falls, but is returned by spring action as it rises—this ensures that all needles K will resume their full forward

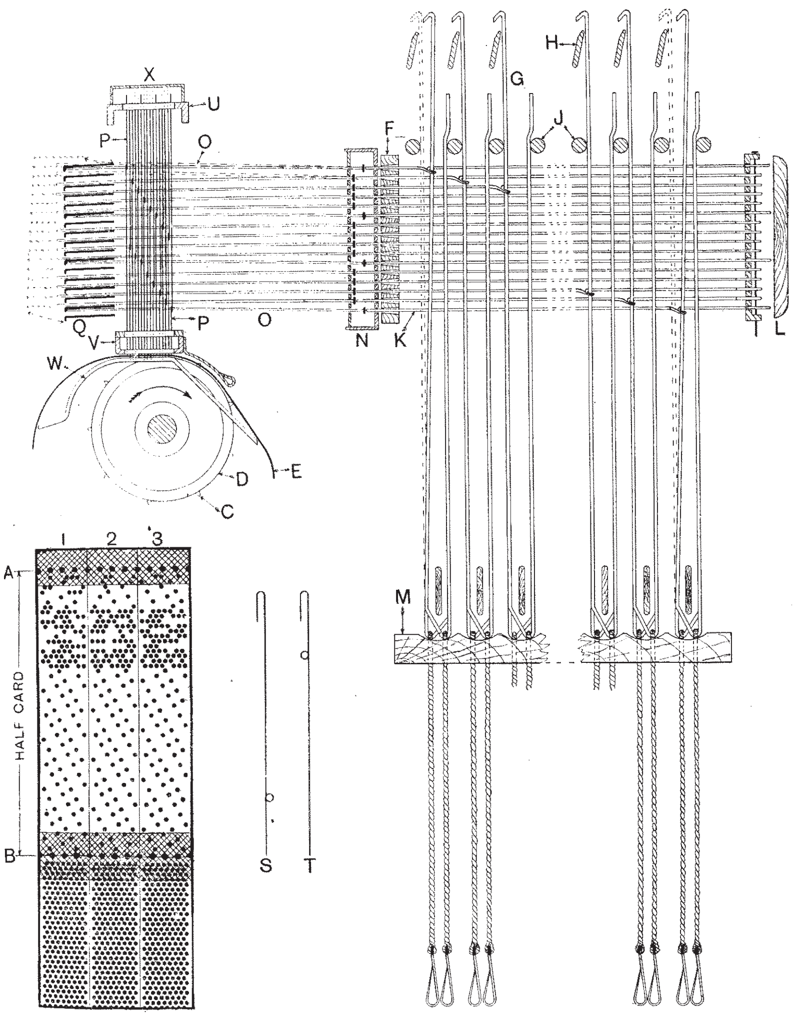


Fig. 156.

position. The jacquard proper is not very closely set, the pitch of the needles K being 5 mm. or practically 5 per inch. It may be made as a centre shed machine if desired, but is widely used as an ordinary bottom shed jacquard; the illustration represents one of the latter type. In the centre shed machine the doubled part of the hook is continued above the head of the hook for about 5 inches, and the hole board M is arranged to fall and rise respectively in unison with the rise and fall of the griffe.

To the left of the needle board F, an auxiliary machine is provided which performs the selecting part of the jacquard, and indirectly presses back the needles K and the hooks G of the jacquard proper. Each needle K, after passing through the needle board F, enters a perforated plate N, and abuts against the enlarged end of a supplementary needle O. Each needle O in turn passes through a looped eye formed on a vertical needle P, and is normally supported by one or other of a series of steel plates Q. The vertical needles P are formed in two series of eight each, as shown detached at S and T, in order that they may occupy two rows of holes on the card and yet act upon the same row of needles O. The tops of needles P are supported by a specially slotted grate U, while their lower ends are all entered in a double guide plate V; if required the tips of the needles P may pass through the card E and the supporting needle plate W. All needles P are free to move vertically as far as the cover X will permit, and all are moved vertically every pick as the griffe rises in order that their tips may be clear of the card E to permit the latter to rotate for the next selection. Vertical movement of needles P is obtained indirectly as follows: the steel plates Q, seventeen in number, are firmly fixed in a framework of brass, and all move outwards and rise

slightly coincident with the rising of the griffe—see dotted positions. This movement raises all needles O, and through them the vertical needles P, so that the card sheet may be advanced. But it will be observed that all plates Q are turned down at the front to such an extent that they just leave sufficient room for the free passage of the ends of the needles O if the latter are in their lowest position. If, therefore, the card E is uncut at any point, the corresponding needles P and O will remain in the higher plane, with the result that the ends of all such needles O will be caught by the bend of their respective plates Q as the latter move inwards with the falling of the griffe. Inward movement of any needle O is necessarily transmitted to its corresponding needle K and hook G so that the latter is pressed back clear of the griffe blades.

The movements of the machine are few and exceedingly simple. The griffe is raised and lowered in any well-known manner; the plates Q are reciprocated, raised and tilted, and the cylinder turned by swan-neck movements — simple mechanical contrivances which we have considered unnecessary to show. As indicated, however, trouble is experienced with the expansion of the cards, and also with fluff gathering in and choking the grate, and so preventing the free fall of the needles P and O. The latter difficulty may be partially overcome by placing a loose board on the top of the vertical needles P, but regular cleaning of this part of the machine with paraffin is almost essential.

Originally invented in 1884, this machine seems likely to remain the finest pitched mechanically operated jacquard. It is somewhat extensively used on the continent, but has only obtained a restricted adoption in this country.

Card Frames.—One of the chief essentials to the satisfactory working of a jacquard, whether employed on ordinary work or on cross-border work, is a proper card frame or cradle. In general, little difficulty is experienced in getting the cards to work forwards or in the normal manner—that is, advancing over the top of the cylinder,—but when required to work backwards they often prove

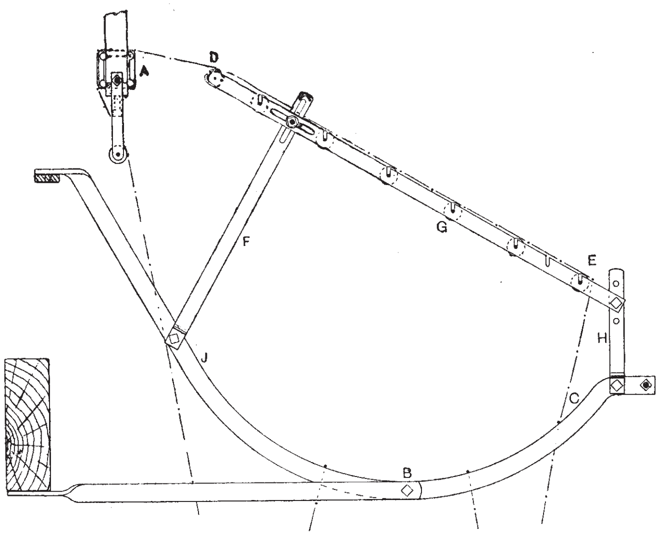


Fig. 157.

troublesome. Several faults tend to cause this, the chief one usually being a want of sufficient height or "drop" from the cylinder A (Fig. 157) to the bottom of the frame B. Other objectionable points are:—A flatness of the frame about C, which causes the wire to linger in its travel—if not to stop altogether—and the cards to slacken up; also a want of sufficient support from D to E, which allows the cards to sag between the rollers. These latter should

be spaced not over 5 ins. apart for 400's cards, and 7 ins. apart for 600's cards. Sagging between the rollers can be effectively prevented by constructing the frame so that the distance between the two parallel rails G, and also the length of the rollers which support the cards, is less than the length of the card. For ordinary 400's or 600's cards, about 16¼ ins. long, the rollers may be 12 ins. long, and the supporting rails G the same distance apart. Supports F may be readily modified in form to suit the alteration in the position of rails G. The angle between the cards and the face of the cylinder at A should be less rather than greater than that shown in the figure in order that the cards may not appear to rise above the level of the roller D. This rise, if too great, has a tendency to cause the card to slacken and fall between the cylinder and D. The parts F, G, and H of the frame can be readily adjusted to reduce the angle. The lower portion of the frame from J to C is part of a circle with a radius of about 16 ins. This would accommodate from 1500 to 2000 cards if wired in twenties—that is, hanging ten deep.

In the weaving of cross borders where the total length of the cloth or napkin is of reasonable extent, and where the jacquard employed is not a cross-border machine, it is usually considered more economical to provide a full set of cards for the entire length of the cloth, than to incur the loss of time and the wear and tear of the cards entailed by the constant changing that would be necessary were a single repeat only of the border and the centre patterns provided. Where the jacquard is of the Verdol fine pitch type as illustrated in Fig. 156, it is at all times considered most economical to provide a complete set of cards for the entire length of the cloth. In other cases, however, where the length of the cloth practically precludes the use of a full set of ordinary cards, and where two sets are provided to work alternately, card frames are sometimes used, with which it is necessary to lift out one set of cards before the other set can be used. The time lost by this method, as well as the number of cards destroyed, is very considerable, and it is preferable to have a card frame of a type somewhat similar to that indicated in Fig. 158, where border and centre cards always occupy their respective sections or curves A and B, whether acting or at rest. Section A is preferred for the border cards, as they work backwards better from it than from section B. In the figure the path taken by the border cards is indicated by the dotted line C, while that taken by the centre cards is shown by the dot-and-dash line D. Rollers E and F, which travel with the cylinder G, serve to guide the border and centre cards to their respective sections while travelling in the normal direction, while the roller F guides the border cards when the latter are working backwards. This type of card frame is also extensively and satisfactorily used for the special cross-border machine illustrated in Fig. 155.

Pressure Harness and Twilling Jacquards.—No treatise dealing with the mechanism of linen weaving could be considered complete without treating on the above associated methods of producing extensive patterns in the finer classes of damask goods. Of the two systems, that of the pressure harness is the older, and although it is applied in power-loom work, it might be truly regarded as an apparatus belonging more particularly to hand-loom weaving and as an aged remnant of that fast-vanishing branch of the industry. In this system of weaving, the harness or jacquard machine is supplemented by a camb of five or eight leaves, according as the twill employed is the five or the eight end sateen. This combination of "camb" and "harness" in the hand-

loom has probably led to the adoption in certain districts

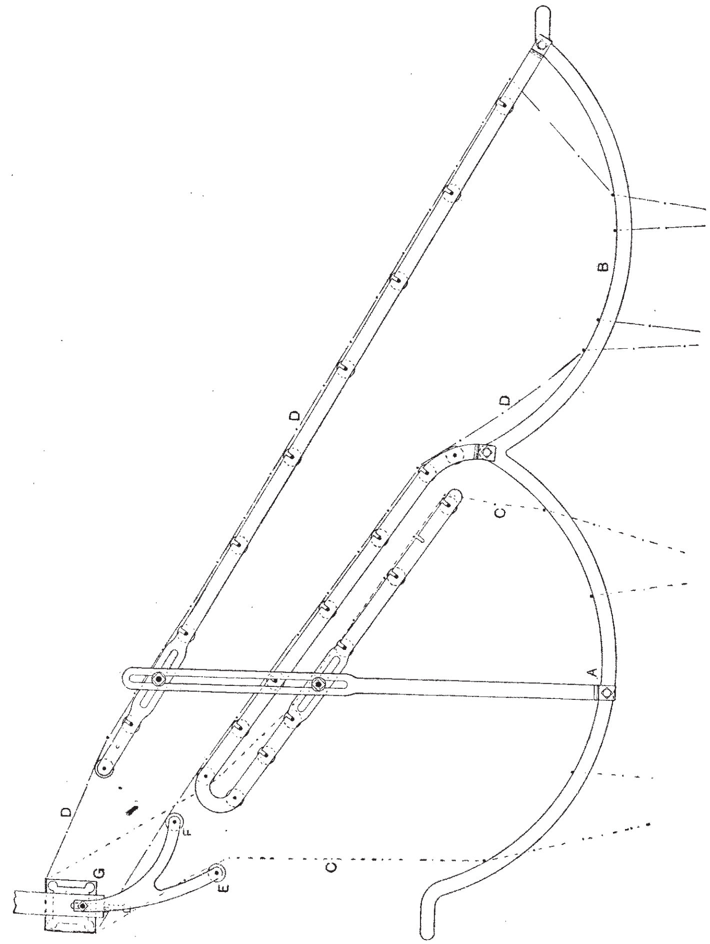


FIG. 158.

of the somewhat misleading term "common harness" as applied to both the above systems of weaving, in contradistinction to the term "full harness" generally applied to ordinary jacquard work. These terms have become so well established that we shall adopt them for further reference. With a pressure-harness loom it is, generally speaking, possible to increase the pattern in size to any predetermined extent without increasing the capacity of the jacquard or the number of cards in the design, and without decreasing the sett of the cloth. It is therefore evident that in this respect the system is a saver of cards and machines to a considerable extent. Take a simple case to show the saving of cards alone at its lowest estimate. Say a warp of 2400 ends is actuated by a 600's jacquard full harness with four repeats in the width; the pattern is square, and there are the same number of warp and weft threads per inch, thereby giving 600 cards in one repeat. It is desired to make the pattern double its present size, or only two repeats in the width. This with a full harness mounting, means 1200 hooks, or two 600's jacquards instead of one, and also 1200 cards in the repeat on each machine, or 2400 cards in all. With a pressure-harness mounting in which two threads are drawn in each mail and two picks given to each card, only one 600's machine, with 600 cards in a repeat of the design, would be required, or only one-quarter of that necessary with the full-harness system—a saving of 75 per cent. in cards alone. In practice this saving is often carried as far as making one card under the twilling jacquard system do duty where sixteen cards would be necessary with a full harness mounting—a saving of fifteen-sixteenths, or nearly 94 per cent. It has been stated elsewhere, however, that this saving is too often accomplished at the expense of the appearance of the cloth and of the pattern.

In pressure-harness weaving the warp threads A, Fig.

159, from the yarn beam, after passing over the lease rods B, are drawn through the mails C of the harness in 2's, or 3's, or 4's, or any predetermined order according to the extent to which it is desired to increase the capacity of the jacquard. The grouping of the threads in the mails of the harness may be all 2's, all 3's, or all 4's, or it may be

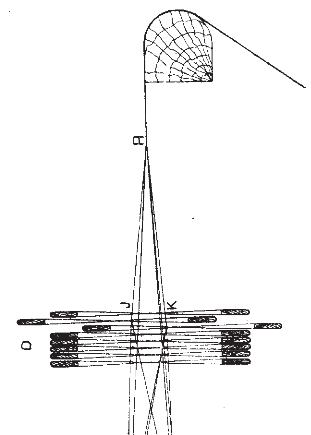
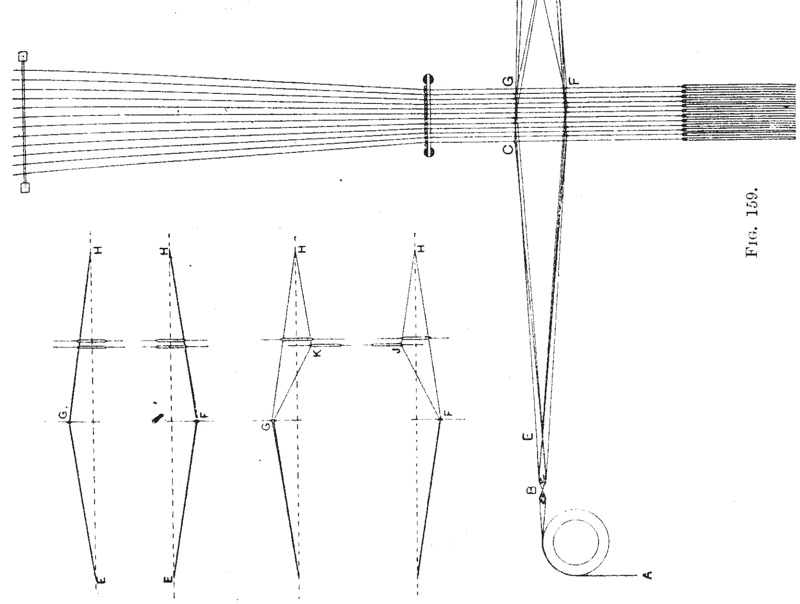



Fig. 159.

3, 2, 3, or 3, 3, 2, or 4, 3, 3, or any other arrangement, which, to be most convenient, should repeat on twelve mails, or once across the harness. In cases where more than two threads are passed through each mail, it is preferable that the mails should be decked—that is, have two or more openings for the warp in order to prevent the latter from twisting. The warp threads are then drawn singly in the camb leaves D—*i.e.* the first thread on the left is drawn through leaf No. 1; the second through leaf No. 2, or beginning from the right the first thread is drawn through leaf No. 8 (or No. 5 if the 5-leaf twill is to be woven), the second through leaf No. 7, and so on, the draft being repeated in that manner as often as necessary, and each thread being drawn singly on its proper leaf irrespective of the order of drafting in the harness mails C. The heddle eyes on leaves D are usually from $2\frac{1}{4}$ to $2\frac{1}{2}$ ins. long. The warp threads are then reeded in the usual manner, in 2's or 3's, as the case may be. Fig. 160 shows graphically the draft order 4, 3, 3 drawn once over the harness and giving five repeats of the draft on eight leaves. The horizontal lines connecting each succeeding three threads indicate that the reeding is in 3's.

One of the benefits of this system of weaving is that only the figure requires to be painted on the design paper and cut on the cards, since the twilling is effected by the leaves D independently of the harness. The figure only being cut on the cards, it is evident that when the jacquard griffe is lifted, the warp will be left down or lifted by the harness in solid portions, depending upon the uncut and cut parts of the card which is presented to the needles of the machine. With the shed thus formed all threads assume one of two positions—viz. E F H or E G H, Fig. 159; but in order that the warp may be properly

bound with the weft at regular intervals, both in figure and ground, it is further necessary to depress under the weft one thread from every eight (or from every

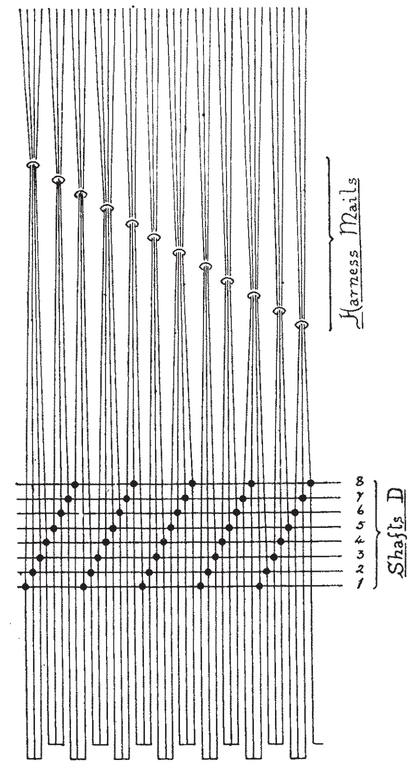


Fig. 160.

five) of those lifted by the harness, and to raise over the weft one thread from every eight (or from every five) of those left down by the harness. This is accomplished by depressing one, and at the same time raising one of the eight leaves D. The warp threads may now occupy one of four positions—viz.:

E F H = left down by the harness and the leaves.
E G H = raised by the harness.
F J H = left down by the harness and raised by the leaves.
G K H = raised by the harness and depressed by the leaves.

With this shed formed a pick is inserted. For the following picks the harness griffe may be retained in the "up" position for theoretically any number of successive picks, while the camb leaves D alone are changed to form the cloth. As has already been stated, a considerable saving is effected when two picks are given without changing the card or harness, but in some cases it is not unusual to find even five and six picks given to one card.

From the foregoing it is evident that the leaves D may occupy one of three positions—a central one or that of inaction, and also one either at the top or the bottom of their travel. They are usually mounted about midway between the harness and the fell of the cloth—a common distance being 10 to 12 ins. from both,—and are trimmed in such a position that the warp from the harness mails almost touches the bottom of the heddle eyes when the leaves D are level in their central position. This arrangement permits of a full lift of the harness being imparted to the warp without any interference on the part of the leaves D while the latter remain in their middle position. But the movements of the leaves D in depressing one-eighth of the lifted warp and in lifting one-eighth of the warp from the low position put a considerable amount of extra strain upon the warp. To minimise this strain as much as possible

it is customary to have the yarn beam at least 25 ins. to 30 ins. behind the harness mails C, so that a good length of yarn may be in play. Notwithstanding this, however, the distance of the harness mails C from the reed, and the action of the leaves D on a portion of the yarn, together combine to reduce the size of the shed available for the shuttle to such an extent that the use of very shallow shuttles—$\frac{1}{2}''$ to $\frac{3}{4}''$ deep—is entailed, with a corresponding reduction of their capacity, and increase of labour in refilling them.

When this system of weaving is applied to the power-loom the griffe or brander of the jacquard is most simply actuated by a connecting rod from an ordinary treadle or lever fulcrumed at the side of the loom and acted upon by a negative tappet or cam fixed on a short supplementary shaft, which is driven by suitable gearing from the crank or the wyper shaft. This forms one of the defects of the system, as it is not so easy to arrange an irregular number of picks to the card in this manner as in that adopted in the twilling jacquard. Tappets can, of course, be constructed and driven by suitable gearing to give any order of lifting—*i.e.* to retain the griffe in its highest position for any number of successive picks,—and Fig. 161 shows a tappet constructed to keep the griffe up for three successive picks.

We would refer the reader to pp. 122 and 123 for a discussion of the chief points requiring consideration in the construction of negative wypers in general; but we should like here to direct particular attention to those points which influence the outline of the machine lifts of the type under present notice. They are almost invariably found actuating single-lift jacquards, and since with these machines it is practically impossible to get "cover" on the cloth, the question of dwell resolves itself entirely into one of sufficient time to enable the shuttle to pass comfortably through the shed while retaining a maximum of time in which the

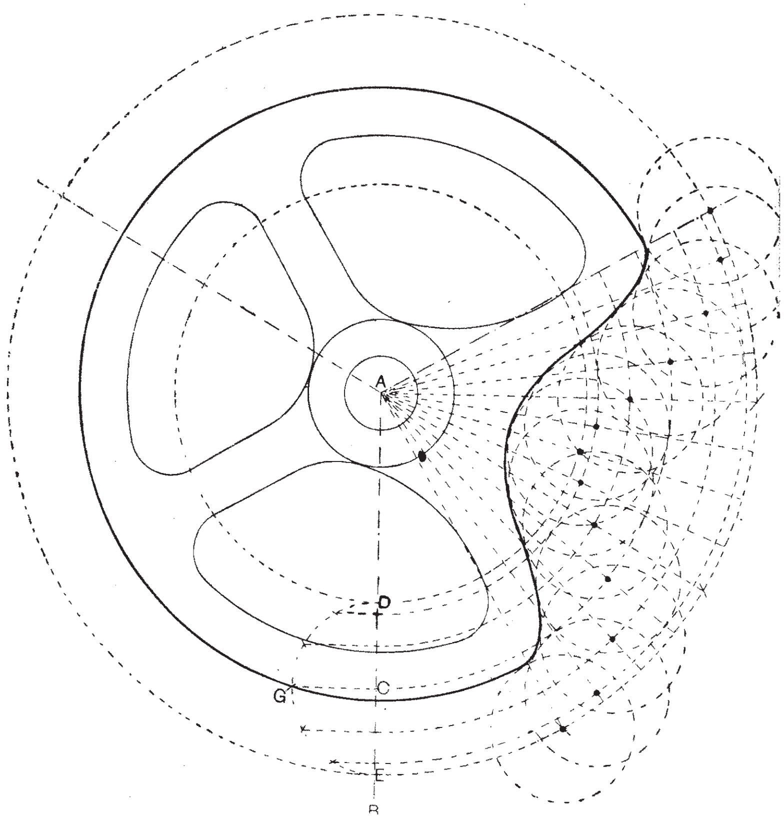


FIG. 161.

change of shed may be accomplished. Whilst a liberal estimate of the time which the shuttle takes to pass across the race may be taken at 120° or one-third of the crank's

revolution, in many cases 90° to 100° would be more correct. Now it has already been shown (p. 125) that in open-shed looms where the tappets are constructed to give "cover" to the cloth, only approximately 50° of the dwell in narrow looms to 100° in very wide looms is available for the passage of the shuttle before the leaves begin to close. This being so, and since in constructing the wyper its outline is so formed that it imparts little movement to the treadle for some time previous to entering on and to leaving the dwell —in effect practically increasing it,—we consider that 90°, or one-quarter of the crank's revolution, is ample time to allow for the passage of the shuttle. Besides this point, it is sometimes urged that time must be allowed for the hooks changing when the griffe is in its lowest position. With regard to this we would again point out that the construction of the wyper is such that when the griffe is nearing its lowest position it will travel slowly, and after reaching the bottom position will begin again to rise slowly; that the griffe blades have cleared the hooks some little time before the extreme low position is reached; and, moreover, since the card cylinder is usually actuated by what is known as the "swan-neck" motion, the cylinder will be close to the needle board, and therefore the hooks will have actually changed before the griffe has reached its lowest position. Such being the case, it is unnecessary to allow any dwell or time purely for this purpose.

Data for the construction of machine wyper:—Distance from the centre of supplementary shaft to centre of anti-friction roller in lever when the latter is level, say 6 ins. Dwell for passage of shuttle, say 90° or $\frac{1}{4}$ of a pick. Throw of wyper = travel of lever at the centre of anti-friction roller, $3\frac{1}{2}$ ins. Diameter of anti-friction roller, 3 ins.

Construction: On the line A B set off A C = 6 ins.; also set off C D and $CE = \frac{3\frac{1}{2}}{2} = 1\frac{3}{4}$ ins. With A as centre, and A D, A E as radii, describe circles. Divide these into three equal portions, each of which represents one revolution of the crank-shaft, or one pick. Subdivide any one of these into four equal portions. One of the latter may now be set aside for the dwell and the other three for the changing of the griffe. Again, subdivide the remaining three-quarters of a pick into twelve equal portions of time—six to be taken for lowering and six for raising the griffe. With C as centre and C D as radius, describe the semicircle D G E Divide this into six equal portions, and from these points drop perpendiculars to D E. With A as centre and the points thus obtained on D E in succession as radii, describe concentric arcs to cross the part set aside for change. With the points of intersection thus obtained in succession as centres and the radius of the anti-friction roller, describe circles indicating the roller at these points. Complete the wyper by drawing its outline for the change tangential to these circles, and for the dwell draw the remainder as part of a circle.

In pressure-harness looms the leaves for weaving the twill may be actuated by :—1st. A special arrangement of hooks from the jacquard. In this case the jacquard griffe would require to rise and fall every shot—a decided disadvantage. 2nd. A small dobby for the purpose. 3rd. A positive box tappet of the Woodcroft type, situated outside the loom proper, the treadles being connected to the leaves in a manner similar to that indicated in Figs. 76 and 77. The last is perhaps the best and most generally preferred method.

In hand-loom weaving the leaves are usually actuated by five or eight treadles, which the weaver controls with his

right foot, the left being engaged for working the treadle which is connected to the jacquard. The latter treadle is shown at A, Fig. 162, and the former treadles (in this case for five leaves) are indicated at B. They are fulcrumed on a pin C at the front of the loom, just under the weaver's seat, and extend under the camb leaves D, three of which —Nos. 1, 2, and 3—are shown. No. 1 is in the centre position, while No. 2 has been raised and No. 3 depressed. All leaves assume the centre position immediately they are released from the pressure of the foot by means of the following connections. The top shaft of each leaf of the camb is connected overhead to the outer end of the short wooden levers E, these being in turn connected by short cords to the levers F, the outer arms of which support counterbalance weights G, which raise the leaf to which they are connected as far as the stop bars H will permit. The leaves are raised and depressed as follows :—Each treadle B is connected to two leaves through the lames or counter-marches J, and acts so as to lift one leaf and sink the other. Treadle No. 1 is attached to the underside of leaf No. 3, while a further connection is taken up through the warp (in the figure this is shown attached to the top of leaf No. 3) to the inner arms of a pair of levers E, the outer arms of the same pair being connected to the upper side of leaf No. 2. When this treadle is depressed by the foot, leaf No. 3 is also depressed, while at the same time leaf No. 2 is raised. This is indicated in the small weaving plan K to the right of the treadles, where a circle indicates a leaf sunk and a cross one lifted. In a similar manner—

Treadle No. 2 sinks leaf No. 1 and raises No. 5.
,, ,, 3 ,, ,, 4 ,, ,, 3.
,, ,, 4 ,, ,, 2 ,, ,, 1.
,, ,, 5 ,, ,, 5 ,, ,, 4.

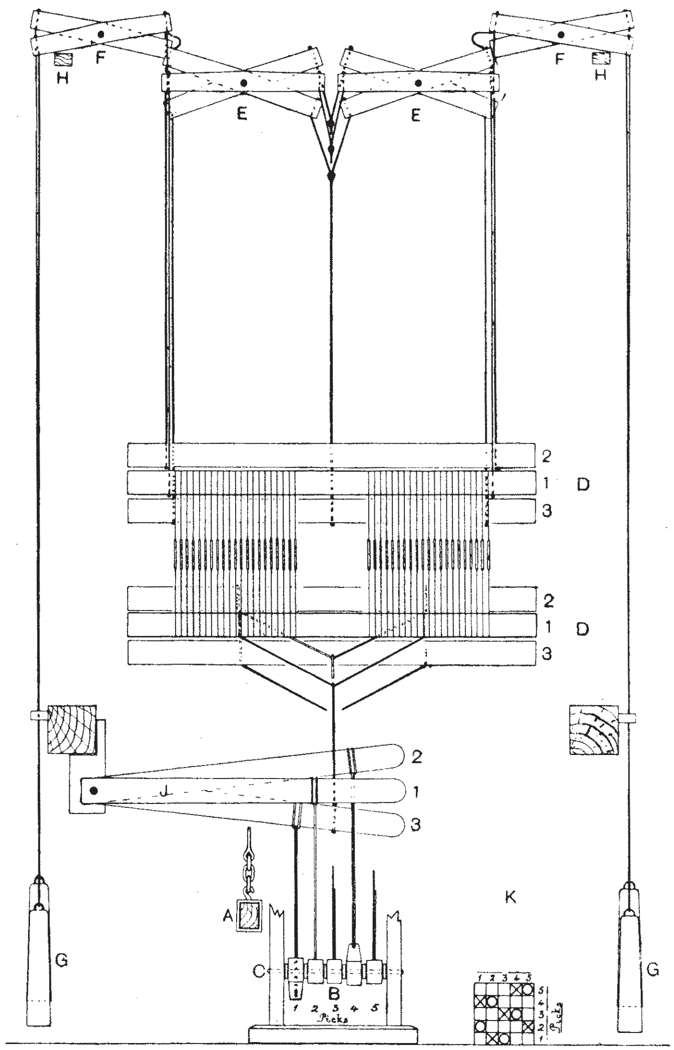


FIG. 162.

Twilling Jacquard.—This machine may be said to do for the power-loom what the pressure-harness system does in hand-loom weaving. The main difference between the two systems is that in the latter an ordinary jacquard is used, the pattern being increased or extended by drawing two or more threads of the warp through each mail of the harness, and then drawing them separately through the leaves in front of the harness in order that the binding or twill of the weave may be properly formed, whereas with the former system a special jacquard is used, in which each needle of the machine controls two or more hooks (instead of one mail taking two or more threads), and the yarn is drawn singly through the harness mails. This machine performs the twilling operation automatically without the aid of leaves, and forms a shed of the bottom-closed type, as in an ordinary single-lift jacquard. Its action on the warp yarn is less severe than the pressure-harness system; while ordinary shuttles and pirns can be used, and production therefore kept up. When compared with the pressure harness, the most obvious and probably the only serious disadvantage of the twilling jacquard is the fact that the griffe or brander of the machine requires to rise and fall every pick in order that the twill may be effected. This causes the card cylinder to move out and in, and thus strike the needles every shot, although no change of card may have been made. Cards, therefore, last a shorter time than on the pressure-harness system. A further objection that is sometimes urged against the twilling jacquard is that it does not make so firm a cloth as the pressure harness; but the advocates of this objection usually say in the same breath that the pressure harness is harder on the warp, and better yarn must therefore be used. Now better yarn invariably results in the production of a superior piece of cloth, so that the above is an unfair comparison. Provided the yarns are the same, we have no hesitation in saying that the twilling jacquard will turn out as substantial and as satisfactory a piece of damask as will the pressure harness; indeed, in some cases better results will be obtained, since the machine has not the same tendency to strain the yarn beyond its elastic limit.

It is true that the pressure harness offers better facilities for extensive enlargements of pattern, for each harness mail may take any practicable number of threads, and the pattern may thus be increased in any desired proportion. On the other hand, the twilling machines are generally made in certain well-defined sizes or arrangements, and the increase of the pattern is to some extent limited.

The needle board A (Fig. 163) of a twilling jacquard is identical with that of an ordinary 600's machine, and therefore contains 12 horizontal rows of 51 needles each, or 51 vertical rows of 12 needles each. In the ordinary machine each needle controls one hook; consequently there are 12 hooks in one row of the jacquard from the needle board to the spring-box. In the twilling jacquard, however, each vertical row of 12 needles usually controls 24, 25, 32, 40, or 48 hooks in one row from front to back, or from the needle board to the spring box. The capacity of the twilling jacquard may therefore be stated as $\frac{24}{12}$, $\frac{25}{12}$, $\frac{32}{12}$, $\frac{40}{12}$, or $\frac{48}{12}$ of the ordinary full-harness machine. The number of hooks in one complete row of a twilling machine must be a multiple of the ends in a repeat of the binding weave to be employed, and since this is almost invariably either the 5-end or the 8-end sateen, we find that the number of hooks in one row is a multiple of either 5 or of 8, or of both. It is the general custom to make the

25-row machine answer also for the 24-row, by arranging

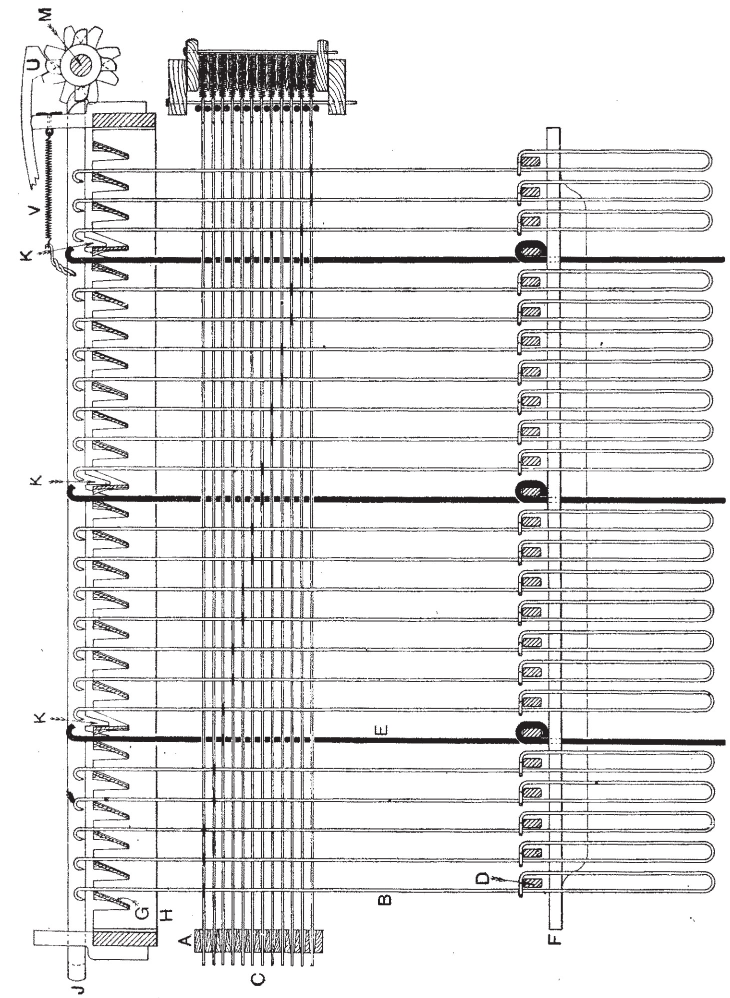


Fig. 163.

it so that if the 5-end twill is required, the whole 25 hooks are utilised (1 needle with 3 hooks, and 11 needles with 2 hooks each—see Fig. 163), whereas if the 8-end twill forms the binding, then only 24 hooks—two to each needle —are in use, the first row being left idle. In the 32-row machine 8 needles govern 3 hooks each, and 4 needles govern 2 hooks each, arranged 3, 3, 2, for 4 times, while in the 48-row machine each needle controls 4 hooks. The two latter machines are suitable for the 8-end twill only, but the 40-row machine is suitable for either the 5-end or the 8-end twill; here 4 needles control 4 hooks each, and 8 needles control 3 hooks each, arranged 4, 3, 3, for 4 times. The 32-row machine is sometimes filled 3, 2, 3 for four times instead of 3, 3, 2, so that it may be readily changed to a 30-row machine for the 5-thread twill by leaving idle the first and the last of each row. It is, of course, necessary when changing from the 8-thread twill to the 5-thread twill, or *vice versa*, to make a corresponding change in those parts of the machine which automatically control the self-twilling apparatus.

The hooks B, 17½ ins. long, are similar to those generally used in the Scotch jacquards, while the needles C have 2, 3, or 4 cranks in them, according as they are intended to control 2, 3, or 4 hooks respectively. The hook rest D is an iron bar, oblong in section, which passes right through one long row of hooks, and is itself supported at each end by a special strong hook E, the head of which is turned towards the spring-box—*i.e.* in the opposite direction from that of the ordinary hooks. These heavy hooks E are supported in their lowest position, and guided in their vertical movement by a special guide-plate at F, through which the lower end of the hook passes, and on which the bent portion rests when the hook is in its lowest position. Another plate, not shown in the figure, is situated about

level with the top needle, and assists in keeping the hooks E vertical. This arrangement permits of a full row of 51 hooks being raised at will without the intervention of the card on the cylinder. All the griffe or brander blades G in this machine rest loosely in semi-V-shaped cuts in the supporting bars H of the griffe frame, and are capable of being rocked into one of two positions—inclined or vertical —by means of special twilling needles or bars J, which pass across the top of the blades or knives G at the extreme end of the latter (see Fig. 164), and control them by means of two fingers K projecting from the underside. Five bars J are necessary for the 5-end twill, and 8 bars for the 8-end twill. When the former weave is used, the bars J are usually all situated at one end of the griffe blades G, but when 8 bars are used, 4 may be placed at each end of the griffe blades. Each bar J controls 1 griffe blade G in each repeat of 5 or 8, as the case may be, while one bar must always control an extra blade, since the first and the last fulfil the purpose of only one blade.

In a 40-row machine arranged for the 5-end twill we might have :—

1st bar	controlling	griffe blades	3, 8, 13, 18, 23, 28, 33, 38.
2nd	,,	,,	1, 6, 11, 16, 21, 26, 31, 36, 41.
3rd	,,	,,	4, 9, 14, 19, 24, 29, 34, 39.
4th	,,	,,	2, 7, 12, 17, 22, 27, 32, 37.
5th	,,	,,	5, 10, 15, 20, 25, 30, 35, 40.

In Fig 164, which is a plan of the 25-row machine shown in section in Fig. 163, the first row is idle, and the other 24 rows are arranged for the 8-end twill. Here there are 8 twilling bars J, 4 at each end of the griffe blades G, those blades which the bars J control being indicated by a cross on the respective bar. If we neglect the first blade altogether, we find that counting from the bottom of the figure :—

Bar No. 1	. . .	controls blades	3, 11, 19.
,, 5 (next to act)	.	,,	6, 14, 22.
,, 2	. . .	,,	1, 9, 17, 25.
,, 6	. . .	,,	4, 12, 20.
,, 3	. . .	,,	7, 15, 23.
,, 7	. . .	,,	2, 10, 18.
,, 4	. . .	,,	5, 13, 21.
,, 8	. . .	,,	8, 16, 24.

In both the figures bar No. 5 is represented in action, having rocked its respective blades 6, 14, and 22 from the inclined to the upright position. When the griffe rises with the blades in this position, all the hooks on the 6th, 14th, and 22nd rows will be left down, no matter whether pushed back or not by the action of the card on the needles C; but at the same time a bent portion L near the end of each blade lifts the heavy hooks E at the ends of the rows immediately in front—*i.e.* the 5th, 13th, and 21st,—thereby raising all hooks in these rows, whether left on by the card or not. In this manner every 8th thread is raised from the groups that were to have been left down by the action of the card, and every 8th thread is left down from the groups that were to have been lifted. It is, of course, understood that with this machine, as with the pressure harness, the pattern only is painted on the design paper and cut on the cards. Of the few hooks indicated in Fig. 164 it will be noticed that the first twelve (No. 1 being idle) are in the "on" position, and that all would have been lifted had the blades G been fixtures as in the ordinary machine; but since blade No. 6 has been rocked into the vertical position, that hook will be left down to form the binding with the weft. At some other points in the design,

as at hooks 12 to 19 inclusive, a number may be in the "off" position. Here again, however, the rocking of the

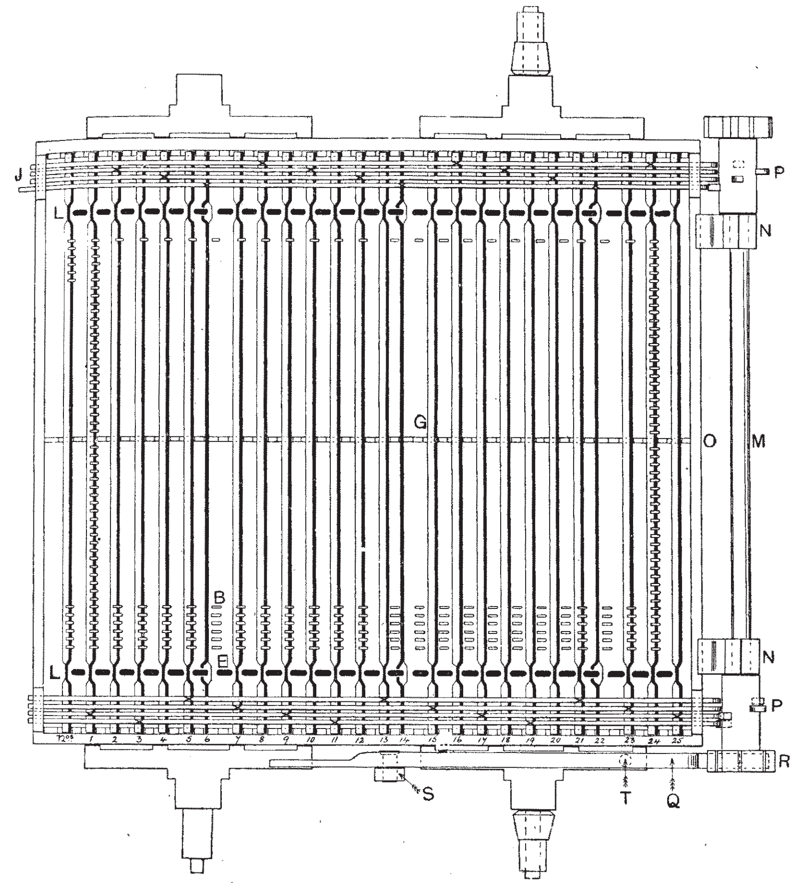


FIG. 164.

blade No. 14 will cause hook No. 13 to be raised above the weft to form the twill or binding. Similarly, throughout the machine or the warp one thread out of every eight forming the ground will be lifted above the weft, and one out of every eight forming the figure will be left down. The blades G are changed every pick in the following manner:—At the back of the machine, just above the spring-box, a twilling shaft M (see also Figs. 163, 164, and 165) is supported in brackets N set-screwed on the griffe frame O. The diameter of shaft M is enlarged near each end, and round the periphery of each of these portions are fixed four small tappets P, one for each bar J. As the griffe descends, this shaft M is rotated one-eighth of a revolution by means of a pushing pawl Q which acts on the underside of the 8-toothed ratchet wheel R keyed on the end of the shaft. The pawl Q moves backwards and forwards as the griffe rises and falls by means of the stud S projecting from the end of the pawl into a fixed swan-neck bolted to the inside of the framework of the machine. A spring hammer T, enclosed in the framework immediately underneath pawl Q, keeps the latter in close contact with the ratchet R. At the other end of the shaft M another spring hammer U (see Fig. 163) prevents undue rotation of the shaft. The twilling bars J and the blades G are returned to their normal position by the spiral spring V fixed to the bar as shown in the same figure.

An improved and simpler method of rotating the twilling shaft M is illustrated in Fig. 165. A bracket 18 is bolted to the framework, and near the end of this bracket is secured an upright stud 19. A pawl 20 is centred loosely at 21 in stud 19, but is kept from dropping, and its height is regulated, by set-screw 22 fixed to bracket 18 as shown. When the twilling shaft M rises with the griffe O, the end of pawl 20 is lifted sufficiently high by ratchet wheel R to allow the latter to pass, but the pawl

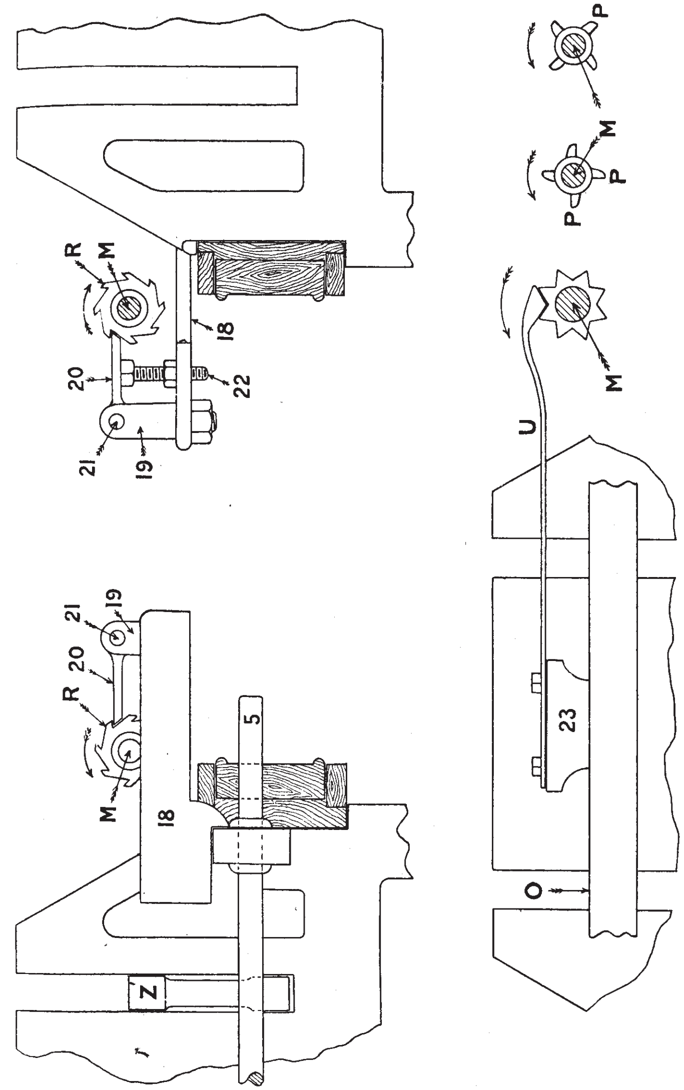


Fig. 165.

drops to its present horizontal position immediately it is released by the ratchet. As the griffe descends, one or other of the teeth of rachet R comes in contact with the upper edge of pawl 20, and, consequently, the twilling shaft M is rotated, in the direction indicated by the arrows, one-eighth of a revolution for the 8-thread weave. The upper left-hand figure is a view taken from the end of the jacquard, while the upper right-hand figure is from the inside of the machine. The small tappets P for the 8-thread weave are shown in the two small detached figures, while the spring hammer U is set-screwed as shown to a small bracket 23, which is in turn set-screwed to the griffe frame O.

Fig. 166 is a side elevation of the machine with the outside framing removed, and besides showing the majority of the parts already mentioned, gives an idea of the method usually adopted for actuating these machines. The shaft W, seldom under 2 ins. in diameter, is generally supported in suitable brackets in the framework (see Fig. 167), and is actuated in the usual manner by means of a simple lever, connecting rod, and crank from the crankshaft. Set-screwed on the shaft W are two arms X, one at each side of the machine, carrying anti-friction rollers at their ends, on which the bottom portion of the lifting block Y rests. Vertical movement is ensured by means of two portions Z of the lifting block working in suitable guiding slots in the frame proper. The machine, of course, descends by means of its own weight and that of the harness attached. In many cases this weight is so excessive that it becomes imperative to arrange some counterpoise to aid the loom in lifting the machine, and to prevent the machine from driving the loom when the former is falling. This generally takes the form of a dead weight, sufficiently

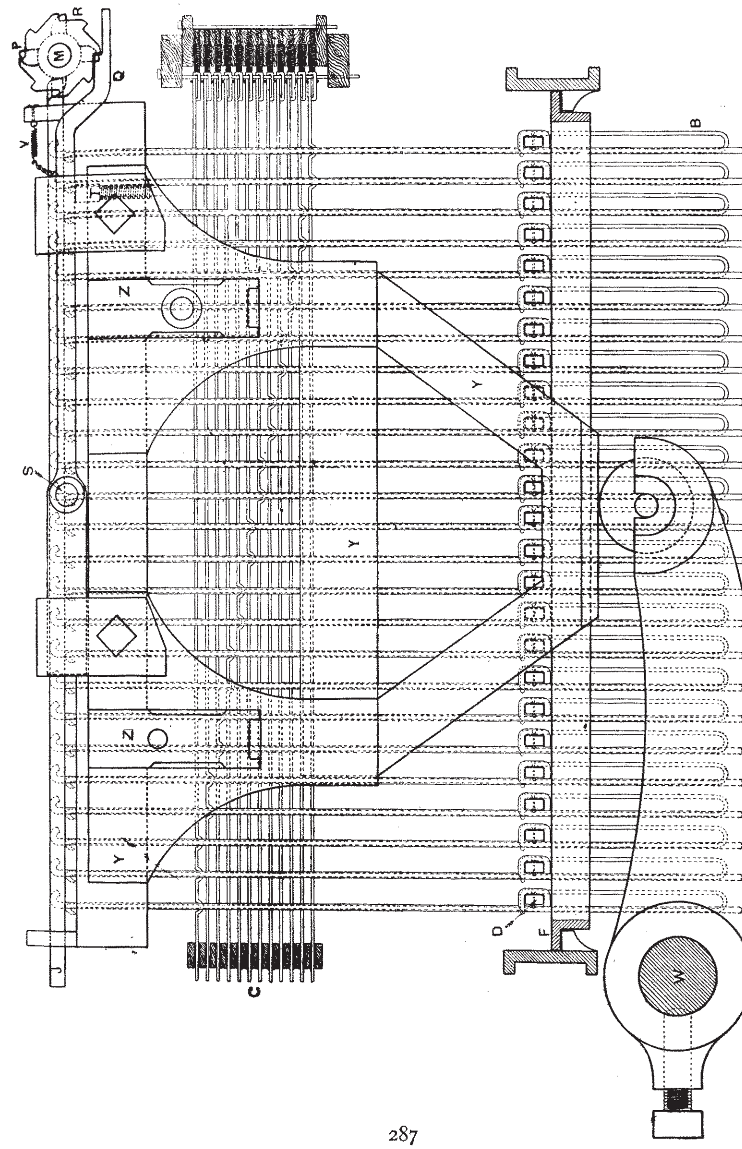


Fig. 166.

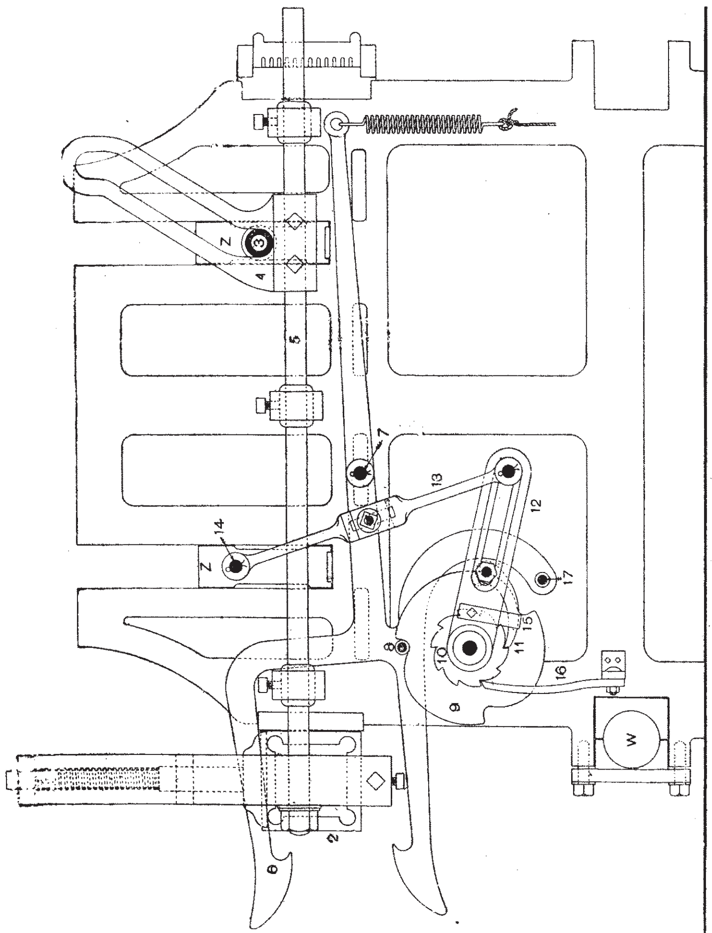
heavy for the purpose, which is attached by a connecting rod to a second lever keyed on shaft W. In most cases the connecting rod for the counterpoise extends practically to the floor of the weaving shed, and supports the counterpoise weights directly, but in other cases the rod is attached by a pin to the free end of a long lever which is fulcrumed either at the back or at the front of the loom; this long lever is situated near the floor, and the counterpoise weights may be slid along it to increase or decrease its effect upon the jacquard griffe. Besides weights, which are probably to be preferred on account of the constant nature of their action, heavy spiral springs are often attached, or fixed in such a manner that they are compressed when the griffe is falling, while they again extend and give out their force as the griffe rises. The whole question of effectively driving and counterpoising these heavy machines is a troublesome one, and it is doubtful if an ideal method has yet been evolved. Many firms have adopted the top-lifting principle illustrated in Fig. 136 with considerable success; others have introduced compound systems of levers; while others again have arranged to push up the griffe from two points, ZZ, Fig. 166, instead of from one. Fairly satisfactory results have attended each method.

For 3-machine and 4-machine lifts it is a common practice to have driving cranks and connecting rods at each end of the loom to correct the torsion in the machine shaft W.

Top lifts require long connecting rods, and their tendency to vibrate has to be counteracted in some simple and effective way. Top lifts also make it difficult to remove the griffe of the machine when this becomes necessary for repairs, or for the replacement of bent and

worn-out hooks and needles. Compounded levers, on the other hand, multiply the number of working parts, and these are usually accompanied by backlash and a jerkiness of movement which is undesirable, and which is usually absent from a top lift. Circumstances very often determine which general method shall be adopted, as, for example, the lack of sufficient height in the shed, which naturally makes it impossible to adopt the top lift. In all cases the connections should be such as will enable the weaver to place the lay of the loom in any desired position with comparative ease.

Fig. 167 shows the outside framing of the machine, and indicates chiefly the mechanism for controlling the number of successive picks for each card. The cylinder 2 is moved out and in every pick in the usual manner by means of the stud 3 projecting from the lifting block, and working in the ordinary swan-neck 4, which is set-screwed on the slide rods 5. The double catch 6, fulcrumed at 7, is, however, controlled in such a manner that it can be made to take or miss the cylinder head at will. Projecting from the side of the catch 6 is a stud 8 which rests by gravitation on the periphery of a cut disc 9. This disc is compounded with a ratchet wheel 10, which is rotated one tooth each pick by the pawl 11, lever 12, and rod 13 attached to the stud 14 in the lifting block. The flat spring 15 keeps the pawl 11 in touch with the ratchet 10, and the spring 16 prevents rotation in the opposite direction. Were disc 9 a complete circle, the stud 8 in the catch 6 would be so supported that the latter would never take the cylinder head, and the same card would be presented always; but at certain points in the circumference of the disc 9, notches are cut which allow the stud 8 and catch 6 to fall, and so rotate the cylinder as the latter recedes. A further arm of the catch supports a stud 17



at the underside of the disc to serve the same purpose as stud 8 when the cards are working backwards. If the

ratchet wheel contained, say, twelve teeth, and the disc 9 only one notch or recess corresponding with one of these teeth, then it is evident that the catch 6 would operate on the card cylinder only once in twelve picks, and each card would be presented to the needles for twelve picks in succession. The ratchets and discs can be cut to suit any order of changing; but where, say, two picks to a card are wanted in regular succession, the ratchet would probably have twelve teeth, and the disc 9 would be arranged cut one, miss one, six times over—that is, twelve equi-distant points would be taken on the circumference of the disc, and at alternate points recesses would be cut for the reception of the studs 8 or 17. If four picks to the card were wanted, the same ratchet could be used with a new disc cut three times in the circumference at points 120 degrees apart. The order 3, 3, 2 could be obtained with a ratchet of eight teeth, but one of sixteen teeth would probably be used, and the order cut twice in the revolution of the disc. All three picks to the card would be obtained by a ratchet of twelve teeth, and a disc cut at points 90 degrees apart. Ratchets scarcely ever exceed twenty to the round, although some of greater capacity are found in use; that indicated in the figure has ten picks to the round—4, 3, 3.

To calculate the order of the disc required for any cloth, or, in other words, the picks to the card, it is necessary to know (1) the proportion of warp to weft in the finished cloth; (2) the ruling of the design paper used; and (3) the capacity of the machine—*i.e.* the average number of hooks controlled by one row of needles, as 24, 32, 40, or 48, or any intermediate number.

For example, suppose a cloth in the finished state were to contain 80 by 120 per inch; the design paper to be 12 by 12; and the machine to contain 32 hooks per row—*i.e.* 12 needles control 32 hooks.

In one square of the design paper twelve vertical divisions indicate twelve needles of the jacquard, and therefore 32 warp threads, since twelve needles control that number of hooks. But in the same space on the design paper there are twelve horizontal divisions, and therefore only twelve cards will be cut. Now the proportion of warp to weft is as 80: 120, and for every 32 warp threads we shall have a proportionately greater number of weft threads in the same space:

$$\therefore 80:120=32:x.$$
$$\text{Whence } x=48 \text{ picks.}$$

But to these 48 weft threads or picks there are only twelve cards given:—

$$\therefore \frac{48}{12}=4 \text{ picks to the card.}$$

One other example will suffice: A cloth is to be finished 95 by 135 per inch; the design paper is 12 by 15, and the machine has 40 hooks to the twelve needles:—

One square of design paper = 40 warp threads.

One square of same design paper $=40\times\frac{135}{95}=57$ nearly, weft.

But there are 15 divisions weft way:—

$\therefore \frac{57 \text{ picks}}{15 \text{ cards}}=3\frac{4}{5}$ picks per card $=\frac{19}{5}$, or 19 picks on 5 cards. This would require a ratchet with 19 teeth and a disc cut to give 4, 4, 4, 4, 3.

To utilise the same set of cards for a finer or a coarser cloth in the way of the weft—that is, with a greater or a less number of picks per inch,—it is only necessary to

increase or reduce the number of picks per card in the corresponding proportion. If a cloth is working with three picks to the card to be finished 80 by 80, and it is desired to work a cloth 80 by 120 with the same cards, it would be necessary to give:—

$3\times\frac{120}{80}=4\frac{1}{2}$ picks to the card, or 9 picks on two cards, *i.e.* a 5 and a 4.

It is not, however, so simple a matter to alter the sett of the cloth in the way of the width and to use the same cards. If the sett be increased, it becomes necessary to use a machine of greater capacity; but if it be decreased in fineness, it is possible to use the same cards and machine by "fileying" the latter down—*i.e.* casting out hooks not required at regular intervals to the necessary extent. To do this it is evident that the machine must be refilled, since not only must every needle be employed to ensure the pattern being complete, but hooks must be left out in fives or eights, as the case may be, in order to keep the twill even or continuous.

For example, a 24-row machine may be reduced to a 20-row machine, even although working on an 8-end twill, by taking four hooks off the end of one row, and four off the beginning of the next row, or eight altogether. This is reducing the sett by one-sixth. The machine would now require to be refilled with 20 hooks to 12 needles, or 2, 2, 1, for 4 times. This, of course, entails new needles in many cases, and a machine refilled in this fashion, although containing 20 hooks to the row, is not suitable for the 5-end twill, since the hooks are not all omitted at one end of the row.

Further examples of this fileying, or reducing, process are as follows:—A 25-row machine working the 5-end twill may be reduced to a $22\frac{1}{2}$-row machine by removing 3 hooks from the end of one row, and 2 hooks from the beginning of the next. The machine would then be refilled as follows:—

All odd rows—5 needles with 2 hooks each } twice over.
1 needle ,, 1 hook }
All even rows—11 needles ,, 2 hooks each } once.
1 needle ,, 1 hook }

Again, a 32-row machine may be reduced to a 28-row by taking 4 hooks from the end of one row, and 4 hooks from the beginning of the next. The order of refilling would then be 3, 2, 2, for 4 times. Under this system it is possible to reduce the capacity of a twilling jacquard to any extent or degree intermediate between its full capacity and a full-harness or 12-row machine; the latter point being occasionally reached in practice.

By the same procedure,—viz. by altering the picks per card and the capacity of the machine—the dimensions of the cloth and the pattern may be varied to a considerable degree both in length and in width without any variation being made in the sett of the fabric, and without in any appreciable measure affecting the original proportions of the fabric, or the design.

One general defect inseparably connected with pressure harness and twilling jacquard weaving, and to which reference has already been made, is the somewhat ragged and broken appearance which appears on the outline of the figure upon the cloth. This is due to the fact that one needle controls two or more adjacent threads according to the number of hooks per needle or to the threads per mail; also to the fact that two or more picks are given to each card. The result of this is, that although the pattern

changes by steps of one on the design paper, the same step on the cloth is represented by two, three, four, or even more threads and picks. In very fine damasks this fault is not so prominent, but as the cloth decreases in fineness, and as the number of threads per mail or hooks per needle is increased, the defect becomes more pronounced.

A further objection to cloths woven on this principle, and one which has hitherto been an eyesore to the trained observer, is the fact that where straight vertical or horizontal lines of any considerable extent occur in the pattern, only one of the edges of the line "cuts" or binds properly with the adjacent ground weave. Where the stripe is continuous throughout the piece, it is possible to bind the faulty edge by making a wrong draft in the harness; but this solution of the difficulty is available only in such cases. When the ground and figure weaves twill in opposite directions, as in full harness, the perfect cutting is easily effected, as will be seen by Fig. 168, which shows 8 threads and 8 picks of figure surrounded by the ground weave; but the method adopted for twilling in both the pressure harness and the twilling jacquards causes the twill in both ground and figure to run in the same direction; hence the stitching points of the ground and of the figure twills do not "cut" at both sides of the figure. This matters little in curved lines, as the change of angle in these generally creates sufficient binding of itself, but in straight lines either along or across the piece it is always possible for the thread at one edge of the line to work away from its proper position in the cloth, thus giving the idea of a fault in the weaving. In rectangular figures three of the sides are imperfect, as will be seen by referring to Fig. 169. Here the only binding point is that made by the 8th and 9th threads on the 11th pick, the other three sides allowing the figure to work loose to an undesirable extent.

Since the above objectionable feature is generally corrected in full-harness designs by cross twilling, as in Fig. 168, it would appear that the simplest way out of the difficulty would be to construct the jacquard to twill the ground and figure accordingly. Cross twilling by mechanical means was introduced, but when the twills are produced mechanically, the principles of binding impose so many limitations on the designing of the pattern, and

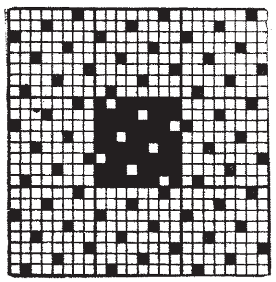


Fig. 168.

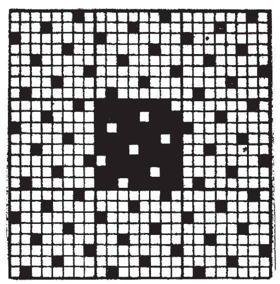


Fig. 169.

upon the working of the jacquard, that the method was found to be well-nigh impracticable. For example, if the jacquard were working the 8-thread twill it would be necessary to give every card either two or four picks, since every change from ground to figure must be made in multiples of four picks in order to bind properly. If the arrangement were for 3 picks per card, a change from ground to figure would require to be made in multiples of 12 picks. When weaving three picks to the card with the 5-thread twill, no change could be made under 15 picks, while with four picks to the card the minimum number is 20.

Changes in the warp with the 8-thread twill require to be made in multiples of four. On a 24-row machine this could be obtained by painting the design in multiples of two, but with a 32-row machine it would be necessary to paint in multiples of three, as the first two needles take six hooks, and the third needle two hooks, or eight hooks in all; the pattern would therefore require to step in 8's. With a 40-row machine, which is arranged 4, 3, 3 repeated, it would be possible to obtain a four by the first needle alone, but the next multiple of four would not be obtained until 16 hooks or threads were taken. With the 5-thread twill, greater difficulties are encountered in the painting of the design and in the arranging of the machine to work the cross twilling, since at every fifth shot it becomes necessary to lift and to leave down hooks of the same row.

Other efforts have been directed towards obtaining the binding effect automatically without cross twilling, and without limiting the design, but so far the method is applicable to warp threads or to vertical lines only. Its application complicates an already complex machine, and so far it has been adopted only in a few cases. Self-twilling jacquards are also made by which the ground twill of the cloth may have shorter floats than those in the twill used for the figure. In full-harness work it is not unusual in certain medium qualities to develop the figure pattern in 8-thread twill, while the ground weave is the 5-thread twill, and the above-mentioned machines reproduce this effect automatically. They are subject to the same general defects as the ordinary self-twilling jacquards, with the additional objection that rectilinear figures are not bound anywhere with regularity, and that the principle is restricted in its application to complete machines. Nevertheless it is an ingenious machine, and on the whole does the work as satisfactorily as can be expected when the difficulties to be encountered are considered. The chief feature of the jacquard is the provision of two griffes in different planes which rise and fall together. Each upright wire is provided with two hooks at different levels to correspond with the two griffes. The top griffe lifts all pattern hooks in the ordinary way, and the griffe blades are controlled as usual to leave down every eighth hook to form the pattern twill, while the effective part of the second or lower griffe is not continuous but in sections, and so arranged that it can move longitudinally to take up the hooks in the 5-thread sateen order.

Where jacquards are more or less extensively used as the shedding mechanism it is desirable for many reasons to have a simple and ready means of turning the card cylinder backwards or forwards rapidly in order that any desired card may be brought into position to face the needles. While this is necessary in all harness weaving when a weaver requires to "pick back," *i.e.* to remove a number of shots of weft in order to correct a fault in weaving, it is still more necessary with almost all self-twilling jacquards, where the patterns are generally of such a nature that it is usually essential to run or turn back the cards rapidly to a given point without weaving, and where it would be too expensive to provide a set of cards sufficient for the complete length of the cloth without repetition. As a matter of fact in many cases it would be impossible to accommodate such a complete set. For example, to weave certain table-cloths each of three jacquard machines requires 4500 cards from start to finish, but the pattern on the last 1800 cards is the same as that

on the first 1800 cards but in the reversed order, while the pattern on the central 900 cards is not repeated. The complete pattern may therefore be produced by providing 2700 cards only, and weaving straight on from card No. 1 to card No. 2700, then reeling back the last 900 cards without weaving until No. 1800 is reached, and then to continue weaving with the remainder of the cards working backwards from No. 1800 to No. 1.

In many cases no special provision is made for the reeling back of the cards, with the result that they are often torn by the weaver as she pulls them round by hand. In other cases an apparatus of a makeshift nature is provided, which acts more or less indifferently. A card reeler which has been found to give perfect satisfaction, and which is patented by Mr. Alexander Duncan, is that illustrated in Figs. 170 and 171. It consists of two shafts A and B which are mounted on the cylinder frames C, and therefore moves out and in with them; sprocket wheels D, D on shaft A; pitch chains E, E and sprockets F, F on the card cylinders G, G. Further sprocket wheels H and J and short pitch chain K are provided in cases where the cards fall over the warp, *i.e.* when they are at the back of the loom, in order that the large sprocket wheel L, in this case compounded with J, may be mounted on the rear end of the cylinder slide rod M, and thus be more or less vertically above the front rail of the loom on which the hand sprocket wheel N is mounted in a convenient position for the weaver. When the cards fall over the weaver's head the sprocket wheel L is fixed on the shaft A, sprockets H and J and chain K being dispensed with, and the long pitch chain O falls directly from shaft A to hand wheel N. Small pulleys are mounted at suitable intervals on shaft

B, and are connected by straps P to the spring hammers

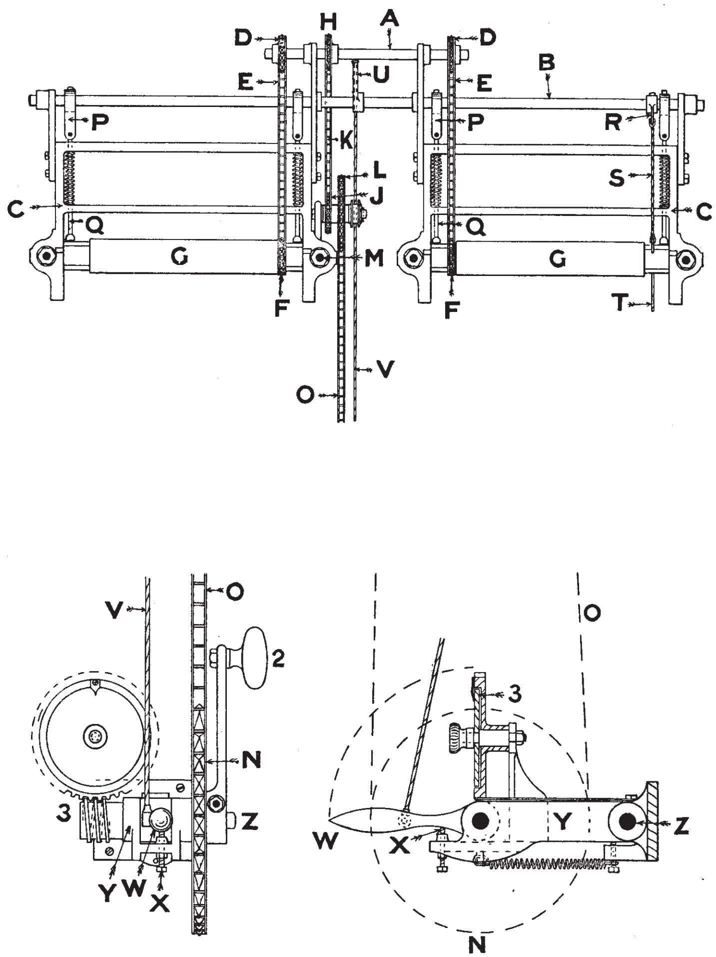


FIG. 170.

Q, so that the latter may be lifted clear of the cylinders

when the cylinders are required to rotate. A short lever R, also fixed on shaft B, and cord S raise the double catch T for similar reasons. Spring hammers and catch are raised by the weaver's hand through lever U,

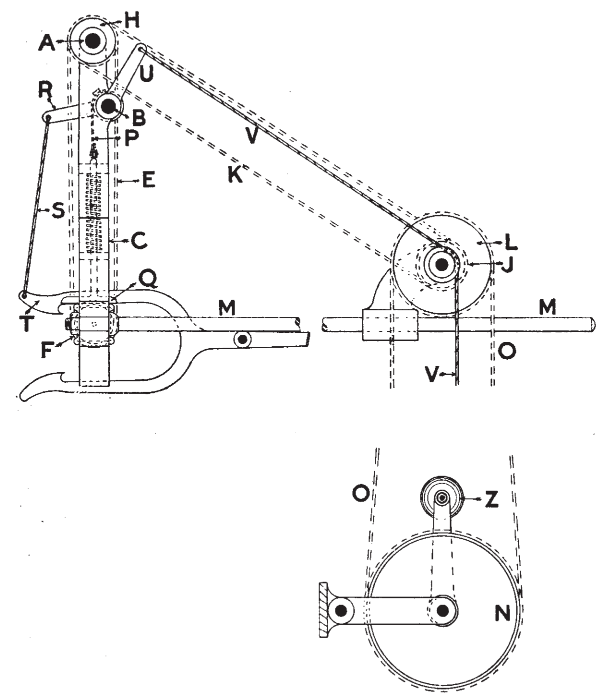


FIG. 171.

cord or wire V, and lever W fulcrumed upon the spindle to which sprocket N is fixed. Since the catch T is double, for working backwards as well as forwards, a stop is provided in set-screw X to limit the travel of lever W and thus prevent the bottom catch from being raised into contact with the cylinder head when the weaver is reeling back. Bracket Y is flexibly mounted on the short spindle Z in order that the chain O may accommodate itself to the slight variations in distance between the centres of sprockets L and N, due to the movement of the slide rods.

It is of course necessary that the cylinders should be placed out of reach of the needles before any attempt is made to reel back the cards, but that being done, the weaver simply pulls lever W down to the horizontal position with the left hand, and rotates the hand wheel N with the right hand as rapidly as she can. Various ratios of gearing can be arranged, but 4 or 5 cards for one revolution of the hand wheel N gives a sufficiently rapid movement to the cards. Five cards per revolution makes mental counting of the cards reeled a simple matter for large numbers, but four cards per revolution enables the weaver to count or to place single cards in position with greater certainty, since the handle 2 must always occupy one or other of the four cardinal points of the circle.

A numbering or counting apparatus, consisting of the usual worm and worm wheel, and shown at 3 may also be provided, but this is usually neglected by the weavers, who prefer to count mentally where counting is necessary. Further advantages of this motion, besides the saving of time and of cards in reeling, are the facts that it ensures simultaneous turning of all cylinders, and simplifies the method of controlling them, since one catch does for all, and only one shotting disc is required for self-twilling jacquards although four machines may be mounted on the same loom.

Harness Mounting.—This term is applied generally to the method of connecting the hooks of the jacquard with the mails or heddles through which the warp yarn passes. Of the two well-defined methods of mounting—viz. the London and the Norwich ties,—the former is what might be termed the more complex system, and is seldom found in the jute or linen industries. In this system the long sides of the jacquard cylinder and of the harness reed or comber-board are at right angles to each other, with the cards falling over either end of the loom. This entails a quarter-turn or twist upon the harness, and while perhaps improving its appearance to the eye and steadying it while working, undoubtedly has a tendency to shorten its life because of the friction generated between the harness cords. It possesses an apparent advantage in the fact that the harness cords may be taken from any side of the jacquard to either the front or the back of the comber-board, thus permitting the draft of the yarn to be straight from front to back, or vice versa, right across the web. This, however, is of little advantage, since it has no effect on the direction of the twill in those portions of the pattern that are mounted backwards or centre tied. For other reasons, such as cases where a number of machines are situated over one loom, and in factories where probably every loom is employed on damask work, the Norwich, system is much more suitable. A further advantage obtains in the latter system when the driving connections and the card space are considered.

In the Norwich system of mounting, the lines of the jacquard cylinder and of the harness reed or comberboard are parallel, while the cards fall either over the warp or over the weaver's head. This gives a straight and simple harness, but the harness cords to the back or to the front of the comberboard must be brought from the corresponding side of the machine. This causes the draft over any turned portion of the harness to run in a direction opposite to the normal, which may be either from back to front or from front to back, beginning at either selvage.

We hope to illustrate and describe the particular mountings or ties necessary for different patterns in a future volume. In the actual mounting of the harness, probably the first points demanding consideration are the height and the position of the machine or machines. The former may vary according to the overhead space available, but generally it should be as much as possible in order to give sufficient drop to the cards while working, and yet leave enough head-room for the weaver; besides, a good height makes the motion easier on the harness, especially if over a wide loom. Machines over narrow looms can be placed at a less height than those over broad looms, since the harness does not open out at so sharp an angle. It is, however, usually more convenient to have one recognised height for all; from 10 feet to 12 feet from the floor to the jacquard is the usual distance.

As to the general position of the machine, this should be arranged so that the central hook of the jacquard, or the central point of the machines, if two or more are to be used, should be vertically over the central point of the comberboard. Beams for supporting the machines may run either with or across the line of the comberboards. The former method is decidedly preferable with the Norwich system of mounting, as it is then only necessary to arrange all comberboards in a line, no matter what the widths of the looms may be. Any practicable number of machines may also be arranged over one loom without any alteration of the distance between the beams. A further advantage is that the beams form a suitable support for the shaft from which

the griffes of single-lift jacquards are driven, besides in many cases affording a suitable base for the feet of the machine itself. This latter is not always advisable, however, since different machines may vary considerably in width; indeed, it is now a fairly extensive practice to leave a space between the beams large enough to meet the requirements of the widest machine which is likely to be used. The machine is then supported by short cross beams or stools bolted to the main beams. Cast upon the upper surface of these stools, which are so constructed as to act as oil drip pans, are hollow pedestals to which the feet of the jacquard are bolted. The main beams may be of timber of satisfactory dimensions, but a stronger, lighter, and more convenient, as well as a more sightly, support is the rolled-steel inverted channel girder, similar to that indicated at A, Fig. 172, or a girder of the usual I section. Brackets may be designed for use with these girders which render it unnecessary to drill the beam for bolt holes at any point. These girders or beams may be supported either by suitable hangers from the roof of the shed, or, and preferably, on special columns from the floor. One method of supporting the machine and the driving shaft is shown at B and C respectively in the same figure.

Comberboards or harness reeds D are necessary in order that the harness cords E and mails F, Figs. 172 and 173, may be kept in their proper position and at the desired width. Comberboards are sometimes made of one solid piece of hard wood drilled to the correct pitch or sett; but the more modern method is to build them of small sections of thin hard wood, each section containing three or four rows of holes. The desired width of the board is then obtained by fixing the necessary number of sections into a grooved frame. Since the comberboards wear away much

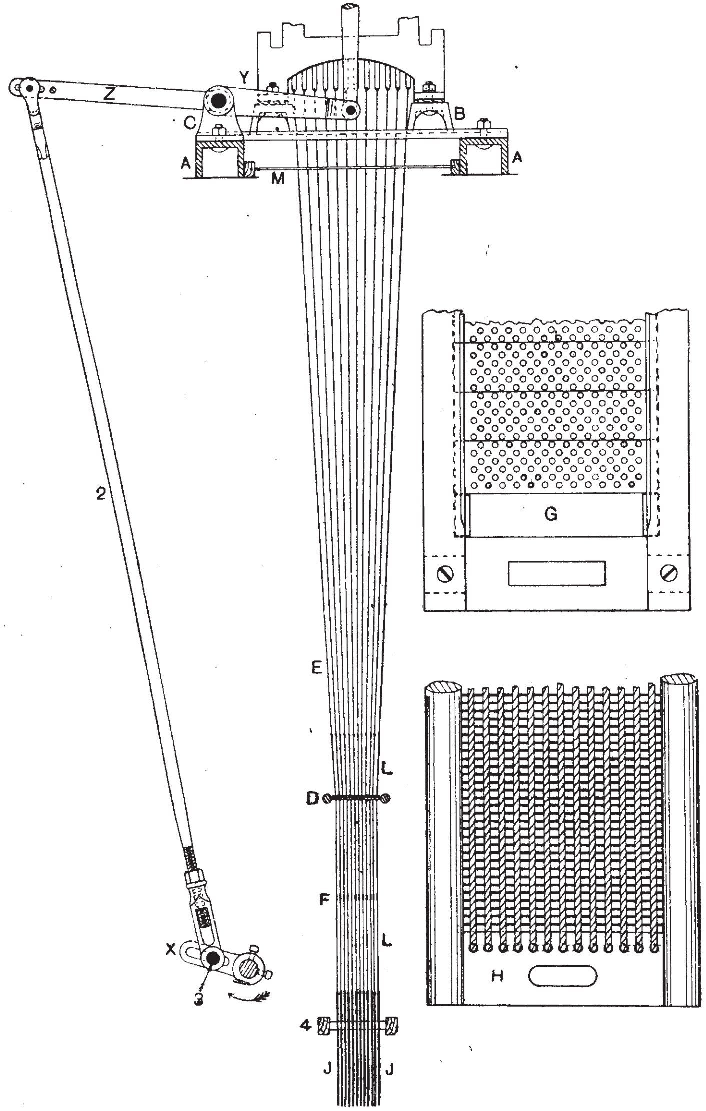


Fig. 172.

more rapidly near the ends than in the centre, this arrangement of sections offers an economical means of replacing worn portions, besides affording facilities for slight adjustments in the width.

Holes are drilled to suit any sett of fabric, but a row from front to back of the board must contain the same number of holes as there are hooks in a row of the jacquard from needleboard to spring box, alternate rows of holes being usually arranged in a zigzag manner as indicated in the detached plan view G, Fig. 172. In double-lift machines two hooks will, of course, count as one. The relation between the sett of the comberboard and the sett of the cloth, reed, or warp may be found as follows:—Suppose a cloth is to have 60 threads per inch of warp in the reed, and is to be woven by a 600's jacquard. It is evident that the board must have 12 holes in a row across and 5 rows per inch, or $12 \times 5 = 60$ holes per inch. If the same cloth were woven by a 400's jacquard, the board would require only 8 holes in a cross row, with $\frac{60}{8}$, or $7\frac{1}{2}$ rows per inch—in reality, 15 rows in 2 ins.

Harness reeds are constructed on the same principle as loom reeds. They fulfil the same purpose as comberboards, are cheaper, and in many respects more satisfactory. They are as adaptable to all changes of work, are as easy upon the

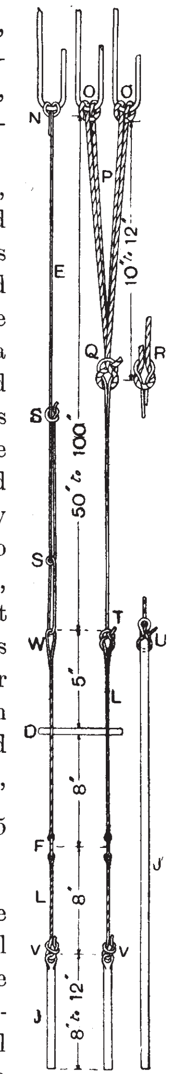


Fig. 173.

harness, and are free from the annoying saw-cuts found in worn comberboards; in general, however, comberboards are more suitable than harness reeds for the "London" method of tying. Harness reeds may be built to any sett, the longitudinal divisions being obtained by passing cords or wires from end to end of the reed, as shown in the detached view H, Fig. 172. The cords may be varied in number as required. Harness and loom reeds should be built on the same basis, so that calculations may be simplified. Given a 50-porter weaving or loom reed, 2 ends per split, the warp being controlled by a 400's jacquard, this would require a $\frac{50 \times 2}{8} = 12\frac{1}{2}$-porter harness reed. This sett of reed could be built, but, in some cases, it might be advisable to use a 13-porter reed and miss or "filey" every 26th row $\left(\frac{13}{13 - 12\frac{1}{2}} = \frac{13}{\frac{1}{2}} = 26\right)$ if there were no broken rows in the mounting of the jacquard. With broken rows in the mounting it is generally necessary to have a finer reed or board than the calculation shows, in order that the harness may not be too wide. Given a 45-porter reed, with three ends in a split and warp controlled by a 600's jacquard, the harness reed necessary would be $\frac{45 \times 3}{12} = \frac{45}{4} = 11\frac{1}{4}$ porter. This would be obtained by using a 12-porter reed and missing splits or rows as follows:—$\frac{12}{12 - 11\frac{1}{4}} = \frac{12}{\frac{3}{4}} = 16$, or every sixteenth row in the harness would be missed. As a matter of fact, the sixteenth row would not be missed entirely, but 6 harness cords would be inserted into the fifteenth split, and the remaining 6 harness cords into the sixteenth split; this would be equivalent to missing

one row in 16, and would also distribute the cords satisfactorily.

Harnesses may be built at the loom or in rooms set apart for the purpose. When the latter method is adopted the work may be done more expeditiously, and where changes of mounting are of frequent occurrence a considerable saving of time is effected, since the harness to be used next may be prepared while the loom is still weaving with the harness which is to be taken out. Both methods are widely practised, but it is generally more satisfactory to tie up the harness at the loom. In determining the position of the comberboard or harness reed, attention has to be paid to the travel of the lay, the lift of the jacquard, and the depth of the shuttle. The board should be supported at each end by slotted brackets, so that it may be moved closer to or farther from the lay of the loom as occasion requires. It should, however, be as low down and as far forward as possible consistent with the free movement of the harness, but clear of the upper shell or reed cap so as to avoid the danger of trapped fingers, and to leave a reasonable amount of room for taking up broken threads. After being placed in position, a harness reed is marked off into its various divisions of borders and centre portions by tying pieces of harness twine around or across the reed. Comberboards may be treated similarly, or chalked, as thought best. The reeds are then filled by dropping prepared lingoes, which consist of a mail F, a lingoe J, and the top and bottom couplings L, Figs. 172 and 173, through the proper split and row, while the boards are filled by drawing the top coupling up through the proper holes. All mails are then threaded upon light steel wires, which are in turn supported in a box or frame by a series of cross pins, which pass above and below those on which the mails are threaded, and retain them in this fixed position while the harness is being tied. This box, or frame, requires to be levelled very accurately across as well as along its entire length, and is usually made of stiff, hard wood (in wide widths preferably of wrought-iron bars), and is for the time being roped to the centre cross rail of the loom, to prevent yielding when tying up. The level of this box, or rather of the mails it contains, has to be very carefully determined, and is in many instances arrived at by means of a gauge which is found by experience to suit a given type of loom. This is cut to indicate the distance from the level of the breast beam to the upper side of the top cross pins. A more general way is to fix the frame so that the centres of the mails are half the depth of the shed plus $\frac{1}{4}$ to $\frac{3}{8}$ in. below the level of the breast beam. Thus, assuming the lift of the harness to be $3\frac{1}{2}$ ins., the centre of the mails would be $1\frac{3}{4}+\frac{3}{8}=2\frac{1}{8}$ ins. below the level of the breast beam. This does not always suit, however, since the position and the bevel of the lay relative to the level of the breast beam vary in different looms, and a better general guide might be to have the centre of the mail about $\frac{1}{4}$ in. under the line of the race of the lay continued backwards when the lay is full back. This extra depth allows for the slight contraction of the harness when the mails are released from the frame, and for the tendency which the lifted portion of the shed has to raise slightly the portion left down. Since the amount of contraction depends almost entirely upon the degree of tension imparted to the harness by the tier or mounter, it is practically impossible to give an absolutely correct rule. Previous to tying up it is, of course, necessary to attach a sufficient number of tail cords to the hooks of the machine, the number to each depending entirely upon the particular mounting. Thus, suppose a 600's jacquard

were to be mounted for a tablecloth, the border of which was arranged 200 double, with 100 single between, and to have six repeats in the centre of 300 each: the first 200 hooks of the jacquard would have four tails each (two for each border), the next 100 hooks would have two tails each (one for each border), and the last 300 hooks would have six tails each (one for each repeat). Selvages, etc., would have to be considered beyond this. Tail cords may be prepared in various ways, a convenient and simple one consisting in having a small frame in which several bobbins may be placed and on which the harness twine has previously been wound. The ends from these bobbins are then taken and warped around two wooden pins, fixed at a suitable distance apart, until the required number of tails has been obtained. If the harness is a narrow one, all the tail cords may be warped of the same length, but if of any considerable width it is more economical to warp them of different lengths to suit the different portions of the mounting. For this purpose one of the warping pins should be made adjustable. Harness twine should be made from the best flax yarns, and is usually 3, 4, or 5 fold, according to the class of work for which it is intended. A 4-fold 3 lb. to 4 lb. flax or 16 to 12 lea yarn makes a very serviceable and satisfactory twine for a wide range of fabrics. On the other hand, some prefer much finer yarns than the above, and for a similar class of work use 9 ply 30 lea. This certainly gives a superior cord, but it is obviously more expensive. With the view of reducing friction and of prolonging the life of the harness, it is customary to coat the tail cords with a wax varnish for about 8 to 10 ins. about the part which comes in contact with the wires of the heck M. For a similar reason the couplings L are varnished and twisted to within about 3 ins. of the upper end of the top coupling, the latter being left free of varnish at this point for the purpose of tying up to the tail cord. These latter are usually attached to the hooks of the Scotch type —that is, closed at the top of the bend, see 2, Fig. 129, in the manner shown at N, Fig. 173; or, as is sometimes done, the tail end of the cords may be passed through the loop of the twine a second time and then drawn tight. A further method of attaching, technically termed the clove hitch, is shown at O. This latter, however, although applicable in principle to both types of hook, is more generally used in the case of double-lift machines, for the attachment to the hooks of the neck cords P. Two methods of tying the tail cords E to the neck cords P are indicated at Q and R respectively, the latter being more easily tied, although the former is the more secure in this instance. The knot at Q is a fair representation of what is commonly known as the "weaver's" knot, and is also known as an over-thumb knot, or sheet bend, while that at R indicates what is very widely known as a reef knot. Both are regularly met with in the operation of weaving, and are therefore worthy of particular notice.

After being attached to the hooks of the jacquard, the tail cords are passed between the wires of the heck M in short rows, and the heck is then fixed in its position beneath the machine. Each long row of the harness is now twisted up out of the way, so that tying up may be proceeded with. Beginning with the back row of the machine—*i.e.* the one farthest from the weaver—the tail cords are leased up by the mounter, hook by hook in regular succession, and, when thus leased, are placed upon two special pins at the side of the loom in such a manner that the cords from the hook at the leading end of the machine can be taken off first. These are now taken and

severally tied to their respective couplings L in the various repeats or portions of the mounting. Cords from the second hook of the same row are next taken and treated similarly, the process being continued until that row is finished and dressed, when the next row is taken, and so on until the harness is completed.

Of the several ways of attaching the tail cords to the couplings, two of the most generally employed are shown in Fig. 173. When there is a probability of the width of the harness being altered, the method indicated at S is most convenient, since it is possible to untie the cord and remount it for a slightly wider or narrower width. This method consists in passing the end of the tail cord through the loop of the top coupling L, then casting it around the main cord about 3 ins. up, and finally tying it as indicated at a farther distance up of 6 ins. This arrangement holds quite satisfactorily, since the twine is dressed or starched after tying. The second method, indicated at T, makes a neat and satisfactory tie, and may of course be used with the tail cord coming direct from the hook, as well as from the neck cords of a double-lift machine. The neck cords P should be about 10 to 12 ins. long from hook to knot, and the latter should be at least 3 ins. clear of the heck beneath. The lingoes J vary in length from 8 to 12 ins., and in weight from 20 to 40 to the pound for ordinary work. For some of the heavy jute fabrics, lingoes, weighing 4 ozs. each, or even more, are used. In many cases the threads forming the borders require heavier lingoes than those threads which form the centre of the fabric; this is due to the smaller angle made between the cords and the comber-board, and the consequent increase of friction. The ordinary lingoes are now invariably made of wire, flattened and punched at one end to receive the ends of the bottom coupling twine L. These are passed through the hole and tied round the lingoe, as indicated at U; this knot is then slipped up over the head of the lingoe, the ultimate result being shown at V. The two ends of the top coupling twine are simply tied together in a weaver's knot about W. The mails F are usually of brass for fine or medium work, and of steel for coarse or heavy fabrics. It is advisable to have the lingoes J surrounded by a wooden or other framework 4 to prevent them from swaying. This framework should be divided into compartments, about 3 to 4 ins. long, by means of cross-plates or wires passing between the lingoes.

Fig. 172 also shows what is probably the simplest and most efficient method of driving single-lift jacquards; that is, by means of a simple crank X set-screwed on the extreme end of the crankshaft of the loom. The slot in X permits of sufficient variation in lift being obtained, while adjustment as to time of shedding is arranged by altering the position of X on the crankshaft with relation to the crank for actuating the swords. Assuming that a lift of the harness of $3\frac{1}{2}$ ins. is desired, the griffe of the machine would require to travel about 4 ins., since the blades must clear the hooks by about $\frac{1}{4}$ in., and the heads of the hooks are from $\frac{3}{16}$ to $\frac{1}{4}$ in. deep. Four inches of a lift means that the lever Y (11 ins.) moves 4 ins. at its extremity, and that the lever Z (16 ins. to the point of connection with the rod 2) must move $\frac{4 \text{ ins.} \times 16}{11} = 5\frac{9}{11}$ ins., say 6 ins. The stud 3 must therefore be fixed 3 ins. from the centre of the crankshaft. As to the time of shedding, this is in a measure subject to circumstances, but the ideal position is undoubtedly to have the crank X and the rod 2 in one straight line, with the griffe at the extreme top position, when the crank of the loom and the connecting arm to the swords are also in one straight line, with the lay full back.

In setting a double-lift jacquard for time of shedding, the same general principle may be followed: place the lay of the loom full back with the crank and connecting arm in one straight line, and fix the double-throw crank on the wyper shaft with one of its crank pins in a straight line with the centre of the shaft and its connecting rod. It is further necessary to see that each griffe, when in the lowest position, is exactly the same distance below the hooks, and that the cylinders are timed to correspond; the cylinders should be close to the needle board when the griffe is rising, with the blades on a level with the heads of the hooks.

CHAPTER XIII

PICKING

PICKING, the technical term invariably applied to the operation of driving the shuttle from side to side of the loom, is necessarily timed or arranged to follow the action of shedding in the sequence of weaving operations. To an untrained and casual observer this operation generally seems a simple one, but there is probably no movement of the loom more elusive as regards the effect of the actions which take place, and certainly no other part of the mechanism of a plain loom which gives more trouble to, or requires more attention from, mechanic and tenter alike. Nor is this surprising when one considers closely the varying conditions under which the mechanism has to act, the functions it is required to perform, and the many different parts of which it is composed. Conditions such as light and heavy warps vary the friction on the shuttle in its passage through the shed. The shuttle itself is a practically rectangular piece of hard polished wood, tapered at the ends, and tipped with iron; it measures, in an average case for ordinary jute fabrics, 20 ins. long by about 2 ins. sq., and weighs 2 lbs., but varies in weight for other yarns and fabrics from something under 12 ozs. to 3 lbs. and over, with a proportionate variation in dimensions. Such a body in a 46-in. reed space loom, running at 150 picks per minute, has to travel an approximate distance of 63 ins. in about $\frac{7}{45}$ of a second. It must therefore attain an average velocity of at least 34 ft. per second without making any allowance for frictional or other resistance. At or near the end of its journey it is more or less abruptly brought to a dead stop; during this time its remaining energy is utilised in pressing out the swell, and raising the tongue of the warp protector clear of the "knee" or "frog," thus permitting the loom to run. Consider also the fact that the plane or race board on which the shuttle travels is not stationary during the passage of the latter, but that, on the contrary, it moves backwards and downwards with a decreasing velocity, comes gradually to rest, and again moves forward with an approximately equal increasing velocity; also that the plane itself is not smooth, since it is formed by that portion of the warp yarn in the lower part of the shed. Then again as the shuttle runs, its load decreases gradually as the weft is withdrawn from the pirn or cop; and, as momentum varies in proportion to mass, it is evident that the force or "pick" must be sufficient to send the empty shuttle across, and will therefore be more than necessary for the shuttle and yarn combined. Further, since the eye of the shuttle is in the front near one end, there will be a certain pull

exerted by the weft thread when travelling in one direction, creating a tendency in the shuttle to leave the reed, and when travelling in the other direction, tending to make it bear hard on the reed. When consideration is also given to the fact that the picker in many looms travels along a spindle which is moving in a direction approximately at right angles to the path of its own travel, that picking arms, and leathers where necessary, are more or less elastic, and that the whole action partakes very much of the nature of a shock, it will be seen that the question is one of considerable difficulty when considered closely in detail.

Of the picking mechanisms employed there are only two types which are usually applied to looms for jute and linen weaving, and of these two the one which is by far the more widely adopted is the cone overpick—the term "cone" being taken from the fact that the anti-friction roller upon which the picking wyper acts is conical in shape, while the term "overpick" is applied in all cases where the picking arm proper is wholly above the shuttle-box. In the pick under consideration the mechanism consists of a picking wyper or tappet A (Figs. 174 and 175) keyed to the bottom or wyper shaft B, and therefore revolving with it; also of a stud C (carrying a conical anti-friction roller) firmly bolted in a tapered hole in the vertical shaft D, to the head E of which is clamped a wooden picking arm F. The head E is invariably made in two portions, an upper and a lower, the faces of which come together and have radial teeth cast upon them to ensure a rigid grip, while permitting any necessary adjustment in the position of the arm F. As the shaft B revolves, the wyper A, in a rapidly increasing ratio, drives the cone stud C through a certain arc of movement (the effective value of which depends upon the stroke of A, and also upon the point of contact of A with

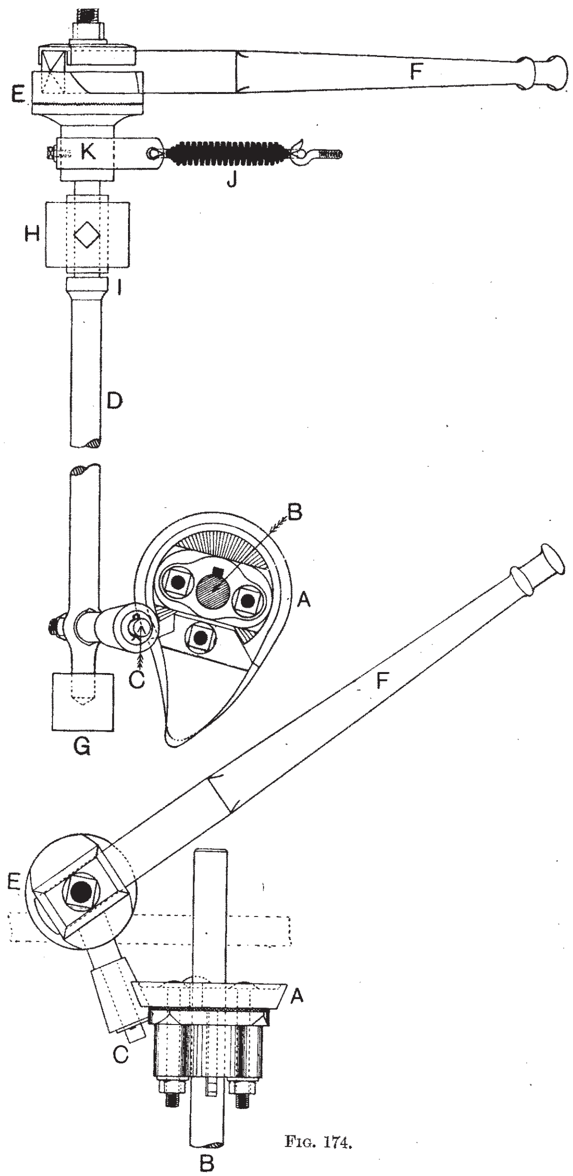


Fig. 174.

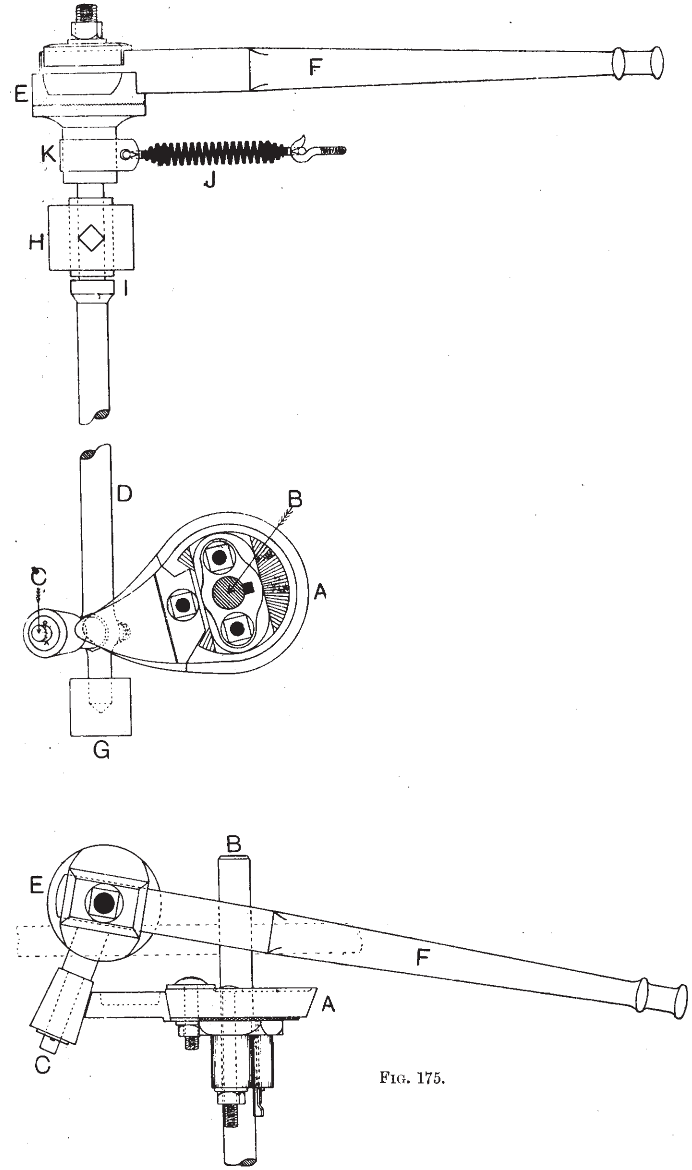


Fig. 175.

the cone), the shaft D rotates, and the arm F travels rapidly inwards. From the extremity of the arm F a leather strap is connected to the raw-hide picker on the picking spindle (see Fig. 83, page 153), and thus conveys the movement of the arm to the shuttle.

Figs. 174 and 175 show respectively the wyper A, and therefore the arm F, at the beginning and at the end of the stroke. The shaft D is supported by a footstep G at the bottom, and in a bracket H near the top. Both G and H are cast upon or bolted to the outside framework of the loom, so that the wyper A may be brought as close as possible to the bearing of the shaft B in the framework, securing by this arrangement the greatest amount of stability and rigidity in action. On the shaft D a shoulder I is formed, which impinges against the bush in the bracket H, and counteracts the tendency of the wyper A to impart a vertical movement to shaft D. This might be termed the one objection to revolving the crankshaft in the direction shown in Fig. 58 (page 114). When revolved in this direction the wyper A must always act upwards, and as the bush in the bracket H is simply held in position by a set-screw countersunk into the bush, it is in time driven upwards, by the action of shoulder I enlarging the countersink, until a very harsh pick results, producing an exceedingly undesirable vibration in the loom. As things are at present situated, the only remedy is to turn the bush partially round and drill out a fresh countersink; but we think it is worthy the attention of loom-makers to try to devise some method of fixing the bush in such a manner that the impact of the shoulder I would be taken up by the bush as a whole, and not by the point of a set-screw, and that play, if any, could be taken up in a better method than at present.

In looms which revolve in the direction shown in Fig. 59, page 115, the wyper always acts in the downward direction, the impact here being sent into the footstep G. In many looms where this downward motion obtains, the shaft is not provided with a shoulder I, consequently D rebounds slightly immediately the pressure of the wyper A has left the cone stud C. When acted upon in this direction the cone stud C should be as much above the level of the shaft B as it is shown below that level in Figs. 174 and 175.

There is one decided objection, however, to revolving the crankshaft in this direction. When the loom is at rest the crank is liable to fall, or to be accidentally pushed to the bottom position, and, as this is near the picking position, the shed is open, and the crank in an undesirable position for restarting the loom; in addition to this the warp threads are in tension, and the weaver is given unnecessary trouble in taking up or mending broken threads. It also follows, that in many cases during the whole period of rest, the threads are in tension, whereas with the wyper revolving as in Figs. 174 and 175, the leaves in plain cloth are level, and the threads therefore slack, when the crank occupies the lowest position. It will be understood that a duplicate set of similar parts to those shown in Figs. 174 and 175 is arranged at the other side of the loom for the purpose of returning the shuttle, the only difference being that the wyper A of the second set is fixed with its point diametrically opposite to that of the first set.

After being acted upon by the wyper, the stud C and the arm F are returned to their original positions by the action of the spring J, which is hooked to the top rail of the loom by one end, and secured by the other end to a strap K, set-screwed to D as shown. In some cases the cone stud C, instead of being in a fixed position in shaft

D, is so arranged that its position or plane with regard to the plane of the wyper shaft B may be changed. When this is so, the shaft D may be slotted for a short distance, and C bolted in the slot; or the inner end of C may be enlarged and bored out to receive the shaft D, to which it is so keyed that the action of the wyper always tends to tighten C on the shaft.

Everything considered, we are of opinion that the adjustable stud is not so satisfactory as the fixed one, since, although intended as a ready means of hardening or softening the pick of the loom, and being in some cases necessary, due to badly designed picking wypers which allow of no lateral adjustment on the wyper shaft, they are often, through ignorance or indifference, found too near the same level as the wyper shaft itself, allowing the wyper A to get too much under the cone, and thus sending the force intended for picking, vibrating through the loom instead.

As the cone stud C traverses a horizontal plane throughout its movement, it follows that the smoothest working pick will be obtained when the force acting upon C acts in the line of its movement, and that any tendency to force it upwards or downwards, as the case may be, is simply energy spent in destroying some portion or other of the loom. It is practically impossible to make the picking wyper act in a perfectly horizontal direction, but as in the construction of any picking wyper the stud C is assumed to be a certain distance above or below the level of the shaft B, this position should always be rigidly adhered to, and on this account it is an advantage to have the stud C a fixture in shaft D.

For practical and economical reasons, such as replacing worn or broken portions, the wyper A is built of three

parts: the truck or boss L (Fig. 176), the circle or plate M, and the point or nose N. The truck L, which is keyed to the wyper shaft, is provided with radial teeth on its face to take into corresponding radial teeth on the face of the plate M, to which it is bolted through the bolt-holes O in the truck L and concentric slots P in the plate M. The point N is semi-dovetailed at Q, and is bolted to the plate M, which is grooved to receive it. The slots P permit of a certain amount of adjustment of the wyper with regard to the time of picking; but if further adjustment be

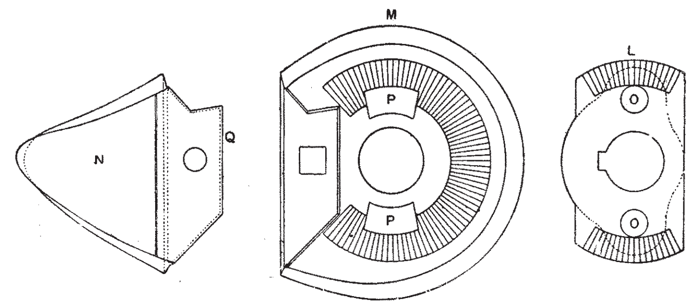


FIG. 176.

necessary, it can be obtained by taking the spur pinion and spur wheel of the crank and the wyper shaft out of gear, and advancing or retarding the wyper shaft by one or two teeth as may be desired.

In approaching consideration of the construction of a picking wyper, it would appear that one of the first points which would naturally fall to be considered is the velocity at which the shuttle must travel. It is probably true, however, that in no case of actual practice has the construction of the wyper been approached from this point as a basis, but rather that the present form of wyper has been developed by years of experience and trial until its working outline has been reduced to some suitable form of geometrical construction.

Referring to the text in connection with Figs. 58 and 59, pages 114 and 115, the reader will readily see that the time available for the shuttle to travel across from box to box cannot be more than 165 degrees of the crank's revolution, otherwise the loom will knock off. The shuttle begins to move at the top centre, and it leaves the picker approximately 40 degrees later, so that the maximum angle for the travel of the shuttle is, according to the points marked in Fig. 58, $205° - 40° = 165°$. In many cases the knocking off position is at 180°, which leaves a maximum angle of $180 - 40 = 140°$. Now the total length of lay in a 46-in. reed space loom intended for jute fabrics is made up as follows :—

$$\text{Reed space} + \text{Two boxes} = \text{total length of lay}$$
$$46 \text{ inches} + (27 \text{ ins.} + 27 \text{ ins.}) = 100 \text{ inches,}$$

and the distance through which the shuttle has to travel is :—

Length of Lay.		Pickers and Box Ends.		Shuttle.		Travel of Picker.	
100″	−	[(3″ + 3″)	+	20″	+	11″]	= 100″ − 37″ = 63 ins.

Therefore the shuttle must travel the full distance of 63 ins. in 140° of the crank's revolution. If the speed of the loom is 150 revolutions or picks per minute, the total time occupied by the shuttle from the time it leaves one box until it comes to rest in the opposite box will be :—

$$\frac{60 \text{ seconds}}{150 \text{ picks}} \times \frac{140°}{360°} = \frac{7}{45} \text{ of a second.}$$

Therefore the average velocity of the shuttle over the full distance of its travel is :—

$$\frac{63 \text{ inches}}{12'' \text{ per foot}} \div \frac{7}{45} \text{ of a second,}$$

or
$$\frac{63}{12} \times \frac{45}{7} = 33{\cdot}75 \text{ feet per second.}$$

In the first edition of this work we based our estimate of the maximum velocity of the shuttle on its average velocity for its full travel, but it will be evident that greater accuracy in this direction will be obtained by basing the necessary calculation on the average velocity of the shuttle for that restricted time during which it is crossing the warp, for, immediately it comes into contact with the box front or swell, its velocity is rapidly diminished. From recent experiments conducted personally and under our supervision we are able to state that the shuttle in the above loom travels approximately 42 inches in 90 degrees of movement or one quarter of a revolution of the crankshaft. The average velocity of the shuttle on this basis is therefore :—

$$\frac{60 \text{ secs.}}{150 \text{ picks}} \times \frac{90°}{360°} = \frac{1}{10} \text{ second for 42 ins. travel,}$$

and
$$\frac{42 \text{ ins.}}{12 \text{ ins.}} \times \frac{10}{1} = 35 \text{ feet per second.}$$

The problem, therefore, is to construct a picking wyper which will act upon the stud C in such a manner that the arm F, in conjuction with other parts, will convey to the shuttle a maximum velocity sufficiently greater than the average velocity ultimately to overcome the resistances of friction, etc., which are presented to it in its passage from box to box. It is not our intention to attempt to deduce the force which must be developed to accomplish this, nor to discuss the particular distribution of metal contained in the loom frame, or the weight and dimensions of the parts employed, but it is naturally essential that all parts should have sufficient margin of strength to enable them to meet the force, and also to withstand the resistances due to the action of the swell upon the shuttle at rest in the shuttle-box.

We may now try to determine what the maximum or initial velocity of the shuttle must at least be in order that it may attain an average velocity of 35 feet per second. To do this, however, the following points should receive due consideration :—

1. The frictional resistances offered to the progress of the shuttle by the warp yarn, the reed, and the lay.
2. The retardation due to various changes of direction in the shuttle.
3. The retardation due to the pull of the weft.
4. The resistance of the air.

Of these the two latter are the least important, and a sufficiently close approximation to the value of the first one may be ascertained. The coefficient of friction due to this resistance, when starting the shuttle from a position of rest was originally determined by the authors as varying from 0·27 to 0·43 under normal conditions, but reaching as high as 0·53 in exceptionally adverse circumstances. In other words, when using a shuttle weighing 2 lbs., it would be necessary, under normal conditions, to exert a constant force varying from $2 \times 16 \times 0{\cdot}27 = 8{\cdot}64$ ozs. to $2 \times 16 \times 0{\cdot}43 = 13{\cdot}76$ ozs., or

an average of $\frac{8{\cdot}64 + 13{\cdot}76}{2} = 11{\cdot}20$ ozs. to keep the

shuttle moving through the shed, such variations depending upon the position of the lay, as well as upon the state of the shed, and the quality and weight of the warp. Facilities are not yet available for the due determination of the value of resistances 2, 3, and 4, and, in further consideration of the subject their value and influence have been neglected.

All moving bodies have, in virtue of their weight and motion, a certain quantity of kinetic energy stored in them which is represented by the formula :—

$$\text{K E} = \frac{Wv^2}{2g}$$

where K E = kinetic energy ; W = weight of the body in lbs. ; v = velocity in feet per second ; and g = gravitational attraction, 32·2. Therefore the energy stored in the shuttle of 2 lbs. weight calculated upon the average velocity of 35 feet per second will be :—

$$\text{K E} = \frac{Wv^2}{2g} = \frac{2 \text{ lbs.} \times 35^2}{2 \times 32{\cdot}2} = 38{\cdot}04 \text{ foot lbs.}$$

But, since friction acts to reduce the velocity, the above average energy will be less than the initial energy by the equivalent of half the frictional resistance, that is by

$\frac{3{\cdot}5 \text{ feet}}{2} \times 2 \text{ lbs.} \times 0{\cdot}4$ (the coefficient of friction, which we purpose using, and which is greater than the average of normal conditions) $= 1{\cdot}4$ foot lbs.

Taking the average energy as above, *i.e.*, 38·04 foot lbs., and the average velocity as 35 feet per sec., the initial or rather maximum velocity of the shuttle may be found as follows :—

$\frac{V+\mu}{2} = v$ where V = maximum velocity

v = average ,,

μ = velocity when the shuttle has travelled $3\frac{1}{2}$ feet.

Now $V^2 = \mu^2 + 2\ as$ where a = acceleration

s = distance travelled

and acceleration : gravity = frictional resistance : weight,

$\therefore\ a : 32{\cdot}2 = (0{\cdot}4 \times 2 \text{ lbs.}) : 2 \text{ lbs.}$

$$\text{hence } a = \frac{32{\cdot}2 \times 0{\cdot}8}{2 \text{ lbs.}} = 12{\cdot}88$$

$$2\ as = V^2 - \mu^2 \qquad (1)$$

$$v = \frac{V+\mu}{2} \qquad (2)$$

divide (1) by (2)

$$\frac{2\ as}{v} = \frac{2(V+\mu)\ (V-\mu)}{V+\mu}$$

$$\text{hence } \frac{as}{v} = V - \mu$$

Substituting values already found we have :—

$$V + \mu \text{ or } 2\ v = 2 \times 35 = 70$$

$$V - \mu \text{ or } \frac{as}{v} = \frac{12{\cdot}88 \times 3{\cdot}5}{35} = 1{\cdot}288,$$

$\therefore$ by addition we get

$$2V = 71{\cdot}288$$

or $$V = 35{\cdot}644 \text{ feet per second,}$$

and by subtraction

$$2\mu = 68{\cdot}712$$

or $$\mu = 34{\cdot}356 \text{ feet per second.}$$

It must be remembered that while the average velocity of 35 feet per second has been determined by experiment, the maximum and final velocities have been calculated, as already indicated, without consideration of the influences of the resistances alluded to in items 2, 3, and 4.

We shall now explain the construction of a picking wyper, the outline of which is very similar to many of those in actual use in looms for jute weaving, and will then endeavour to show how the combination of parts and power may develop the necessary maximum velocity which the shuttle must attain in the loom. Data necessary: distance from centre of vertical shaft D, Fig. 174 to centre of wyper shaft B = $6\frac{1}{8}$ ins. (see A to B in Fig. 177). Centre C of cone stud L over or under the level of shaft B, say $1\frac{7}{8}$ ins., see J to K, Fig. 177 (in looms with an upward beat this centre is above the wyper shaft, but in looms with a downward beat the centre is below the shaft). Distance from the centre of picking shaft A to the plane of centre of wyper = $5\frac{1}{4}$ ins. Angle described by the cone stud L = 37°, 30° of which are for the development of the pick, and 7° for rounding off the nose of the wyper. Acceleration to be given to the cone stud L, and therefore to the picking arm F (see Fig. 174) in the ratio of 1.2.4.6.10.18 for the first 30° of movement in six equal portions of time. Length of arm F from the centre of picking shaft D to point of connection with picking band, say $24\frac{1}{2}$ ins. Time for development of pick = 60° of the wyper shaft, and 10° for rounding off the nose. Approximately 40° of the first 60°, or 80° of the crankshaft, *i.e.*, from the time the lay is full forward, or about 10° above the true front centre until it reaches the top centre, are occupied in drawing up the band or strap, the other 20° of the wyper shaft or 40° of the crankshaft being occupied for driving the shuttle out of the box.

From any line, say B J in Fig. 177, which represents the line of the wyper shaft, set off B A at right angles

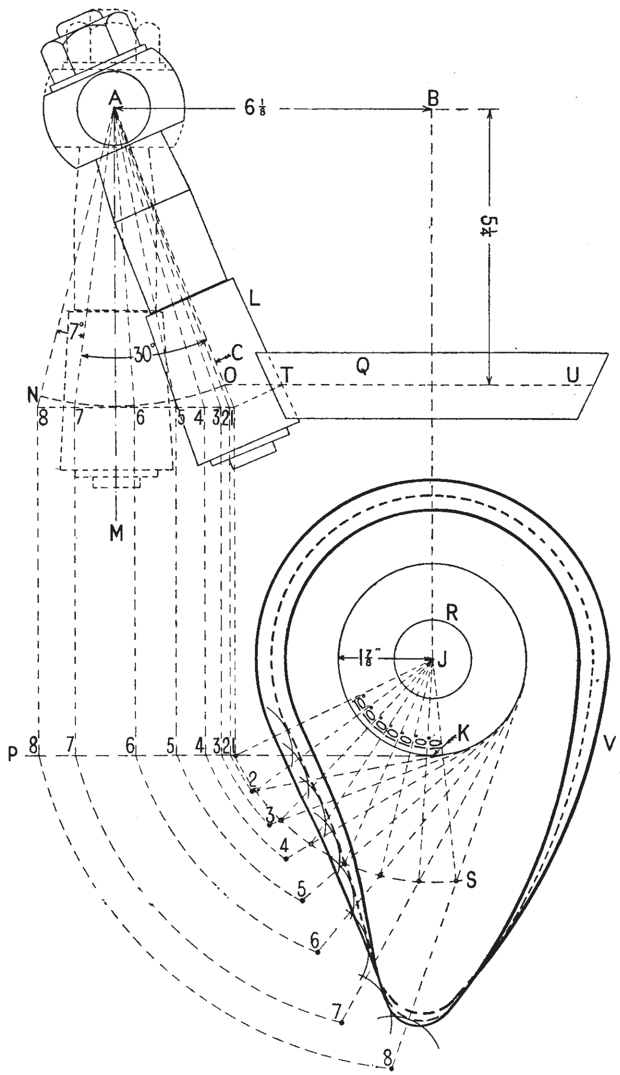


Fig. 177.

to B J and $6\frac{1}{8}$ ins. long. At right angles to A B draw A M parallel to B J. With A as centre and a radius of $5\frac{1}{4}$ ins. describe the arc N O so that the angle A N O equals 37° Divide the first 30° into six spaces in the ratio of 1.2.4.6.10. and 18. From centre A and through the points on this arc draw lines to meet the horizontal tangent to the arc at points 1.2.3.4.5.6.7. and 8. Project these points to line P K, parallel to A B, and sufficiently removed from the plane of the wyper Q to enable the elevation of the wyper to be drawn without interfering with the other parts of the drawing; or having chosen the centre J of wyper, draw line P K at a distance of $1\frac{7}{8}$ ins. below centre J. With J as centre describe circle R to represent the wyper shaft, and circle K to touch line P K, and join J to point 1 on line P K. With J as centre and J 1 as radius describe the arc 1 S. From point 1 on this arc set off 7 divisions of 10° each, or 70° in all; six divisions of 10° each are for the development of the pick, and one division of 10° for rounding off the nose. These points are represented by the small circles.

Since P K, the plane of movement of the cone stud L, is $1\frac{7}{8}$ ins. below point J, the centre of the wyper shaft, it follows that further lines representing this plane must be drawn tangentially to circle K. Seven further lines are therefore drawn tangent to circle K, passing through the circles on arc 1 S, and continued until they meet the corresponding arcs drawn from 1.2.3.4.5.6.7. and 8 on line P K and terminating at similar numbers 1 to 8. The points thus obtained represent the generating curve of the wyper and would be parallel to the face of the wyper if the same size of circle were drawn to represent the cone at these points. It will be quite clear, however, that the radii for the representation of the cone at the various points will be of different values, since the effective diameter of the cone is constantly changing. Further, on neither side of the central line A M can any two radii be of equal length. When the wyper is at the commencement of its stroke, the effective radius of the cone is O T, but as the stroke is developed, the cone is moved outwards, or to the left in the drawing, and the effective radius decreases until the cone and the wyper shaft are parallel, when the radius of the cone is at a minimum; while beyond the central line A M, the working radius gradually increases, but remains less than the corresponding radius on the right of the central line. Also since the central line of the wyper is only at one point perpendicular to the axis of the cone, it is necessary, at all places except this one point, to use the major axis of an ellipse instead of the diameter of a circle to form the primary curve. The primary curve of the wyper, shown in dotted lines in Fig. 177, has been obtained by using the proper radii as found by the position of the cone at points 1.2.3.4.5.6.7.8. on the arc NO. The major diameters of the ellipses coincide in each case with the tangential lines, and the major radius is the distance from the central line of the cone stud to the outside of the cone along a line in the same plane as the central line T U of the wyper.

Such a wyper, even if it were drawn geometrically correctly and cast and finished accurately, would work properly only in one position on the wyper shaft—that indicated in the figure. All wypers of this type are capable of being adjusted on the wyper shaft in order that they may move the cone through a greater or a lesser arc for the important purpose of imparting a harder or a weaker pick, but such changes should only be made when it is impossible to obtain the desired result from other sources. If a change

of position on the wyper shaft is absolutely necessary, it is clear that the radii of the various ellipses on the drawing would not suit the changed conditions, and the face of the cone would not touch the face of the wyper at all points. It is therefore impossible to construct a wyper geometrically correct for more than one position, and for this reason the primary curve is often obtained by drawing circles at the points 1.2.3.4.5.6.7.8. instead of the major axes of ellipses. In rounding off the nose, circles of different radii are used in order to obtain the correct shape, and to leave sufficient metal for trimming up when it is worn. Although the actual sizes of these circles are more or less unimportant, it is very desirable that every point across the nose should be in contact with the cone until the last moment, so that the stroke will be as perfect as possible, and that the wear and tear of the two parts in contact shall be at a minimum. If only a part of the face of the wyper bear on the cone, grooves will soon be cut into the latter, or the part of the wyper which is bearing on the cone will be worn away, and imperfect picking will result. When the cone stud reaches its maximum velocity it flies entirely clear of the wyper, and in its backward movement impinges against the back of the wyper about point V. The back of the wyper from the nose to a point a little above V is drawn with a radius of about 11 ins.

In so far as the construction of a picking wyper is concerned, there are three distinct methods by which a harder pick may be obtained for wide looms and for other slowly running looms: (1) The arc of effective travel of the cone may be increased by using a larger nose; several different noses are made for this purpose; (2) The ratio of acceleration may be increased; (3) The time of development of the pick may be reduced.

To determine the velocity of the picking arm due to the mechanical contact between the picking wyper and the cone, we proceed as follows:—Determine by calculation the measurement of the chord of the arc described by the cone stud, and therefore of the picking arm, during the last period of acceleration. It will be noticed from Fig. 177 that, during this last period of acceleration, between points 6 and 7, that particular part of the arc is little removed from the horizontal line, and, in adjusting the various parts of the picking arm, it is desirable that during this same period of acceleration the end of the picking arm should travel approximately parallel to the line of the picking spindle in order that the movement of the arm will be conveyed unimpaired to the picker. The 30° in Fig. 177 are divided into 41 equal parts, of which 18 parts are allotted to the last period of acceleration, *i.e.*, $\frac{18}{41}$ of $30° = 13° 10'$. For further explanation these positions are indicated in Fig. 178, where the arc A C of 30° represents the effective travel

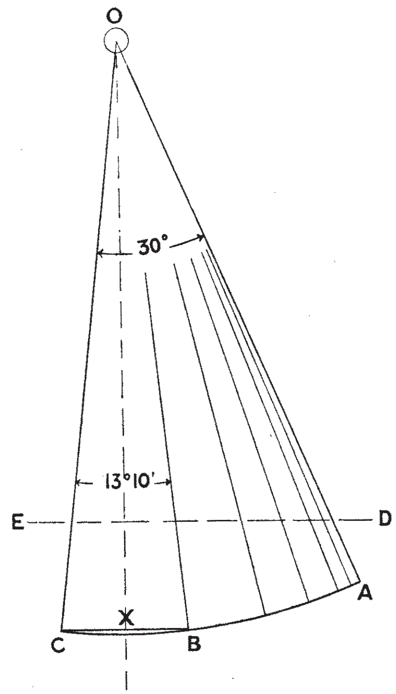


FIG. 178.

of the arm due to the action of the wyper alone. This arc is divided into six parts in the ratio 1.2.4.6.10.18, the last of which (13° 10′) is so arranged that the chord of its arc B C is practically parallel to the line of the picking spindle represented by the dotted line D E. Now B X and C X are each the sine of an angle of 6° 35′, so that the chord $BC = 2 \sin 6° 35'$. From a table of natural sines we find that sin 6° 35′ for one-inch radius is 0·1146, and therefore for $24\frac{1}{2}$-in. radius is $0·1146 \times 24·5 = 2·8077$. Consequently B C, the effective travel of the $24\frac{1}{2}$-in. arm during its last period of acceleration through the action of the wyper is $2·8077 + 2·8077 = 5·6154$ ins. According to our construction this distance is covered in one-sixth part of 60°, or $\frac{1}{36}$th. part of a revolution of the wyper shaft. Assuming the speed of the loom to be 150 picks per minute, or 75 revolutions per minute of the wyper shaft, the time occupied in travelling this distance will be :—

$$\frac{60 \text{ seconds}}{75 \text{ revolutions}} \times \frac{1}{36} = \frac{1}{45} \text{ of a second,}$$

and

$$\frac{5·6154 \text{ ins.}}{12'' \text{ per foot}} \times \frac{45}{1} = 21·058 \text{ ft. per second}$$

as the average velocity of the extremity of the picking arm during the last period of acceleration. Since the acceleration over the whole pick is in the ratio of 1.2.4.6.10.18. the average velocities during the various previous periods will be in proportion to the last in the above ratio, and may be determined by calculation to be as follows :—

Ratio of acceleration	1	2	4	6	10	18
Period of acceleration	1	2	3	4	5	6
Average velocity	1·176″	2·352″	4·704″	7·056″	11·948″	21·058″

These, however, are only average velocities, and to determine the ultimate velocity of the picking arm at the end of the 6th or last period, or at the end of the stroke of the wyper, it is necessary to estimate the average velocity of the arm for a further period of acceleration in the same ratio, and then to plot out a velocity curve to scale using the various average velocities as ordinates, and any convenient distance as abscissa. A sufficiently close approximation to the result obtained by the method suggested above may be got by taking the mean of the average velocity of the last period of acceleration and the estimated average velocity of a further period of acceleration. Now since the differences between the last four periods of the ratio of acceleration chosen are 2, 4, and 8 respectively, and therefore in geometrical ratio, it may be assumed that the succeeding difference will be in the same ratio, and therefore equal to 16 ; hence the further period of the original ratio will be $18+16=34$. From this the average velocity is found to be :—

$$21{\cdot}058 \times \frac{34}{18} = 39{\cdot}776 \text{ feet per second,}$$

and the velocity of the picking arm at the end of the 6th period of acceleration is therefore :—

$$\frac{21{\cdot}058 + 39{\cdot}776}{2} = 30{\cdot}417 \text{ feet per second.}$$

This velocity, however, is still considerably lower than the average velocity of the shuttle already determined at 35 feet per second, and is therefore necessarily less than the maximum velocity which the shuttle must attain. As pointed out in our First Edition, the picker in many cases travels 11 ins. while the arm travels 9 ins., this increase being due to the relative movements of the picking spindle and the picker, and the end of the picking arm. As the lay moves backwards, the spindle and picker are further

removed from the end of the picking arm as the latter is travelling towards the cloth, and hence an increased movement is imparted to the picker. It therefore follows that the velocity of the picker is considerably in excess of that of the picking arm. Then again, at this particular time the shuttle gets clear of the swell, and the pressure on the arm and straps is more or less removed, with the result that the arm springs forward a certain distance. All these conditions tend to increase that velocity which is a positive result of the mechanical movements of the wyper, cone and picking arm, but as we have not been able to bring our investigations in this direction to a mutually satisfactory conclusion we simply state that there seems to be no doubt that all further increase of velocity which it is necessary to impart to the picker and to the shuttle is obtained as a result of these relative movements of the picker and spindle, and to the elasticity of the picking arm and strap.

Underpick Motions.—A general idea of the ordinary underpick motion, or what is sometimes termed the lever pick, will be gathered from Figs. 179 and 180, which show respectively the side and front elevations of one of these motions as made by Messrs. Robert Hall and Sons (Bury) Limited. On the end of the wyper shaft A a boss or truck B is keyed, which carries, bolted in a concentric slot, the picking bowl C. This arrangement permits of the adjustment of the bowl C as to the time of action on the picking plate D as the shaft A revolves. The plate D is bolted to the horizontal picking lever E fulcrumed at F on a bracket bolted to the framework. Slots are sometimes provided in the plate D to permit of its vertical adjustment for regulating the strength of the pick, although this is usually done by raising or lowering the fulcrum F to the necessary extent. The end of the lever E is made to project over the short arm G of the bracket H, to which is bolted the picking stick J, all moving about the fulcrum K. The extreme end of the lever E passes through and is guided

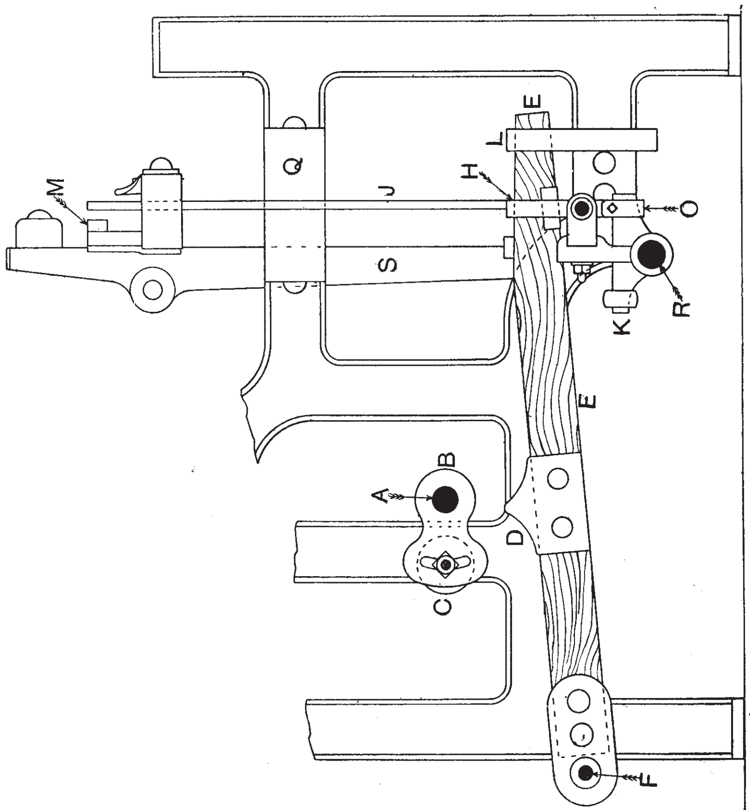


Fig. 179.

by a bracket or grate L. The bottom of the shuttle-box is slotted for the passage of the upper end of J, over which a leather or raw-hide picker is dropped and kept from rising from its position by a wooden slip M. The position

of rest or inaction is that shown in the figures, but it is obvious that as the shaft A revolves, the bowl C will depress the lever E, which in turn will force G downwards,

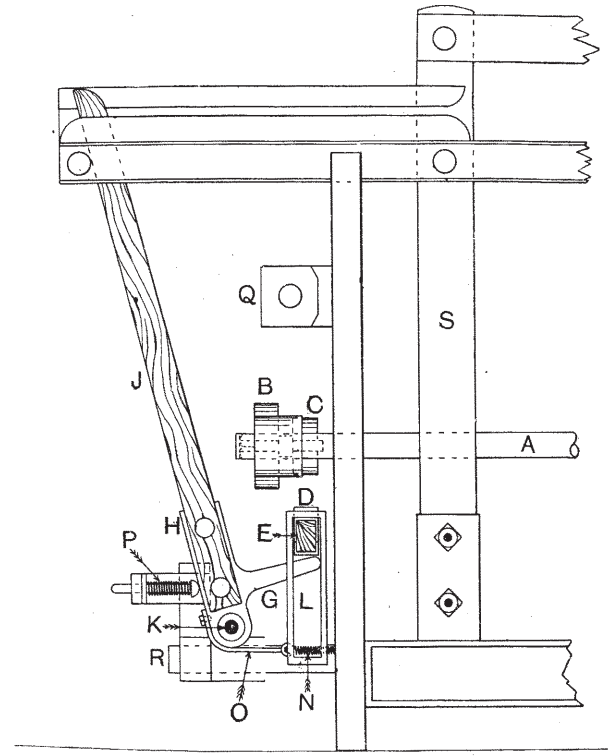


Fig. 180.

at the same time compelling the upper end of J to travel rapidly inwards, and thus propel the shuttle. The stick J is returned to the position shown by means of the spring N and the strap O attached to the bracket H. The spring

P serves as a buffer to J when the latter is returning. A buffer or check strap Q is also provided for the inward motion of J. The bracket H—and all that it supports—is keyed upon and rocks with the rocking shaft R in unison with the lay sword S. The character of the action of this picking motion and the acceleration of movement conveyed to the shuttle will, of course, depend upon the shape of the picking plate D, the proper curvature of which might be determined by a process somewhat analogous to that thoroughly gone into in the case of the cone overpick.

Underpick motions of this type have all the advantages of cleanliness to recommend them—a most desirable element in the production of some classes of linen goods,—and it is probably mostly due to this that the cone overpick has not entirely displaced them, as it has done in the case of jute weaving. Although possessing the above-named advantage, these motions are by no means perfect. The reader will easily see that, in common with all negative picking motions, the end of the picking stick describes an arc while moving, instead of travelling in a straight line, and the stick in this case being in direct communication with the picker, it follows that were it not for the presence of the guides the picker would move along the same path as the end of the stick. Notwithstanding the fact that the guides to a certain extent prevent this, the tendency is for the picker to rise as it approaches the centre of the box, and to fall as it moves towards either end, thus creating a certain amount of unnecessary friction between the picker and the top guide, and also between the picker and the stick, as the latter, in approaching the vertical position, forces its way through the slot in the former. There must of necessity be a certain amount of clearance to allow the picker to move from one end of the box to

the other, and consequently there always exists a slight tendency for the rear end of the shuttle to be depressed, and the forward end elevated, during the picking action. This in many cases results in the shuttle being thrown out, and especially is this so when the shuttle tip is pretty high. In any case, the motion of the shuttle partakes more or less of a wave-like movement instead of a steady transitional one.

Several methods of imparting a perfectly horizontal movement to the end of the picker stick have been tried, one of the latest being that of Messrs. Hollingworth and Knowles, represented in Fig. 181. Here the picking stick A passes as usual through the slot in the bottom of the box, and the picker may be either dropped over the end or fixed to the front of the stick. The lower end of the stick is fulcrumed at the end of lever B, which in turn has its fulcrum on the stud C (detached figure), the latter connecting the parts D and E, and the whole, together with the lay sword F, rocking on the shaft or pin G. The picking stick A is connected to the upper end of E by means of the link H. Motion is imparted to the stick from a bowl and picking shoe—to be described later—through the rocking shaft J, lever K, link L, and straps M. It is at once evident that since the part E is bolted firmly to D, the link H will gradually draw down the stick A as it passes from X or Y to the vertical position, thus imparting a horizontal movement to the picker, and of course to the shuttle. To make sure that the two extreme positions of the stick make equal angles with the vertical, a ready means of adjustment is provided between the parts D and E. A set-screw N passes through the lug at the upper end of D and abuts against the projecting piece O on the face of the part E; the upper end of E may thus be made to move backwards or forwards as required. When once in proper position it is firmly bolted to D by the bolt S. The flat spring P rests on a projecting part of B and acts

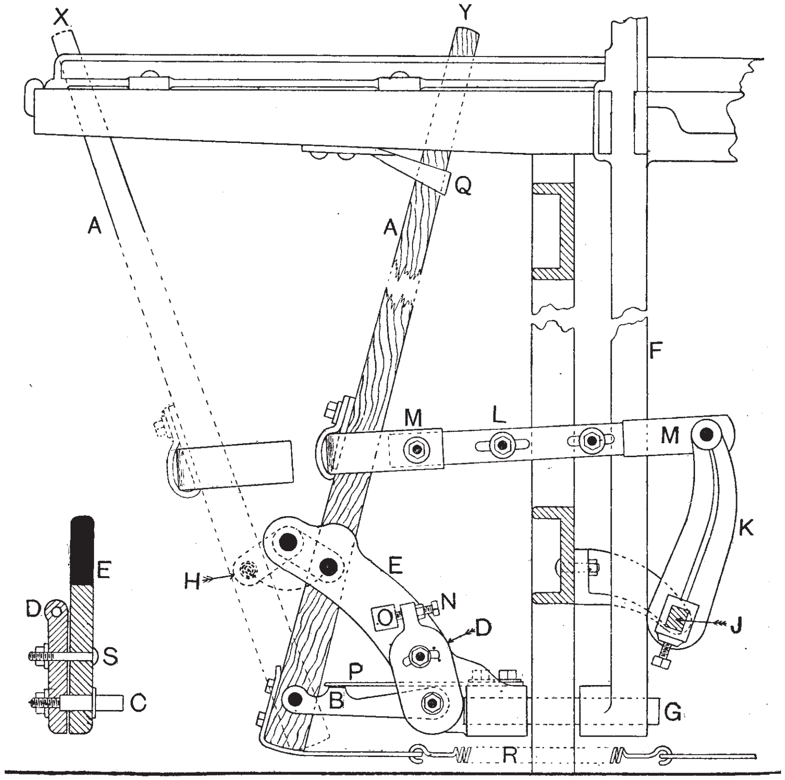


Fig. 181.

partly as a check to the incoming shuttle, and partly as a check to the forward motion of the picking stick. The strap Q performs a similar function when the stick reaches its extreme forward position. After the pick has been

delivered, the stick is returned to its normal position by the strap and spiral spring R, the end of which may be fixed to some convenient part of the loom or coupled with the corresponding spring for the opposite side.

Another method of obtaining the parallel motion of the picking stick is that illustrated in Fig. 182 (front elevation and plan). A is the rocking shaft or stud, upon which is set-screwed the bracket B. The picking stick C is secured to the rocking shoe D, the lower end of the stick and part E passing through a slot in B. A similar slot is made in D, through which passes the tongue F. Projecting from B is a bracket which supports the rotating shell G, inside of which is a strong helical spring, and on its periphery is fixed the connecting strap H. Immediately the picking stick reaches its vertical position the end J commences to rise, raising the picking stick bodily and counteracting the tendency of the head to fall. The shoe D thus acts as a kind of lever with its fulcrum about K, and causes the head of the picking stick C to move in a plane parallel to the race of the lay. After the pick has been delivered, the picking stick is returned to its normal position by means of the afore-mentioned spring inside the shell G. This motion is adopted in the Northrop automatic loom.

Underpicks similar to that illustrated in Figs. 179 and 180 may with little trouble be converted into the so-called pick-at-will motions, or motions which pick as desired from either end of the lay. Pick-at-will motions are, of course, fitted to those looms only which have either drop or revolving boxes at both sides, the "under" pick-at-will being fitted on drop box looms only. An "over" pick-at-will is suitable for either drop or revolving box looms. In certain cases special mechanisms are found by which a limited number of single picks are inserted, but, in general, when it is necessary to insert single picks of one colour, a pick-at-will motion is essential. One of

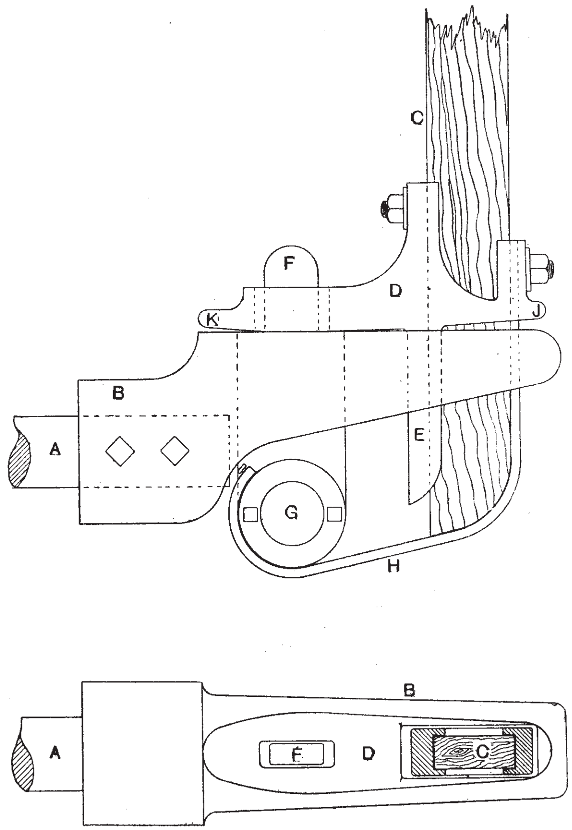


Fig. 182.

the simplest and at the same time most certain of these motions is that of Messrs. William Smith and Brothers Limited, Heywood, shown in Figs. 183, 184, and 185.

Here the picking plate or shoe A, instead of being a fixture on the horizontal lever B, is considerably lengthened and is supported on two brackets C and D, which are bolted to B. Near one end of A a hole is drilled to receive the fulcrum pin E, which also passes through and is set-screwed in the upper portion of bracket D. The plate A is prolonged behind pin E in order that both picking shoes, one at each side of the loom, may be connected together by rods F and studs G. This

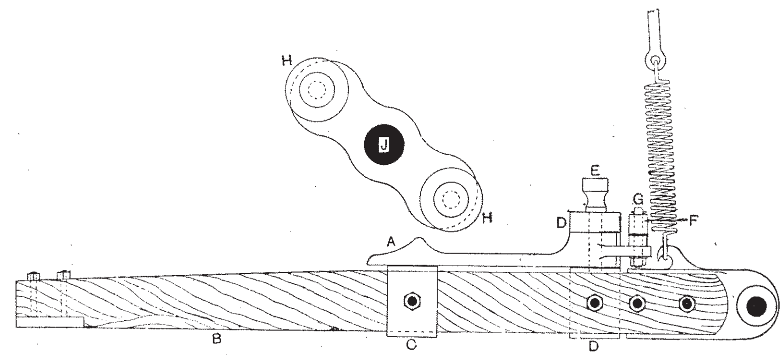


Fig. 183.

arrangement enables either shoe to be withdrawn at will from the vertical plane of action of the picking bowls H, two of which are fixed diametrically opposite each other at each end of the wyper shaft J (see Figs. 183 and 184, which show respectively elevation and plan of the arrangement). From the plan view it is seen that rod F, in absence of any other force, is controlled by a spiral spring K, fixed to the loom frame; this spring continually tends to place shoe A in position under the line of the picking bowls H and to withdraw shoe A^1. In Fig. 184 the opposite position is shown; this is obtained in the following manner :—The elliptical cam L (see Figs. 184 and 185) is set-screwed on and rotates with the wyper

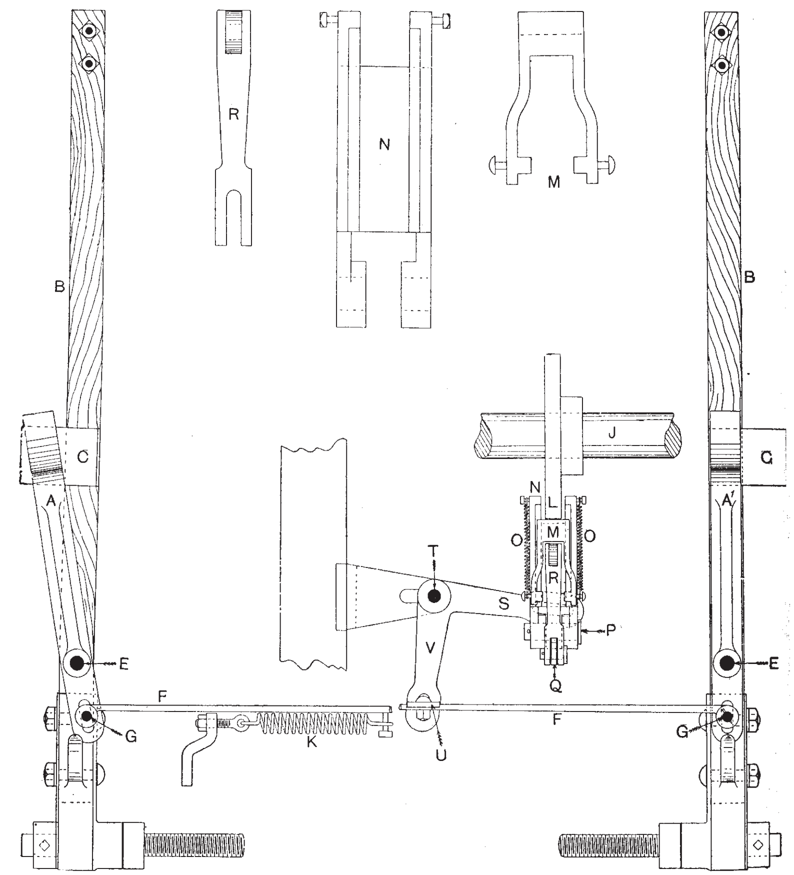


Fig. 184.

shaft J ; twice, therefore, in each revolution of the wyper shaft, or once in each revolution of the crankshaft, this

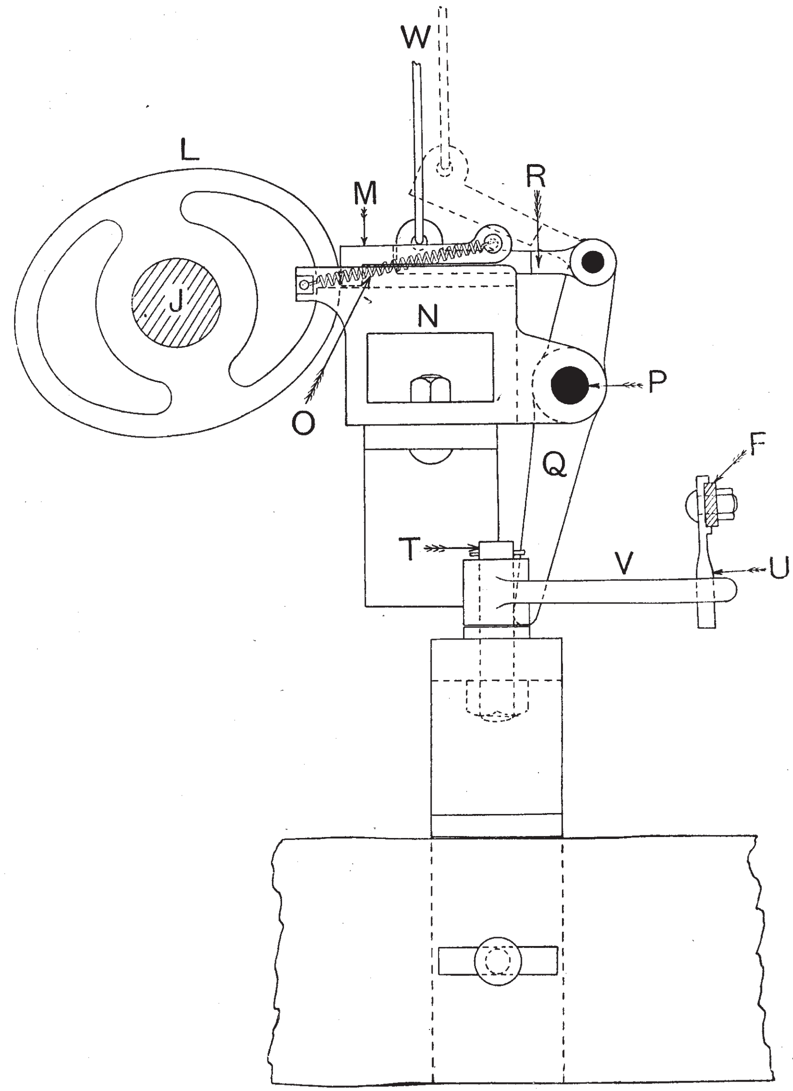


Fig. 185.

cam pushes outwards the sliding piece M (see detached view Fig. 184), supported on box N and kept in touch with the face of cam L by springs O. Fulcrumed at P in box N is a lever Q which carries at its upper end a hinged piece R, while its lower end enters the slot of arm S of a bell-crank lever fulcrumed at T. Finger U bolted to rod F projects into the slot of the arm V of the same lever, which thus controls the positions of the picking shoes A and A^1. The hinged piece R may be connected by wire W either to a hook of the dobby or the jacquard machine, or to one of the needles of the box motion. In any case R may be left down, for any pick, in the path of the sliding piece M, or raised clear of it as shown by the dotted position, when M passes freely underneath. Should R be interposed in the path of M it is pushed backwards as the latter advances, the upper arm of lever Q recedes, the lower arm advances, and bell-crank lever S V is rotated, taking with it finger U and rod F. Shoe A^1 is thus placed in position and shoe A withdrawn. If piece R be lifted out of the path of sliding piece M, spiral spring K places shoe A in position and withdraws shoe A^1.

Another, but particular, type of underpick motion is that found in the Hollingworth and Knowles loom, and illustrated in Figs. 186 and 187. From the latter figure—which shows a back elevation of the shuttle-box frame A—it will be seen that the picking stick B passes up entirely behind the box frame, but between the latter and the spindle C, which, along with a slot in the box frame, guides the picker D, the latter being thus held horizontally. The picking stick B is supported, as shown, by a pin in the bracket E secured to the rocking shaft, and is actuated by a strap F and link G from the picking arm

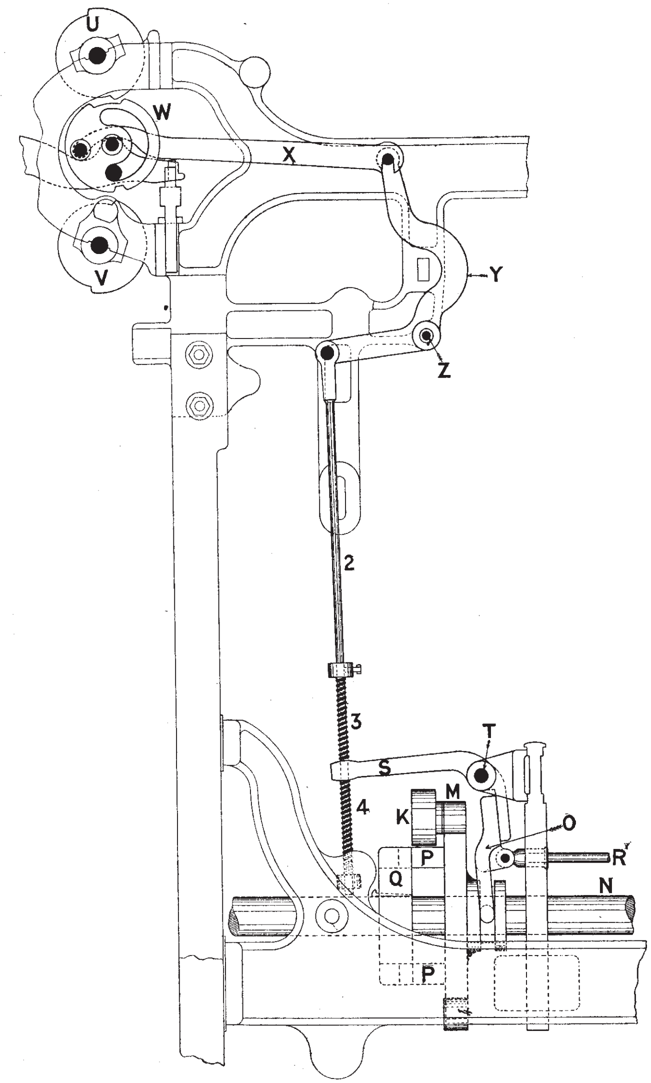


Fig. 186.

H set-screwed on the horizontal picking or rocking shaft J. This shaft J is caused to rock by the action of the picking bowl K on the picking shoe L, also set-screwed on the shaft J. (The picking shoe L is now made in two

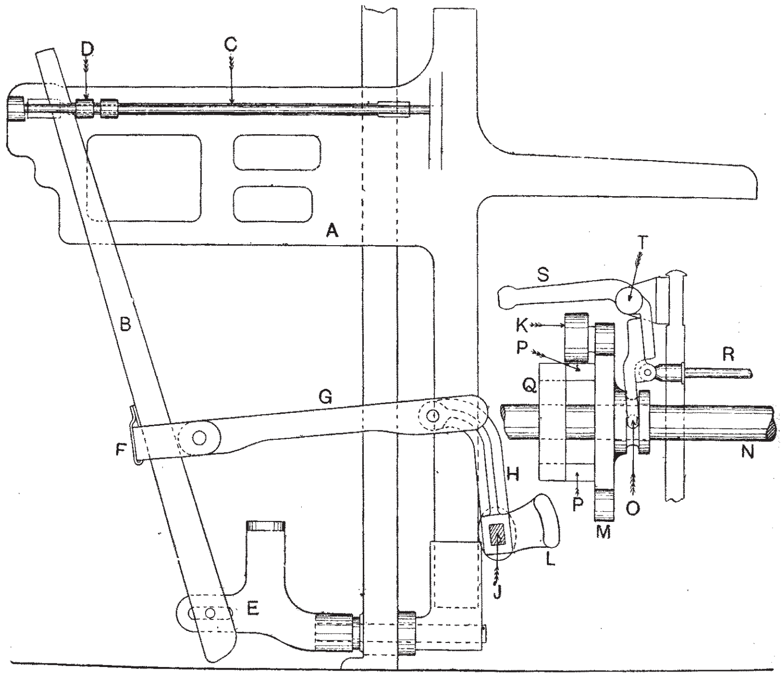


FIG. 187.

parts and bolted together, this arrangement permitting of the rapid replacement of a broken or worn shoe.) The bowl K is carried on a stud bolted in the plate M, the boss of which is extended along the wyper shaft N to form a clutch with the clutch fork O. The plate M is loose upon and may slide freely along the shaft N. The

pins P project from the face of the plate M into slots of the picking block Q keyed upon the wyper shaft, and thus keep the plate M and the bowl K rotating with Q.

From the position of the parts in the figures it is evident that as K revolves with the shaft N it passes clear of the picking shoe L. But it must be remembered that the shaft N in this loom revolves at the same speed as the crankshaft, and that at a corresponding position on the shaft N near the other side of the loom there is a similar arrangement of parts, all connected by the rod R and a similar clutch fork O, and that by means of this connection the plate M and bowl K at the other side are in such positions that as the shaft N revolves the bowl strikes the picking shoe, and the shuttle is propelled from the opposite end of the lay. So long as the parts remain in their present position the loom continues to pick from the same side. To bring about a change of position of the parts, and to bring the bowl K over the shoe L so that the loom will pick from the end shown, the bell-crank lever S fulcrumed at T is caused to act upon the clutch fork O; when this occurs plate M is moved towards the boss Q, while the corresponding plate at the opposite end is withdrawn. It is therefore obvious that by the movement of the lever S the loom may be caused to pick at will from either end. The method of actuating the lever S will be understood by reference to Fig. 186. U and V are the two fluted or toothed cylinders already referred to in connection with Figs. 117 to 124, and they impart motion to the gear wheel W and connecter X in the same manner as that indicated in connection with the figures mentioned. The connecter X is attached, as shown, to the vertical arm of the bell-crank lever Y fulcrumed at Z, the horizontal arm of this lever in turn being connected by the rod 2 and springs 3 and 4 to the extremity of the lever S. By means of a small chain built of bowls and bushes, as required, which controls the movements of the box and picking levers, the picking bowl K may be brought at will into position over the picking shoe at either side of the loom.

Messrs. G. Hattersley and Sons' method of operating an over pick-at-will mechanism in connection with their revolving box motion is illustrated in Figs. 188 and 189. The former of these views shows an end elevation and part plan of the selecting and operating parts, while Fig. 189 shows a back elevation of the picking apparatus and connections. Eccentric A, Fig. 188, is mounted on the crankshaft B, and performs the usual functions of a similar eccentric in the revolving box motion, *i.e.*, it raises the bell crank levers C, and their pins D, clear of the card cylinder E, just before the latter commences to make a partial revolution; it then lowers the same parts so that the pins D may rest upon the card, or enter the cylinder E through the card, should the latter be cut for this purpose; these two motions take place every revolution of the crankshaft. Naturally, there are two similar levers C side by side, to correspond with, and to act upon, the two vertical hooks F F^1, which are connected to corresponding levers G G^1 fulcrumed on stud H. See also same parts in Fig. 189. Both hooks F F^1 pass through slots in the end of lever J, and are normally retained in the back position, see F^1, by means of springs K, so that the lever J may rise and fall without operating upon the hooks. The free ends of levers G G^1 are bent outwards sharply at right angles till they are about eight inches apart, see detached plan view, so that the extremity of each lever may enter a corresponding slot in the three-armed lever O fulcrumed on stud P, see Fig.

189. Should a card be perforated, and a pin D enter the cylinder E, the lower end of the corresponding lever C will press forward the head of the hook on which it operates

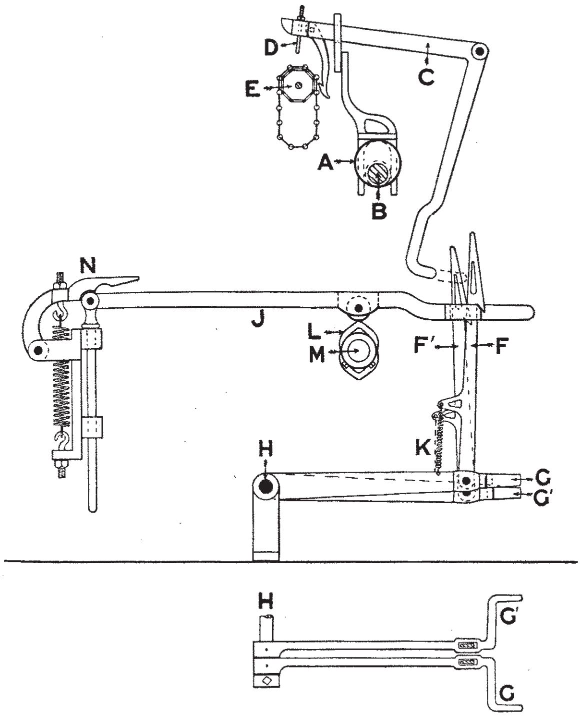


Fig. 188.

(see hook F in Fig. 188), with the result that as bent lever J rises, hook F and lever G will rise with it, and the vertical arm of lever O, Fig. 189, will be rocked to the right as shown. At the same time lever G^1 and hook F^1, Fig. 188 will descend in a corresponding degree. Now lever O, Fig.

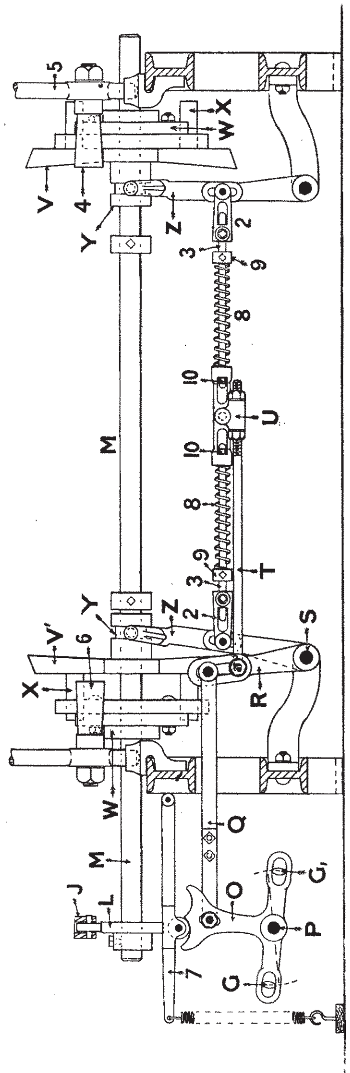


FIG. 189

189, is connected by arm Q to lever R, fulcrumed on stud S, and through lever R to rod T and coupling U, all of which necessarily move to the right with lever O. Picking plates V^1 and V are double-nosed as shown so that each may, if desired, act twice in one revolution of the wyper shaft M. Each picking boss or truck W is keyed to the wyper shaft, and controls its corresponding plate by means of rectangular slots and projections X, which are free to move in, but never entirely leave, the slots in the boss W. Each picking plate is free upon the wyper shaft, and is compounded with a clutch Y, which is in turn controlled by a clutch fork lever Z. Both levers Z are then so connected through couplings 2 and rods 3 to coupling U that, as the latter is moved to the right, picking plate V is moved hard into contact with its corresponding boss, while

plate V^1 is simultaneously removed from contact. In these positions it is evident that the pick will be delivered by V through cone 4 and shaft 5, and that cone 6 will remain undisturbed. Should lever G^1 be raised, however, all parts to the right of O will move to the left, and the pick will then be delivered from that side of the loom. Spring hammer 7 steadies lever O after it has changed to one or other of its extreme positions. The connections between the coupling U and the coupling 2 are so arranged that the closing of either picking plate upon its boss is accomplished through the medium of the strong helical spring 8 and collar 9, the former of which yields should there be any obstruction in the way of the plate closing. On the other hand, the plates are withdrawn positively by means of a set screw 10 in the extremity of each coupling rod 3. The revolving boxes are, of course, controlled in the usual manner, all six indicating levers C, Fig. 188, being mounted upon the same stud, and selected by the cards as the latter pass round the cylinder E.

CHAPTER XIV

BEATING UP

BEATING up, as the driving home of the weft thread by the reed is invariably termed, is generally considered as being one of the three chief actions in the operation of weaving. Of these actions, two—viz. shedding and picking—have already been discussed so far as they are generally found to apply in jute and linen weaving, whilst the third, which is generally taken as following picking, now falls to be considered.

The mere act of beating up is in itself a simple matter, but under this heading it is usual to consider not only this single action, but in general the whole movement of the lay for one revolution of the crankshaft; and in particular to discuss the position of the centre of this shaft in relation to the parts which it actuates through the medium of the connecting arm—or, rather, the effect of such position and relationship.

Without entering into the history of the development of the present practically universal arrangement, which is illustrated in Fig. 190, we may state that the lay A, a heavy beam of well-seasoned wood, is supported on brackets cast upon the lay swords or arms B, and is bolted to the latter as shown. To the upper side of A a thin raceboard, also of wood, is fixed. In some cases a longitudinal groove is cut at the back of A to receive the lower rib of the reed C, whilst the upper rib is held in position by a heavy wooden or cast-iron cap D grooved on the underside and bolted at each end to the head of the swords B. In all looms for jute weaving, however, instead of the lay A being simply grooved to receive the lower rib of the reed, the latter is securely fixed to the lay by means of a special wooden clamp E, bolted to the lay at regular intervals by means of bolts F, which pass entirely through the lay. The swords B are centred upon the rocking shaft G, and are fixed to the latter by means of friction keys or set screws. In the majority of cases the shaft G extends from side to side of the loom, and is supported there either in a fixed position or in adjustable brackets. In some few cases the part of the rocking shaft is fulfilled by two short studs suitably supported at each side of the

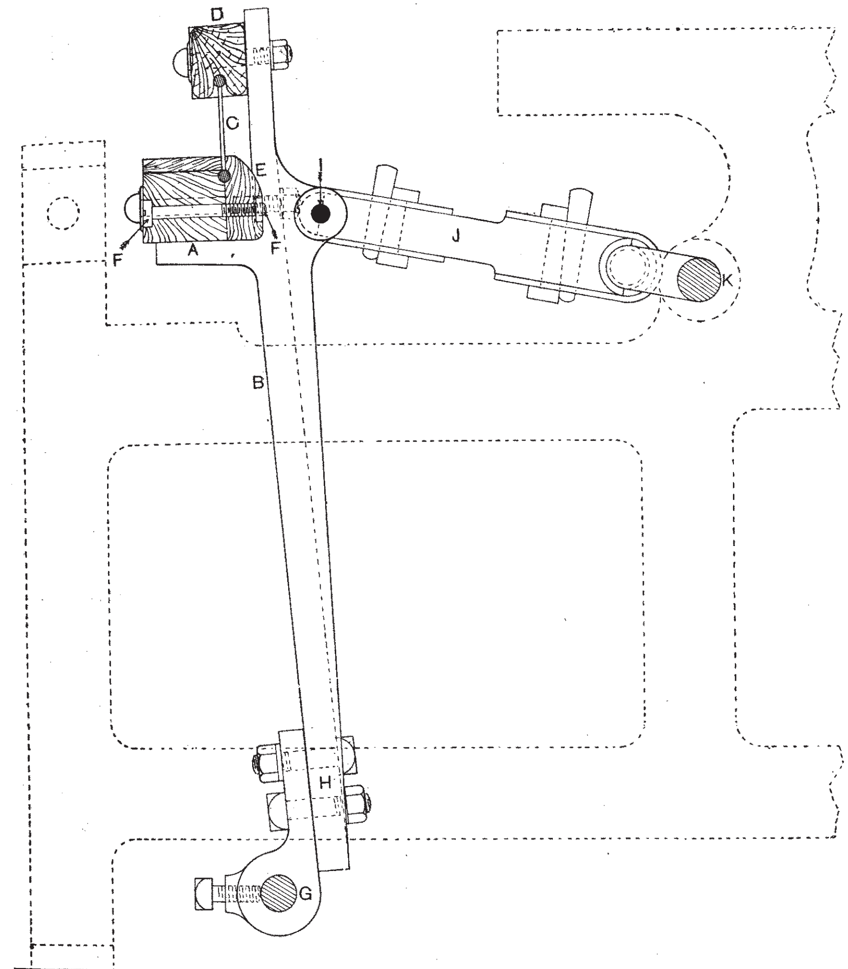


Fig. 190.

loom. In all looms for jute and coarse linen weaving the swords B are practically in one piece from the rocking shaft up, and in these the lower shed line has to be adjusted to the level of the race; but in looms for fine linens, and in general where harness work is anticipated, the swords are made in two portions, as at H, to permit, where necessary,

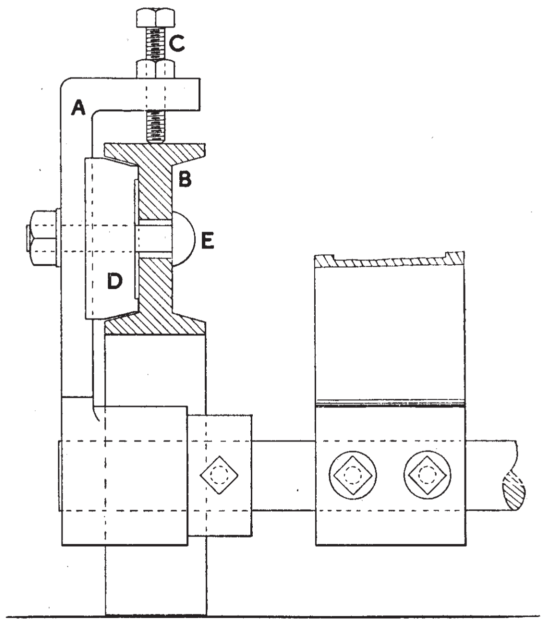


Fig. 191.

of the vertical adjustment of the race to the under shed line.

Another method by which the race of the lay may be adjusted to the proper height in harness looms is illustrated in Fig. 191. Besides being more simple, more easy of access, and more accurate than the former method, it also

permits of the swords being made in one part instead of two. In this method, the rocking-shaft bracket A is extended upwards, and turned inwards over the loom frame B, so that it may be tapped and provided with a set screw C, which abuts against the frame, and by which the height of the bracket and rocking shaft may be finely adjusted. A making-up piece D engages with the bracket A, keeps it clear of the frame B, and ensures that it will move vertically. After adjustment, the whole arrangement is bolted rigidly to the loom frame by the bolt E.

Swords B are usually of cast iron to ensure rigidity or stiffness in the support of the lay while the shuttle is travelling, as well as during the beating-up process; but the liability of such swords to snap under the sudden shock of "knocking off" and under the repeated blows, or rather stresses, of beating up is well known. To obviate this as much as possible, and to impart a greater amount of resilience or spring to that part of the mechanism, sword arms of ash or hickory with cast malleable iron supports have been recently introduced in looms for the manufacture of the heavier classes of linoleum backing cloths. In other cases the whole of the sword is of cast malleable iron, or cast steel in T or ⊓ section.

On the swords B, and usually at a point immediately behind the lower portion of the lay A, lugs are cast to receive the ends of the connecting pin I at the one end of the connecting arm J; the other end of this arm is connected to the crank or sweep of the crankshaft K. Connections between the arm J, the pin I, and the crankshaft are usually made by means of straps, gibs, and cotters, to permit of the correction of play caused by the wear and tear of the bushes on the crank and arm.

The three points, the relative positions of which more immediately concern us, are the centres of the rocking shaft G, the connecting pin I, and the crankshaft K. It is almost needless to say to those who have any knowledge of the loom in detail that there are nearly as many positions for each of these three points as there are loom makers. Why this should be so is difficult to understand, unless we assume that loom makers have as yet not decided upon that relationship which should uniformly be adopted for a given type of loom, or that they have each decided upon a different relationship between these points as being the best.

As regards the relative position of the first two—that of the rocking shaft G and the pin I—it is now a generally accepted rule that the pin I shall not, in its forward movement, pass the vertical plane of the centre of the shaft G, and on this account the full forward position of the pin is usually found to be about $1\frac{1}{2}$ to 2 ins. behind this plane. In most narrow looms it is usual to find the lay at least 2 or 3 ins. in front of the connecting pin, and it is therefore evident that the great mass of the lay will, in moving forward, pass the vertical plane of the shaft G, and begin to fall. Nevertheless, the arrangement is almost universal, and is to be found working satisfactorily in looms of all widths up to 130-in. reed space. In wide looms, however, the connecting pin is frequently found at a much greater distance behind the lay, so as to permit shorter connecting arms being used in order to increase the eccentricity of the movement of the lay.

With regard to the lateral position of the rocking shaft being fixed or adjustable in any one loom, we are of the opinion that the former method is preferable, since, if due consideration be given to this position to begin with, there should never be any necessity to change it; and in looms where it is fixed, the necessity never arises. Any alteration in this point invariably necessitates an alteration in the lift of the tongue of the warp protector, and sometimes in its length; it changes the inclination of the race of the lay to the shed line, necessitating an alteration in the raceboard or other parts, for no matter what the position of other things may be, the under shed line must be at the same inclination as the raceboard, and touching it during the passage of the shuttle. Another point in connection with the race worthy of attention is that it should never dip forward at any point when the shuttle is out of the box, otherwise it is clear that the tendency for the shuttle to fly out will be increased; indeed it should not dip forward at any point. A simple means of helping to prevent flying shuttles is to make the raceboard level from front to back when the lay is full forward. This arrangement gives a maximum dip of the race and of the under shed line when the lay is full back; but, to compensate for this, the back beam or rail over which the yarn passes may occupy a lower position than in the case of those looms where this arrangement does not hold good.

In proceeding to consider the relative positions of the connecting pin and the crankshaft, we would beg to point out that it has been usual in works on weaving to consider that the chord of the arc of travel of the connecting pin I is always twice the throw of the crank, or, in other words, the same length as the diameter of the crank circle, no matter what position the centre of the crankshaft occupies with relation to that of the connecting pin. This assumption is slightly inaccurate, and we now wish to draw the reader's attention to the fact that it is only when these two points bear a certain relationship, only when the centre of the crankshaft is in one definite position with relation to the travel of the pin, that the assumption is correct. Any deviation from this position, either up or down (assuming the dimensions of the crank and connecting arm to remain constant), will result in an increase of travel being conveyed to the connecting pin I. Further, only when the position to which we refer is adhered to will exactly half a revolution of the crankshaft be occupied in the backward movement of pin I, and exactly half a revolution in the forward movement.

Before proceeding further, let us make our position clear as to the direction in which the crank revolves. In practically all looms for jute weaving, and in a number of those for flax canvas and coarse linens, the crank revolves so as to beat up when rising, or to pick on the top centre as already indicated in Fig. 58 (page 114), whilst in nearly all other looms, the most noteworthy exceptions being those for Brussels and Wilton carpets, and the Hollingworth and Knowles' and similar looms for woollen goods, as well as other looms of American origin, the crank revolves so as to beat up when falling, or to pick about the bottom centre, as indicated in Fig. 59 (page 115). In the further explanation of this point we shall assume that the crank revolves as indicated by the latter method. Generally speaking, therefore, any explanation with regard to the points under discussion will require to be applied conversely if intended to be read in connection with the former method of rotation.

To raise the crankshaft above the position which we shall shortly define will increase the time taken in the backward movement of the pin, and therefore of the lay. It will also correspondingly decrease the time taken in the forward movement. To lower the shaft below the position indicated will have exactly the opposite effect—*i.e.*, will

decrease the time taken in the backward movement, and correspondingly increase the time taken in the forward movement.

In order that the travel of the connecting pin may be

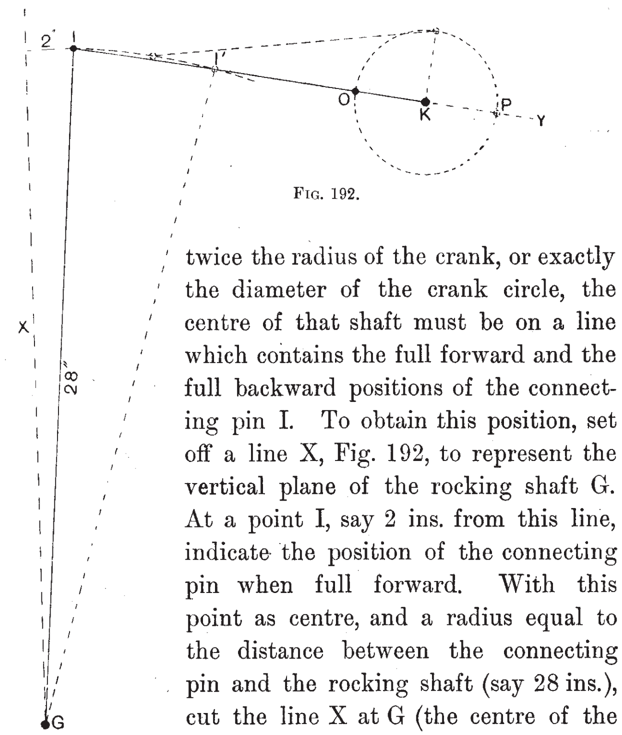


FIG. 192.

twice the radius of the crank, or exactly the diameter of the crank circle, the centre of that shaft must be on a line which contains the full forward and the full backward positions of the connecting pin I. To obtain this position, set off a line X, Fig. 192, to represent the vertical plane of the rocking shaft G. At a point I, say 2 ins. from this line, indicate the position of the connecting pin when full forward. With this point as centre, and a radius equal to the distance between the connecting pin and the rocking shaft (say 28 ins.), cut the line X at G (the centre of the rocking shaft). With G as centre and radius G I, describe an arc. Cut off I to I^1 (6 ins.) equal to twice the radius of the crank. From I, and passing through I^1, draw the line I Y. With I as centre and radius equal to the length of the connecting arm (12 ins.), plus the radius of the crank (3 ins.)—*i.e.*, with a radius of 15 ins.,—

cut the line I Y at K, then K is the centre of the crank-shaft.

From the method of construction it is evident that the pin I will be farthest forward when the crank is at the point O on the crank circle, since at that point the crank and the arm are in one straight line. It is also evident that the pin I will be full back at I^1 when the crank is at the point P on the circle, since at this point the crank and the arm coincide; but as these two points (O and P) are diametrically opposite to each other on the crank circle, or 180° apart, it follows that the chord of the arc I I^1 will be exactly the diameter of that circle, and that exactly one-half of a revolution of the crank will cause the pin to travel backwards from I to I^1, and that the other half will move it forwards from I^1 to I. Although the pin I moves through the part of a circle, the effect of such movement is for all practical purposes along the chord of the arc described—*i.e.*, along the line I Y.

It now remains to discuss the eccentricity of this movement, the term eccentricity being invariably used to indicate the varying velocity of the pin as it travels between its two extreme positions I and I^1. Generally speaking, the eccentricity or variation of velocity, which is not only unavoidable, but is really necessary, is due to the fact that it is the conversion of a circular motion into a rectilinear motion by means of a crank and a finite connecting rod. Were the connecting rod of infinite length, the movement of the pin for a given angle of the crank's rotation from the line I Y would in all cases be the versed sine of that angle, or, in other words, the whole movement would be that of a simple harmonic motion. As a matter of fact, however, the connecting arms are comparatively short, usually varying in length from two to six times the radius of the crank,

or from 8 ins. to 14 ins. long, with cranks of from 4 ins. to 2 ins. radius. It is due, therefore, to the fact that the motion to the pin is imparted through a connecting arm of finite and in some cases relatively short length that this eccentricity of velocity is increased in a great measure to the benefit of the weaving process, particularly that of the time allowed for the passage of the shuttle through the shed. As the crank revolves from the position indicated by the point O, the connecting arm assumes a position more or less inclined to the line I Y, and is thus, as it were, reduced in its effective length. The angle of inclination increases until an angle of 90° has been traversed by the crank, at which time the pin I (due to the oblique position of the connecting arm) will have covered a distance considerably more than the versed sine of that angle—*i.e.*, will have travelled more than the radius of the crank. Beyond 90° the angle of inclination becomes gradually less, or the effective length of the arm gradually increases until point P is reached, or when 180° have been traversed, when the arm again coincides with the line I Y. Then the full travel of the pin will be, as already stated, equal to the diameter of the crank circle. It is therefore obvious that if during the first 90° of the revolution the pin travels more than half the diameter of the circle it must travel less than half the diameter of the circle by a similar amount during the second 90° of revolution; and it follows that a similar but opposite action will take place during the further 180° of the full revolution of the crankshaft.

The actual amount of travel of the connecting pin for any angle of the crank's movement may be calculated by the following formulæ, and the use of a table of natural sines. The problem is in reality the solution of a triangle of which two sides (the crank and the connecting arm) and the angle opposite one of them (that angle opposite the connecting arm) are known.

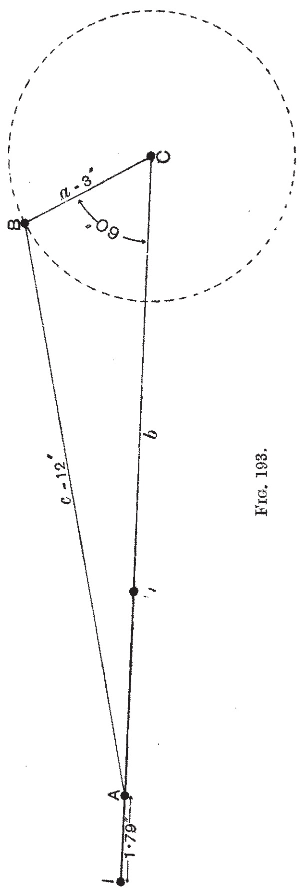


FIG. 193.

In the triangle A B C (Fig. 193) we shall assume the letters A, B, C to represent the angles at the points mentioned above, and the small letters a, b, c to indicate the measurement of the sides opposite the respective angles A, B, C. Thus A = the angle made by the connecting arm ($c = 12$ ins.) with the line I Y when the crank ($a = 3$ ins.) has rotated through the angle C (say 60°), traversing the pin from I to A. The line I C will of course be equal to the crank plus the connecting arm—*i.e.*, $3 + 12 = 15$ ins.,—and the distance travelled by the pin will be 15 ins. minus the length of the line A C (or b), which has to be found. Given the angle C and the two sides a and c, we must first find the value of the angle A. Now the sides of any triangle are proportional to the sines of the opposite angles—*i.e.*,

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}.$$

$$\therefore \frac{a}{\sin A} = \frac{c}{\sin C}.$$

and $$\sin A \times c = \sin C \times a\,;$$

whence $$\sin A = \frac{\sin C \times a}{c}.$$

Substituting the known values in the right-hand side of the equation we obtain—

$$\sin A = \frac{0{\cdot}866 \times 3 \text{ ins.}}{12 \text{ ins.}}$$
$$= 0{\cdot}2165 \text{ of an inch,}$$

which is the sine of an angle of $12\frac{1}{2}°$; hence the angle $A = 12\frac{1}{2}°$. The sum of the three angles of any triangle equals 180°.

$$\therefore \text{angle B} = 180° - (\text{angle A} + \text{angle C})$$
$$= 180° - (60° + 12\tfrac{1}{2}°)$$
$$= 107\tfrac{1}{2}°\,;$$

and since the sine of an angle is equal to the sine of its supplement—

$$\therefore \sin 107\tfrac{1}{2}° = \sin (180° - 107\tfrac{1}{2}°)$$
$$= \sin 72\tfrac{1}{2}°$$

and $$\sin 72\tfrac{1}{2}° = 0{\cdot}9537.$$

But by above $$\frac{b}{\sin B} = \frac{c}{\sin C}\,;$$

hence $$b = \frac{\sin B \times c}{\sin C}.$$

Again substituting, we have—

$$b = \frac{0{\cdot}9537 \times 12 \text{ ins.}}{0{\cdot}8660}$$
$$= 13{\cdot}215 \text{ ins.}$$

The same result may be obtained, after having found the angle B, as follows :—

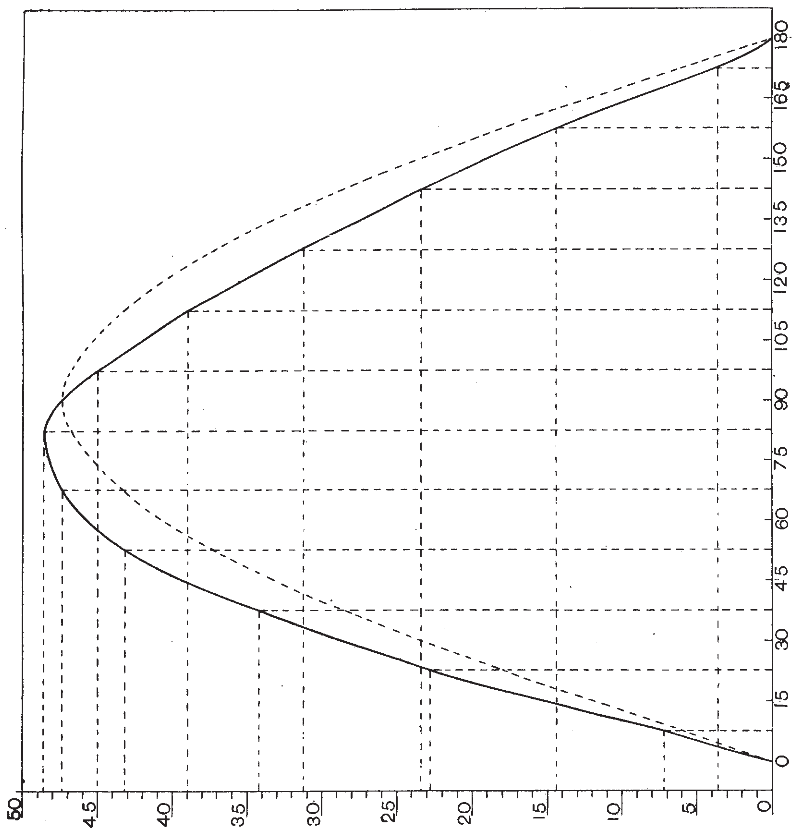


Fig. 194.

$$b^2 = a^2 + c^2 - 2 \times ac \times \cos B$$
$$= 3^2 + 12^2 - 2 \times 3 \times 12 \times \cos 107\tfrac{1}{2}°$$
$$= 9 + 144 + 21{\cdot}6504$$
$$= 174{\cdot}6504$$

hence $b = \pm 13{\cdot}215$ ins.
Then 15 ins. $-$ 13·215 ins. $=$ 1·785 ins.

as the amount of travel conveyed to the pin I for 60° of the crank's movement.

In a similar manner the travel of pin I may be calculated for any number of degrees of the crank's rotation. In the following table, which has been calculated in the above manner, we give the travel of the pin I for every 15° of the crank's rotation in one direction—*i.e.*, going backwards; when going forwards a similar but opposite movement will result. We have assumed the crank to be making 150 revolutions per minute, and have included in the table the average velocity of the pin over these different periods. We have also, for comparison, included the average velocities which would obtain in the case of a simple harmonic motion, or with a connecting arm of infinite length; this, to show the difference of effect produced in approximately extreme cases.

In Fig. 194 two curves are plotted out which show graphically the important results noted in the above table, and indicate clearly the eccentricity of the velocity of the pin under ordinary circumstances. The curve in the solid lines shows the actual velocity, while that in dotted lines shows the harmonic motion.

It is of course evident that the actual velocity will change with the speed of the loom; but given the same crank and connecting arm, and provided the centre of the crankshaft remains in the position indicated, the eccentricity of the velocity will not vary.

[TABLE.

Movement of Crank in Degrees.	Total Travel in Inches of Pin I.	Actual Travel in Inches for Period of 15°.	Time for 15°: $\frac{60 \text{ secs.}}{150 \text{ pks.}} \times \frac{15}{360}$.	Average Velocity in Inches per Second for 15°.	Average Velocity in the Case of Harmonic Motion.
15	0·12	0·12	$\frac{1}{60}$ of a second.	7·2	6·0
30	0·50	0·38	,,	22·8	18·0
45	1·07	0·57	,,	34·2	28·6
60	1·79	0·72	,,	43·2	37·2
75	2·58	0·79	,,	47·4	43·4
90	3·39	0·81	,,	48·6	46·8
105	4·14	0·75	,,	45·0	46·8
120	4·79	0·65	,,	39·0	43·4
135	5·31	0·52	,,	31·2	37·2
150	5·70	0·39	,,	23·4	28·6
165	5·94	0·24	,,	14·4	18·0
180	6·00	0·06	,,	3·6	6·0

Variation of the eccentricity, or, as it might fitly be termed, the ratio of acceleration and retardation of the pin's movement, can only be obtained by changing the length of the connecting arm or the radius of the crank, or by altering the relative position of the crank and connecting arm from that indicated in Fig. 192. By increasing the length of the arm the ratio of acceleration will be reduced—that is, the acceleration will more nearly approach a harmonic one,—while by reducing the length of the arm the ratio will be increased. Similar results will be obtained by decreasing or increasing respectively the radius of the crank. It is therefore evident that in changing any one loom an increase of the crank will not be accompanied by an increase of the arm, but by a retention of the same arm or the introduction of a shorter one. It is also obvious that an increase in the length of the crank will not only affect the eccentricity of the pin's movement, but will also increase its travel. In some instances the latter point only

is aimed at, chiefly in cases where a shuttle of larger cross section is to be used; but in general an increase of the crank's radius is accompanied by a reduction of the length of the arm. Where it becomes necessary to reduce the length of the arm it is usual, as already indicated, to cast ears of sufficient dimensions on the back of the lay swords, in order that the lay and reed may be retained in their original positions when full forward; but in order to retain the relative positions of the crank and connecting pin I, the centre of the pin must still be retained on the line I Y (Fig. 192), although at the necessary distance nearer the centre of the crankshaft. The centre of the rocking shaft must be moved backwards a corresponding distance on a line drawn parallel to the line I Y, and by adopting this method the relative positions of all three points remain unchanged. Should it be necessary to increase the radius of the crank as well as to reduce the length of the arm, the new position of the pin when full forward must still be on the line I Y at a point whose distance from the centre of the crankshaft is equal to the new radius of the crank plus the length of the new arm. The new position of the rocking shaft will now be farther back than the original position on the line parallel to I Y by a distance equal to the difference between the length of the original crank and arm and the new crank and arm, plus the increase in the radius of the crank—*e.g.*, given the original crank and arm $= 3 + 12 = 15$ ins.; the new crank and arm $= 4 + 8 = 12$ ins.; the new position of the rocking shaft will be $(15 - 12) + (4 - 3) = 3 + 1 = 4$ ins. back from the old position on a line parallel to I Y.

In the numerical example it is evident that in the new position, the pin—when full forward—will be nearer the vertical plane of the rocking-shaft centre by the increase in the radius of the crank, but if the original position be chosen 2 ins. behind the vertical plane, it is evident that the radius of the crank may be increased by 2 ins. before this plane is reached.

Various alterations due to a change of position of the rocking shaft have already been indicated, but this change of position, while retaining the lay in approximately the same position, may result in the race of the lay being caused to dip forward too much, and for reasons already indicated care must be taken not to overdo this.

We should now like to draw attention to the fact that it has been usual to believe that for the beating up of the weft a smart blow of the lay or reed is necessary, and that for the passage of the shuttle a protracted movement is desirable. We are entirely in accord with the latter opinion, but as regards the former we should like to make a few observations. Firstly, in the great majority of cloths it might be doubted whether the actual beating up of the weft is necessary. We think it is not, and that the action simply consists of placing it in position. Nothing really of the nature of a blow takes place—nothing but a pushing forward of the weft by the reed; and not only is this the case, but the pushing forward comes on gradually. If the loom is in proper order, the moving shuttle enters the box before the lay is half-way forward, and therefore the reed and the weft are in contact long before the cloth is reached. Under these circumstances we think it scarcely correct to speak of the lay as travelling forward at a high velocity, and imparting a heavy blow to the weft thread at the fell of the cloth; nor do we think it possible for the reed to do this with the ordinary type of crank and connecting arm. In some few exceptional cases it may be an

advantage to have an increased speed of the reed as it approaches the cloth, but in most cases it is undesirable. It must be remembered that the lay, when travelling, is, unlike the shuttle, not a free agent; that it is governed by the crank; and that as it approaches the full forward point it is rapidly decreasing in velocity until it ultimately comes to a dead stop, and then begins to recede. Anything, therefore, of the semblance of a blow which it does impart is due to the thickness and the hardness of the weft and the opposition which it may offer to the forward motion of the reed, together with the resistance of the warp when the fell of the cloth is reached.

In negative uptake looms we admit that all the movement which the uptake motion can make is due to the pressure which the reed imparts to the fell of the cloth as it approaches, and when it reaches, the full forward position. But this, we hold, will be more efficiently performed, and will be easier upon the loom and the warp, if done slowly rather than rapidly. In positive uptake looms, where the motion is actuated by a pawl and ratchet (and this type forms the majority), the uptake motion acts either when the lay is receding or advancing, and therefore between the recurrence of the beating up; this statement naturally ignores the comparatively few looms in which the uptake motion is either continuous, or is intermittently actuated from the wyper shaft, and therefore only every second pick. If, therefore, the reed, when full forward, has pressed home the weft thread, that thread will (in virtue of the uptake motion) have moved forward a distance equal at least to its own diameter plus a small fraction (depending upon the weave and other considerations) before the reed again approaches to place in position the next shot of weft. We are well aware that with certain shedding mechanisms, and some classes of weaves, the fell of the cloth does not occupy a constant position, but surges backwards and forwards less or more with every advance and retreat of the lay and the formation of the new shed. In one extreme case observed in this connection the actual movement was $\frac{15}{16}''$ every time the lay pressed against the weft, but the movement was far from desirable, was unnecessary for the proper production of the cloth, and was indeed only practicable in that particular case by using the best of warp yarns. In such a case beating up is certainly of the nature of a shock or blow, because the reed and weft are in contact comparatively early, but it cannot be contended that such a shock is productive of good either to the warp yarn or to the cloth produced. In by far the majority of fabrics no such movement takes place to any great extent, although something analogous is observable in $\frac{1}{1}$ plain weaving due to the slackness of the warp in the upper part of the shed. On this account the last two or three picks inserted in a plain cloth are not really incorporated in the fabric until a pick or two later in the weaving process, but are simply bunched up at the fell of the cloth, over and under it, as the reed comes forward. These threads are partially withdrawn as the reed recedes, to be again pressed into position on its return. But the resistance offered by them to the advance of the reed is more or less elastic; it is indeed a frictional resistance generated between them and the part of the warp under tension, and is distinctly most readily and gently overcome by a relatively slow movement of the reed. Let us, however, assume that the uptake motion has not acted, and that when the reed comes forward a second time the first weft thread is in exactly the position in which it was

left by the reed when forward the first time; then the distance through which the reed will require to move the cloth (assuming it to be a plain weave) will be approximately the diameter of the weft thread plus the diameter of the warp thread. These we shall assume to be 8 lb. jute (equal to 6 lea flax), with an approximately equal diameter of $\frac{1}{32}$ in. each. The maximum distance, then, through which the reed actually forces the cloth is $\frac{1}{32}+\frac{1}{32}=\frac{1}{16}$ in.; or the velocity at which the reed is travelling when it meets the cloth will be its velocity when at a point $\frac{1}{16}$ in. from the full forward point of its travel. In order to calculate this velocity accurately, we should trace the motion from the reed to the connecting pin, since the latter, being nearer the centre of motion (the rocking shaft), will receive a correspondingly reduced movement. It would be also necessary, however, after having found the velocity of the pin, to increase it proportionately again to the reed. To avoid this complication, we shall assume the motion at the reed to be that conveyed to the pin, and that the pin I, Fig. 190, is $\frac{1}{16}$ in. back from the full forward position when the reed and the cloth come into contact. Due to the fact that the acceleration of the pin is not uniform, it is a difficult matter to determine its actual velocity at any one point; we shall assume, therefore, that it is uniformly but negatively accelerated during the last 15 degrees of the crank's revolution before reaching the full forward point, and that the average velocity of the pin during that time will be its actual velocity at the middle position. But from the table already given we find that for 15 degrees of rotation from the full forward point the pin travels 0·12 in.—practically $\frac{1}{8}$ in.,—and that its average speed during that time (if the crankshaft be making 150 revolutions per minute with a 3-in. crank and a 12-in. connecting arm) is 7·2 ins. per second. This, therefore, according to our assumption—which, due to the acceleration not being uniform, acts adversely towards our contention rather than otherwise—is the actual speed of the pin when at a point $\frac{1}{16}$ in. back from the full forward position—namely, 7·2 ins. per second, less than half a mile per hour: rather a low velocity with which to impart a smart blow.

If, therefore, we cannot consider the lay as a free agent striking against the weft and cloth at a certain high velocity with a definite store of kinetic energy, we must search for another solution of the problem, and the matter seems to us to be rather a question of overcoming a certain resistance (that offered by the friction generated between the warp and the weft threads) by a given uniform force. Now, it is a well-known law in mechanics that if resistance be overcome slowly, less power is developed than if it be overcome rapidly; in other words, that power developed is proportional to the rate at which the resistance is overcome or inversely proportional to the time taken. We therefore hold that a slowly-moving lay, having a uniform force actuating it, is capable of overcoming a given resistance more easily than a quickly-moving lay with the same force actuating it. From this point of view, then, as well as from that of the fact that the warp will bear the strain of beating up better if it is brought on gradually rather than suddenly, we consider that a slow movement when nearing the full forward position is, in most cases, more of a benefit than otherwise.

One point in beating up which is probably of more importance than the speed of the reed, is its rigidity or

stiffness, and this more especially in wide looms. To obtain this rigidity in these looms it is a common practice to make cap D, Fig. 190 (page 357), when of wood, of great breadth; yet notwithstanding this increase of breadth it is not unusual to see the cap bending in the centre like a bow, if the work be anything heavy. In certain classes of work this exceptional breadth of the cap is objected to because of the light it obstructs and the shadow it throws on the yarn in the shed, and on this account cast-iron caps of smaller cross section, but of great rigidity, are often used. For similar reasons it is not unusual to find the lay stiffened underneath or at the back by the addition of an angle or a **T** iron bar.

After considering the foregoing contentions, therefore, it seems that any change of the length of the connecting arm, of the radius of the crank, or of the position of the crankshaft itself, having for its intention the modification of the eccentricity of the lay's movement in regard to beating up, should be with the object of decreasing rather than increasing its speed when nearing the full forward position.

It is not, however, from the point of view of beating up that the eccentricity of the lay's movement should chiefly concern us, but rather from that of the time allowed for the passage of the shuttle, or the portion of a revolution of the crankshaft which is occupied in moving the connecting pin from a given point on the line of its travel (that point at which time the shuttle just enters the shed, or when the pick is fully developed) backwards to the full back position, and forward again to the same point, at which time the shuttle should leave the shed. This is an object of importance even in tappet looms, where, in general, any amount of dwell can be given to the shedding wyper, and the shed therefore retained in the full open position for any reasonable degree of time; but more especially is it of importance in looms in which the shed is formed by a jacquard or a dobby machine, where the only approach to a dwell in the shed is that imparted as the actuating crank passes the dead centres of its revolution. In order to obtain the greatest advantage of this semi-dwell, the cranks which operate the dobby or jacquard should be so set that they will be on the dead centre, with the shed full open, when the connecting pin I is at the full back position, or when the crank and the connecting arm coincide. The best results will be obtained when the picking is so timed that the shuttle will be in the centre or slightly beyond the centre of its travel from box to box at the same time. By adopting this arrangement, and assuming that the shuttle takes the same time to travel to and from the centre of the shed, we shall have the reed, when the shuttle leaves the shed, at exactly the same position as it was at when the shuttle entered the shed, and a maximum opening of the shed will therefore be presented to the shuttle at both times.

As already indicated (page 324), the maximum amount, *i.e.*, 140° of the crank's revolution, is sometimes occupied by the shuttle in passing across the lay from the time the pick is fully developed until the shuttle is dead in the opposite box. If from this we deduct 20 degrees as being the time taken in coming to rest in the box, we are left with 120 degrees as the time during which the shuttle is in the shed. Now we think it will be generally conceded that it is not desirable to impart any greater travel to the connecting pin I, and, therefore, to the race, than is necessary or is intended (*i.e.*, the diameter of the crank circle); also that it is desirable, as already indicated, that during the passage of the shuttle the pin I, and, therefore, the lay, shall be as far back as possible, presenting to the shuttle during that time a maximum opening of the shed; and that the travel backwards of the pin I during the 60 degrees of the revolution of the crank immediately preceding the full back position of the pin, shall be exactly the same as that forwards during the 60 degrees immediately succeeding this position.

In order, therefore, to fulfil these two conditions—viz. to ensure that the travel of the pin will be no more than that intended, or that it be exactly the diameter of the crank circle, and that the lay will be as far back as possible during the passage of the shuttle—we would submit that only one relative position of the crankshaft K and the connecting pin I—that position which we have indicated—is possible. In Fig. 196, the original of which was drawn full size in order to avoid inaccuracy, and which has been introduced in proof of our contention that any deviation from the relative position shown in Fig. 192 will result in an increase of travel to the pin I, the position we have already indicated is shown in solid lines, while two other positions, chosen 3 ins. above and 3 ins. under the first position, are shown respectively in dot and dash lines and in dotted lines. We may at once state that we have not found either of these two latter positions obtaining in any loom, but from data of different looms before us—looms sent out by makers of repute in both England and Scotland—we find a variation in the relative position of the crankshaft of from 1 in. above to $1\frac{1}{8}$ ins. under the position shown in solid lines. The two dotted positions were chosen intentionally exaggerated in order that our contentions might be more easily shown. In each case the connecting arm and the crank radius are the same.

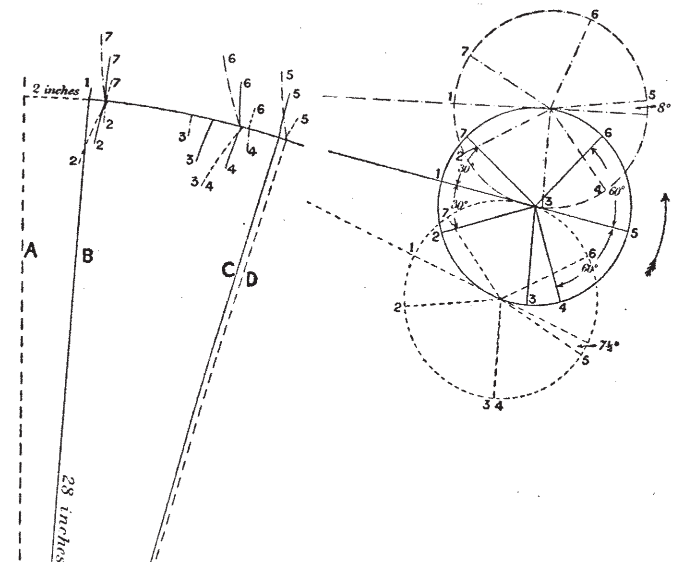


Fig. 195

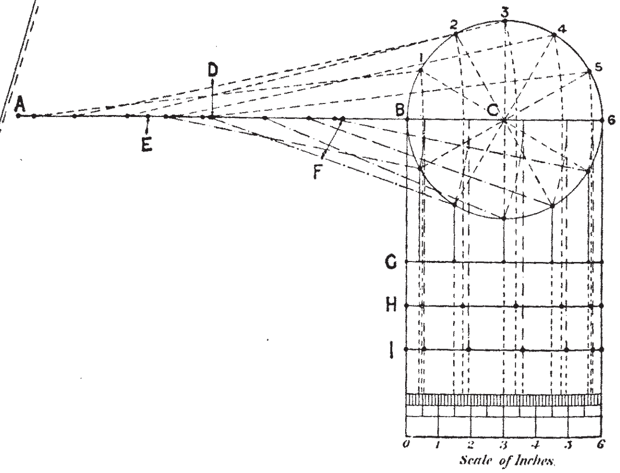


Fig. 196.

In regard to the increase of travel conveyed to the pin due to the raising or lowering of the crankshaft centre, this increase is indicated by the distance between the lines C and D on the arc described by the travel of the sword pin. It measures, in the cases given, about $\frac{2}{9}$ in., and is obtained by taking the compasses with a radius equal to the length of the connecting arm and passing one point round the dotted circles, at the same time retaining the other point on the arc described by the connecting pin. The exact point on the crank circle when the lay is full back is obtained by drawing a line from the point 5, thus found on the arc, through the centre of the crankshaft to cut the circle. From the figure it might be imagined that the increase of travel conveyed to the pin is the same in each extreme case. This is not so, but the difference between the increases is so small that it is impossible to reproduce it in the figure. By raising the crankshaft centre, the increase of travel is approximately 0·23 in., whilst by lowering the shaft centre the increase of travel is approximately 0·20 in. In the former case, if, as we assumed, the crank travels backwards by the bottom centre, approximately 8 degrees more than half a revolution of the crank's movement is taken to traverse the pin backwards, and 8 degrees less than half a revolution to move it forwards, or 188 degrees for the backward movement and 172 degrees for the forward movement. In the latter case—*i.e.*, when the crankshaft occupies the low position—the opposite holds good, 7½ degrees more than half a revolution being necessary to move the pin forwards, and 7½ degrees less to move it backwards.

One point that attention might be drawn to here is the fact that, in adjusting the loom for picking, while it is customary to do so with the crank in one definite position

—say the bottom centre,—it is necessary to observe that the position of the connecting pin, and therefore of the reed, when the crank is on the bottom centre, will vary according as the centre of the crankshaft is raised or lowered. In this figure we have indicated, by corresponding numbers on the arc of travel and on the crank circles, the positions which the connecting pin would occupy when the crank is on the bottom centre with the crankshaft in the three different positions.

Then, as regards the position of the pin when the shuttle enters the shed and when it leaves it: On each crank circle we have marked off 60 degrees before and after the full back position, and have indicated the positions of the pin upon the arc of its travel with the crank in these positions. It will be observed in the case of the solid or centre circle that these positions of the pin are practically coincident. In the case of the upper dot-and-dash circle the pin, and therefore the reed, are farther forward at 60 degrees after the full back position than at 60 degrees before it. With the lower dotted circle the opposite is the case, the pin in this instance being farther back at 60 degrees after the full back position than at 60 degrees before that position. It may be urged that in no case are any of these positions farther forward than in the case of the solid circle, and that the movement of the crankshaft out of that position is therefore advantageous. But any advantage gained in this respect is nullified by the fact that an increase of friction is conveyed to the warp by the increase of travel, beyond that which is necessary or desirable, which is imparted to the reed.

The effect of the movement of the crankshaft into either of the dotted positions, so far as the velocity of the pin when beating up is concerned, is practically nil, as the

position of the pin when the crank is yet 30 degrees on either side of the full forward position is practically identical in each case.

Numbers.	Positions.
1	Crank full forward.
2	,, rotated 30 degrees backwards.
3	,, on bottom centre.
4	,, 60 degrees from full back position.
5	,, at full back position.
6	,, 60 degrees after full back position.
7	,, 30 degrees from full forward position.

The above table, in which the numbers given refer to similar numbers on the crankshaft circles and to the lines indicating the position of the connecting pin at these times, will assist materially in reading the diagram.

We do not think, however, that change of the position of the crankshaft is ever resorted to for the modification of the eccentricity of the movement of the connecting pin, as the variation in actual practice which is made on either side of the position which we have indicated should obtain, is indicative rather of a want of knowledge of the results obtainable from such variation of position than of a desire to obtain them. Modification of the eccentricity of the movement of the pin is best obtained by the reduction of the length of the connecting arm, and the increase of the radius of the crank, and is usually resorted to for one consideration only—that of the time allowed for the passage of the shuttle, or the reduction of the travel of the connecting pin for a given portion of the crank's revolution round the full back position. As a result of thus decreasing the velocity of the lay about the back centre, an increase of its velocity when about the front centre is obtained; and because of this unavoidable result of the