This is very easy of accomplishment. Hooks are set apart in the machine corresponding with the number of levers employed to act upon the boxes. A corresponding number of extra levers are placed in front of the Jacquard harness or healds. One end of these levers is connected with the hooks in the figuring machine, and the other end attached, or made to act upon the lever which would otherwise be actuated by the box cards; then holes are cut in the figuring cards to correspond with the hooks set apart for the box work, and the levers are actuated in precisely the same manner as they would be if an independent set of cards were used.

Harness or Dobby looms are generally fit up in duplicate so that the boxes can be worked either with their own cards or from the figuring machine.

RISING BOXES.

In dealing with rising boxes a difficulty arises from the multiplicity of systems used, but in principle they may be reduced to two, one of which we may describe as the negative motion and the other as a positive motion. Again each may be sub-divided in such a manner as to indicate the method of operating. For instance, in the negative motion we may have a lever fulcrumed at one end near the back of the loom, and attached to the box by a connecting rod at the other end, and a lever connected anywhere between those points which is attached to a third lever. This second lever may then be caused to rise and fall, either by means of tappet chains or plates; or it may be that the lever to which the box is attached is balanced by a weight at one extremity, nearly equivalent to the weight of the box itself, and the fulcrum placed anywhere near the centre; then motion may be communicated

All the circular boxes shown here are made by Messrs. Hattersley, of Keighley, and no greater compliment could be paid them than the fact that as soon as their patent in the skipping box expired, all the leading makers of circular box looms adopted their system in a greater or less degree.

to it either by means of a chain, or non-positive cams, which may be brought into action through the medium of card cylinders, somewhat similar to those in use in the circular boxes.

Boxes of a positive type may be acted upon by grooved cams, each cam determining whether the box should be raised one, two or more holes, or what is equivalent, by a series of eccentrics. Perhaps the principle of the positive boxes will be more readily understood if the non-positive is thoroughly dealt with first. One of the earliest forms of the non-positive motion, and upon which all others have been based, is known as Diggle's chain. This contrivance will best be understood by reference to Fig. 65, which shows an end elevation of the loom or at least that portion of it having direct reference to the box, and a full view is shown at Fig. 66, to work up to four shuttles. B is the box carried upon the rod from the end of the lever A. C is a rod connecting the lever A with the upper lever D. F is a star wheel driven by means of toothed wheels from the crank shaft, and in such a manner that at every revolution of the crank shaft the star wheel is carried forward one tooth, corresponding with the size of the link of the chain. The chains are so arranged that there are several heights, or projections, in the links and are made interchangeable, so that as each one comes under the lever D it determines the exact position of the box. Suppose, for instance, the box has four shelves, or made for four shuttles, then there would be four heights in the links each corresponding with the depth of the shelves of the shuttle-box, so that if we call the links 1, 2, 3, 4, and the boxes 1, 2, 3, 4, counting from the top box or shelf, No. 1 link will allow the box to remain at its lowest point; No. 2 link will raise it so as to bring the second shelf on a level with the shuttle race; No. 3 would raise it to the third shelf, and No. 4 to the fourth. So that to bring any shuttle required it only means placing the links in the order required for the pattern. The different parts of the chain for actuating the box are shown at Fig. 67, consisting as they do of links of various heights and forms, and pins and connections for holding them

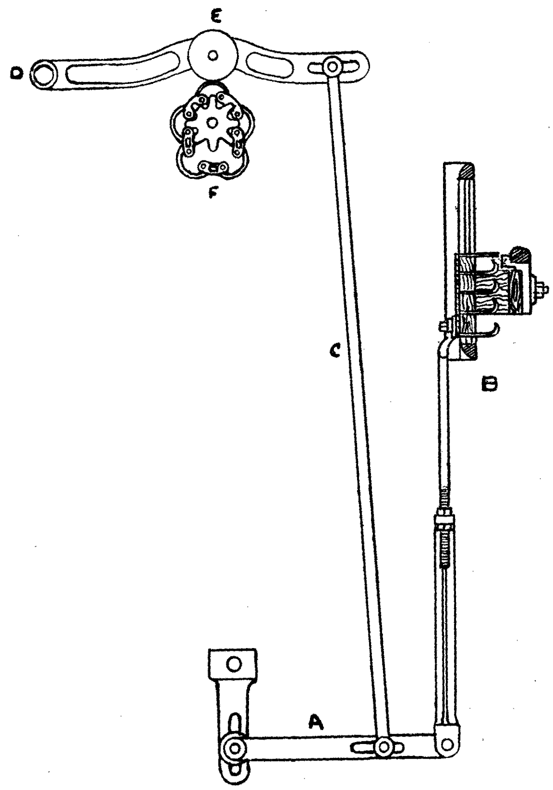


Fig. 65.

together. From these it will be seen that any variety of combination may be made and any one box kept in position as long as desired. The chain must of necessity have as many links as there are picks in the pattern. One feature

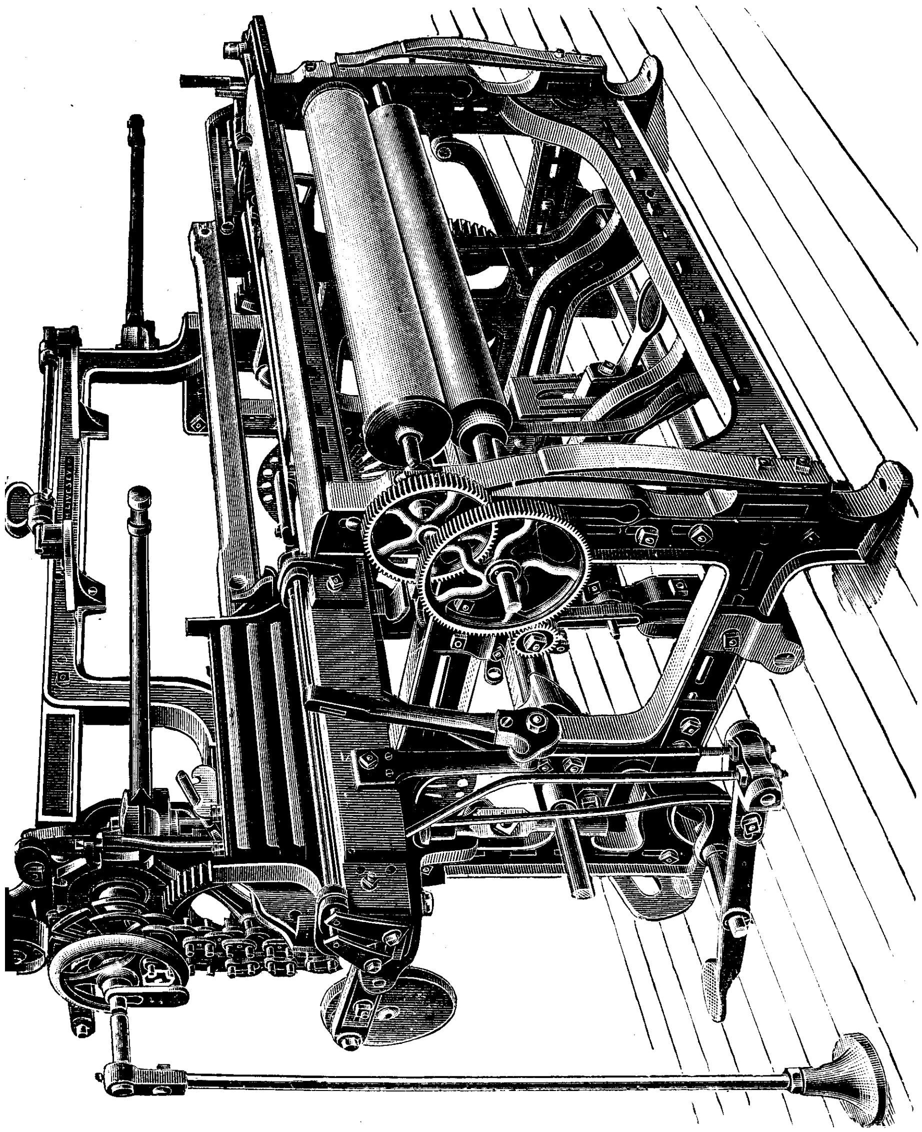


Fig. 66.

in this class of loom, and which is common to all negative motions, must not be overlooked or treated too lightly, the box is raised by the direct action of the chain, which is simply a non-positive cam, but it must fall by gravitation, and this fact alone renders it an unsafe arrangement. If the parts are so carefully balanced as to ensure easy working then there is considerable risk of hesitancy in the box dropping; on the other hand if this is sufficiently weighty to ensure its dropping, then power is required to raise it, and as a consequence wear and tear. The latter alternative is certainly the best as ensuring something like perfection of working.

The system possesses several disadvantages, one of which is, the difficulty in moving the box from any one position to another to change shuttles or when the weft has run out. Theoretically it can be done at once, but practically, as a glance at the details will show, it involves some labour and also some loss of time. Another disadvantage of this system, in making large patterns, is the enormous weight of the chain, as well as the time and labour involved in putting them together on a change of pattern taking place. But in spite of the disadvantages accompanying it the system has been in use now for about half-a-century, and still looms are being made where the principle is kept, although some of the details are varied.

KNOWLE'S CHAIN.

The next following chain motion is known as the Knowle's chain, and applied to the "Hollingworth and Knowle's" looms as made by Messrs. Hutchinson and Hollingworth, Limited, of Dobcross. The arrangement is in reality a combination of levers and chains; take the Fig. 68 and we have a chain there carried upon a cylinder A operating the lever at B, this again is made to act upon a rod, one end of which is carried by a toothed wheel C,

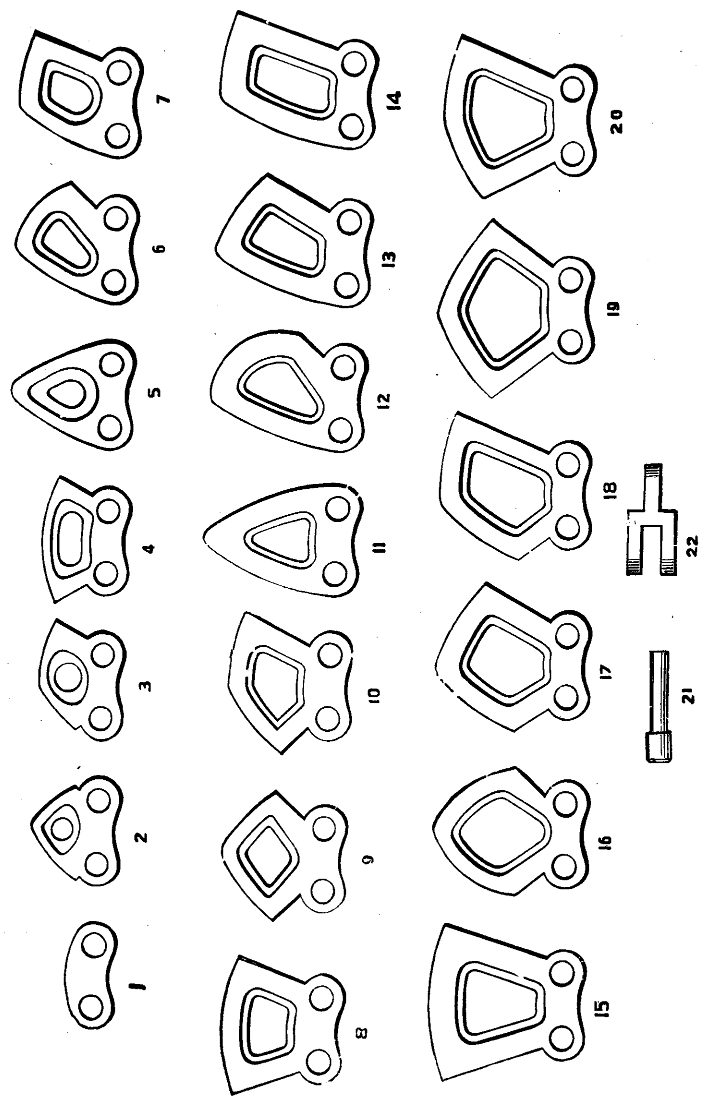


Fig. 67.

and from the end a long lever is carried downwards as shown at D, and to a point near the centre of this a chain E is attached, carried over the pulley F and the guide pulley G to the shuttle-box, or a lever connected with it. Then these connectors operate the two levers D and H—the roller F being attached to one end of the lever H. Then by altering the relative position of the two it is possible to bring any one of the four shuttle-boxes into

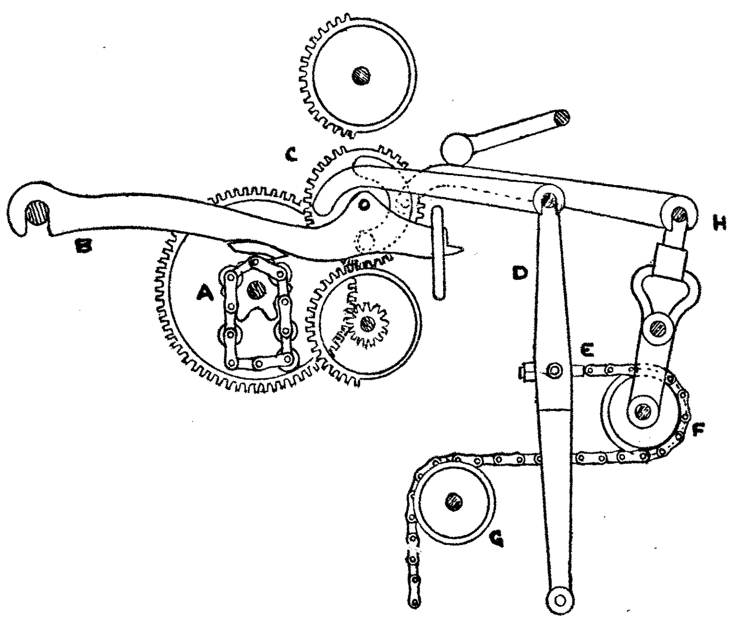


Fig. 68.

position for working. The details of the operation are as follows:—Above and below the wheel C are placed two wheels, each having teeth on half their periphery, and revolving in opposite directions—they form in reality part of the dobby motion, which will have to be described fully later. The wheels C are really a series of thin plates turning freely on a centre pin. The vibrator lever B consists of two thin plates rivetted together and betw··en which the wheel C is placed. The lever B will be raised or depressed by the chain A, a roller bringing the wheel C in contact with the toothed wheel above and a link with that below. In the wheel C a semi-circular slot is cut and a rivet in the plates forming the lever B will prevent it turning too far in either direction. A connecting bar is now hinged to the wheel C and the lever D, and in like manner the lever H is connected to a wheel plate. By raising the lever B the connecting arm of the lever D or H

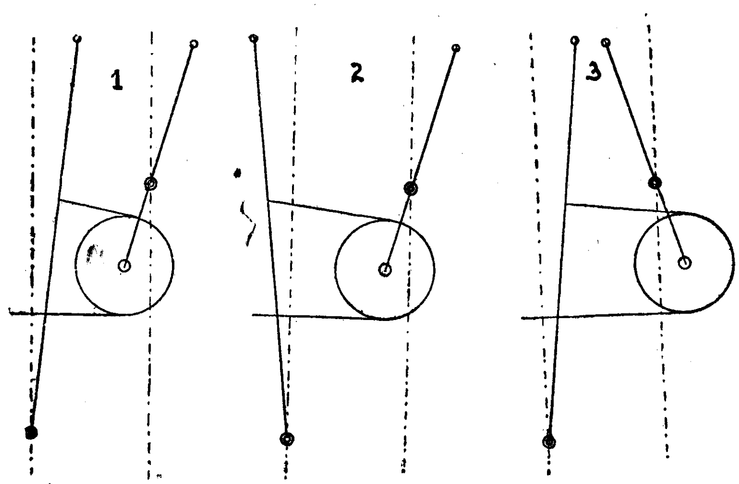


Fig. 69. *Fig.* 70. *Fig.* 71.

would be carried to one extremity or "dead centre," through the medium of the wheel above, and on being lowered it would be carried to the opposite extremity through the medium of the wheel below, so that either or both of the levers may be placed at the front or back extremity at will. It will be noticed that on the wheel C a tooth is omitted at one side of the wheel and several at the opposite side, so that when in gear, say, with the lower wheel, the upper one can revolve freely and *vice versa.*

Now let it be supposed that the box No. 1, that is, the upper box in the series, is in position when the pins connecting D and H are at the front extremity of the stroke as shown in Fig. 69. The second box when H is at the front and D at the back as in Fig. 70. The third box when H is at the back and D at the front as in Fig. 71. And the fourth box when both are at the back as in Fig. 68, or the reverse of Fig. 69.

The description given here applies to four boxes, but by the multiplication of levers, as shown at Fig. 72, which is for six boxes, any number of shuttles may be used.

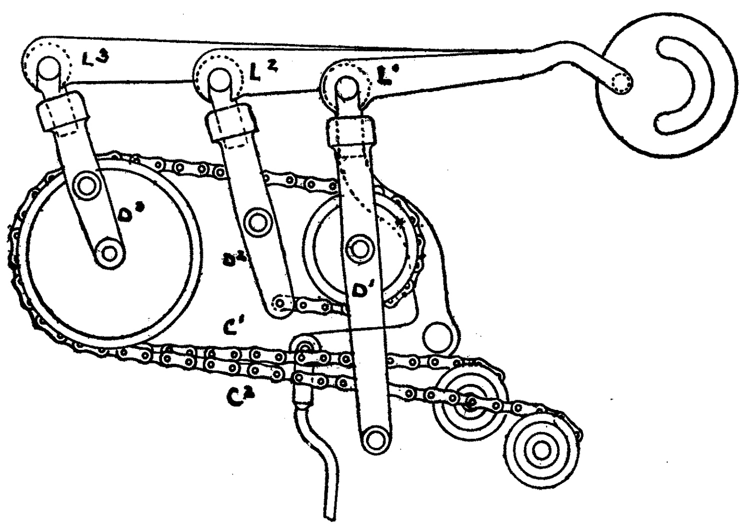


Fig. 72.

In this illustration all the wheels have been left out except that acting upon the vibrator and corresponding to C in Fig. 68. Here it will be seen there are three levers, D^1, D^2 and D^3, each with its corresponding vibrator, L^1, L^2 and L^3, and also with their corresponding chains, C^1 and C^2. The lever D^1 corresponds to D in Fig. 68, and D^3 to H, whilst D^2 is supplementary. The chain from D^2 is carried over a guide roller on D^1, so that the movement of D^1 will affect it much in the same manner as would the movement of D^3. The movements will be best understood by reference

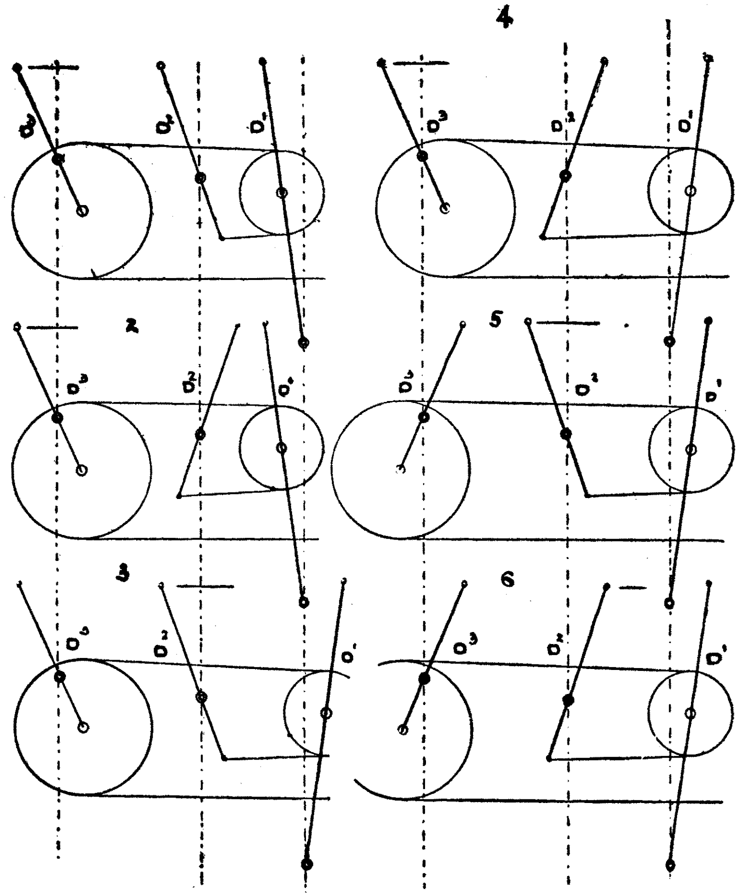


Fig. 73.

to the line drawings at Fig. 73, where the position of the levers for each box in succession is shown.

There is probably no more ingenious contrivance in the whole system of box looms than is displayed here. Whatever opinion one may hold as to the relative merits of balanced as against positive box motions.

At first sight the mechanism seems very intricate, in reality it is very simple, we have in the wheels C what are virtually cranks, and through their medium the chain I passing round the roller at the end of the lever H and over guide roller G direct to the lever operating the box, thus giving a compound motion which enables us by working the two cranks in unison to give any degree of movement to the chain I and consequently to the box.

Some attempts have been made from time to time to make chain motions, as applied to boxes, partake of the character of the positive motion by the simple expedient of employing two chains to operate the same lever, one to raise and one to depress the box. A lever has its fulcrum placed between two chain cylinders, and connected by a rod to the lever which operates the box. Now suppose for a moment two shuttle-boxes only are employed, then two forms of link would be employed, one having a projection and the other being without; let a projecting link be placed upon one cylinder and a blank link upon the other—both being in contact with the lever at the same time—and the box must be depressed; then reverse the links, placing the projection in place of the blank link and *vice versa*, and the box will be raised, so that by the employment of two chains, one always the exact reverse of the other, a positive motion will be imparted, but of course having the accompanying disadvantage of not only having the double weight of chain to carry, but double the amount of labour in preparing it; at the same time it may be argued that ensuring the positive action is a sufficient compensation for the slightly increased amount of labour in preparing the chains and the additional weight the loom must carry. If this can be done then with two boxes it necessarily follows that with the links arranged to the several heights corresponding to the number of boxes employed, or required to be moved, not only may any number of box be used but skipping may take place from any one to another.

There have been from time to time numerous modifications of the chain system but in effect many of them retain the same faults, the same liability to go wrong, but of course having the slight advantage of requiring a minimum of power to operate them as compared with some of the positive motions. The negative action in boxes differs from the negative action in some other machines, inasmuch as there must often be such a careful adjustment of levers so that the box, forming a weight at one end of the lever, is counter-balanced by what is equivalent to a weight at the other end.

POSITIVE BOX MOTIONS.

One of the most effective forms of positive box motions is that manufactured by Messrs. Hacking & Co., of Bury, and based upon what is known as Whitesmith's principle. The essential features of the motion consist in a combination of eccentrics—so connected with a lever which will actuate the box that the latter can be moved any distance required. Suppose for instance it is required to operate a shuttle-box having four holes, then two eccentrics will be sufficient for the purpose. The first, or inner one, for it must be remembered that one is outside the other, would be sufficiently large to move the box one hole, the outer one would be large enough to move it two holes; then by combination any distance can be moved from 1 to 3, so that allowing box 1 to be in the normal position three movements would bring up box 4.

This will be best understood by reference to Fig. 74, where the eccentrics are shown in four positions. In the position 1 the two are placed so as to both tend to bring the connecting rod to the lowest position, and therefore the top box, which we will call No. 1, into the working position; in position 2 the inner eccentric is reversed in position, so moving the boxes a distance corresponding with one hole; in No. 3 the inner eccentric is returned to the normal position, and the outer one reversed thus moving the box two holes, and in No. 4 both are reversed, thus moving the box three holes, or from one to four, so that it will be seen at a glance that by moving the eccentrics in conjunction any one of the four shuttles can be brought up at will.

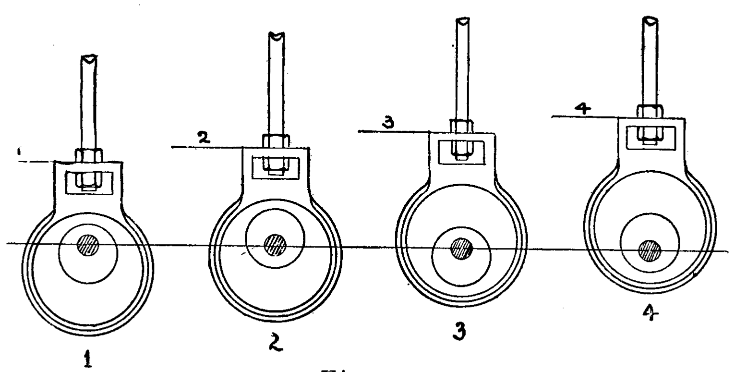


Fig. 74.

Now the mechanism connecting these eccentrics with the box may be examined. Fig. 75 shows the mechanism of the box separated from the other parts of the loom. The boxes themselves are shown at B^1 to B^4, supported on the vertical rod A attached to the lever L. This lever is connected by the rod R to the eccentrics E already described.

Leaving that portion for a moment it will be as well to follow the power from the driving shaft up to the eccentrics. On the driving or crank shaft of the loom a pinion P is placed communicating motion to a wheel W of double its own dimensions, and which has three teeth projecting more prominently from its circumference than the rest. On one side a cam is formed, the whole being carried upon a tube which will not only revolve upon

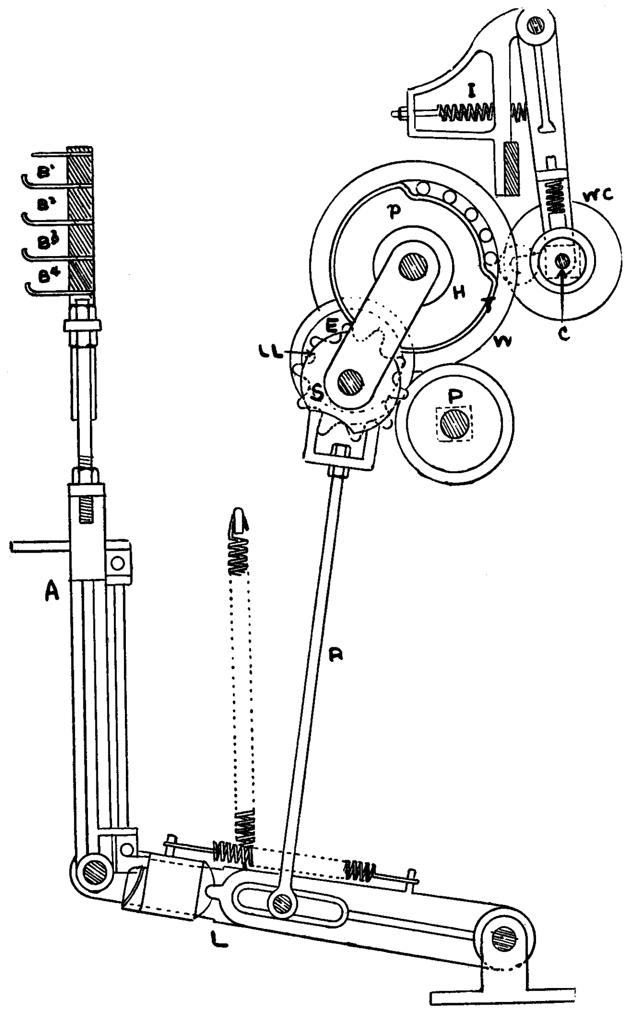


Fig. 75.

the stud or spindle, but also receive upon its surface two slotted hoops suggested at H. Two discs, or peg wheels

T are placed upon this tube and are made to rotate with the tube by the projections *p* upon it. These peg wheels are kept apart by a spiral spring (they are not seen in this elevation as one is behind the other), but are moved towards each other by needles and grooved cams. A card cylinder C is carried on a frame swinging from above, and has a bowl resting against the cam T on the face of the wheel W. As the cam revolves the card cylinder is pushed free of two horizontal needles, and at the same moment the three projecting teeth on W fall into teeth in a wheel WC and cause it to revolve so far as to bring the next pattern card in front of the needles. The card cylinder is returned to its position by a strong spring I.

Five teeth are cast upon the peg wheels, so that they may serve as teeth, and as the two are made to approach each other they may be made to actuate one or both of star wheels S, one of which actuates the smaller and the other the larger eccentric. The smaller of these is loose upon a spindle, the larger encloses it, and this is in turn embraced by a strap, or loop connected to the rod R. A locking plate L, L, with two pieces cut out at opposite sides coincide with the full curved surface of the tappet plate. The peg wheel then acting upon one of the star wheels the eccentric is moved from one position to the other, and the movement necessarily partakes of the nature of a crank, or slow at each extremity and quick in the centre of movement. The motion then is communicated through the rods R and A and the lever L direct to the box.

As will be seen the lever L is of the "broken backed" species, already mentioned, so that the result of any accident will be minimised, and assistance is given by a strong spring in balancing the several parts.

One of the difficulties connected with this motion lies in the preparation of the cards. The eccentrics moving in one direction only it is necessary to know exactly what position the boxes occupy before preparing the card to make a change, but this difficulty, like others of a similar kind in shedding motions is easily got over by the exercise of a little patience and skill.

An improvement upon this is shown at Fig. 76. In this there is a separate needle acted upon by the pattern card for every box, each needle acting in turn upon levers C^1 to C^4, and so actuating the eccentrics as to cause the

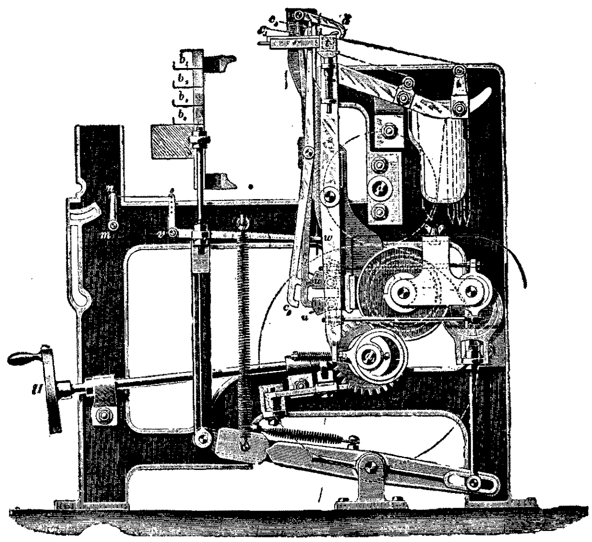


Fig. 76.

corresponding box to come into position, no matter what the position of the boxes previously; thus the needle C^1 will bring the box b^1 into positon, C^2 will bring the box b^2 into position, and so on for all the others. The pattern card barrel *t* is, as will be seen, placed within easy reach of the weaver when it is desired to turn the barrel in one direction or the other, and a simple contrivance of the levers *n*, *s*, *v*, acted upon by the weft fork arrangement raise the catch *d*, the moment the weft breaks, thus stopping the revolving of the card barrel *t* and keeping the pattern cards in the proper position for the construction of the pattern when the shuttle has been replaced, and saving the weaver the trouble of turning the cards over to find the correct position in the pattern.

A convenient arrangement is also provided for moving the boxes into any position. By pulling the needles, or levers C, and turning the handle H, any one of the boxes can be brought into position at once. Any weaver will understand the value of a simple contrivance like this.

The construction of this loom permits it to be run at a high rate of speed, and the changes of the box, no matter how they are skipping, must, from the manner in which they are operated, be perfectly smooth and steady, and being positive the changes may be relied upon. It will be seen from the diagram that it is provided with the hinged, or "broken backed" lever as a safeguard in the event of anything preventing the boxes moving easily.

This loom is made by Messrs. Hacking, of Bury.

LIVESEY'S DROP-BOX.

Another arrangement of a positive drop-box motion is shown at Fig. 77, which is by Messrs. Livesey, of Blackburn, the principle of which will perhaps be more easily understood by reference to the detail drawing Fig. 78. The essential features of this motion are a forked rack A, a straight one B, and two wheels at C. The straight rack is attached to the lifting rod of the boxes. The rack A is suspended from the lever D, which is acted upon by cams or tappets at E. One of the wheels at C is in contact with the rack B, and the other is placed in the centre of the space between the arms of the fork A, so that unless moved to one side there would be no contact with either of the racks and the wheel, but when moved and brought into contact it would cause one of the wheels at C to

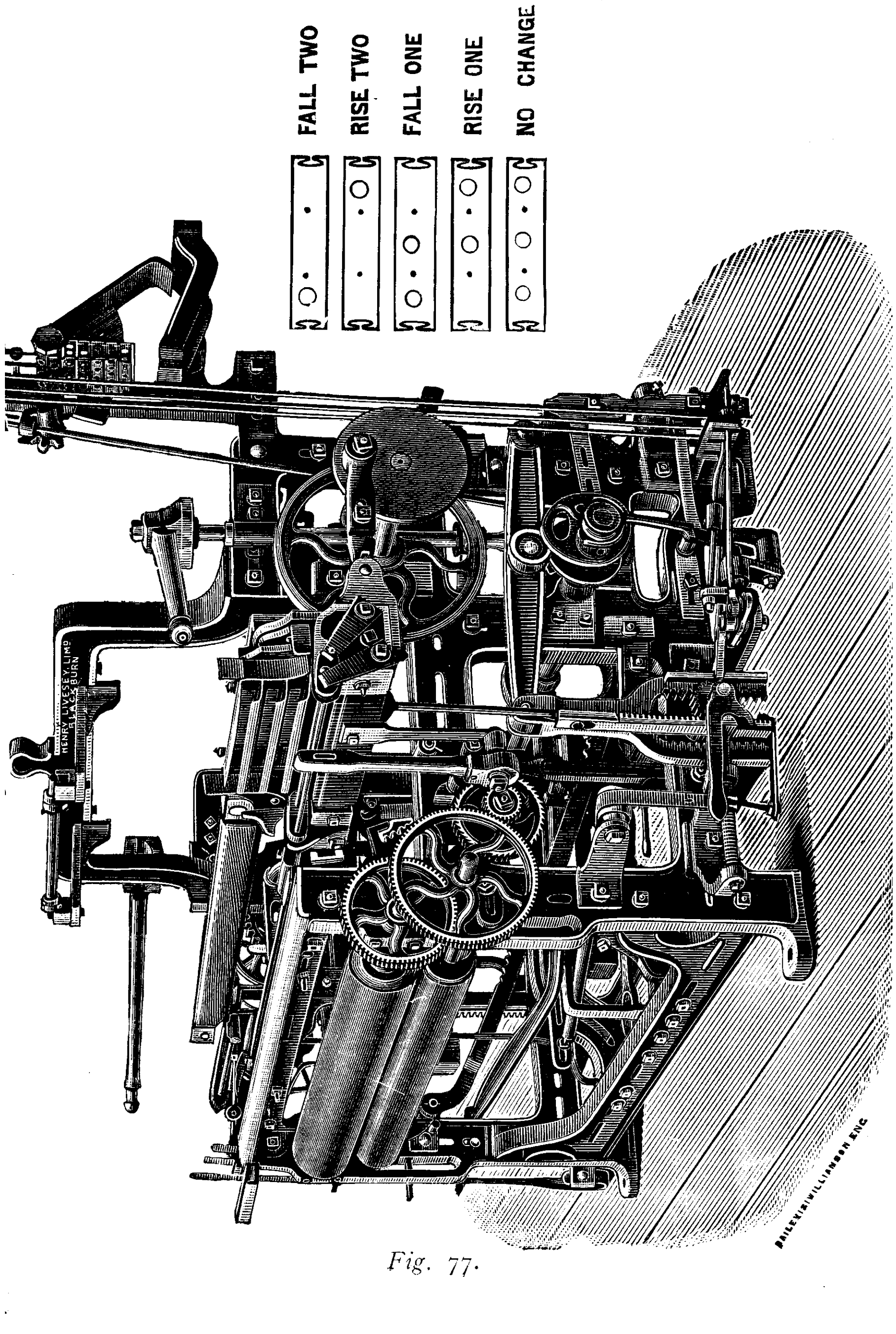

FALL TWO
RISE TWO
FALL ONE
RISE ONE
NO CHANGE
HENRY LIVESEY, LIMD
BLACKBURN

Fig. 77.

revolve, and that carrying with it the other wheel would move the rack B, and raise or lower the box. Then the cams at E are so arranged that one of them will cause the lever D, through A, C, and B, to raise or lower the box one or two holes; lower it by pressing A towards B and raise it by pressing A towards the back of the loom.

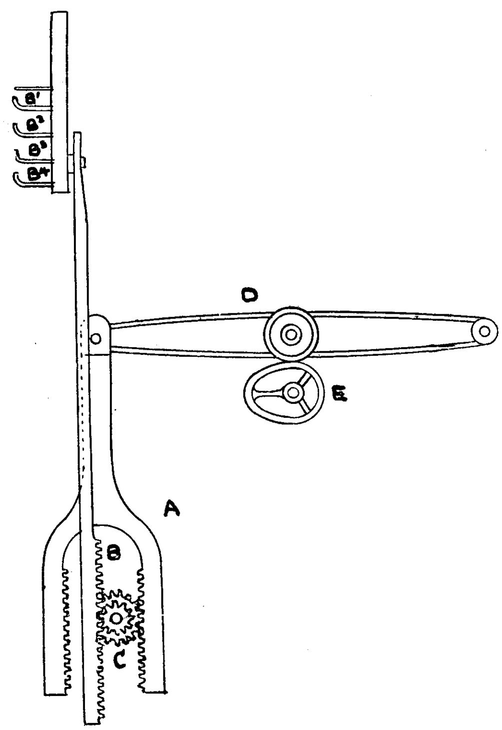


Fig. 78.

A pattern card arrangement is shown on the loom Fig. 77. At the back of the loom are three vertical rods acted upon by pattern cards carried over a cylinder or bar, and acting upon levers near the foot of the loom, two of which act upon the forked rack, and one upon a clutch which moves the cams at E, so as to bring either one or the other under the lever D, as seen in the loom. The method of changing the boxes will be understood from the diagram of the cards at the side of the loom. No. 1 card would cause the boxes to "fall two" by pressing the rack A forward and being lifted by the larger cam will carry the wheel C round and pull down the rack B a distance equal to two teeth; No. 2 card will reverse the motion by reversing the rack A and consequently the movement of the rack B. No. 3 card will "fall one" by bringing the small cam at E under lever D, through the medium of the clutch, and No. 4 will reverse the motion by reversing A, as did No. 2. No. 5 will leave matters as they are by allowing the small cam to remain under D, and dropping A into the vertical position and free of the wheel at C, so that changes can be of either one or two boxes, rising or falling, as from 1 to 2, or 1 to 3, from 2 to 3, or 2 to 4, or *vice versa*, and of course with the same degree of precision in either direction.

THE ECCLES DROP-BOX MOTION.

In the arrangement of the details of this loom it may be said that there is something which partakes of the character of both the positive box of Messrs. Hacking & Co., and of the Knowles' arrangement already described. In the former as it is a positive motion, and in the latter in that the motion is communicated by cranks, the crank taking the place of the eccentric in one, and a direct lever with spring escapements taking the place of the balanced lever in the other. A back view of the loom showing the box motion is given at Fig. 79, and which must be followed carefully in conjunction with the end elevation at Fig. 80, so that the details can be thoroughly mastered; the lettering being upon Fig. 80 only, and some of the parts appearing in duplicate, though for separate purposes, in Fig. 79. The boxes B^1 to B^4 are carried on a vertical

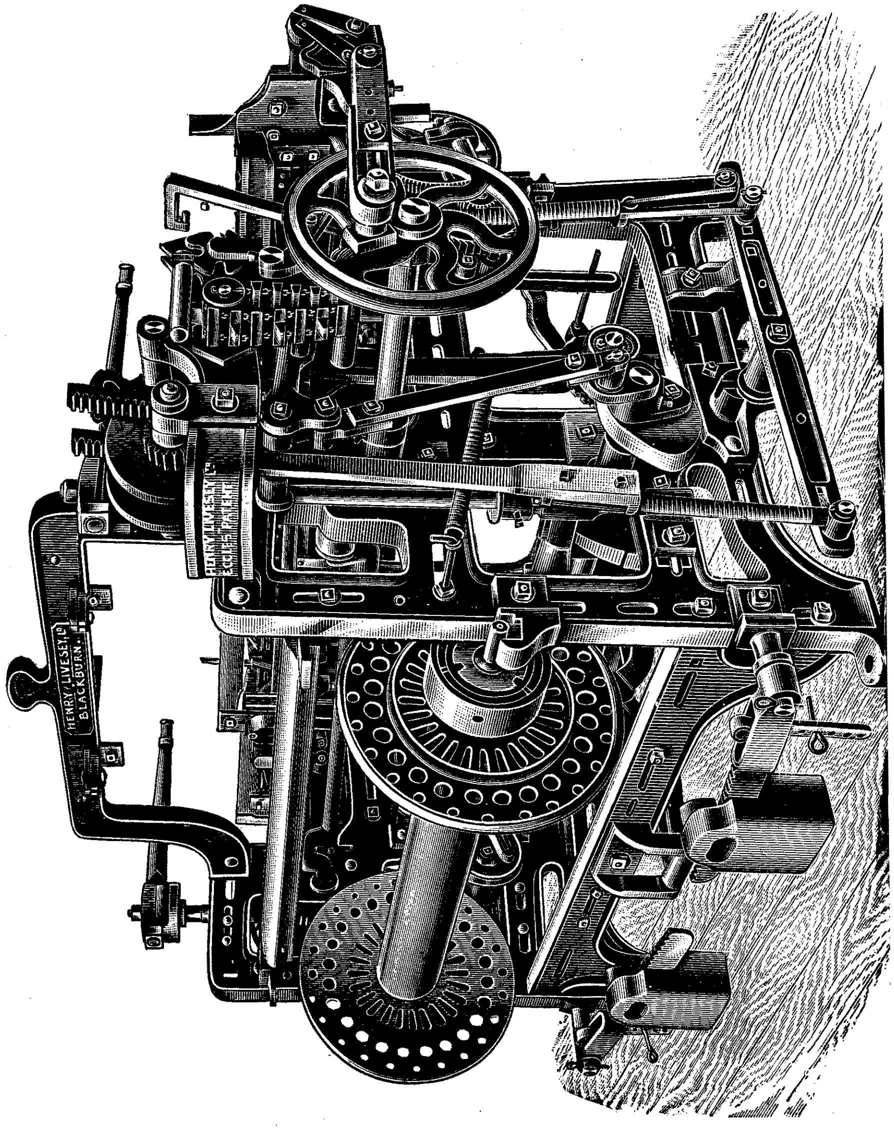


Fig. 79.

rod on the lever L, the other end of the lever being connected by a corresponding rod to a crank on the disc D. Although only one disc D is seen in the elevation, there are really two as seen in the view Fig. 79, each having

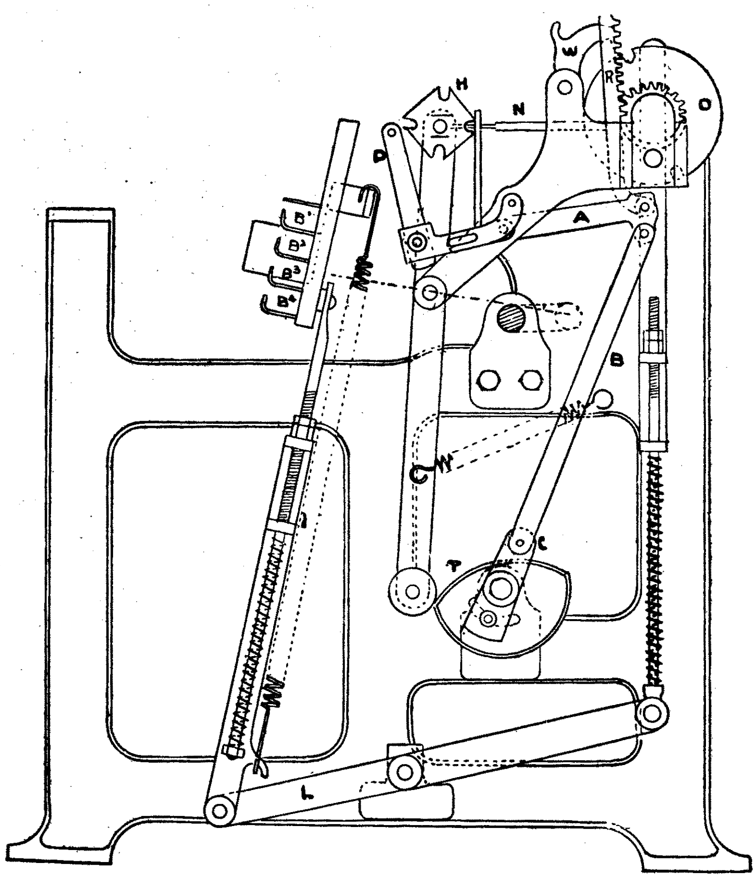


Fig. 80.

upon it a toothed wheel engaging the rack R in the one case and a corresponding one in the other. These racks having their fulcrums so placed below the disc D as to fall backward by gravitation. A lever A is actuated through the rod B by means of the crank C, and constantly working the rack R upwards and downwards. A pattern card cylinder H is oscillated so as to act upon the needles N and engage either of the racks R with the toothed wheel upon the disc D at will, and as the rack is always moving upwards or downwards it will cause the disc to revolve whenever the teeth are engaged, and will always carry it a distance equal to half a revolution, so raising the crank to the top, or bringing it to the bottom. So far the principle of the disc is the same as that noticed in the

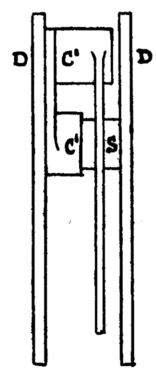


Fig. 81.

Knowles' chain, but actuated in a different manner. Now let us see how the boxes are moved. An elevation of the discs and wheels is shown at Fig. 81, apart from the other mechanism. The outer disc D carries a crank C^1 calculated to move the lever L a distance corresponding with one box. On the end of this crank another crank C^2 is fitted loosely, which will move the lever a distance equal to two boxes, the pin of which passes through a slot in the inner disc. Now let the crank on D and the second crank on the inner circle be both at their lowest points No. 1 box will be in position; bring them both to the top and the boxes will be moved to No. 4. If the crank on the front disc is brought to the top and that on the back to the bottom No. 2 will be in position and when reversed No. 3 will be in position.

The rods connecting the discs and lever L, and L with the boxes are provided with spring escapements, so that in the event of the shuttle being caught by the box, they will give way and prevent breakages. The card cylinder is actuated by the tappet T on the bottom shaft of the loom in its movement to and from the needles, and the cylinder is turned by the lever arm P having a pin at its upper point, and moved backwards and forwards by the arm A connected to B. When brought into position the box is locked finally by the catch W being forced into a notch in the disc by means of a spring, so that no movement or vibration can take place until the catch W is removed by the action of the card cylinder and needles.

The reader may now easily reckon for himself the advantages and disadvantages of circular and rising boxes of positive and non-positive motions for the work which they are likely to be called upon to perform. For heavy work there can be little doubt of the advantage of the rising box loom as giving all the stability required by the use of a fast reed. When changes from one shuttle to another, which involves skipping are required the positive motion presents apparently all the advantages; though the Knowles' chain is a masterpiece of non-positive action, and for ease and facility of change the circular box presents features which cannot be ignored. It is difficult to give a positive verdict in favour of any one, each has its own sphere.

LECTURE 6.

SHEDDING MOTION.

In the second lecture the general character of the movements involved in shedding, or separating the warp threads, was described, and it will be remembered that it was there placed under three headings. First what we speak of as the open shed, or that where the threads remain at their highest and lowest points respectively as long as required for the formation of pattern; second, where all the threads meet in the centre between each shed and separate again; and third, where one portion remains at the lowest point and the other portion is raised the entire distance representing the depth of the shed, or, as the latter two systems are known, centre and bottom shedding. Leaving aside the question of the advantages or disadvantages of each system, beyond what was laid down in the lecture referred to, attention may now be turned to the methods adopted for forming those sheds.

Of course every one will know that the separation of the warp threads, in addition to forming a passage for the shuttle, must also form that passage in such a manner that by the order of succession of the threads, in being raised and depressed, the pattern upon the fabric must be formed; so that we have not merely the consideration of the character of shed but also the production of pattern. Perhaps it would be best to take the simplest of the forms in use, or what is known as tappet shedding, first, and examine that thoroughly.

There are two distinct systems of arrangement of the mechanism connected with tappet weaving, but both have for their objects the separation of the warp threads by means of what are commonly known as negative cams, or tappets. In the one case the treadles are placed under the loom, and the tappets acting upon them upon the lower shaft, and acting directly as shown in the plain loom at Fig. 82. The object then is to convert this negative motion of the cam into a positive one. In the

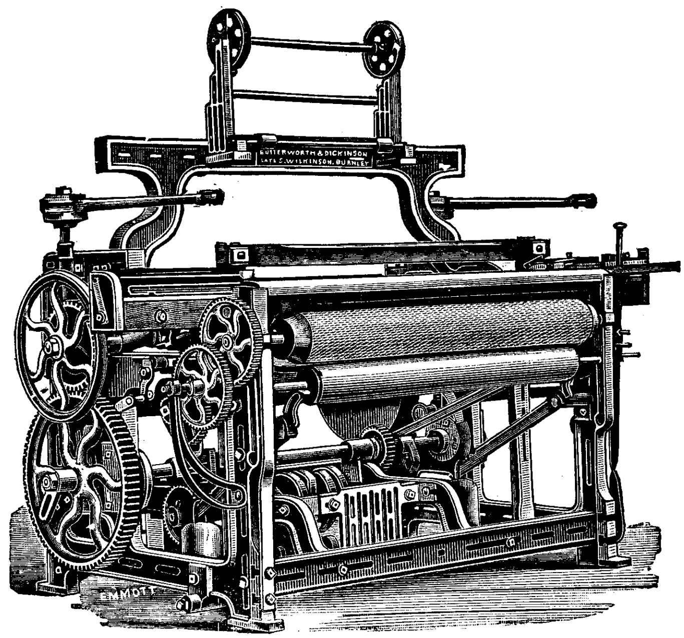


Fig. 82.

weaving of a plain cloth this is quite easy of accomplishment, the two treadles are connected as shown in the illustration, to the bottom of the two healds. The tops of the healds are attached to each other by means of cord or strap over a roller, or made fast to a shaft above the healds as shown in the figure, so that as one heald is depressed the other is raised through the medium of this cord or strap, The weight of the treadles alone will serve to keep the healds at tension, but the tappets should be so constructed that as one is depressing its treadle the other is allowing the treadle upon which it acts to rise. Now to ensure good work those two tappets should be in contact with their respective treadles throughout the movement, otherwise at one moment considerable tension will be thrown upon the cords, and at another they would be comparatively slack, having only the weight of the treadle to keep them in position. This is one of the first points that must be attended to in weaving for the production of good work. The sheds should be perfectly even, not only as previously pointed out in the tension upon the warp threads, but also in the tension upon the healds. Two things will occur if this is not properly followed. First, the healds will, at one point of the movement, be very tight and have to bear considerable strain, whereas at another point they would be slack and liable to "knuckle."

In connection with tappet shedding there are three distinct questions to be considered; first, the formation of the tappet so as to keep the healds at a perfectly even tension; second, to give the exact depth of shed required so that we are neither overshedding, which will involve unnecessary strain upon the warp threads, and cause probable breakage; or undershedding, which would cause undue friction upon, and resistance to, the shuttle in its passage; and third, the exact amount of eccentricity required for the work. Again of course in tappet working we may have what is termed unequal shedding, which may mean either that the healds are not raised to their proper height in relation to each other, or depressed so that the threads passing through them will form the same straight line; or it may mean that one end of the heald is raised higher than the other and so cause inequality in the shed from side to side. Again we may have the mis-timing of the movements of the healds in relation to each other, which really means that the tappets are not properly placed upon the shaft; and again we have the dwell or pause of the tappet, which may be a variable quantity according to the work to be done.

The question of evenness of tension has been already dealt with in the second lecture when speaking of the relative positions of the back rail and breast beam.

The depth of shed must be determined presently when the size of shuttle, stroke of the going parts and other details as to leverage of treadles, &c., are taken into account. The general character of the eccentricity has also been dealt with, but the exact method of obtaining that must now be dealt with along with the question of drawing the tappet. The timing of the tappets in relation to each other must also form part of the work of drawing, but the "dwell" must be governed by the character of the fabric to be woven. Then taking those questions in the order in which they occur we should have the tension, not only of the warp threads but of the healds, to deal with; the tension upon the warp threads passing through each of the several healds will be readily determined by the general rule laid down in the second lecture, but the tension upon the several healds will be governed entirely by the form of the tappets, their position in relation to each other, and the leverage of the treadles and any intermediate lever that may be employed; so that the question of drawing the tappets and of determining their position on the shaft in relation to each other must be reduced to a most exact science.

It is often said in practical working that no man can so adjust a loom that he will have even an approximation to evenness of tension in each of his healds at the several points of their passage in shedding, but on the other hand it has more than once been asserted that a man who cannot construct his tappets, and adjust the leverage of the treadles and intermediate parts, so that a spring balance placed anywhere will show a difference of strain upon the cords of more than a few ounces, is not worthy to occupy a position of responsibility. Now we must see how this works out. Before coming to the actual construction of the tappet it will perhaps be as well to take each of the other points seriatim, so that we should have only actual dimensions to deal with when preparing the drawing. Then first as to the depth of shed. Take the elevation of the shedding motion as shown at Fig. 83, and we must suppose some dimensions, first we have the going part travelling a distance of 6 ins. from the cloth to its furthest extremity at the back, we have the healds placed at a distance of 12 ins. from the cloth, and we have a shuttle of 2 ins. wide and 1½ ins. deep, which must pass through the shed. Now we must determine the depth of the shed to allow the shuttle to pass through without too much friction upon the warp The lower half of the shed being laid flat upon the shuttle race the shuttle will run upon that, consequently the depth of shed must be determined by the depth required for the upper half of the warp to just clear the front upper corner of the shuttle, as shown in the illustration. Now we have the depth of the shuttle, its width and the stroke of the going part given, so that taking the position when the shuttle is midway in its passage, and where we may suppose that the shed is sufficiently open to give it absolute freedom of movement, we should have from the cloth to the shuttle front 4 ins., depth of the shuttle 1½ ins., then the depth of the shed at that point, and at that moment, must be at least equal to the depth of the shuttle; therefore the depth of the shed at the healds must be as 4 ins. from the cloth to the shuttle front is to 12 ins. from the cloth to the heald, so is the depth of the shuttle to the depth of the shed required at the healds; then of course we have reliable data to work upon to guide us as to the stroke of the tappet acting upon the warp. The depth of shed at the healds being $4\frac{1}{2}$ ins. the displacement of the treadles

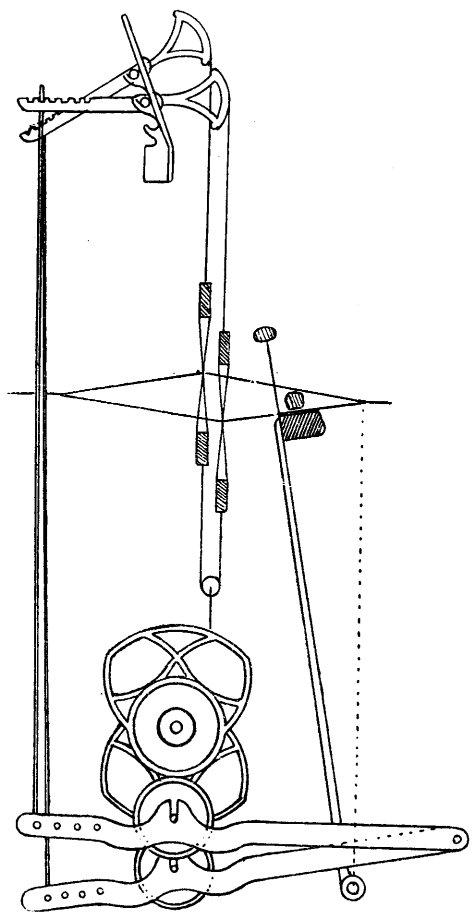


Fig. 83.

at the point of connection of the cords moving the healds must be equal to the exact displacement of the healds themselves, therefore to find the stroke of the tappets we have only to take the leverage of the treadles into account; for instance we have the friction rollers placed at a point between the fulcrum and where power is applied to the heald, then as the distance from the fulcrum to the point where power is applied, is to the distance from the fulcrum to centre of friction roller, so is the stroke of the treadle at the point connected with the heald, to the stroke at the friction roller; so that if the displacement of the heald is $4\frac{1}{2}$ ins., the length of the treadle is 28 ins., the distance of friction roller from fulcrum is 16 ins., then as 28 ins. is to 16 ins. so is $4\frac{1}{2}$ ins. to $2\frac{4}{7}$ ins.

Before going further into the question of tappet formation another phase of the subject must be considered. Dealing only with what are known as negative tappets, that is, leaving aside all such contrivances as Woodcroft's section tappets, Nuttall's tappets, or Diggle's chains, we have two systems of working to deal with; the one just referred to where the treadles are placed in the centre of the loom under the healds; and where the treadles are placed at the side of the loom, or what are sometimes known as outside tappets. In the first case as already mentioned the treadles are connected direct to the healds, in the second case as shown in Fig. 58 and in Fig. 83, where the treadles are placed on the outside of the loom, they are connected to the healds by levers placed above, so that a second question of leverage will come in in determining the stroke of the tappet. Of course, that second question will be sufficiently simple, if looked at from the point of view of considering the displacement of the heald and treadles respectively. In the illustration given the displacement of heald and the treadle point must be equal because one is connected directly to the other; in the latter case it cannot be so, because the arm from which the heald is suspended is shorter than the arm connected to the treadle; therefore the displacement of one will be to that of the other as their relative lengths. Suppose the length of the arm from which the heald is suspended is 6 ins., then the length of the other arm is 8 ins., then the displacement of the lever from which the heald is suspended will be to the other arm as 6 ins. is to 8 ins., so that the latter will represent the displacement of the treadle, and the rest of the working will be, of course, as before.

The depth of the shed and the question of leverage having now been determined it will be necessary to approach the question of eccentricity of movement of the healds, how this eccentricity may be obtained by the formation of the tappet, and how it may be affected by the relative positions of the several working parts.

Then taking the position of the treadles for the outside shedding as shown in Fig. 58 and Fig. 83, we may first consider the influence of the position of the tappet shaft in relation to the anti-friction roller, and the position of the treadle fulcrum in relation to the movement from top to bottom as affecting the amount of eccentricity of movement imparted. First suppose that the centre of the anti-friction roller, when the treadle is in a perfectly horizontal position, is in a vertical line with the centre of the tappet shaft, or in other words that a line drawn through the centre of the fulcrum and anti friction roller will be at right angles to one drawn through the centre of the anti-friction roller and the tappet shaft; and that the movement imparted to the treadle is equi-distant above and below that line, then a certain amount of eccentricity will be given to the heald from the fact that the point of the treadle is moving in an arc of a circle. Now it necessarily follows that in placing our tappet, and in forming it also, instead of interfering with this eccentricity, by reducing it at either extremity, we must increase it, hence the necessity for careful consideration of the position of treadle and tappet, as well as the actual formation of the tappet itself. Suppose, for instance, the centre of the anti-friction roller is moved to one side or the other of the vertical line, then an increased amount of eccentricity would be given to that side from which it had been moved, and a decreased amount to the opposite side, so that if we say that, for convenience, the centre of the roller must be on one side or the other of the vertical line, then that fact must be taken into consideration in drawing the tappet, or the character of the movement is interfered with.

Having now determined the depth of shed, eccentricity of movement, and the influence of the position of the treadles upon the movement, there are three other questions which must be carefully considered, quite apart from that of formation of pattern, before we can proceed to the question of tappet drawing. Those considerations are, first, the size of the anti-friction roller, or, as it is commonly termed, the treadle bowl, the shape of the treadle and the leverage, so as to determine the stroke of the tappet for the depth of shed required. Then as to the anti-friction roller, as influencing the form of the tappet, the smaller it can be made the better. By what is commonly known as the method of cam drawing the point of contact of the cam with the lever upon which it acts is of necessity considered a point, and, if the action is direct upon a given point of a lever, the assumption will be quite true, and the method of working correct; but when instead of a point a large roller is introduced, and this roller of necessity moving to and fro in an arc of a circle, the point of contact of the tappet in relation to the centre of that friction roller, which after all is the conveying point of the power received, must be constantly changing; hence the necessity for adapting the shape of the tappet to the size of the friction roller. If we are working with the friction roller of, say, 1 inch diameter, we may treat it as a point, for all practical purposes, in the drawing of the tappet. If it assumes the dimensions of 3 to 4 inches diameter, as is the case in a large proportion of the looms now in use, then the dimensions must be taken into account as an important factor in the formation of the tappet. The question is often asked, why have this large anti-fricton roller? And the general answer given is, that it reduces the friction and liability to jump in the treadle. But, as I shall have to show presently, whatever advantage may be gained in that direction may be more than counterbalanced by disadvantages in another direction. A roller acted upon by the surface of a cam or tappet, which is usually polished iron, cannot be looked upon as subject to the same treatment as a wheel passing over a rough road; as in the latter case the bigger the diameter of the wheel the more easily its circumference will bridge over roughs or irregularities in the road; but that could not apply in the case of a roller running on a smooth

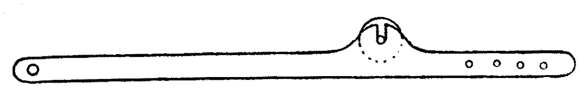


Fig. 84.

surface, so that the advantages in that direction are more fancied than real. Then there is only one other advantage which can possibly be gained, and that is in the actual form of the treadle. Suppose the treadle is made as a perfectly straight lever and a small roller is placed upon it to be acted upon by the tappet, this roller would never touch what is known as the inner circle or disc of the tappet, simply because the length of the wings, more especially in larger fancy patterns, would cause them to be in contact with the treadle at each side of the anti-friction roller before the roller could reach the inner circle; hence of course it would be impossible to work. This may be overcome in two ways, first, by raising, by means of a species of bracket, as shown in Fig. 84, the roller from the treadle sufficiently high to overcome this difficulty, but another and a better form is shown in the bent lever Fig. 85, which accomplishes exactly the same purpose. In fact it may be said to do more, for the curves given to this lever at the several points will tend to give considerably increased strength; take for instance the point where the anti-friction roller is placed and a kind of bridge is built over an arch which must give considerably increased strength at that point, Again, towards the point of the treadle another arch may be formed, and this at the point where the power received by the roller from the tappet is communicated direct to the healds, so that all the strength possible is obtained whilst meeting the requirements of the shape of the tappet to keep in contact with the small roller. The

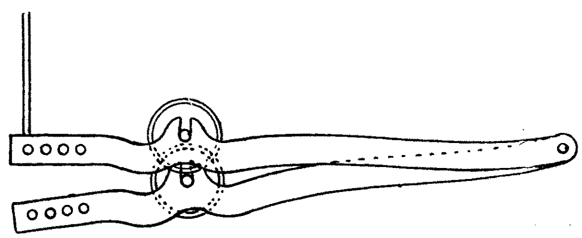


Fig. 85.

necessity, as well as advantage, of the small roller will be more fully demonstrated presently when dealing with other forms of shedding tappets or cams.

Before entering upon the question of the accurate drawing of the tappet, some consideration may be given to the dwell or pause of the healds at the highest and lowest points respectively. As already said, the theoretical time occupied by the shuttle in passing across the loom is equal to half a revolution of the crank shaft. In practice, really, somewhat less, more especially in light running looms, and in the heavier looms compensation is given by the length of the crank and the amount of eccentricity given to the movement of the going part. In many cases the actual time occupied by the shuttle will not exceed one third of a revolution, and may be even less than that, but there are other considerations beyond the time occupied by the shuttle which may materially influence the dwell of the healds. It is often considered that the dwell should be as short as possible, and many look upon it that the period might be somewhat less than the time occupied by the shuttle in passing. If we were looking only to the question of friction upon, or resistance offered to, the shuttle, this view might be taken, but when we consider the influence of shedding upon the fabric then it must be obvious that, apart from the time of the shuttle passing across the warp, the regulation of tension in relation to the beating up of the weft must also be taken into account. Suppose for instance we are weaving a fabric where we wish to throw the least possible amount of strain upon the warp, and where the distribution of the warp threads, as affected by the shedding, is a matter of little moment; then we must give the least possible amount of dwell to the healds at the extremities of their movements, as by doing so the passage from the highest to the lowest point, or *vice versa*, occupies the greatest amount of time than can be given to it, and consequently reduces the strain upon the warp to a minimum. But in such case as weaving plain cloths, or cloths where the warp threads must be distributed, then a longer dwell must of necessity be given. Take for example the references to the warp line in the second lecture, where it is shown that the length of yarn between the back rail and the fell of the cloth is materially influenced by the position of the back rail, and also by the position of the healds. If the back rail and the breast beam are placed in the same horizontal plane, and the warp threads are sunk considerably below that plane when the shed is closed, then, on separation for the formation of the shed, one portion is carried below that point and the other an equal distance above it; that forming the upper half will be much slacker than that forming the lower half, because it more nearly approaches a straight line, as demonstrated in my "Treatise on Weaving and Designing."

Then the general practice is, when the warp line is sunk in this manner, for the sheds to be crossed, or changed sometime before the reed beats the weft up to the cloth. The length of this period will vary according to the quality of the fabric and the ability of the yarn to bear strain. In some cases the change will take place when the reed is, say half an inch from the cloth, and will vary from that up to a distance of an inch and a half, or nearly equal to one-third the stroke of the going part. Then taking the extreme case it must be clear that the further the reed is from the cloth at the moment when the shed is changed the longer must be the time for the shed to be kept open, otherwise the shuttle could never be passed through the warp before the shed began to close upon it. One word of explanation is perhaps needed here; the reason for crossing the sheds so early is, that the warp threads forming the lower half shall be as tight as possible and the upper half correspondingly slack when the reed comes up to the cloth, thus forcing the slack threads into the space between the tight ones, and this occurring alternately with the two halves of the warp causes a most perfect distribution. In extreme cases the length of pause given to the healds, to assist in this distribution, will vary from three-fifths to two-thirds of a revolution of the crank; whilst at the other extreme, where attention to distribution is not so much regarded, more especially in fast running looms, the time may be one-third or two-fifths of a revolution.

Then the next question to be dealt with is the proper form of the tappet, and, as a consequence, the true method of drawing that tappet. In the second lecture it was pointed out very clearly that the movement of the healds must be decidedly eccentric, moving slowly at first with a gradually increased speed to the centre of the motion, and from that gradually decreasing. Then we have to consider how the tappet must be formed to ensure this, and what is the correct method of drawing. To make the subject perfectly clear, I will suppose a pin to be so placed that it can be acted upon by a cam and moved only in a vertical direction, the cam revolving continuously upon a horizontal axis. Now suppose that, in the first place, a roller is placed in contact with this pin and the roller revolving upon this axis with its circumference in contact with the pin, there would be no movement. It would simply be one surface in contact with another without any motion imparted, but let the roller either have projections placed upon it, or indents cut into it, then movement will be imparted to the pin wherever this alteration in the circumference takes place. In looms, whatever form of arrangement we adopt, whether inside or outside tappets, whether positive or non-positive tappets, the same rule must hold good : the tappet must be so formed as to impart the exact motion required to the healds. Perhaps this will be better understood by a comparison : the pin already mentioned may be attached to a lever which can move in a vertical plane ; a lever is placed in contact with it moving in the horizontal plane ; this lever is moved backward and forward, but will impart no motion to the pin or the lever to which it is attached, but let a projection be placed upon the horizontal lever, and movement would be at once communicated : the character of the movement being determined by the exact form of the projection. Suppose, at first, the projection forms an angle of 15° with the horizontal plane, by degrees that is increased to an angle of 30°, then to 60° ; as the lever is moved along, the motion communicated to the pin would be at first slow, gradually increasing until the top of the incline is reached ; exactly the same thing will occur with the tappet ; a circle revolving upon its axis is simply equivalent to a lever moving in the horizontal plane, and any projection upon the surface of the circle is equivalent to a projection upon the horizontal lever. The angle formed with the circumference of the circle corresponds with the angle formed with the lever, so that a line drawn from the centre of the circle through its circumference, at any point, is exactly equivalent to a vertical line drawn to a horizontal lever.

Then what we have to consider is how to draw from this circle of the tappet a line which will communicate motion of the exact character required. Suppose a line is drawn from the centre through the circumference of the circle at any given point, and another line is drawn through another point exactly at right angles to it, or representing one quarter of the circle, as shewn in Fig. 86, at the points

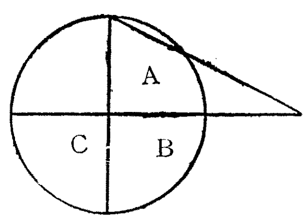


Fig. 86.

A B, now the angle formed by the two lines A B is one of 90°, then take the distance on the line B equal to the diameter of the circle from the centre C, or double the length of A; then a line connecting A B would form an angle of 60°, therefore it would be seen that that angle should be one of 60° with the circumference of the circle. In the aggregate that would be true, in detail it is not true; for at the point nearest to B a portion of the circle is cut off, and consequently the angle is more obtuse than 60°, but after cutting the circle it becomes more acute, in a proportionate degree, so that although the average may be equal to 60°, it will impart a variable movement to the tappet. Now suppose another illustration be taken. Divide a square as in Fig. 87 into six equal parts, in both directions, and draw a line diagonally through the intersections, that line will be at an angle of 45° throughout, that is, the angle is precisely the same in each of the smaller squares as in the larger one; now take another square as in Fig. 88, and divide it vertically into six equal portions, but horizontally into six unequal portions; then draw a line diagonally through each of those divisions in succession, and it will be found that the first, second, and third, give very varying angles, and the fourth, fifth, and sixth in opposite directions; so that any body travelling along the incline formed by this line will have an accelerated speed from the commencement of the movement to the centre, and from that point a

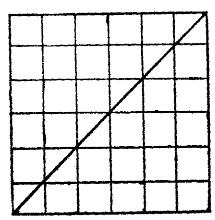


Fig. 87.

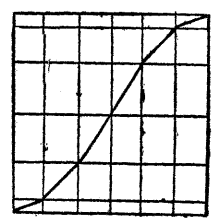


Fig. 88.

decreased speed. Now this is the kind of movement to be imparted by the tappet to the treadle, but the question then arises as to the degree of acceleration. Generally speaking it may be assumed that the best motion is that which is commonly known as harmonic, which consists of an accelerated ratio as follows: 1 is to 2 as 2 is to 3, &c.

This harmonic motion will be best understood by a reference to Fig. 89, where a line A B is drawn of any given length, and a semi-circle having A B as its diameter; now divide the semi-circle into any number of equal parts and from each of those divisions drop a line to the diameter. Now suppose a body to be revolving within the circle A B and connected by a crank to another body which it moves in the horizontal plane, then the ratio of speed of the second body will be as indicated by the divisions from A. to B. and as represented by the figures given above. Now let it be supposed that the Fig. 88 is divided in the same ratio as indicated in Fig. 89, then the inclined plane would represent the varying velocities of a fallen body exactly corresponding to Fig. 89, and whether the space, as represented in Fig. 88, be a square or a parallelogram, the principle would not be affected in the slightest degree. Now take Fig. 90 for the purpose of explaining the practical application of the system of division of circles. Draw two circles, and from the centre two lines forming an angle of 90°, then the space between the inner and the outer circle and the lines A B will represent

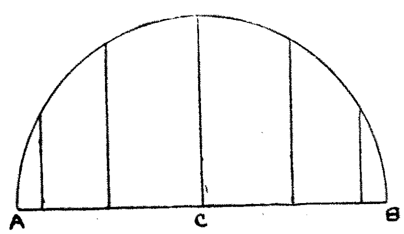


Fig. 89.

a parallelogram, and we desire to draw a diagonal line across that parallelogram as we have done in Fig. 88. It will be remembered that lines drawn from the centre through the circumference are vertical to the circumference of the circle, therefore arcs of circles struck from the same centre as the circles, must be parallel to the circles, and therefore are the same in relation to the vertical lines as are those in Fig. 88. Then make the divisions between the two circles in the same harmonic ratio, and a line drawn through the intersections of the arcs and radial lines as in Fig. 90 will exactly correspond with the diagonal in Fig. 88, so that the method of drawing the curved line of the tappets can be easily determined.

The next question is the division of the circle and the laying out of the tappets for the pattern. In weaving a plain cloth we have perhaps the best means of laying down a general principle. We all know that there are only two picks in the complete pattern of a plain fabric, so that the tappet must be so constructed as to raise and depress the treadle alternately for each succeeding pick, so that the circle representing the tappet would be divided into two equal portions. Then suppose a line to be drawn through the centre of the circle, cutting it at the points A B, Fig. 91, then A to B may be said to represent a period of time when the

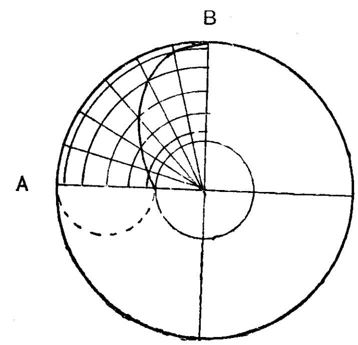


Fig. 90.

tappet is in contact with the treadle for one pick of the pattern, and B to A for the other pick. Now in this we must have a theoretic starting point, from which we may depart, in a greater or less degree, as occasion may require afterwards.

It has been suggested that at the moment when the reed is in contact with the cloth, the shuttle is in the box; the shed is closed; and practically all things are at rest. As the going part begins to move backwards, the shed should begin to open, and when the going part has travelled half-way from front to back, the shuttle should be leaving the box. Then at that moment the shed should be fully opened, and if half a revolution of the crank is allowed for the shuttle to pass from side to side, the shed should be open during the whole of that period; then it should begin to close, and the healds meet in the centre of their passage when the reed is again in contact with the cloth. If that is so, the distance from A to B might be conveniently divided into four equal parts, as in Fig. 91, corresponding with the periods just referred to, and of course from B to A divided in a similar manner, each portion representing its own pick. Then it must be evident that from three on the inner circle to one on the outer circle will correspond to the period of time when the heald will be moving from the lowest to the highest

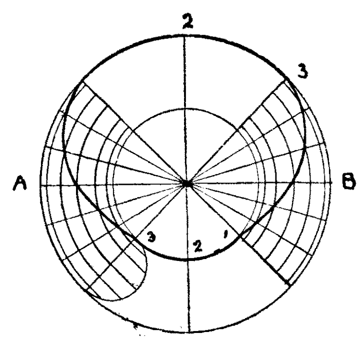


Fig. 91.

point, and from three on the outer to one on the inner circle the movement will be represented in the opposite direction. Therefore from three to one a curved line must be drawn in the same manner as from A to B in Fig. 90. This will represent the true movement of the treadle at the point where in contact with the tappet. From one to three will represent the dwell at one extremity, and three to one the other. This then, will represent one complete tappet, and for the purpose of a plain cloth, another of exactly the same size and form must be placed opposite to it, to act upon the second treadle and heald. Now this tappet is theoretically true on two assumptions ; first, that the division of time in the movement of the shuttle, going part and healds is exactly as suggested. Second, that the point of contact of the tappet with the treadle is a point without the intermediary anti-friction roller. It would be equally true if the anti-friction roller could be said to have no dimensions, and practically so if the dimensions were small, but when, as pointed out in the second lecture, the friction roller is made large, then its dimensions must be taken into account. This can be readily done by following

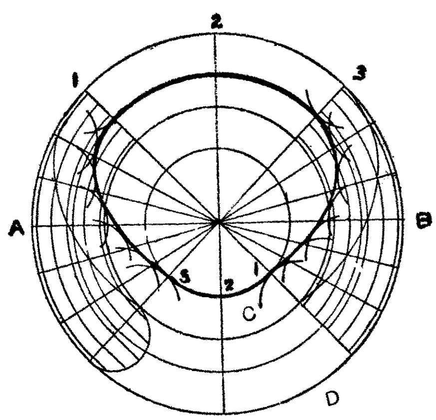
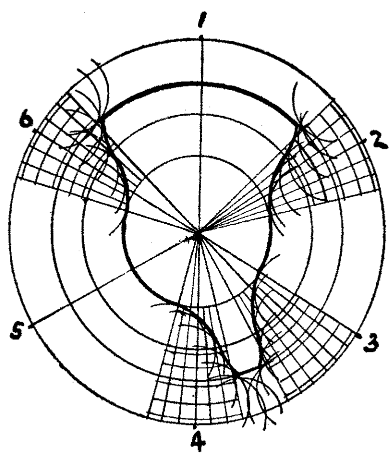


Fig. 92.

the proceeding indicated in Fig. 92. There, the two circles are drawn as in Fig. 91, but two other circles indicated by the circles C and D, each at a distance from the others equal to the radius of the friction roller, so that those lines would clearly represent the movement imparted by the tappet to the treadle. Then if the tappet were drawn from one of the lines C, D, to the other on the principle shewn in Fig. 91,' and from that, arcs of circles be drawn cutting each other as shewn, and truly representing the position of the anti-friction roller at every point of its passage from one extremity to the other, the circumference of the tappet would be indicated by a line drawn, which will be a true tangent to every one of the arcs of circles from the outer to the inner circles of the tappet. Then what is true of this plain tappet is equally true of all others, and it would only be a question of dividing the circle into as many parts as there are picks in the pattern, and of each part in succession in the manner indicated in Fig. 92, and proceeding to draw the curves for each pick, so as to raise and depress the heald according to



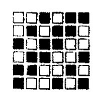


Fig. 93A.

Fig. 93.

the pattern. For example, Fig. 93 is a tappet for a six-end twill as shewn at Fig. 93A, and drawn strictly upon this principle. Then it must be obvious, if two patterns, varying so widely as the plain and twill here given can have a tappet drawn on this principle, that a tappet can be equally well drawn for any other pattern. There are several things to observe however. In the Fig. 93, one of the wings of the tappet is what is commonly known as a double one, that is, it holds up the healds for two picks, and one of the depressions is also a double one, leaving down the heald for two picks. This, it will be remembered, has been pointed out as one of the features of tappet shedding. A heald is kept at its highest or lowest point, as long as required for formation of pattern, so that, what otherwise would be two wings for picks one and two, or two separate projections, is made as one projection or wing, thus avoiding the dropping of the heald half way down and bringing it back again; and in the same way what is a double depression for picks five and six would otherwise have a small projection in the centre to raise the heald half way and drop it back again. Both these requirements are avoided by this form of tappet.

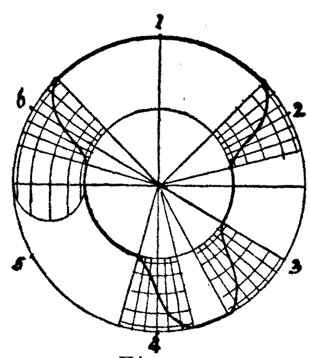


Fig. 94.

The next matter for consideration is the size of the tappet and the manner in which the size may be affected by the diameter of the anti-friction roller. Now take the Fig. 93 which is drawn for an anti-friction roller of 3½in. diameter, and Fig. 94 which treats the anti-friction roller as having no dimensions. And compare the space between the wings of the tappet and the incline formed by the surface of the tappets, and it will be found that in Fig. 93 not only is the space very small, although sufficient to give the requisite pause, but what is of more importance, the incline is very steep, consequently the movement runs the risk of being very seriously interfered with; and although theoretically a steep incline may act upon a large friction roller, in exactly the same manner, and obtain exactly the same movement as an easy incline upon a small friction roller, yet in practice, and more especially in a fast running loom, this is found not to be the case. In fact, the wing of the tappet, with the loom going even at a moderate speed, may run away from the friction roller and allow it to drop without ever touching the back of the wing. Consequently instead of that easy movement being imparted a sudden jerkiness would be the result, so that at one side of the stroke we should have tremendous pressure by the steep side of the tappet coming upon the friction roller, and, on the other side, the jerkiness referred to. This character of movement must be avoided for the two reasons, that it would cause too much reaction in the movement of the loom generally, and, that the jerkiness imparted to the healds would be seriously detrimental to the warp; nothing must occur which will affect in any degree the smoothness of motion already pointed out as being that which should be imparted to the healds. Then there are but two ways of obviating this difficulty, first, by increasing the size of the tappet; and, second, by decreasing the size of the anti-friction roller.

Let any one, for example, draw a tappet for a pattern of ten or twelve picks in the round, and with an anti-friction roller of say $3\frac{1}{2}$ inches diameter, and the necessary stroke of $2\frac{3}{4}$ to 3 inches, and it will be found that the space between the wings, when the diameter of the inner circle is anything reasonable, as say 6 or 8 inches, a dimension which may be considered as large as practicable in any ordinary looms, will be such as to reduce the dimension of the wings to an absurdity, even if they can be formed at all. Then if the diameter of the tappet is increased so as to permit the incline approaching a convenient one, the whole tappet must be so large as to be out of the range of practical working. A very brief consideration of these points will give force to what has already been said of the desirability of working with small anti-friction rollers; and again another consideration will materially influence us, for with a large anti-friction roller the angle formed by the point of contact of the tappet with the circumference of the roller, and its centre, will be constantly changing; hence a considerable interference with the eccentricity which it is intended to impart to the healds from the tappet, so that however carefully a tappet may be drawn, unless this constantly changing angle is taken into account, along with the other items referred to, there is nothing to guarantee that the work will be satisfactorily done.

SPEED OF TAPPETS.

Apart from the questions of leverage, the depth of shed, and stroke of tappet, already dealt with, there is but one system of calculation required, and that is as to their speed; whether we are dealing with inside or outside tappets the regulation of the speed is an all important, though a very simple matter. The speed of the tappet in relation to the driving shaft must be governed by the number of picks in the pattern; it is a common error with people, who have not a thorough grasp of the subject, to suppose that the number of picks in the pattern, and therefore the speed of the tappet, must be governed by the number of healds. Very frequently there is some relation between the two, but it does not necessarily follow, either that they should be exactly the same or that one should be a measure of the other. This depends entirely upon the character of the design, but whatever the number of picks in the pattern the speed of the tappets must be governed by them. Suppose then, to begin with, there are four picks, then the tappet must revolve once for every four revolutions of the crank shaft; then to assure this the driving wheel upon the crank shaft and the wheel carrying the tappets must be to each other as one to four. For convenience, and so as to prevent change in both wheels, an intermediate wheel is generally employed, which simply receives motion from the crank shaft wheel and communicates it direct to the tappet wheel. In that case the intermediate wheel has no influence upon the relative speeds, it simply receives and communicates power from one to the other; so that the change necessary to be made is only in the top, or crank shaft wheel. In a large number of looms the tappet wheel contains 120 teeth, simply because that is a convenient number; if there are four picks in the pattern then thirty teeth are required in the top wheel; if five picks a twenty-four wheel; if six picks a twenty wheel and so on. So that it is only necessary to have the intermediate wheel carried upon a bracket with a slot, so that it can be set in or out to accommodate the size of wheel required. But in cases where the number of picks in the pattern is not a measure of the teeth in the tappet wheel then double intermediate wheels may be required, and the calculation is a little more involved though not difficult. The simplest plan is that laid down in my book on "Weaving and Designing," of placing any convenient wheel on the top shaft and taking that multiplied by the number of picks in the pattern as a numerator, and the number of teeth in the tappet wheel as a denominator; then the two terms of the fraction will represent the two intermediate wheels. This will be perhaps better understood by reference to Fig. 95 which shows the train of wheels as they would occur in a loom. The upper wheel we may say, for convenience, contains twenty teeth and the tappet wheel 120, and there are nine picks in a pattern, then $\frac{20 + 9}{120} = \frac{180}{120} = \frac{18}{12}$ or as 3 is to 2, so that any two wheels bearing those proportions to each other may be employed as intermediate wheels, and so ensure the exact relative speed of the shaft and tappets.

There is only one consideration here, and I desire to mention this from a knowledge of mistakes into which I have known people fall, and that is as to the size of the wheels. Of course any two wheels bearing those proportions will give the requisite speed, but if, as sometimes may happen, they are too near each other in actual size, as for instance, should one be 60 and the other 54, there would be a danger, in the event of any obstruction, or of the shafts springing a little, of the tappet wheel slipping into gear with the wrong intermediate, and so causing gain or loss of a few teeth; this being repeated would cause a gradual gain of the shedding upon the picking, or *vice versa*,

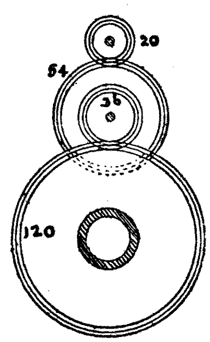


Fig. 95.

and would so disarrange the working that the whole loom would be out of gear. A very few minutes consideration would enable one to overcome this difficulty.

As the tappets so far dealt with act only in one direction, that of either raising or depressing a lever, some arrangement must be made for acting in the opposite direction. Where the tappets are placed inside the loom they usually act direct upon the healds and pull them down; then to ensure a return the healds are connected by straps over rollers at the top of the loom as shewn in Fig. 82. Where the rollers are seen in front of the top rail, but this is only done for a very limited number of healds, as two or four; but where the tappets are outside the loom they are connected by means of levers so as to raise the healds; then some arrangement must be made inside the loom and underneath the healds to bring them back again. There are two methods of dealing with this, one by means of springs, or levers and springs combined, and the other by means of levers or rollers. In the first case each heald acts independently and may be raised in any order; in the second the healds are connected one to another, so that as one is raised it will pull another down. In the great majority of cases the latter mode is preferable, simply because there is no more work, or weight, thrown upon the loom than is absolutely necessary; whilst when springs are employed, in whatever form, a considerable amount of energy must be exerted in raising the healds and extending the springs. There is one disadvantage perhaps accompanying the use of levers, and that is, that the patterns must be perfectly regular, always the same number of healds raised for every pick in the pattern; this of course the great majority of patterns will comply with naturally, but there are always some exceptions, and whenever the exception arises, a general resort must be made to springs for every heald, or at least one heald must be provided with springs, even if coupled to others, so as to give the necessary degree of elasticity. One thing must be clearly understood in connecting healds together without the use of springs, and that is that the connection must be so made that, although one heald is coupled only directly to one other, yet the whole series must be connected indirectly. Take for example the illustration given at Fig. 96, which is really a representation of one of the earliest forms of pulley boxes, or pulley arrangements; in this it will be seen that every heald is connected indirectly with all the others, so that being once adjusted with, say one heald raised, then any other may be raised in any order of succession and one will be depressed through the medium of the pulleys.

As will be seen by reference to the figure, the healds are coupled in pairs, each pair then is connected through the medium of a larger pulley to the next pair, so that the connection might be carried to an unlimited extent, and

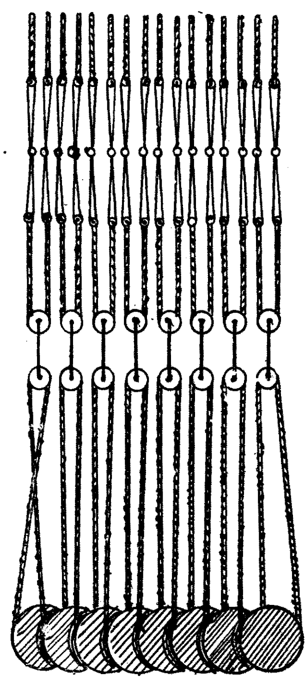


Fig. 96.

before the invention of the jacquard this system of connecting was very largely used in hand looms where, what was termed "witches," were used, as it enabled them to dispense with weights, which in heavy work is a great advantage. However it will be seen that the system would be too cumbrous for a modern power loom, and it is more convenient to have some simpler arrangement which will serve for a fixed number of healds, and can be readily changed as the number of healds is changed. Fig. 97 will give a very clear conception of the arrangements adopted at present. Here we have a lever and pulley combined and so

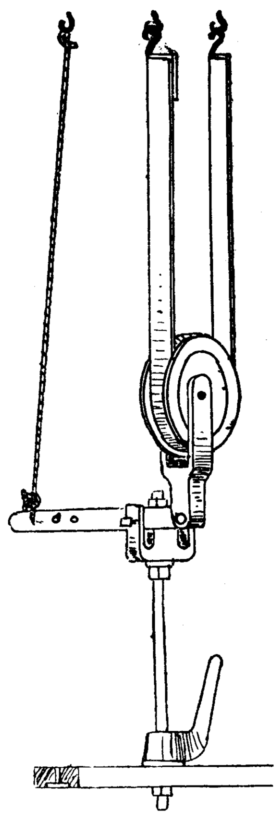


Fig. 97.

arranged as to actuate the healds; now the question of leverage as well as convenience of arrangement must be carefully taken into account. Suppose that the two healds, connected by means of the strap round the pulley, were the only two in use, as one is raised the other must be depressed, and there is no difficulty as to leverage; but when the third heald is raised, and which may be acted upon by either of the others, then the question of leverage must occur. Here a lever is employed, perhaps as a matter of convenience, but a second pulley might equally well be employed, as will presently be shewn in connection with other contrivances. Now it must be obvious that if one heald is attached to one end of the lever and two healds to the other end, that if they are exactly to balance each other the length of the lever arms must be as two to one, just as we should place 2lbs. weight on the short arm of the lever to balance 1lb weight on the long arm. Then all that we have to do in this case is, to have the relative lengths of the lever arms properly adjusted, each heald connected after the tappets have been set, and then adjust the tension by means of the hand screw and nut on the rail below and have it ready for working.

A simple arrangement is shewn in Fig. 98, where provision is made for five healds, where pulleys and lever are again employed; but in this case the relative lengths of the arms of the lever must be as four to one. Instead of a lever, pulleys might well be substituted which answer exactly the same purpose as Fig. 97. Two pulleys of the relative diameters of two to one are made fast together, a small pulley is used precisely as in Fig. 97, but instead of that small pulley being attached to one arm of the lever, it is attached to one of the two smaller pulleys, and the strap of course connecting the third heald is attached to the larger pulley. Of course it must be borne in mind here that not only are the two pulleys made fast together, but that the straps, or cords, are also made fast to them, as the two serving the purpose of a lever it will not be possible for the straps to pass round them. Too much attention cannot be paid in arranging these pulleys so that they can be adapted to other purposes for instance, the small pulley upon Fig. 97 should be so contrived that it can be also used for either plain weaving, or as part of a set for eight shafts ; and in like

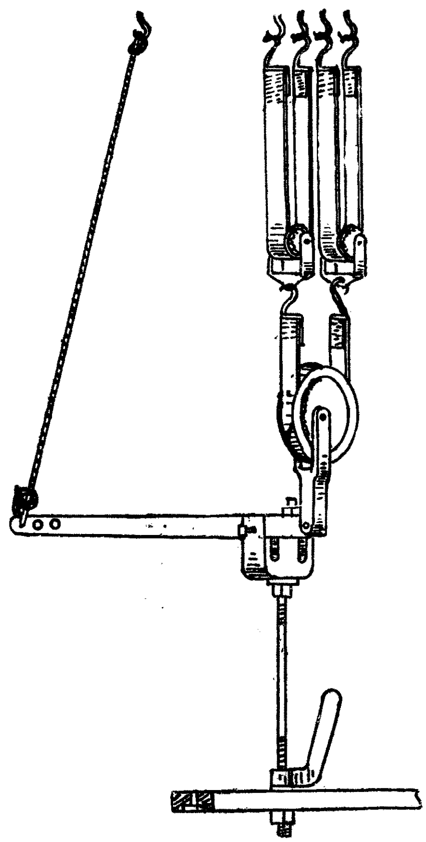


Fig. 98.

manner those upon Fig. 98 should be so that they can be used either for four, or half a set for eight, for it must be obvious that if the pulleys are detached from the lever that, of themselves, they form a complete set for four.

Another example is given in Fig. 99 where six healds are employed, and here it will be seen that not only is the question of leverage carefully considered, but the convenience of altering is also taken into account. If divided into several parts, the pulleys, with the exception of the intermediate pair, may be used as part of any other set, and it is only by this careful consideration of the use of any one article for different purposes that economy of production

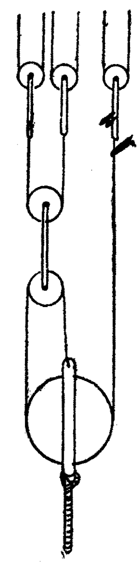


Fig. 99.

can be obtained. The question may be asked : What about seven healds ? Or nine ? The answer is obvious, that if you take the set of four from Fig. 98, and a set of three, as described, and you attach them to the two arms of a lever having the relative proportions of four to three, they must answer all the purposes. And so it may be said that with the few illustrations given here, and proper manipulation of them, they can be adapted to any number of healds coming within the range of tappet work.

Only one more question in connection with this subject need now be considered, that is, the dimensions of the pulleys. Going back to the illustration, Fig 97, let it be supposed that the straps round the pulley are connected to the first and the third healds, and that the cord to the lever arm is attached to the second ; this is a most convenient arrangement and enables the diameter of the pulley to be determined at once. Suppose, for instance, that the healds from centre to centre of shaft measure half inch. Then from the centre of the first to the centre of the third the distance will be one inch, so that determines the diameter of pulley at once. Now in Fig. 98, the most convenient arrangement would be to attach the lever arm, say to No. 1 heald, and the other four healds couple 2 and 4 together, and 3 and 5 ; then the diameter of the pulleys will be determined as one inch as in the first case, and the diameter of the larger pulley below is also immediately determined by the distance from the centre of one small pulley to the centre of the other, so that there need be no difficulty in ascertaining the dimensions required for any number of healds.

It will now be necessary to turn attention to what are known as positive tappets, which consist mainly in contrivances for forming a grooved cam with changeable plates, instead of having a groove cut in the cam itself. The plan most generally adopted is that known as Woodcroft's section tappet, which consists of a plate with a toothed rim and a series of perforations, so arranged that loose plates can be attached to it. In the first place a small plate called the centre plate, and which corresponds with the inner circle of the tappets previously described ; then small sectional tappets are fitted upon this in such a manner as to form a running groove in which the anti-friction roller of the treadle can revolve. There are two forms of these sectional plates, one to cause the roller to rise from the inner to the outer circle, and one to cause it to descend, each having a projecting rim which will carry the treadle the required distance. A view is given at Fig. 100 shewing the manner in which the tappets act upon the treadles, and which will be seen with their

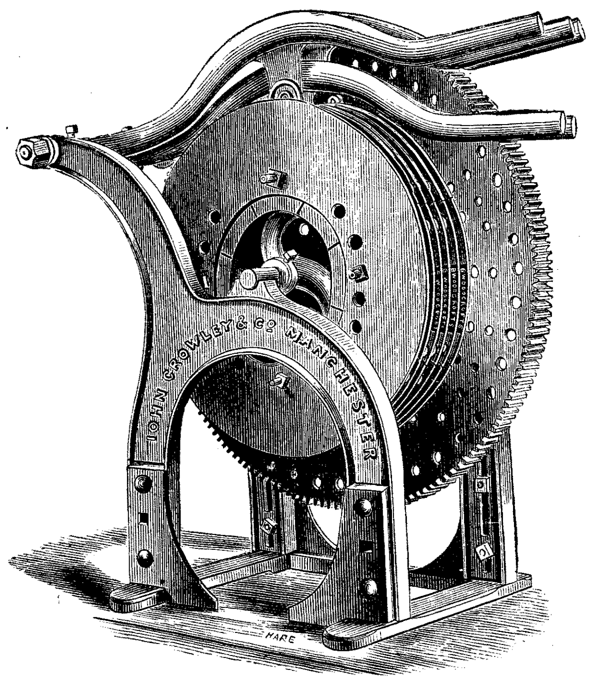


Fig. 100.

connections in the full view of the loom at Fig. 47, page 101, and the riser and faller plates at Figs. 101 and 102. It will be seen that the treadles consist of bent levers, having a roller attached, or carried by arms on the lower side, which may run in the groove formed by the tappet; at the free extremity of the levers, or treadles, cords connect them with levers above and below, the opposite ends of these levers being connected to the healds as shewn in Fig. 47, so that a positive motion is imparted by means of a groove to the treadles and through them to the healds. This contrivance of loose plates certainly possesses many advantages for heavy work, first a positive motion is imparted to the healds, which is in itself a considerable advantage; in the second place it offers a ready means of changing the pattern, the plates having been placed in the position, as shewn, are held

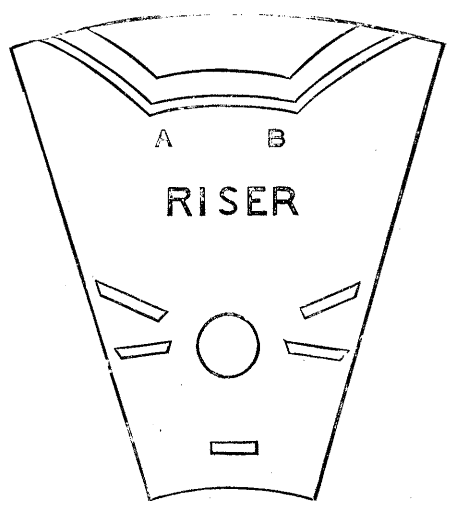


Fig. 101.

there by what is known as an outside plate, which is nothing more or less than a flat disc with bolt holes, so that it can be fastened down to hold the sectional plates in position. It must be understood that in building up a tappet plate, or a set of tappet plates, the same rule will hold good as in making ordinary tappets, viz.: that each treadle must have a separate tappet plate built up for itself, so that if we are working with twelve healds we must build up twelve sets of tappet plates. A decided advantage in the use of this form of tappet, apart from the positive motion, is the fact that each heald being worked separately and distinctly from all the others there is no necessity for the pattern to be a regular one, but any degree of irregularity may exist. One reference made to the diameter of the anti-friction roller will be understood. As was pointed out in working with the non-positive tappets there has been a constant tendency to increase the diameter, and although the disadvantage has not been recognised there, in this case where a positive cam is

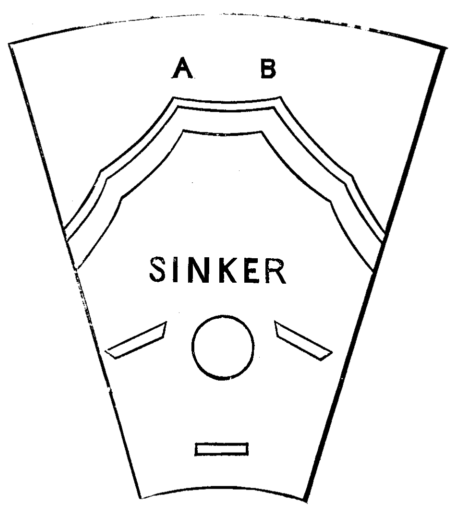


Fig. 102.

required it must be patent. In fact, the smaller the anti-friction roller, the more true the working.

Perhaps one word of warning may be given here, more especially to the student, as to the number of patterns capable of being woven with a section tappet. It has often been stated that the number will be determined by the law of permutation. Just to show the absurdity of this, suppose that our tappet plates are made for twelve healds and limited to twelve picks in a round, we should have twelve changes upon each plate, which multiplied by 12 plates gives us 144 positions. Then by the law of permutation we multiply 1 by 2, the product by 3, then by 4, by 5, and so on until each successive product has been multipled by each number up to 144; this would give us a number represented by at least several scores of figures, of course, an utterly impossible one. This theory is based upon the possible re-arrangements, but this must be without regard to order. Now it is one of the first laws of pattern making, that we must have order and regularity; therefore reduced to this order and regularity instead of working according to the laws of permutation, we must work according to the laws of re-arrangement in definite order, and the doctrine of combinations. This, although giving us a sufficiently wide scope of pattern producing, and more than any one individual could possibly carry out in a life-time, is yet a very different thing from what we get from permutation.

There are several other forms of tappet to which some reference must be made, although they are not so much in use as those already referred to. One of them certainly deserves some consideration, not merely from the fact that it is still in use, but more especially that it has formed the basis of many forms of working rising shuttle-boxes, that is, what is commonly known as Nuttall's chain. This consists briefly in a lever having a chain at each side of its fulcrum, the chain consisting of alternately large and small anti-friction rollers, as shewn in Fig. 103. In this, a lever, which represents a treadle, has a small barrel at each side of its fulcrum, and round these barrels two chains are passed; one end of the lever or treadle is attached, in practically the same manner, to levers placed above and below, as in the Woodcroft's section tappet, and through these levers actuating the healds; so that to raise or depress the heald a large roller is placed upon the chain at one side, and a small one on the corresponding link at the other, hence if the large roller is placed upon what is termed the heel of the treadle, the point will be depressed and the heald raised, but if the large roller is placed on the opposite side of the fulcrum, then the lever will be raised and the heald depressed. Without entering into the question of the exact nature of movement imparted to the heald by this method of working, one thing may certainly be said for it, that in addition to having a positive

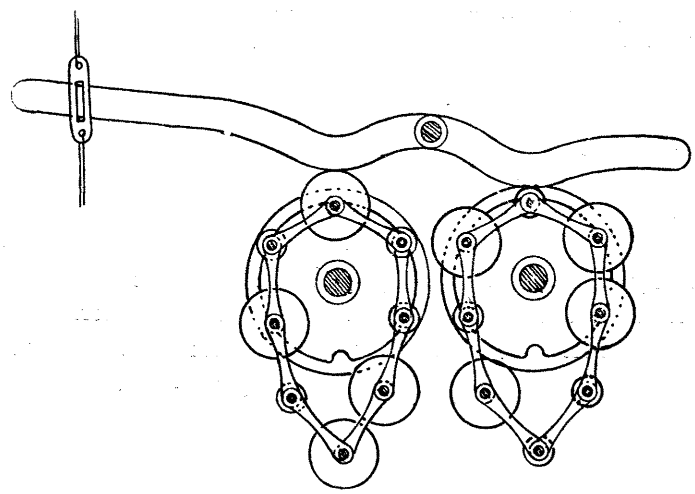


Fig. 103.

motion imparted to the healds we have the distinct advantage of being able to make a pattern of any length.

In all other forms of tappet working the number of picks in the pattern is limited, but in this it is practically unlimited, so that it presents the same features as the dobby in this respect. Of course if the chains get very long in the pattern they become heavy and cumbersome. In that one respect only, as well as the readiness of changing the lags or cards, may the dobby be said to possess an advantage. Another form which is closely akin to this, is what is known as the oscillating tappet, or sometimes known as Clark's and Knowles' inventions. Practically the same principle is involved as in Nuttall's chain, but a slight difference occurs in the working detail.

Tappet working may now be easily summarised, whatever may be the particular form adopted, two priciples are involved, viz: negative or positive action on the healds, and, further, the open shed principle is almost universally adopted. For fast running looms all the advantages are in favour of tappets; for weaving a large proportion of fabrics, such as twills, and twills really represent the great bulk of woven goods, the tappet is most likely to ensure the production of well made cloth. Once being set, the healds work with a steadiness and precision which can scarcely be obtained by any other system of shedding; therefore the subject cannot be too closely studied, more especially the correct mode of forming the tappet, for upon the truth of the form and the equalisation of tension on the healds, almost everything depends in the production of good cloth.

LECTURE 7.

DOBBIES AND PATTERN SHEDDING MOTIONS.

The dobby, as known in the modern power loom, and the witch, as known in the hand loom, are machines coming intermediate between the treadle and jacquard loom in the one case, and the tappet, which is of course equivalent to the treadle, and the jacquard in the other. In fact the early witch of the hand loom was the forerunner of the jacquard, the principle being precisely the same in both, the difference being in the jacquard the substitution of the harness for the healds of the witch loom. The hand loom weaver in the early part of the present century, and in fact within the memory of some now living, would frequently have as many as 120 healds in the loom at one time. There were four standard numbers in regular use, viz., 52, 72, 96, and 120: of course comparatively few of the latter number as compared with the smaller ones. But by degrees the jacquard supplanted these, and for a long time there was a gradual decrease until it came to be looked upon as a machine which, in the power loom, should not carry more than from 16 to 24 healds, and in the hand loom from 16 to 32; but within recent years there has been a development in power loom dobbies, and patterns woven with them, which has brought the number up to 40, and even 48, though that number is very unwieldy and undesirable. There is but one reason that can ever be satisfactorily given for the use of such a large number of healds in the loom, and that is, that with healds and a well constructed dobby, a positive motion can be given, and consequently for many heavy fabrics a decided advantage gained over the harness where a negative motion is necessary. The earliest forms of dobby were taken from the pattern of the hand loom which was simply a negative action machine, having in the majority of cases weights attached to the healds. This machine as seen in the illustration, Fig. 104, consisted in its essential working part of an upright hook having the healds suspended from the lower extremity; near or under the other extremity a lifting knife is placed. The machine shown has two lifting knives acting alternately to obtain speed in the power

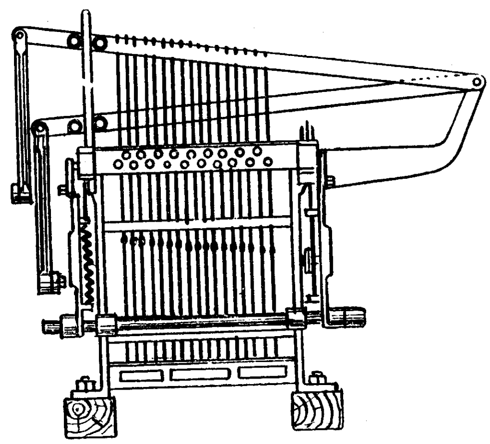


Fig. 104.

loom. This lifting knife having its fulcrum at one end and motion imparted to it by means of a connecting rod and treadle, so that as the lever was raised the hooks being placed intermediately between the fulcrum and the point where the power is applied, those furthest from the cloth would be gradually raised higher than those in front, this inclination being adjusted so as to form the upper half of the shed perfectly. Then to ensure the perfect formation of the lower half, the healds would be hung gradually sloping from front to back. This of course is, apparently, a minor detail, but must be mentioned as leading up to an explanation of some of the points in more elaborate dobbies of the present day. So far as the internal mechanism of the machine is concerned, there is little in this case that requires elaborate explanation. The method of actuating or selecting the healds so as to form the desired pattern being the most important item. In this form of machine, a flat spring is placed in a vertical position in front of the hook, and from this spring a cross wire having a loop, through which the upright hook can pass, is carried to the back of the machine, so that whenever the spring is pressed back the hook would be pressed back also, so as to be free of the lifting knife. At the moment the pressure is released, the spring will return to its normal position, bringing the hook back over the lifting

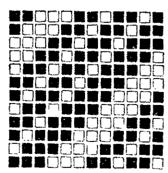


Fig. 105.

knife; so that what we shall have to consider first of all is, the method of selection to form the desired pattern.

Perhaps this point had better be made clear from the outset. Fig. 105 is a plan of a twilled cloth, that is exactly as we should see it on looking down at the surface of the fabric, the black dots indicating where the warp comes to the surface, and the blank spaces where the weft comes to the surface. Now reading this plan from left to the right, and taking each horizontal line as indicating one pick of the fabric, we should have three warp threads raised, three depressed, two raised, one depressed, two raised and one depressed again, so that the healds must be lifted exactly in the order indicated for the weft to be passed through. On the front of the machine as shown in Fig. 106, we have a cylinder with a grooved surface at C. In each of those grooves is placed a perforated lag as shown at Fig. 107, the lags being connected together by iron links, at such a distance apart as exactly to correspond with those grooves, and having a shape something like a V, as shewn in Fig. 108, where the lag is represented in section, so that it may fall into and be

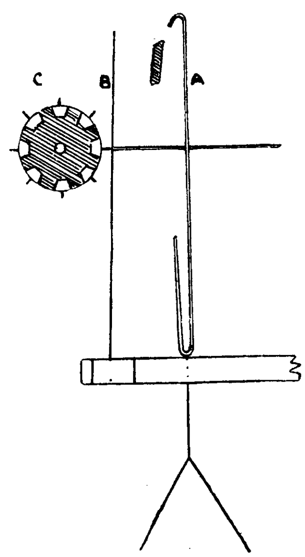


Fig. 106.

held firm in the groove. The perforations in the lag are exactly opposite the springs B, so that pegs may be inserted to strike back those springs and so throw the hooks back from the lifting knife. Then taking the 12 perforations, corresponding to the hooks to which the healds would be suspended, pegs are inserted exactly in the order of the first pick, as shown in Fig. 105, a second lag would be pegged in the order of the second pick and so on, until the 12 lags corresponding with the 12 picks of the pattern have been pegged. Those 12 lags then laid out upon a table would be an exact representation of the plan in Fig. 105, the pegs corresponding with the

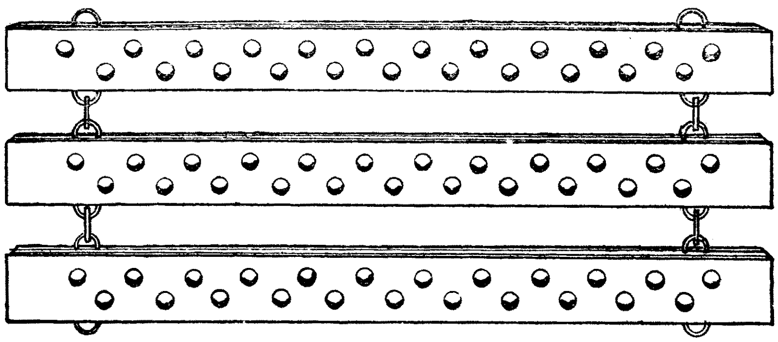


Fig. 107.

black dots, and the unpegged holes corresponding with the blank squares in the pattern. Although this is the simplest form of arrangement of patterns upon lags, it is the one which underlies the whole of the systems. Here it will be seen

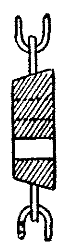


Fig. 108.

that the cylinder is provided with a head, having pegs corresponding to the grooves holding the lags. A pair of catches, or pawls, are affixed so as to pull the cylinder over at each succeeding pick, in order to bring the lags in their order of succession in front of the springs; the object of the second catch being to reverse the movement should anything occur, such as the breaking of the weft, to cause the weaver to have to turn back to any particular lag. The cylinder having been turned into its position is held firmly there by means of a sort of hammer head upon a spindle which is kept closely pressed up to it by a spring, as shown in the illustration, Fig. 109, and the catches are shown at Fig. 110.

Now one point might be brought before the notice of the reader here, as, although apparently trivial in itself,

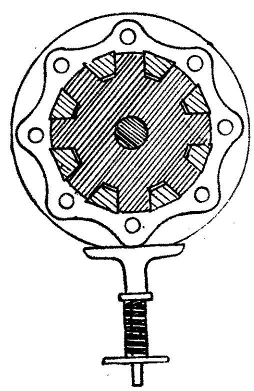


Fig. 109.

at this stage will render a clear understanding of the motive, and of the timing of the movements in the several parts of the machine, in the more elaborate dobbies to be dealt with at a later stage. The cylinder being in contact with the needles, and having by means of the pegs caused the change in the order in which the hooks should be lifted, must evidently be so timed in this movement as not to try to bring about that change when the hooks are actually resting upon the knife, with all the weight of the healds upon them. But the cylinder must be moved round exactly at the moment when the lifting knife is clearing the hooks, and when no undue pressure would be exerted upon the springs, so as to facilitate the changing of positions and allow the lifting knife to pick up the new set of hooks with the least possible interference. This seems such a self-evident proposition that one feels almost called upon to apologise for calling attention to it, yet in the actual work of the mill, both in dobbies and with jacquards, a neglect of this arrangement of the timing of the parts is probably productive of more trouble and mischief than any other.

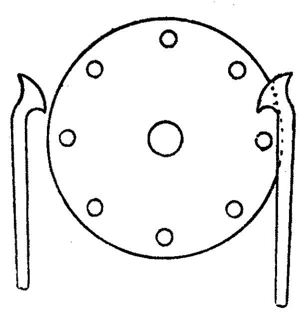


Fig. 110.

Then the next form following upon the lags of operating the needle is by means of perforated cards, and in that case an alteration of the system becomes necessary. Lags may be placed upon a perfect cylinder, and revolved in a stationary position, but when cards are employed this becomes impossible and, generally, a bar having a square section is substituted for the cylinder, although it is still known by the name of the cylinder, even in the most modern jacquards, so that anyone hearing the term cylinder applied to the rectangular bar carrying the cards upon a card machine will understand the origin of the term. This cylinder must be perforated at points corresponding to the cross wires or needles, the arrangement now taking the form as shown in Fig. 111, where the cross wire projects through the needle board in front of the machine, and the vertical spring in front is replaced by a small helical spring at the back of the machine as shown. Then the cards here must be perforated in the same manner as the lag is pegged to correspond with the pattern, *i.e.*—going back to the pattern in Fig. 105,—wherever it is desired that the hooks should be raised, a hole must be cut in

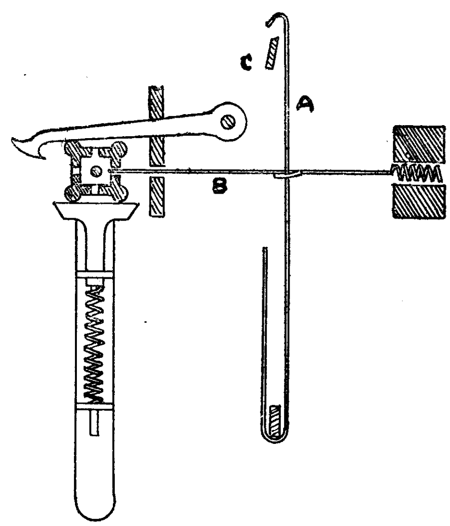


Fig. 111.

the card corresponding to the needle acting upon that hook; and again the cards when laced together as they are by means of string will present an exact facsimile of the plan, as would the pegged lags in the previous case.

The card cylinder must be actuated differently from the lag cylinder; every time the card comes in contact with the needle point, a number must pass through the perforations into the cylinder, generally to a depth of from

$\frac{3}{8}$ to $\frac{1}{2}$ an inch, so that even if the cylinder were a circular one, it could not be revolved with the card upon the needles; it is therefore placed upon an arm as shown in Fig. 111, and at every movement of the lifting knife, when it is engaged with the upright hooks, is thrown back a sufficient distance to enable the bar to revolve without coming in contact with the needle points. The revolution is caused by a catch, as shown, but in this case the catch is a stationary one attached to the side of the machine, so that as the card cylinder is thrown back, it will engage the corner of the cylinder head, and pull it over with the next face opposite the needle. The cylinder is again held in position by a hammer head and spring as in the previous case. Of course in this, as in the previous arrangement, the cylinder must be in contact with the needles when the lifting knife has disengaged itself from the hooks, so that the change takes place when there is no pressure upon the needle or the cards. This principle I desire to insist upon throughout, as it is one of vital moment in jacquard work.

Before going into the question of under motions, or other contrivances connected with non-positive dobbies, I think it will be better to call attention to the positive hand loom witch, so as to make the principle which must underlie all positive dobbies perfectly clear. Then it will leave the mechanical details of the several machines to be dealt with free from any question of principle, beyond an enquiry as to how far they comply with the best principles which can be laid down.

A section is given at Fig. 112, of a positive hand loom witch, where two hooks are employed in the place of one, one of which is attached to the upper half of the heald, and the other through levers to the lower half. The arrangement of the spring, crosswire, cylinder and lags, is precisely the same as in the ordinary witch, but the second hook which is introduced, is placed with its back to the other one, and a second lifting knife is introduced so that as one hook is struck off the lifting knife, the other is struck on. Therefore as one rises the other will descend, and whichever of the two may be struck upon the hook, so as to either raise or depress the healds as the case may be, the character of the movement will be the same. To facilitate this, the bottom board of the

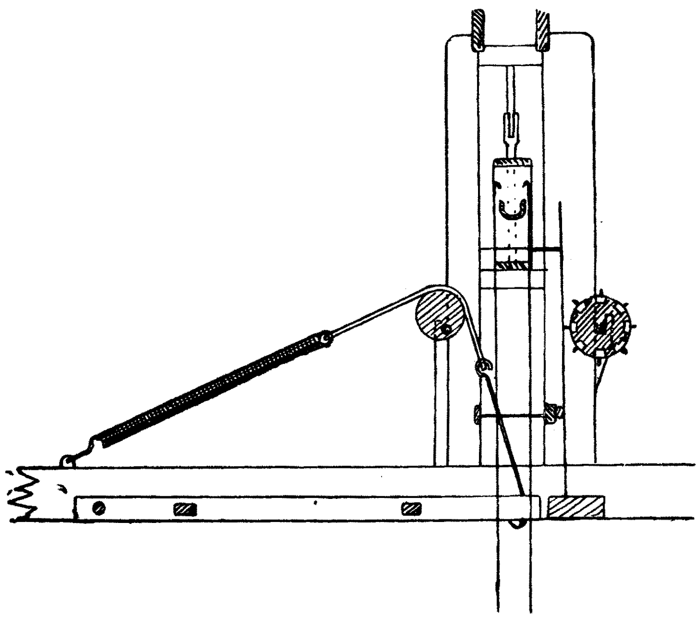


Fig. 112.

machine, upon which the hooks rest, when in the normal position, is made movable and descends exactly the same distance, and at the same rate of speed, as the lifting knives ascend. This bottom board is carried down by the pull of the cords through the healds of the rising hooks, and is brought back to its normal position by a lever and weight, or spring, so that not only do we get a positive movement of the healds, although dependent for the return upon a lever, or spring, but we get, what is commonly termed, also a centre shedding motion, where the threads meet in the centre of the passage from the highest to the lowest point, instead of always descending at the lowest point, as in the previous case. This illustration will make the principle upon which all positive motion dobbies are based clear to some extent at least.

Of course in a power loom the application of the motive power can be varied to a much greater extent than in the hand loom, and therefore an absolute positive motion is more easily obtained. But one word now is necessary to this machine, it is shewn in Fig. 104 that the lifting knife was a lever which imparted considerably more movement to the healds at the back than at the front. In place of this lever, what has been known as a lifting block, or griffe, has been substituted, and this had its knives placed at an angle to obtain precisely the same effect. Where a large number of healds are employed this condition is absolutely necessary, in consequence of the great distance of the healds at the back of the set from the cloth in comparison with those in front. But when we come to the jacquard machine, where the space occupied by the harness is comparatively small, then this provision can be dispensed with.

POWER LOOM DOBBIES.

It will be as well to begin with the power loom dobby as with the hand loom, at the bottom shedding motion, or as it is sometimes termed, the single lift. In detail it is practically the same as that already described; the upright hooks, the needles, the lags and pegs and everything is practically the same, so that little need be said as to the general principle. Then the question for consideration in connection with this machine, apart from what has already been said as to the advantages claimed for the different classes of shedding motion, is as to its ready and perfect application. For simplicity it is unquestionably the best. For weaving many classes of fabrics it has decided advantages, as also for the readiness with which the healds can be changed; but its one great disadvantage is in the employment of springs or weights. Very often this subject is looked upon from a very onesided point of view, but it should be faced fairly. Now taking the weight question first:—The common argument in favour of weights is, that in the average pattern the number descending will counterbalance those ascending, so that it is considered in the light of what has commonly been termed a counter-poise arrangement; but this is altogether overlooking the fact that at all times, whether moving or not, the whole weight is upon the machine though it may be said to be suspended as a dead weight. But in weaving irregular patterns, such for example as backed woollen or worsted goods, the variation in the weights of the sheds of the face and back cloths respectively is bound to have a serious effect upon the general working of the loom. Probably this is not so serious when weights are used as with a spring; for instance we take a spring and attach it to the bottom of a heald, when the heald is at rest there must be a certain amount of strain necessarily npon it for the purpose of keeping the heald tight, and in position, but the moment the shed begins to be open then the tension is gradually increased, so that supposing the tension upon the heald when at rest is equal to the 10 lbs. and the heald must traverse say not less than 4 inches, then as the strain is being gradually increased at every inch of movement, and in the ratio of 10 lbs. per inch, then the strain or tension at the extremity must be 10 lbs. by 4 inches, or equal to 40 inch lbs. in the aggregate.

Now look at the counterpoise in this case. Suppose we have sixteen healds and eight of them at their highest and eight at their lowest points respectively. Then 8 by 40 lbs. at the top as against 8 by 10 lbs. at the bottom represents the difference in the actual weight upon the two halves of the shed. Now here it must be observed that one portion is bearing the greatest strain at the moment when the other portion has the least, so that there cannot be said, by any stretch of imagination, to be any counterpoise here. Then as the strain is being released from the upper portion in its descent that from

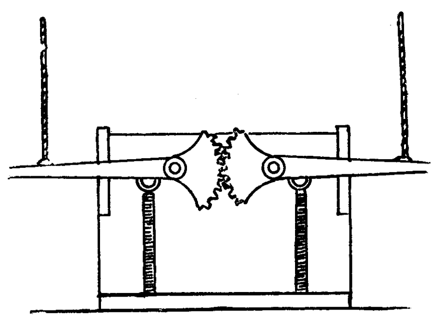


Fig. 113.

the lower portion is being correspondingly increased in the ascent, so that the exact balance of the two parts only occurs when they are passing each other in the centre. Even when the sheds are equally balanced this cannot be considered a satisfactory arrangement of the balance of weight, and with unequal sheds it must of necessity be less satisfactory. Now to meet, or mitigate this, various arrangements and contrivances have been resorted to, the simplest and possibly one of the oldest is shewn at Fig. 113 where two levers are placed beneath the loom having toothed gearing meeting each other in the centre, the fulcrum being very near the toothed gearing and the longer arm on each side being attached to the bottom of the heald. A spring is attached to the lever between the fulcrum and the point of connection with the heald and, by preference, very near the fulcrum; the opposite end of the spring being made fast to the floor or a framework near the floor. The effect of this is that as the heald is being raised the point of connection of the spring with the lever is gradually approaching the fulcrum itself, consequently instead of the strain being a constantly increasing one, in the direct ratio of the length to which it is drawn out, it gradually decreases as it approaches the fulcrum. This is far from being satisfactory, even

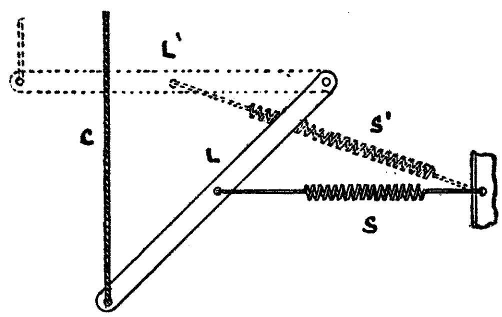


Fig. 114.

though it possesses advantages over the direct acting spring. Then we must look to other arrangements to overcome this in a greater degree. Another motion manufactured by Messrs. Hahlo & Liebreich is an improvement upon this, and another is what is now known as Kenyon's motion.

HAHLO'S UNDER MOTION.

In principle this under-motion is precisely the same as that of Kenyon, but instead of the lever as described in that motion an eccentric is used, this will be more readily understood by reference to Fig. 116, where the levers are seen attached to the eccentric at one side and the spring at the other. The spring is made fast to the frame at one end, and from the other end a strap is carried to the eccentric and forward direct to the lever, being made fast to the eccentric by means of a small bolt at the point where the leverage is greatest, or at the furthest distance from the centre, so that as the lever is raised the eccentric is pulled round and a gradual decrease of pressure, or tension, upon the spring follows in precisely the same manner as in Kenyon's motion, shewn in Fig. 115. This has perhaps the advantage of compactness, as it will be seen that very little space is occupied by the apparatus itself and the methods of adjustment are quite as easy as in the previous case. It simply means the lengthening

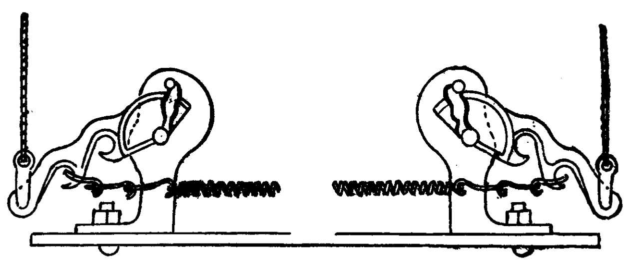


Fig. 115.

or shortening of the strap on one side or the other to ensure any amount of strain, great or little as required. It is claimed for this arrangenent that, with the eccentrics as shewn, the spring is distended only ¾ of an inch for a shed of 5 inches in depth. Then it must follow that the amount of weight upon the heald can be ascertained with absolute accuracy. Suppose one of Salter's springs being taken we know the strength of the first pull, and allowing for its being distended ¾ of an inch we can determine the exact ultimate weight upon the spring, and then we have only to ascertain the amount of leverage given by the eccentric and the weight upon the healds both at the highest and lowest point is determined at once. One form is illustrated in Fig. 116 where two levers are shewn, one in the raised and one in the depressed condition. Another illustration of the same motion is given at Fig. 117. In this case two sets of levers are employed, one attached to each side of the heald so as

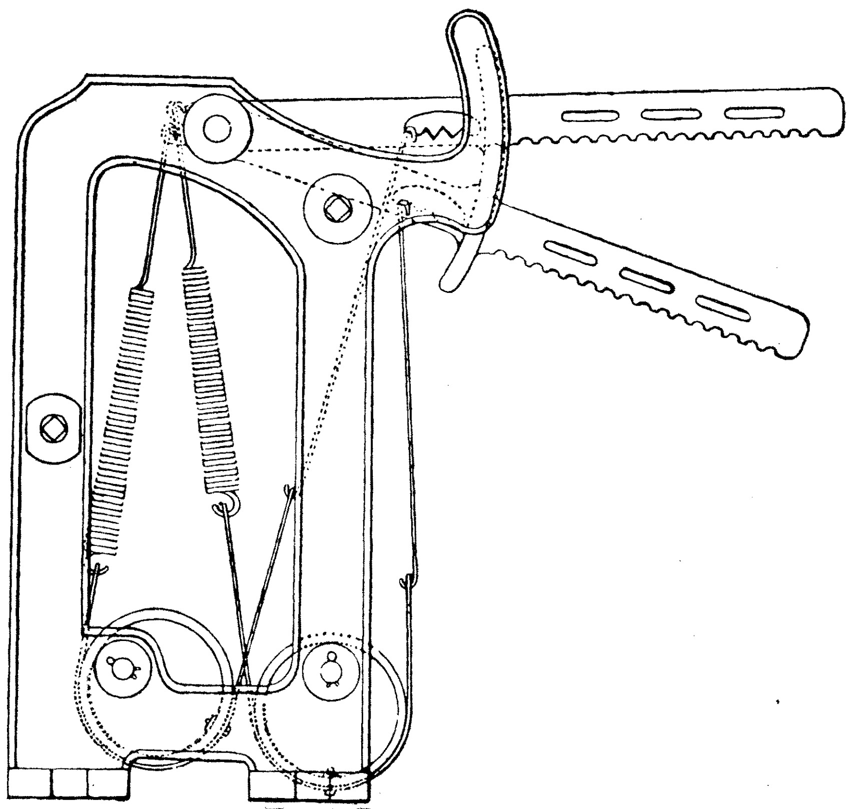


Fig. 116.

to dispense with bow bands. In this the two levers are hinged together at the centre in such a manner that one spring serves for both levers, this ensuring the action being precisely the same on both sides of the healds. This of course has the double advantage of not only

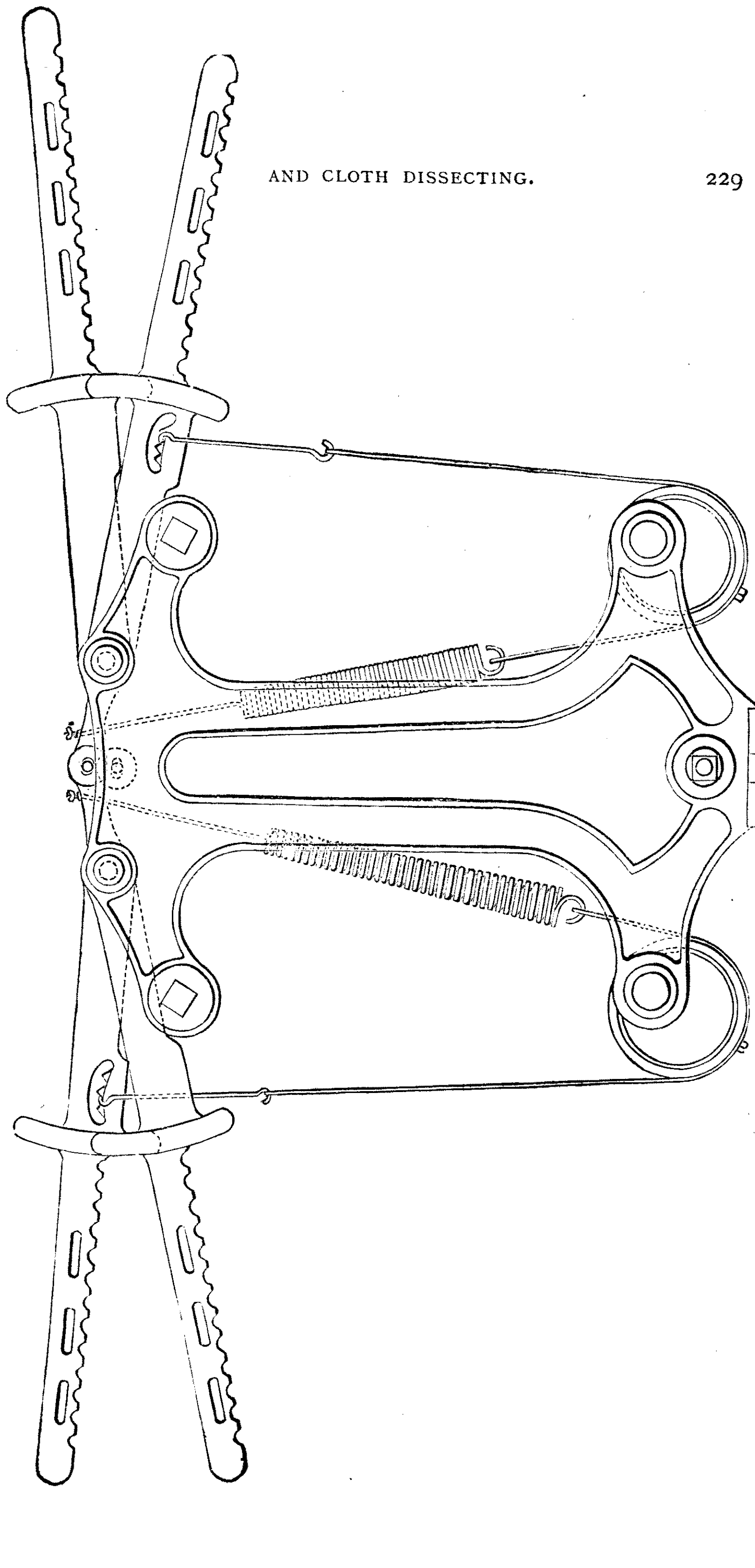


Fig. 117.

ensuring regularity of motion but of economising space. The amount of tension of each spring can be regulated first by means of a wing nut as shewn, and also by the provision of several notches in the levers so that all facilities for regulation are provided for. This is based upon an old and well-known principle. Suppose you take a lever L, Fig. 114, and place it at an angle of 45°, attach a cord to the free extremity and attach a spring S at any point between the fulcrum and where the cord is attached. You now apply force to the cord and raise the lever, the nearer you bring the lever to the horizontal line, as shown at L^1, the more you are diminishing the strength of the spring, or the resistance it will offer to the movement of the cord, simply because the line of direction of force as exerted by the spring and shown by S^1, is gradually approaching the horizontal, or is being exerted upon the fulcrum of the lever, so that when the lever reaches the perfectly horizontal position the tension upon the cord will be absolutely nothing, and if you pass that position the strength of the spring will be exerted in pulling the lever upwards and actually freeing the cord, as indicated by the dotted lines in the illustration. Now this principle has been applied over and over again in some of the earliest power looms, so that in its present form it is merely a revival of a well-known method which has always been more or less in use for this purpose.

Now one little point occurs here as influencing its practical application. The lever must be formed with a fairly broad base, so that the chain, or strap, connecting the spring with it may rest upon, and bend round the base to prevent, in the event of the lever being drawn beyond the horizontal position, the contingency which has been suggested, and to ensure that sufficient strain may be kept upon the healds. By a careful adjustment of the foot of the lever, that is by making it partake somewhat of the character of a projection, the tension may be made to slightly increase after the lever has passed the horizontal. There is probably no absolute necessity for this, but often it may be somewhat desirable, so as to give sufficient impetus to the movement on the return. Now the question of leverage or power, or tension applied to the heald, may be very easily determined, the strength of the spring being known.

Let the pull upon the spring be 10 lbs. when at rest, and it is stretched 3 inches, the strength would be increased and three-fold added to the existing weight, thus 10 lb. $\times$ 3 = 30, add to that the 10 lbs. already existing and it would be 30 + 10 = 40 lbs. for a straight pull, but in the case of a lever such as this, the 10 lb. would be gradually decreasing, as shown.

One important modification has been introduced into this, as shown in the illustration, Fig. 115, and that is the ability to lengthen the chain connecting the spring with the lever, by introducing fresh links, or moving from one notch to the other on the lever, as shown in the illustration. A rather serious difficulty often arises in the use of under motions. In a large proportion of dobbies, what are commonly called bowbands must of necessity be used, *i.e.*, the two sides of the heald must be connected to the lever at one point above. Now suppose springs only are used, and one spring should be slightly stronger than the other, or there is the least variation in the tension upon the cord; at every effort to raise this heald, one side will constantly be rising above the level of the other, and it is only by the most careful adjustment that this tendency can be overcome, and even when everything appears to be perfectly correct in working there is no certainty that a little slipping, or stretching at the cords, will not cause a derangement at any moment. In the method shown at Fig. 113, this is overcome in some degree by the gearing of the two levers into each other, and so equalising the strength of the springs, but that is not nearly so perfect as the method shown in Fig. 118, which is one of the improved modifications of Kenyon's, and ensures always the same freedom being given to both sides of the heald, and perfect equality in lifting, along with the advantage mentioned of a release of the spring as the heald is being raised. Of course in practical working, many modifications of the system as described may be found in use, but practically the principles are covered by what has been referred to.

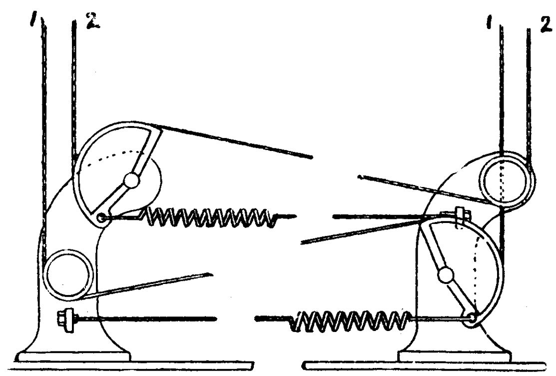


Fig 118.

Now to turn to the actual machine; there are several points in connection with this machine, which may well be thoroughly cleared up now, and it will serve as a basis for consideration of jacquard machines afterwards. In the first place, it has been pointed out that the lifting hook has a cord attached to it for the purpose of raising the heald, but no mention has been made of the constant tendency on the part of this hook to turn itself half round. This tendency exists not only in the single dobby, but in every machine, up to the most elaborate jacquard. There are several methods of obviating this, and those, if pointed out at present, will considerably assist in the understanding of the details of the jacquard later on. A very simple contrivance is shown at Fig. 119, which shows the hook as being a double one. The second or shorter hook resting upon a bar or iron rod at the bottom, or in the middle of the machine, and the upper half having its hook placed over the lifting bar in the ordinary manner. The card cylinder acts upon it through the medium of

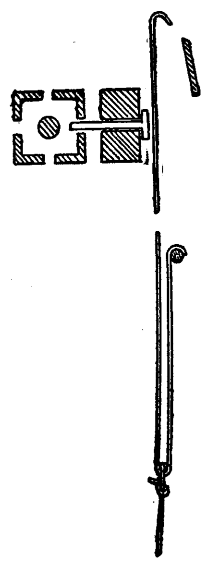


Fig. 119.

a small needle with a head, and the hook practically forms its own spring. One considerable advantage exists in this arrangement, and which is of much more importance in large jacquard machines, *i.e.*, that the lower half of the hook projects considerably below the bottom of the machine to permit of the ready replacing of a neck cord when necessary. A further arrangement is, where the bottom of the hook is simply turned up, and passed through a second eye in the needle or cross wire, so of course effectually preventing its turning, but making a somewhat cumbersome arrangement.

There is but one other method we need dwell upon here, and that is, the method of actuating the card cylinder or bar. As already pointed out, the cylinder for lags may be revolved without its position being moved, but obviously a square bar cannot be so treated. It must be thrown back a sufficient distance from the needle points that its corners cannot come into contact with them. To accomplish this, two methods are adopted; one is to throw the cylinder back upon an arm, and the other to move it upon a bar having horizontal motion imparted to it. Both methods will be more fully described in connection with the jacquard. There are no special advantages attached to either of those methods, it is simply a question of mechanical arrangement. Only one thing must be considered in connection with either of them, and that is, the proper timing of the movement in relation to the lifting knives, as already indicated.

HATTERSLEY'S DOBBY.

After the single lift dobby came what is known as the Keighley dobby, or Hattersley's patent dobby. This machine is generally looked upon as an open shed dobby, strictly speaking it is not so, but one of those as already described where the upper half of the shed descends midway to the point where the change takes place, though the amount of descent is mitigated by the form and arrangement of the levers. This will be best understood by reference to the illustration at Fig. 120, which is a section of the machine as made by Messrs. Ward Bros. showing the whole of the working details. The leading features of the machine consist in a T lever having its fulcrum at A and connecting rod B attached to the long

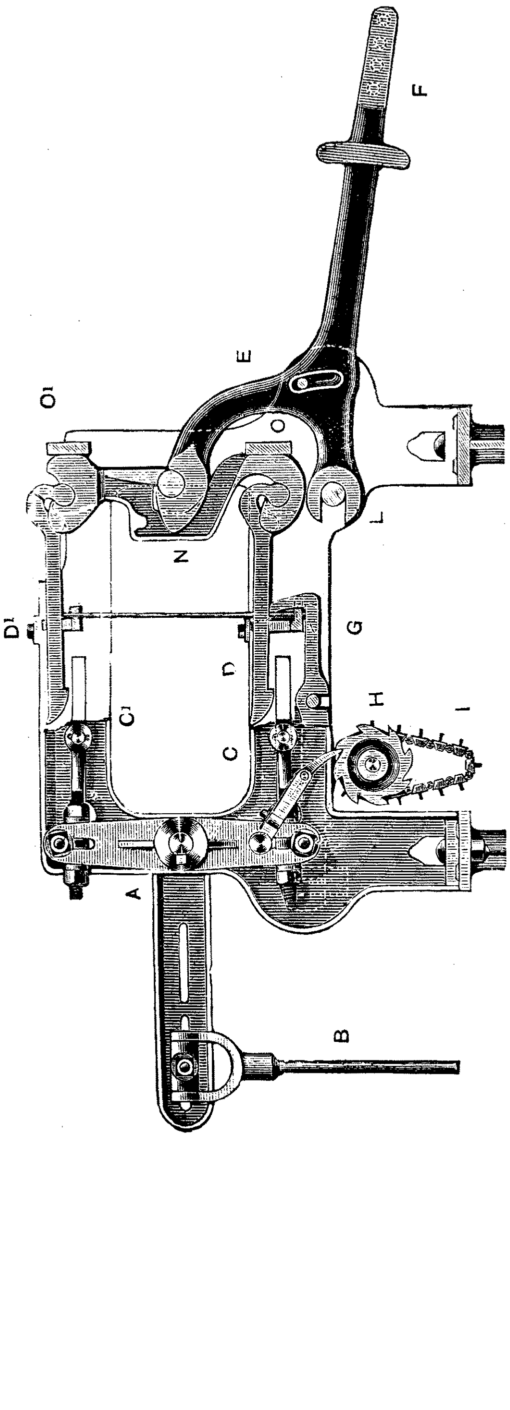


Fig. 120.

arm of the lever. Each extremity of the head of the T acts upon a draw knife, C and C^1. Those draw knives in turn actuating the hooks D and D^1, each of which being connected with opposite arms of the lever E actuate the heald by means of the bow bands from F. So far this is sufficiently simple, the connecting or treading rod B is connected with a crank on the lower shaft of the loom, so that at each revolution of that crank the draw knives C and C^1 are both actuated, or one serves for one pick of the loom and the other for the next pick, the lower shaft revolving once for two picks. The manner in which the lever E is connected to the hooks D and D^1 and the readiness with which the hooks or levers can be removed will be best understood by a reference to the details of the illustration.

But the method of selection of the hooks to be actuated is at the present moment of much more importance to us as involving more important considerations. Immediately below the hooks are a series of levers G, and so contrived that a lever can act directly upon the hook D^1 by means of a vertical needle and one act also upon the hook D. Beneath this series of levers is placed the lag cylinder H with the lags I revolving upon it. This cylinder may be made to revolve by means of a pawl or catch which being connected to the lower arm of the T, lever A, will cause the cylinder to move one tooth at each stroke of that lever, so that each lag placed upon the cylinder must serve for two picks of the pattern. The method of pegging the lags will be described presently, let us consider at the present moment the exact action of the dobby.

Now refer to the lever E and note its peculiar form. It will be seen that at its lower extremity it has what might be termed a fulcrum at L, and a connection at M with another species of lever N. This lever N is the one connected with the hooks D and D^1, so that although E at the point of connection at N is movable, the point L remains stationary. Now suppose the heald is at its lowest point. Both ends will be resting against the bars O and O^1, but should the heald be raised, say by the top hook, the bar N would be drawn away from O^1 a sufficient distance to raise the heald, or should it be acted upon by the lower hook it would be drawn away from the bar O in a similar manner. Now suppose the heald has been raised by the action of the hook D and the draw bar C, and held up for one pick, it is desired that it shall return to its lowest point after that pick, the hook D^1 would be raised by means of the peg in the lag and so prevent its acting upon the lever N, thus that lever would return to its normal position, resting against the bar O. But should the heald require to be held up for another pick then the hook D would be allowed to come in contact with the draw bar C, and so draw the lever N at its lower extremity away from the resting bar O, so that a double action would be taking place the draw-bar C would be pulling away at the lower end of the lever at the same moment that the draw-bar C^1 would be returning the upper end towards O^1, so that at the point where they meet for the change to take place from one draw knife to the other the heald would have been allowed to descend some distance from its highest point towards the centre of stroke, and then would be brought back to the highest point, so that although nominally an open shed dobby, strictly speaking it is not so, the lower half remains stationary but the upper half must always descend not less than one-fourth the entire depth of the shed as each change takes place. Strictly speaking there is no disadvantage in this, for the amount of work thrown upon the machine and the slight variation in the tension is of little moment compared with the advantage gained by the rapidity of change from one draw-knife to the other, and consequently the increased speed at which the loom can be run. No better evidence of this could be adduced than the long and successful career of the machine itself, and the fact that it has been copied, modified and improvements patented by some of our best machine makers since the expiration of the original patent. There is one possible disadvantage connected with it, more especially for wide looms or slow running looms. The lever A being actuated from what is termed the tappet shaft of the loom and the manner in which the draw-knives act upon the healds through the levers L and E, comparatively small pause is given to the shed when fully open, consequently it is often found difficult to pass a shuttle across during the time when the shed is open. Attempts have been made to assist this by giving more pause to the going part, and in several modifications of the machine, both by the original inventors and others, the defect has in some measure been overcome.

The machine shewn at Fig. 120 is a modification, or improvement of the Keighley Dobby. This modification is simply in detail, there is no alteration whatever in the principle involved. As will be seen the working joints are made strong, the draw hooks are made solid instead of having looped eyes so that strength is obtained by increasing the width of the machine. Then not only are the needles reduced to half in quantity but the small collars have been dispensed with. The bottom draw hooks are brought into direct contact with the pegs so that the intermediate wire needles are dispensed with. Again the draw hooks are made to work in a grate so as to ensure a straight direct lift, and in fact the machine is put together in such a manner as not only to increase the efficiency, but so that every part of the machine can be removed without disturbing any of the other parts. This in itself is a considerable advantage

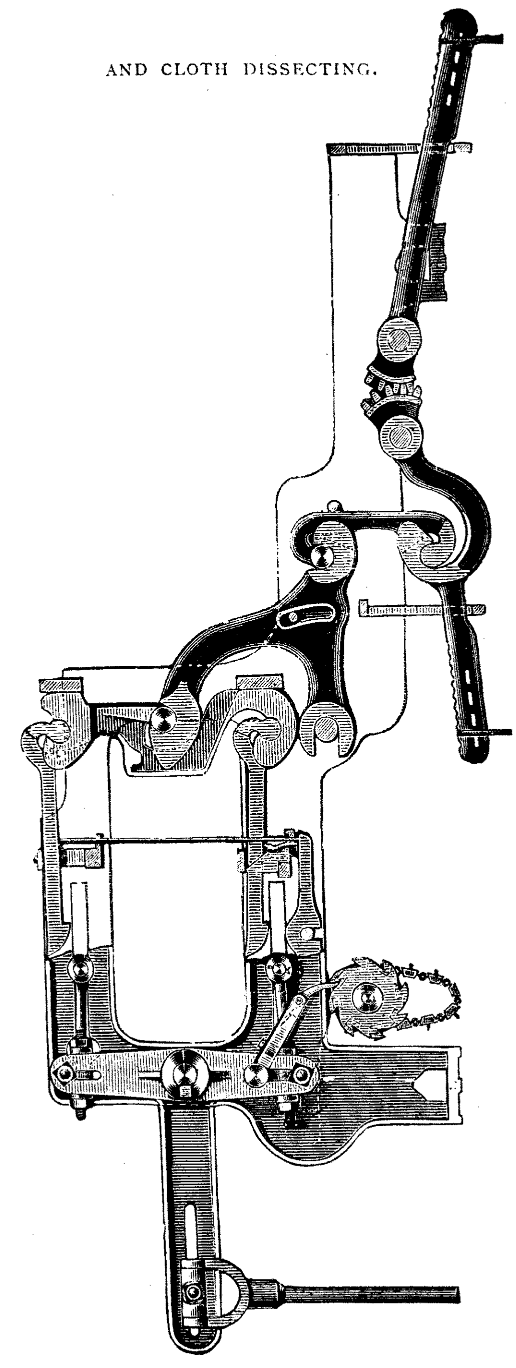


Fig. 121.

as saving time and preventing mishaps in making alterations or repairing damages.

Another modification and improvement of the same machine is shewn at Fig. 121, and a view of Hattersley's own make at Fig. 122, where double jacks are used dispensing with the bow bands above the healds, sufficient has been said already as to the use of bow bands and the disadvantages attending them that nothing more need be said as to the advantages of this class of machine.

A still further modification is shewn at Fig. 123, where instead of the double lever shewn in 121, extension levers

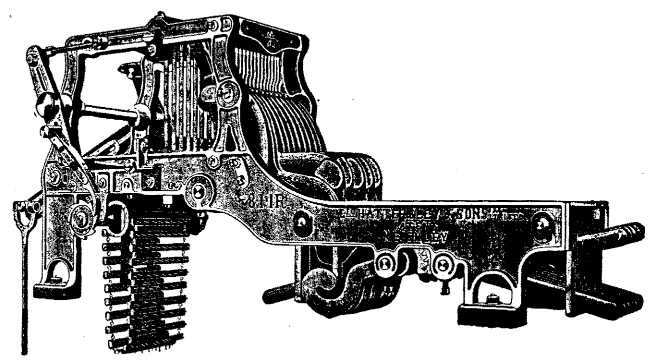


Fig. 122.

are employed, making it much more suitable for heavy strong goods and more especially for wide looms.

Another developement of the same machine and giving positive motion to the healds is shewn at Fig. 124, where by an ingenious connection of the levers the healds are either raised or depressed direct from the machine, thus dispensing with under-motions or springs. This loom is Messrs. Hattersley's make.

Now we come to another important improvement in this class of machine, namely, the use of what are known as cross border motions. Every one familiar with weaving is also familiar with the disadvantages attending the use of

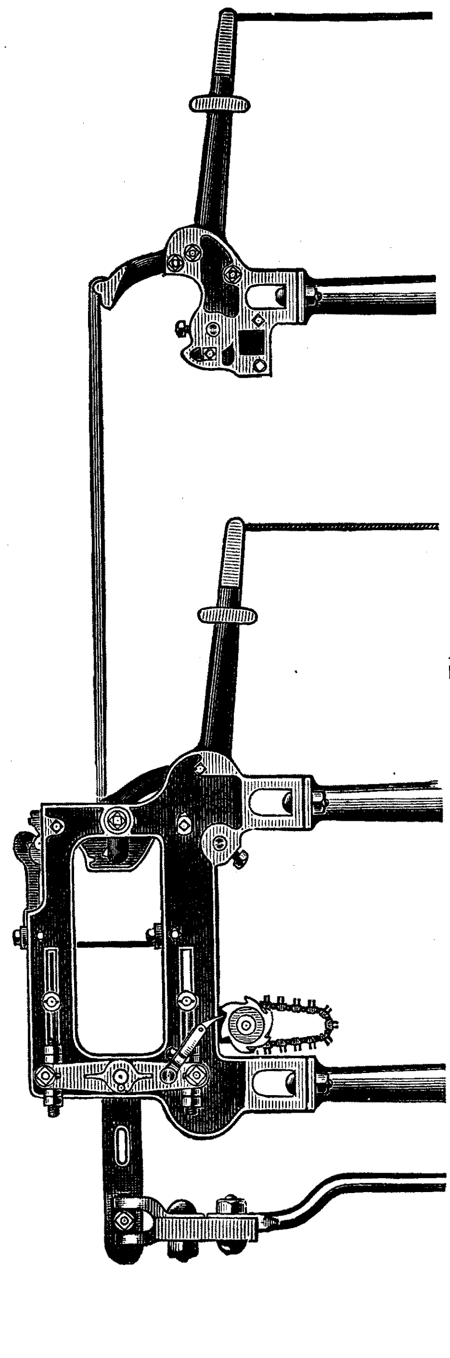


Fig. 123.

two sets of cards or lags; consequently the introduction of the machine which will enable the weaver to change from one to the other without actually taking the cards or lags off the barrel must of necessity be of great convenience to the weaver. A contrivance of this kind is shewn at Fig. 125

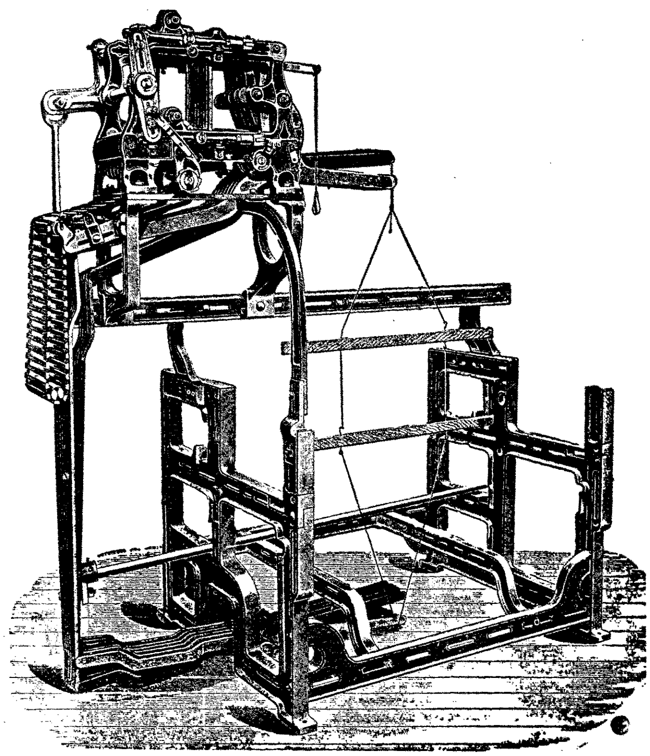


Fig. 124

in what is known as the L. and Y. Dobby of Messrs. Ward Bros. Here it will be seen that the apparatus is one of the double jack, or double lift motions, and is provided with two lag cylinders, one for working the cross border and the other for working the middle, or body of the towel or other articles being woven.

A glance at the machine will explain the simplicity of the arrangement; the two card cylinders are placed on opposite arms of the lever and so arranged that either one or the other can be brought into play at will by pulling the handle to the right the cylinder to the left is brought into action, and by pulling that to the left the opposite takes place. This will perhaps be better understood by reference to Fig. 126, which provides for an automatic arrangement to serve the same purpose. In this case there is nothing left to the weaver, but the machine

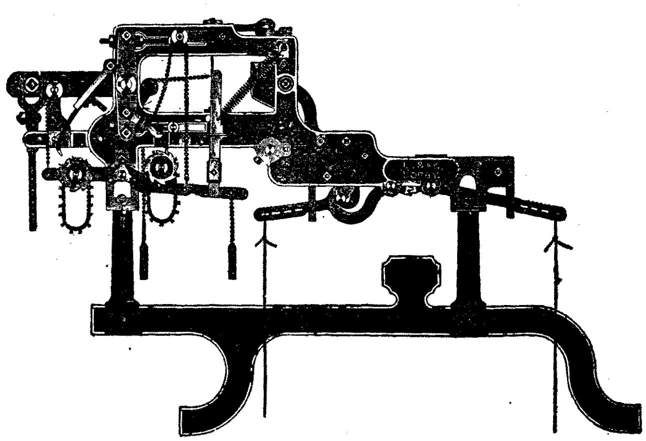


Fig. 125.

performs the change itself. The two lattice or lag barrels are carried on the lever CC, the inside barrel, or the one to the right, is shewn in working position, and upon it are carried the lags for weaving the cross border. A link E connected by a bracket and upright bar D on the rocking lever CC locks the inside barrel firmly in position when required. A series of jack levers marked A are employed exclusively for changing the barrel or bringing either of them into action at will. This lever A has no heald attached to it. When it is desired to bring the

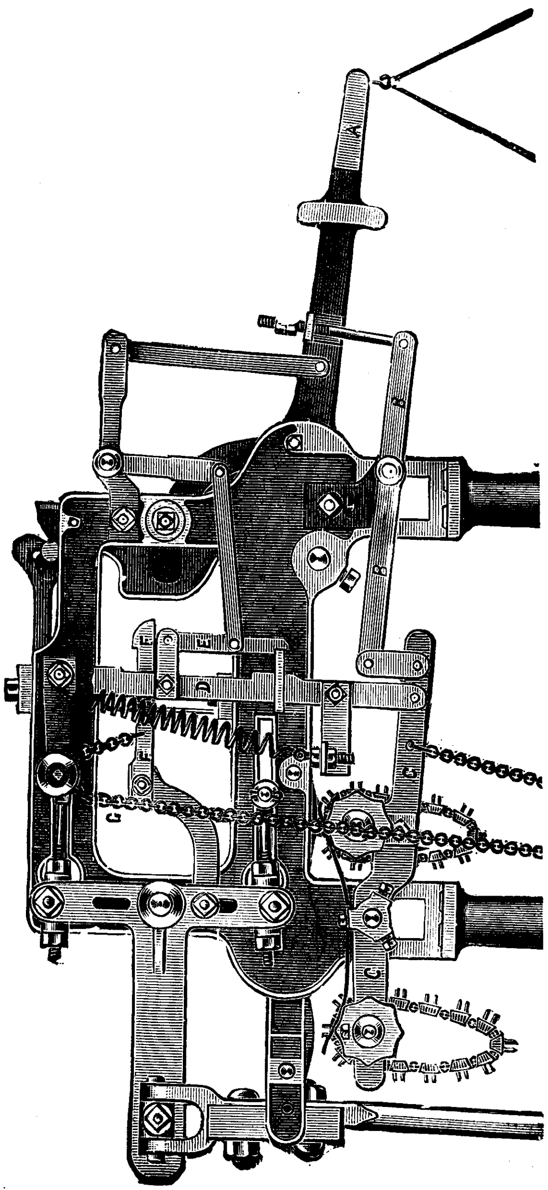


Fig. 126.

outer barrel, which carries the lags for weaving the ground portion of the fabric, into position, a peg is inserted on one of the lags on the inside barrel so as to operate the lever A, which in its movement first withdraws the locking link E, and then by means of the lever BB changes the position of the barrels by reversing the position of the lever CC. They are then locked in that position again by means of a ledging on the upright bar D. Now to return the barrels to their original position after the ground fabric has been woven, and with a view of weaving a second cross border, the catch F is caused to withdraw the bar D from its fastening by means of a chain GG, enabling the upright spiral spring, as shewn, to bring the whole of the mechanism back to its original position, and so the operations go on alternately, thus saving either the constant changing of cards or lags by the weaver, or the use of a sufficient number of cards to weave the whole length of the towel or handkerchief.

One other feature connected with this class of dobby must be noticed, and that is the use of a positive driving chain for the lattice barrel; the object of this is to drive the lattice barrel direct from the crank shaft, and is of most importance when the dobby is employed in connection with box looms. In weaving coloured checked goods, where there is a pattern formed by the healds in conjunction with the check, it is necessary that the two should be made to work in unison, so that should the loom be turned back the pattern chain and box chain will be reversed at the same moment. This is accomplished simply by placing a chain wheel B, Fig. 127, which can be driven by the chain from the crank shaft as shewn. On the opposite end of the shaft carrying B is mounted a recessed disc and pin C, each revolution of which will move the latticed barrel a distance equal to the width of one lattice or lag, thus by the simplest possible means continuity of

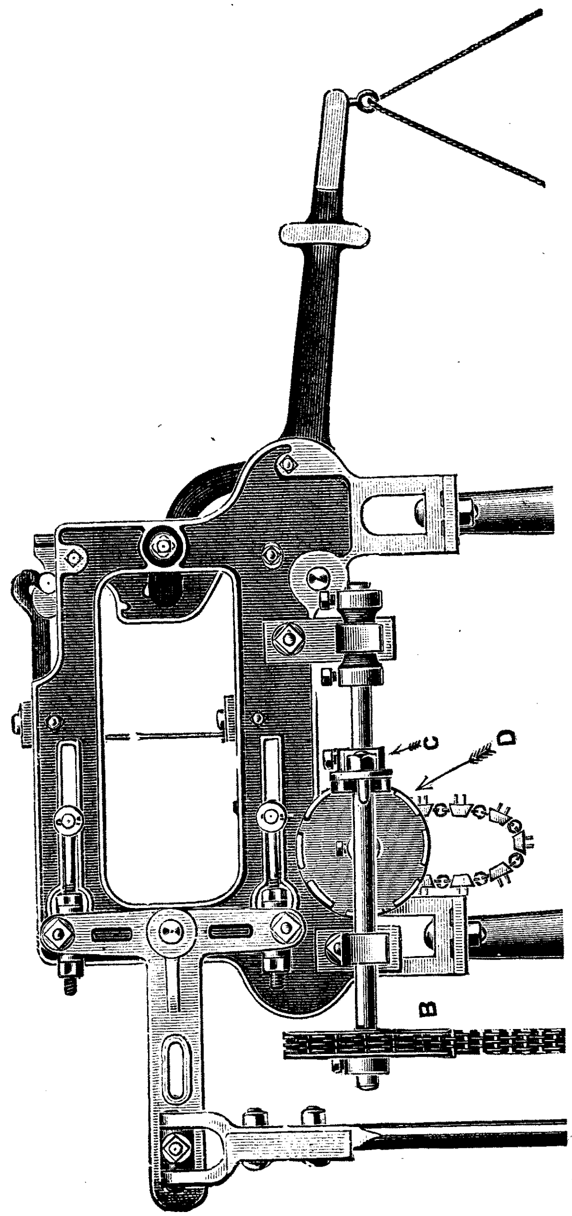


Fig. 127.

driving the lags of the dobby and the card motions is ensured.

HAHLO AND LIEBREICH'S DOUBLE-LIFT MOTIONS.

Now we have another machine somewhat different from the Keighley type but virtually built upon the same principle, a view of which is shewn in Fig. 128. This

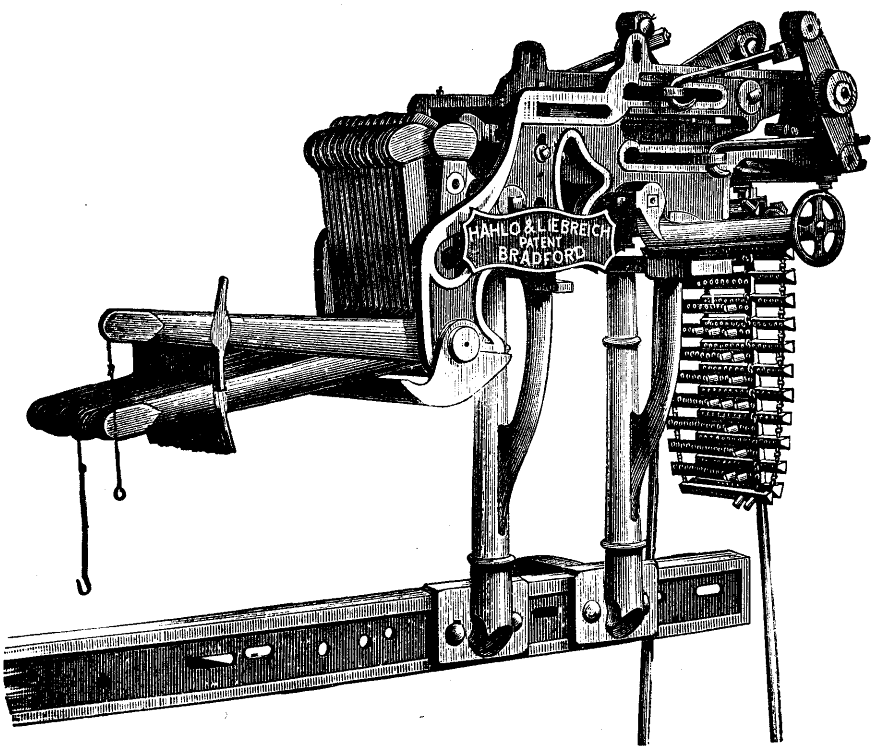


Fig. 128.

possesses the advantage of compactness, and perhaps a little more direct action than the original machine. It will be seen on reference to the drawing which represents the machine arranged to work on looms from 40 to 45 inches wide, where there are two draw bars of practically the same type as the Keighley dobby, but the hooks or draw bars are placed much closer together and act practically as one. The general arrangement of levers, the action of the lags upon the knives in the selection of hooks, the jacks or levers and everything, although slightly differing in detail from the Keighley dobby are virtually the same in effect. Another modification of the same machine is shewn in Fig. 129, which is virtually the same machine but arranged to work with paper cards instead of lags, and with the addition of an automatic cross border motion. So far as the card motion is concerned, it differs from the lags and pegs only as already pointed out, viz:—the cards must be perforated and the card cylinder withdrawn and pressed up to the needles with each succeeding card instead of revolving in one fixed position, as is done in the lag motion. The cross border motion calls for special notice, inasmuch as it differs from the other ones entirely in principle. It will be remembered that in those already referred to two sets of lags or cards were employed, one for the ground and one for the border. In this machine the same set of cards is made to serve a double purpose, and not only may a cross border and ground pattern be woven, but any number of patterns, within reasonable compass, may be put upon the same cards. The arrangement generally is this, there is one row of needles to actuate the hooks, and the cards are so arranged that two, three, or more rows of holes may be cut upon them, and the card cylinder over which they pass is so arranged that any one of the several rows of holes may be brought under the needles at will. It will be seen from the illustration that a vertical motion is imparted to the card cylinder C. And whenever a blank in the card comes in contact with the lever, the draw bar H, drawing the catch P, moves the ratchet wheel R one tooth, thus moving the star wheel carrying the chain of links. Now these links perform a very important function, as will be seen; actuating the end N of the lever O in such a manner that they can alter the position of this lever, raising or lowering it in any degree. This lever is so contrived that it brings one of the rows of holes in the cards opposite the needles which actuate the draw-hooks. Now suppose

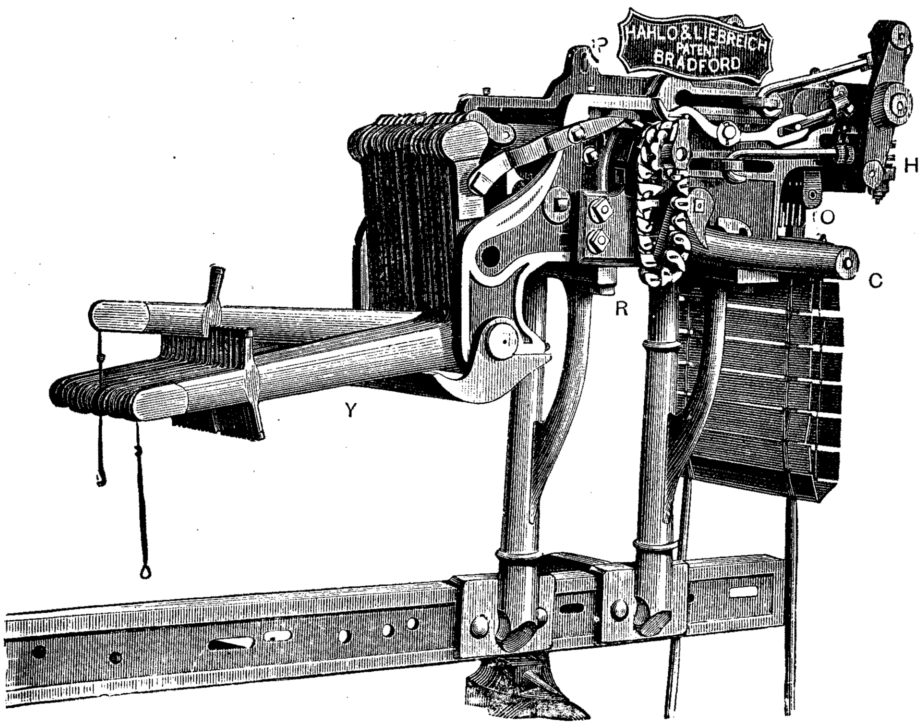


Fig 129.

there are two designs to be woven, one for the border and one for the ground. Then the border pattern would be cut upon the cards on one row of holes, and the ground pattern upon the other row of holes of the same cards, so that whichever row is brought in contact with the needles will determine the pattern to be woven. Then it is obvious that a combination may be woven with any number of patterns and the links in the chain may bring any portion of the pattern in contact with the needles as desired. Then the knives being acted upon in this manner will actuate the healds through the lever Y in precisely the same manner as in the ordinary Keighley dobby.

One feature of this machine however must not be overlooked, there must be a direct connection between the number of picks in one portion of the pattern upon the cards and the number of links in the chain.

A most ingenious contrivance accompanies this arrangement. The chains need not be moved always with the cards, but by means of a separate lever acted upon by the cards, one link of the chain may be moved forward at any time, so that supposing there are twenty or forty cards, consecutively of one pattern, then by cutting a hole moving the chain one link the next pattern will be brought in contact with the needles. This will go on working until the second pattern is complete when another link in the chain will be brought forward, then a third link may be brought forward, and so on for any number; so that a combination of patterns may apparently be made extending to an indefinite number of picks in the whole, and of immense variety in the several parts. But the relation of the several parts of the pattern to each other must not be forgotten. The number of picks in one portion must always bear some direct ratio to that in the other portion. Let one contain for instance thirty picks in the complete pattern, the other must contain some multiple of 30, or the two must be arranged so that the changing will take place at a number corresponding with the least common multiple of the two. So that although there is virtually an indefinite range of pattern within the reach of the designer, yet there is a limitation governed by the figures referred to.

Another feature of this machine must not be lost sight of, and that is, a contrivance for levelling the healds when the loom is at rest; one can easily understand the advantages of a motion of this kind. We may examine it from two points of view, each of which will recommend it; first, a large number of healds may be employed, and a weaver on taking up a thread finds it difficult to have access to any one of the healds required, because of the great space they occupy. If one portion is raised to the highest and the other depressed to the lowest point, the

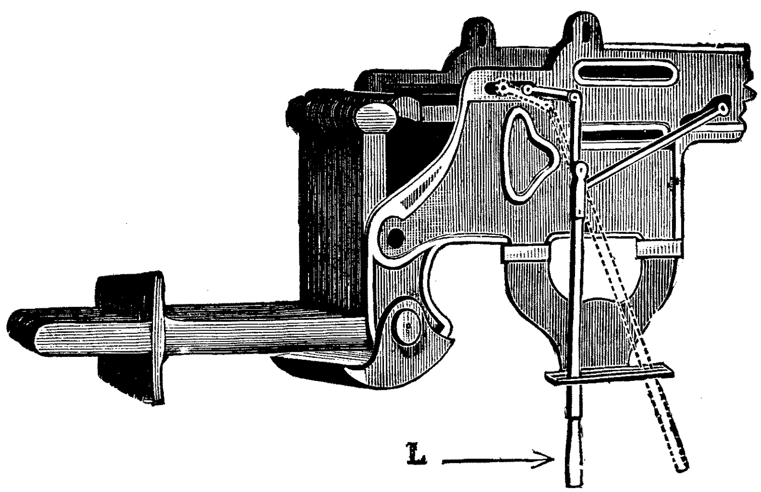


Fig. 130.

difficulty is of necessity much greater than when they are all at the same level. In working with very strong yarn this may not be of such serious moment, except as causing irritation to the weaver, but when working with tender yarn several threads may be broken in attempting to tie up one, thus not only causing irritation but increased work, and probable faults in the cloth. The arrangement of this portion of the mechanism will be understood by a reference to Fig. 130, where the lever L is shewn as controlling it. From this lever are shewn two connecting rods, those connecting rods communicate motion to two bars, so contrived that they release the hooks from the draw knives on the lever L being drawn to the right, and bring the whole of the healds to a level, but on returning the lever to its normal position, as shewn in the drawing, the whole of the draw hooks are restored to the position indicated by the pattern card upon the needles, so that by the simplest possible movement on the part of the weaver any operation in taking up threads or correcting any fault is at once facilitated. For tender material too

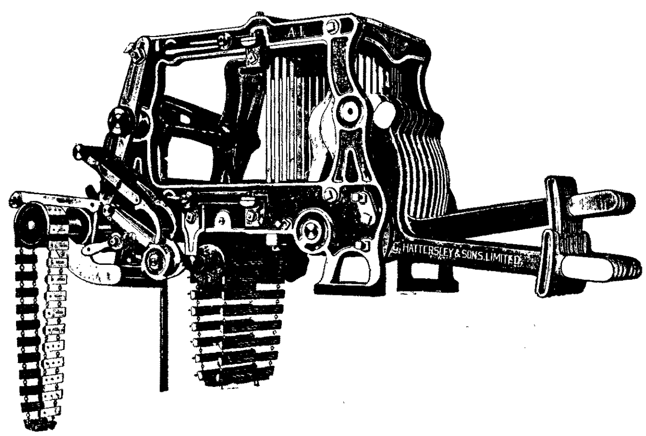


Fig. 131.

much value could not be attached to a contrivance of this kind.

Another automatic border motion is shewn at Fig. 131, which has something in common with that already described. In this arrangement each lag comprising the chain seen under the machine represents two picks, and are pegged alternate lags for ground and border. Two lags are moved forward at each movement of the cylinder by double pushers, either of which can be brought into operation at will. One lever in the machine is reserved to be acted upon by a peg at each revolution of the chain of lags, and this lever turns a secondary chain of lags seen at the left, outside the machine. The lags upon this secondary cylinder are pegged or blank so as to determine which of the pushers shall act upon the primary or pattern card cylinder, and by those means bring the proper lag into position for the formation of border or centre. As will be seen this is one of Messrs. Hattersley's machines.

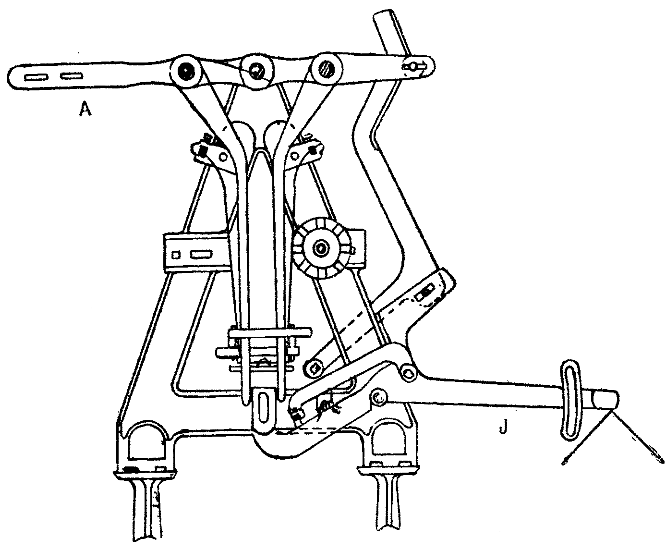


Fig. 132.

THE BURNLEY DOBBY.

The principle of this machine differs from those already described, in the manner in which motion is communicated to the levers, from which the heald is suspended. A long lever A has its fulcrum at what might be termed the apex of the triangle of the outside frame, the details of which will be seen at Fig. 132, and on each side of this fulcrum are hinged a series of bent levers, their lower ends forming a nearly vertical line. Below these are placed the "Jack" levers J, from one end of which the healds are suspended, and the other end is operated upon by the vertical levers just mentioned. For every "Jack" lever there are two vertical levers, and in front of each of the vertical levers is placed a spring, which may be acted upon by the pegs in the lags. There are two sets of pattern lags, one at each side of the machine, and when a peg is inserted it will press the vertical lever into position over a kind of notch in the bent end of the jack lever, a mid-rib of the grate which keeps the vertical levers in position preventing it being pressed too far. As the top lever oscillates the vertical levers are pressed downwards and any that have been struck back by pegs will strike the notch on the jack lever thus depressing the bent end and raising the end to which the heald is attached. The spring in front of the vertical lever, and which is acted upon by the peg in the pattern lag is sufficiently flexible and strong to do its work and prevent any harshness or liability to injury.

As will be seen from the diagram every part of the machine is strong, the working is simplicity itself, and from the nature of the movement lends itself to a high rate of speed.

From this brief description it will be seen that the lower half of the shed remains stationary, and that the upper half must descend midway for the change to take place, so that it is a semi-open shed machine, practically as the Keighley Dobby is, but there is no compensation in the form and working of the levers. For general work this latter item may not be of very much importance, but for gauze weaving it is of some moment, as changes cannot take place in the crossing threads without the healds coming to the same level. Provision is made for this by placing in front of the machine a peculiar bent lever, the upper end of which may be acted upon by the extreme end of the lever A, and the lower extremity carries a bar across the machine, this bar has a series of fingers placed immediately over the jack levers which carry the "standard" healds for the doups, so that at every move of the lever the standards are raised to the middle of the shed to meet the descending healds and facilitate the crossing of the threads.

The form of the lever at the top, when acted upon by the lever A is such as to give a slight pause, thus ensuring

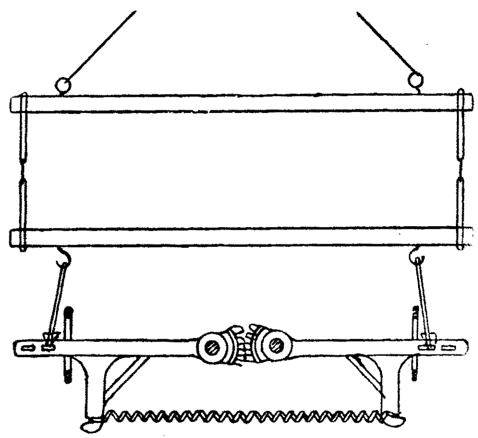


Fig. 133.

sufficient time for the threads to cross readily and prevent "knuckling" either in the doup or warp threads. This contrivance is one of the most ingenious for leno or gauze weaving in fast running dobbies. Provision is made to prevent the pattern lags from getting one in front of the other. An undermotion is attached to this dobby as shewn in Fig. 133, consisting of toothed levers and springs, upon the principles of those already dealt with.

BLACKBURN DOBBY.

The machine next calling for attention is what is known as the Blackburn dobby, an illustration of which is given in Fig. 134. In general principle this is practically the same as what is commonly known as a double lift Jacquard machine. In the machine there are two distinct sets of hooks and two sets of lags. The pegs of the lags acting directly upon the hooks without the intermediary

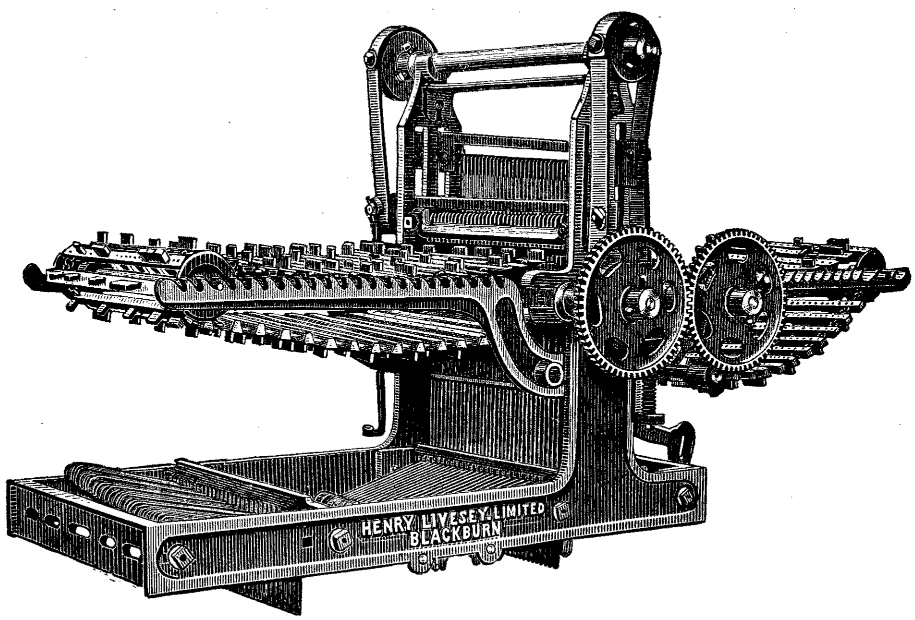


Fig. 134.

needles or cross wires of other machines. The position of the machine on the loom is somewhat similar to that of the Hattersley dobby and the motion is imparted to it by a crank upon the tappet shaft in the same manner as in the Hattersley dobby. A pair of tappets and treadles are also fixed under the loom and worked from the tappet shaft. There are two griffes connected by straps over a pulley carried by a shaft parallel with the rows of hooks, so that as the treadles are actuated by their tappets under the loom pulling down their griffes alternately the connecting strap raises the opposite one. Each lag in the chain of course represents one pick as in the other dobbies, but there is this difference from the ordinary dobby that two sets of lags and two lag cylinders being employed, they act alternately. The odd picks of the pattern would be represented by one set of lags and the even picks by the other set. In this case the pegs by pressing back the hooks represent those which shall not be raised. Instead of the hooks acting directly upon the healds they are attached to them through levers or jacks, these being so joined together at the ends by teeth forming the segment of a circle that their concurrent action is assured. This will be understood by reference to previous figure, where the toothed levers are shewn in connection with each other. The barrels carrying the lags are coupled together by means of a third link and moving slide and bearings.

THE KNOWLES' DOBBY.

As a positive open shed dobby this machine has attracted considerable attention ever since it was introduced into this country, and, as pointed out in reference to the method of operating the box loom, it is quite unique in character. The principle of actuating the healds is practically the same as that of actuating the boxes, referred to at pages 154 to 161. With the exception that a positive motion is imparted instead of the use of the chain.

In the illustration at Fig. 135 a full view of the loom is given when both the box and dobby are seen, and a detailed drawing is given at Fig. 136.

The machine is driven direct from the crank shaft, and by means of a vertical shaft which communicates power to the two cylinders seen on the dobby, and which

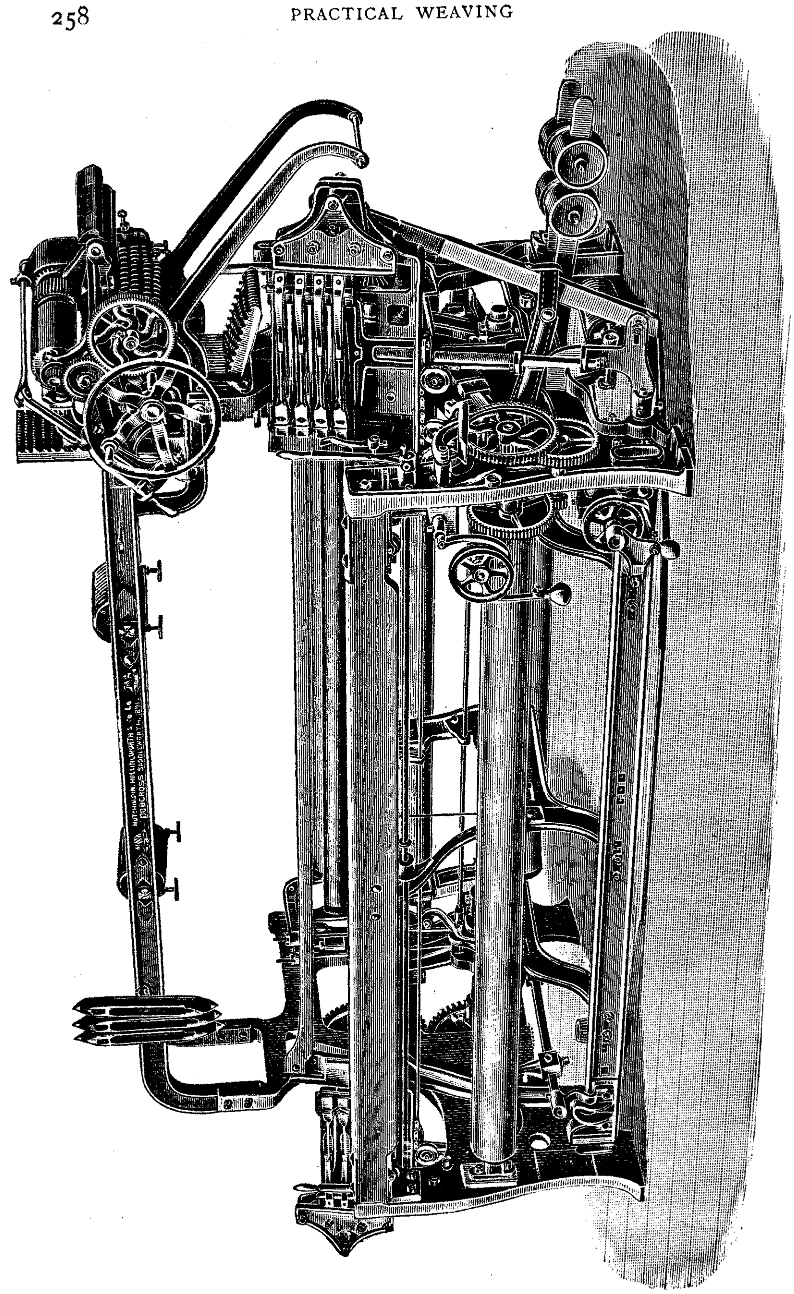


Fig. 135.

are represented in Fig. 136 at B and C. These cylinders have teeth on one-half their circumference, and revolve in opposite directions continuously. Between them is placed the disc wheel A as described in the box motion. To the left is the vibrator lever P (the lettering of the vibrator lever and connector have been crossed in drawing, but the description is corrected to suit it), which is acted upon

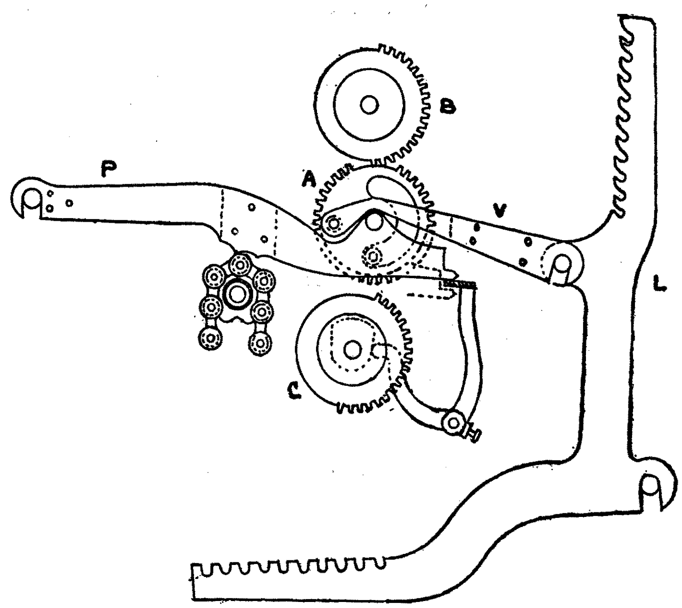


Fig. 136.

by the pattern chain placed below it, so that as the vibrator lever is raised or lowered by the pattern chain, that is by the introduction of a pulley or link, it will raise or lower the disc wheel A and bring it into gear with B or C, and be caused to make a half revolution upon its axis. The connector V then communicates motion to the L shaped lever, which is connected by cords passed over the pulleys, seen on the loom, to the healds, one arm to the top and the other to the bottom, so that as the lever is pulled in one direction the heald will be raised, and when pushed in the opposite direction it will be depressed, and this is done in a positive manner without the aid of springs or weights. The crescent groove and stopping pin on A exactly correspond to, and serve the same purpose as described in Fig. 72, page 158, referring to the box motion.

Motion being communicated as it is by the connector being carried over a semi-circle by the wheel A, the most perfect harmonic motion is given to the healds, so that in this respect the machine is perfect.

One important item is the locking arrangement, which keeps the healds rigidly in position the moment the change

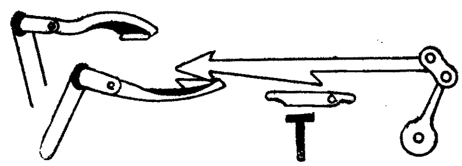


Fig. 137.

has been made until the time comes for changing again. Inside the cylinder C a cam is shown in dotted lines, and which acts upon the point of what is termed the "locking knife finger." This is really one arm of a lever the upper part of which is so contrived as to drop into a notch in the end of the vibrator lever P, so that as the cam revolves it will ultimately press the locking finger out of the notch and allow it to drop back again.

The object of the spaces between the teeth upon A has been already described in the box motion at page 157.

HODGSON'S OPEN SHED DOBBY.

Only a few words need be said of the open shed dobby of Hodgson. The leading features are shown at Figs. 137 and 138. To the left are two draw knives which travel along inclined planes, or grooves, in the machine frame, approaching each other in the centre of the machine, so that they can catch the hook which is hinged upon a lever connected to the top of the healds. Beneath this hook is a short lever which may be raised by a short pin, which in turn is actuated by the pattern card. In Fig. 137 the hook is shown engaged with the lower draw knife, a hole in the card allowing it to drop, and the draw knife is letting it go back so as to drop the heald to the lowest point, and in Fig. 138 the little lever is raised by the pin and the hook engaged with the upper knife. When the heald is to remain up the little lever engages with the notch on the under side of the catch,

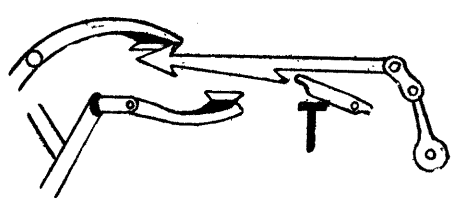


Fig. 138.

and if it is to remain down, the heald lever is allowed to be at rest.

In cutting the cards regard must always be had to the position of the hook and heald, and the little lever held up or dropped according to the nature of the change to be made.

The machine being of the negative kind, either springs or weights must be used to bring the healds down again.

CARD CUTTING AND LAG PEGGING.

This branch of the work is one which often gives considerable trouble to the beginner. In reality the process is simplicity itself. We take the plan as shewn at

Fig. 139, of any pattern, let it be as in this case a fancy twill, and we see there, an exact representation of the pattern as it will appear in the fabric. The dotted squares in the design indicate either that warp is passing over weft or that weft is passing over warp. It is quite immaterial which of the two, so long as there is a clear understanding. Generally speaking, the plans should be made so as to entail the least amount of work, though some have fixed methods; one will prefer to dot always for warp, another will prefer to dot always for weft; then again the machines may be contrived so that in the case of lag machines, pegs mean causing the healds to rise; in others, the reverse.

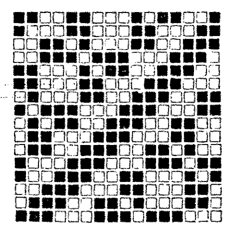
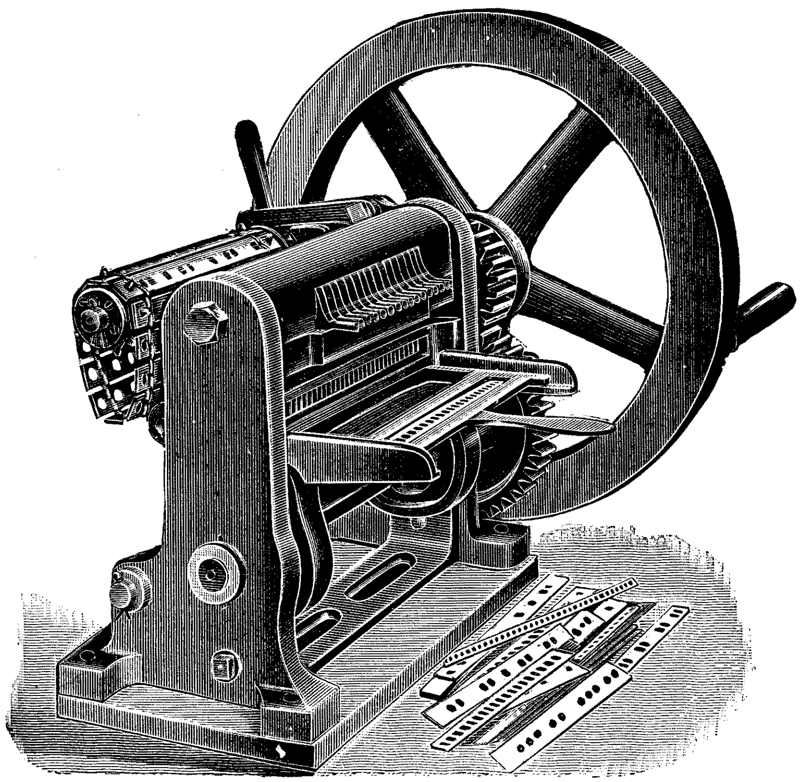


Fig. 139.

In card machines the same conditions prevail, so that before commencing to peg a set of lags, or cut a set of cards, we have to ask ourselves the questions: do the dots on the design indicate risers or fallers? and do the pegs in the lags, or the holes in the cards indicate risers or fallers? Now let us suppose for convenience, that the dots on our plan indicate risers, and that the pegs in our lags also indicate risers; then we should take from the plan, Fig. 139, the first horizontal row of squares, and that will exactly correspond with the row of holes in the lag. Let the two be supposed to be blank to begin with, then wherever we have filled up a square in the design, we fill up a corresponding hole in the lag. Each succeeding lag will be dealt with in the same manner, so that the complete set of lags, when spread out, will be an exact facsimile of the plan of the cloth. I must here make one suggestion to students. Frequently a great deal of time is wasted in comparing a set of lags after being pegged with the design, lag by lag, and dot by dot, so as to ensure that when put upon the loom there should be no error; take the plan of the pattern upon paper and survey it as a whole, spread out the lags as though they represented also the same sheet of paper on a magnified scale, and any error or discrepency between the two, will be visible on the general surface, and even more readily detected than by a detailed examination on the plan generally adopted. What has been said of pegging lags, applies exactly to the cutting of cards, the process is the same, we cut a hole instead of inserting a peg. We have to ascertain first, whether the hole means rising or falling, and so it may be said that when we know how to peg lags, we know equally well how to cut cards.

In connection with some of the machines, the card cutting or lag pegging is somewhat peculiar, though the general principles must of necessity be the same. For instance, in the case of a dobby—and most dobbies working from the lower shaft of the loom—each lag is made to serve for two picks, then there are two rows of holes in the lag, one of which acts upon the lower set of draw knives, or hooks, and the other upon the upper set, so that care must be taken in determining which row belongs to each of the two sets of hooks. One cause of confusion often arises here, the holes in the two rows respectively are alternated, *i.e.*, the hole in one row is opposite the blank space in the other row; this often leads to confusion, as in many cases where one lag is made to serve for each pick, a similar arrangement is made for the purpose of economising space, and as a consequence, the beginner is often confused as to the meaning of this double row. This however with practice is easily overcome. Much more difficulty arises in connection with what are commonly known as dwell-up machines, *i.e.*, where the heald remains positively at the highest or lowest point as long as required for the formation of the pattern. Then pegs or holes are cut only for the purpose of making a change; take for instance, Hodgson's open shed dobby, where by means of the small levers and the peculiar construction of the draw knives, the healds being once raised to the highest point or let down to the lowest, are kept there until a change is required, then a hole simply means the transference of the knife either from one draw bar to the other, or from the fixed position, whichever it may be, to the draw-bar. Consequently in cutting the cards, one must remember, or have some indication upon the design itself, what was the position of the draw knife corresponding to the healds which it is desired to change, prior to the moment when this change must take place. There is some similarity in the cutting of these cards to the cutting of cards for shuttle boxes; one, in making the plan, has to bear in mind what is the exact position of the box, and whether it should be moved backwards or forwards, therefore considerable practice and some skill in making of plans is requisite. In all dwell-up machines or open shed dobbies, this peculiarity exists in a greater or less degree.

As a rule dobby cards are cut by hand with a single punch on a hand plate. The process is slow and tedious, more especially when a number of looms have to be started on the same pattern. A machine is shown here, however, which mitigates this. As will be seen the machine is hand driven; a pinion on the fly wheel drives a wheel on the lower shaft, upon which are mounted two eccentrics against which rest the punching table or slide. This table is guided by vertical slide-ways and raised up to the punches by eccentrics. The punches are placed loosely in a vertical position in the plate, and over them are placed a series of piano-keys. The card is placed upon the slide seen in front, and pushed under the punches. The piano-keys are pulled out according to the marks on the design indicating cutting, and the wheel revolved quickly. The table is



DOBBY CARD CUTTING MACHINE.

raised, and all the punches under the keys which have been moved are forced through the card, so that the operation is rapid and accurate.

The machine can also be converted into a repeater. The cards to be repeated are placed upon a cylinder at the back, after being laced together. At each revolution of the driving wheel the card cylinder is brought up to the piano-keys, and a card having been placed in the slide, the operation of punching is just as if the pattern had been read from the design. When a number of cards are required of the same design, the catch operating the card cylinder is simply lifted until the requisite number has been punched. The machine is by Messrs. Hahlo & Liebreich, of Bradford.

Now as to the advantages or disadvantages of the several systems. It has already been pointed out generally what class of fabrics each system of open shed, centre shed or bottom shed is best suited, and what has been said generally will apply equally to dobbies intended for the production of varied patterns. But something more may be said of dobby shedding. Coming, as it does, between ordinary tappet work and jacquard work, it is capable of doing a great deal which can scarcely come within the range of either of the others; for instance, in open shed work it has had, until very recently, a great advantage over jacquards, inasmuch as until the introduction of the double lift jacquard any approach to the open shed was not practicable, and rapidity of working was even more difficult. Centre shedding in the jacquard is still only a partially solved problem, some attempts have been made such as Ainley's to get over the difficulty, but they have never been compatible with a high rate of speed. On the other hand in weaving gauzes tappet shedding could be readily adapted to the requirements of the case, and jacquard shedding naturally lent itself to it, but few dobbies, except those working strictly on the jacquard shed principle, or bottom shedding, could be said to be suitable for the purpose. A centre shed dobby would certainly come within a reasonable distance of the work, but was not considered so perfect as the bottom shed or single lift.

There is peculiarity in gauze weaving which makes it different from all others. At the moment of the crossing of the threads, either on being lifted by the doup or by the heald carrying the crossing thread, when the crossing thread must change from one side to the other of the standard thread, it is obvious that the crossing cannot take place easily until the crossing threads reach a point below the level of the standard thread, and any attempt to cause the crossing to take place until this point has been reached must result either in considerable strain being thrown upon both threads and healds, more especially the doup, and in all probability of breakage of the warp threads.

Another fault frequently arises when the doups are not adjusted in their movement exactly to the changing of the sheds, *i.e.* what is termed "knuckling." This means the doubling up of the doup slip, or loose half, in the shed, and entangling itself with the warp threads. Whenever this occurs there is not only considerable breakage in the warp threads but wear and tear in the doup itself. It not unfrequently happens that when a doup is not properly adjusted, so as to be brought to tension before any attempt at change is made, it will knuckle within the warp, and be cut to pieces before many yards of cloth are woven. But if it is properly adjusted so as to bring it down to the point below the standard thread, and in a state of easy tension, a doup, which would otherwise be worn out in weaving a few yards of cloth, may be made to last for several weeks. In all open shedding or semi-open shed dobbies, more especially such as those of the Keighley type, gauze weaving has been practically impossible until recently, from the fact that changes could not be made except with the shed partly opened. Various devices have been resorted to to overcome the difficulty; in some cases an extra tappet has been added, so as to raise the standard thread midway between the highest and lowest points of the shed at the moment when the doup, or the heald carrying the crossing threads, has been descending, so as to cause the change to take place in the middle of the shed, whilst the remainder of the healds have been retaining their relative positions for the formation of pattern. This of course may be made to answer when only one doup is employed, but when more than one doup is in use the number of tappets required, and their being brought into action at the proper moment, has rendered the task a difficult and in most cases an impossible one. Several of these devices have been the subject of patents, but where an outside apparatus has to be employed, in addition to the dobby, although it would in most cases be controlled by the dobby itself, the success can only be in working one special class of pattern, and can scarcely be considered of general application. The one exception to this general rule is provided in the Burnley dobby already referred to, where in weaving lenos or gauzes a special provision is made for bringing all the healds, or such portions as carry the standard threads to a level at any given moment when a change in the doups or crossing threads is going to take place. The difficulty has been overcome frequently with the ordinary Keighley dobby by removing one of the draw knives and working the machine from the crank shaft of the loom as an ordinary single lift dobby; thus converting it from the semi-open shed to the common single lift dobby.

LECTURE 8.

TAKE-UP AND LETTING-OFF MOTIONS.

As pointed out in Lecture 2, there are two distinct classes of let-off motion, the positive and the negative, and from the general view given there of the leading features of each, as well as the leading features of let-off by simple friction, we may now be prepared to proceed to a much closer examination of the details of each.

Before taking up the actual forms and particulars of the mechanism in most general use at the present time, a further survey of the principles may assist us in determining what are the distinct advantages of any of the systems, or combinations of several. As the positive take-up motion is the one coming most generally into use for every class of goods, it necessarily will occupy the greatest amount of attention, and whatever may be the result of the enquiry as to the relations of the take-up and let-off motions, there is no doubt that thorough mastery of the relations of the positive take-up and non-positive, or positive, let-off motions commonly in use will be an advantage. In the very great majority of looms in use at the present time, in weaving all but the very heaviest classes of fabrics, the positive take-up and the non-positive let-off motions are in most general use.

As already mentioned the leading characteristic of the positive take-up motion is that the cloth shall be carried forward a given distance every time the reed comes up to the fell, and that this length carried forward is absolutely independent of the pressure of the reed upon the weft as it beats it up to the fabric. On the face of it then it will be seen that a positive let-off motion is the one which should, apparently, naturally accompany the positive take-up motion, but here a difficulty arises, which when considered in all its bearings must help us very considerably in a study of every form of combination.

We begin by saying that the cloth is taken forward at a fixed rate of speed, therefore it follows that the warp must be given off at a rate exactly corresponding with it, plus the amount of take-up of warp caused by the bending of the warp round the weft in the process of weaving; this is one of the first difficulties, we may know that we are taking forward the cloth at the rate of 60 picks per inch, or, in other words, that the cloth is carried forward $\frac{1}{60}$th part of an inch every time the reed beats the weft up to the fabric; then we should have to let the warp off exactly at the same rate, with an additional allowance for the bending of warp round the weft; but it is this additional bending, or, take-up, as it is commonly termed, which causes us the trouble. To adjust a loom so that the amount of let-off, in relation to the take-up, shall be strictly accurate we should have to take into consideration first, the relative diameters of warp and weft, second, the intersections which occur in the pattern, and deduce from these the length of warp which must be used to produce a given length of cloth. This of course would not permit of any consideration of variation in the diameters of the threads, but would have to be carried out on the supposition that the threads are perfectly even in their diameters from end to end, whereas in the best forms of yarns there is a known variation in the diameter of a given thread of not less than 30%; so that it would be obviously impossible, even with the most careful experiment, to adjust the relative speeds with absolute accuracy. Added to this difficulty there is the additional trouble caused by broken picks, and by the weft running out and a number of other little accidents which render it necessary to let the cloth back, so that the reed shall come up exactly to the fell and avoid inequalities in thickness. Unless the adjustments were absolutely accurate, which on the face of it, with two positive motions combined, becomes a practical impossibility, we must have on each of those occurrences a thick or thin place in the cloth; therefore if positive motions are used in combination safeguards must be provided; those safeguards hitherto, although many are of the most ingenious kind, have not been sufficient to bring the positive let-off motion in conjunction with the positive take-up motion into general use.

It may seem very absurd, but it is nevertheless a fact, that the best positive take-up motions are almost invariably accompanied by a negative let-off, and the best negative take-up motions are probably for the same reasons accompanied by a species of positive let-off. Although on the face of it this seems very contradictory, yet when carefully examined it will be found that there are substantial reasons. If there is a variation in the relations between the take-up and the let-off, brought about either by any inequalities in the yarn or pattern, there must of necessity be similar inequalities in the fabric, and, however trifling those may be apparently, they become painfully visible in the fabric, more especially if it be a light texture. Then this involves the introduction of some intermediary between the two motions which shall adjust their relations to each other.

Tension springs, balance levers, and other delicate adjustments have been tried from time to time, but, for anything approaching a light fabric, with only indifferent success. It is evident that this intermediary must be so delicately adjusted that the slightest alteration in the warp tension must affect it.

We must then suppose two cases to begin with. We are weaving an extremely light fabric, where we require only a sufficient amount of tension upon the warp to ensure what is termed a clear shed; and where the reed in bringing the weft up to the fabric does not actually deliver a blow, but simply presses the thread gently into its position. Now let a pick be missed, for instance, either by the weft breaking or the shuttle running out, or in fact from any other cause, the cloth will be carried forward by the take-up motion a distance equal to that allotted to the single pick, the absence of the pick itself would cause a variation in tension, amounting exactly to the difference between the length of cloth represented by that one pick and the length of warp required to bend round it. So that supposing the cloth had 60 picks per inch, and the take-up in weaving equal to $2\frac{1}{2}$ per cent., then the length of warp would be 1/60th part of an inch, plus $2\frac{1}{2}$ per cent.

Is it conceivable that any attachment to an ordinary loom can be adjusted with such a degree of nicety as to take this fraction into account? Then, if not, a space is left equal to the length of warp required to take one pick, this, of course is not perceptible to the ordinary observer. But what follows? The succeeding pick is allowed to go into the cloth but does not leave a clear space equal to this 60th part of an inch; the threads are elastic and allow some encroachment upon the vacant space, so that instead of there being a clear line across the fabric this space will be gradually taken up by succeeding picks, until each one has taken up its normal position; this may extend over any amount of space from half-a-dozen picks upwards according to the character of the cloth. Trifling as the fault is it would be distinctly visible even to an ordinary observer. Here of course I am taking what may be considered an extreme position, yet it is one which is the foundation of much more serious troubles; the variation in tension alone, quite apart from the fact of the cloth being carried forward, even for a single pick, is sufficient to produce inequalities which, especially in light fabrics, would render the goods unmarketable.

But there is another difficulty which has attracted the attention of inventors, of even much greater importance, and that is the variation in tension caused by the decreasing diameter of the warp beam as the warp is being drawn from it. This trouble is none the less real because of the apparently imperceptible effect upon the fabric. Suppose for a moment the following to be the case, we start to weave a cloth from a beam having a diameter of 12 inches, and we adjust the tension of the warp at the outset so as to make our cloth perfect; by the time we have finished the warp the diameter of the beam will have been reduced say to 6 inches, then it must be self-evident that if there has been no adjustment of the weight upon the beam, whether we are dealing with a friction let-off motion, or with any positive let-off motions, which usually gives so much of a fraction of the revolution of the beam at each pick, there must be a considerably increased tension when the end of the warp is reached. This has been gradually increasing. There has been no perceptible difference to the weaver; having the fabric under her eye from hour to hour she could never see that there was any difference in the fabric as it passed forward, and it might be argued by the non-practical reader that the amount of difference could have no material effect upon the fabric. Probably many weavers would say the same thing, but there are two aspects of the question to be dealt with, each of which may be materially affected by this point. Every weaver knows well that the best fabric is produced by having the warp threads stretched at the highest tension which the strength of the yarn will permit. There may be possible exceptions in such goods as soft woollen fabrics.

This is well illustrated by the common expression amongst hand loom weavers in the West Riding of

Yorkshire in former days, and which retains still some hold, that any person who is not of the brightest intellect would be commonly spoken of as "slack set up." Suppose two looms be set to work with the same material, warp and weft, woven with the same number of threads per inch, in fact every particular throughout being identical, except that in one case the warp is woven at the utmost tension, consistent with reasonable working, and the other is allowed to go in loosely, or slack; the difference in value of those two pieces on coming from the loom will be most marked. This remark does not apply merely to a section of fabrics, but may be taken as one which is practically universal. Another feature of the case may be taken into account; we cannot treat the warp threads of any textile fabric as we should treat a piece of brass, copper or iron wire; there is always a considerable degree of elasticity in the yarns, and this degree of elasticity will depend upon the quality of fibre and structure of the thread, and consequently it will have an important effect upon the fabric after it is woven.

Suppose we take a few extreme cases in cotton, let us have a single cotton warp of inferior quality heavily sized, no matter how much tension we put upon it in weaving there would be no "spring" or elasticity, the number of picks per inch put in in the loom would be practically the same after leaving the loom; now on the other hand take a fine two-fold cotton, made say from a good Sea Island cotton, and spun well, afterwards made into two-fold; then we have a thread which is extremely elastic—this degree of elasticity I shall have to illustrate in some measure in the lecture on "cloth dissecting"—weave this warp at the highest possible tension, consistent with good work, and after it comes from the loom a very considerable shrinkage will have taken place in the length of the thread, it will have returned to its normal condition, and in doing so compressed the weft so that the number of picks per inch in the loom, and the number after leaving the loom may vary in any degree from 2½ to 20 per cent.

Again suppose we are dealing with wool. Let worsted yarns be spun from a good quality of English wool and others from a good quality of merino wools, and we shall have practically the same difference, and so it will follow with any material where there is a difference, either in the fibres of which the thread is composed, or in the amount of twist or structure of the thread itself. Pure woollen threads of the best kind as compared with the inferior ones are quite as susceptible to this variation. Again the pattern will influence it by the variations of intersections—as between a plain and a twilled cloth, the amount of take-up in the one being considerably greater than in the other; and the relations or the thickness of weft and warp to each other will have even a greater influence. All these considerations are quite apart from the amount of force exercised, or applied, in beating the weft up to the cloth. Of course the greater the degree of compression of the weft threads as they are beaten up to the fabric the less room there is for the elasticity of the warp threads to assert itself; and consequently in the heavier goods, or in goods woven with warps not so very susceptible to this influence, there is less need for this extreme delicacy of adjustment which is required in the lighter fabrics. At the same time even in the heaviest or the commonest goods the matter must not be ignored, otherwise faults will creep in.

POSITIVE TAKE-UP MOTION.

We may then proceed to make a careful examination of the positive take-up motion, first, in its simplest and common form and afterwards in the somewhat more elaborate forms, which are improvements upon the original one only in so far as fineness of adjustment and accuracy are concerned. First of all, from the very name, we must assume that the cloth is carried forward and wound upon the beam at a given rate. This implies of course a system of driving the take-up motion which shall ensure absolute equality, and therefore must disregard the increase in the diameter of the cloth beam as the fabric is wound upon it. The arrangement will be best understood by a reference to Fig. 140, which shews a plan of a complete train of wheels. First we have the ratchet wheel A acted upon by the

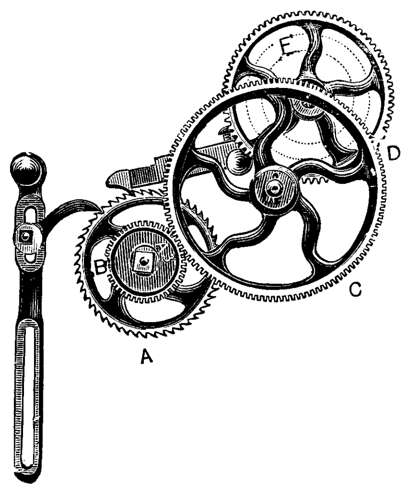


Fig. 140.

catch or pawl shewn to the left, upon this is fastened what is commonly called a change wheel B, which, as its name implies, may be changed so as to regulate the rate of speed at which the cloth shall be taken up; this drives an intermediate wheel, or what is commonly termed a carrier, C having a small pinion fastened upon it driving the beam wheel D. This beam wheel is made fast to the spindle of the driving, or carrying down beam, which causes the cloth to be coiled upon the actual cloth beam.

The general arrangement is to place the cloth beam beneath the carrying beam, and by means of weights and levers to keep the surface of the cloth beam in contact with the carrying down beam as shewn in the view of the loom at Fig. 45, page 98, and Fig. 50, page 104, so that really the cloth is carried forward by friction, the surface of the carrying beam being covered, either by a series of corrugations or teeth, or any other roughened surface which will prevent slipping. Then what we have to determine is the system of calculations which enables us to fix upon the exact number of picks per inch or the rate of speed at which the cloth shall be carried forward.

In principle this calculation is simple enough, but the one great difficulty with the student is often in determining which are the driven and which are the driving wheels of the train; suppose we take the lever to the left of the illustration and we connect that to the going part of the loom in such a manner that at every stroke of the going part the ratchet wheel A is carried forward one tooth, then the change wheel communicates the power received to the intermediate wheel C. The small pinion carried by C communicates the power to D the beam wheel, this in turn being made fast to the take-up beam causes the cloth to be carried forward; then it is evident that the ratchet wheel A receiving its power from the catch is a driven wheel, and the change wheel upon it, communicating that power to the large intermediate C becomes a driver; in like manner the small pinion upon C becomes a driver, and D is driven—thus the cloth beam becomes in turn a driver also, so that we can easily determine which are driven and which are driving wheels in the series. Then if we multiply all the driven wheels together and all the driving wheels together, and divide the greater by the less, we determine at once the relative values of the two series; but we must have a convenient method of calculating which compels us to leave at least one of the wheels out, or to treat it as an unit, so that we may determine the value of the change which we must make in altering from one fabric to another. This unit is most conveniently the change wheel. Then suppose we have our lever adjusted to carry forward the ratchet wheel A one tooth at each pick of the loom, and we treat the circumference of the carrying down beam in inches as corresponding to teeth. Then we can easily arrive at what is commonly termed the standard dividend. Let the ratchet wheel contain 50 teeth, the large intermediate wheel C 120 teeth, and the beam wheel D 75 teeth; then we have all the driven wheels, which may be multiplied together; now assume the change wheel to contain one tooth or treat it as unity, the intermediate wheel on C to contain 15 teeth, and the circumference of the beam to be 15 ins., then we should have the formula as follows:—$\frac{50 \times 120 \times 75}{1 \times 15 \times 15''} = 2000$, that is then, if the change wheel be treated as unity the ratchet wheel A would move 2000 times for one inch, or one unit of the circumference of the beam, or in other words, there would be 2000 picks per inch. But of course a wheel of one tooth is a physical impossibility, therefore we must have one which is at least tangible; then to determine what that one shall be we must determine the number of picks per inch which the cloth must contain. Suppose, for example, that it must contain 50 picks per inch then divide the 2000 by 50 and we should have a change wheel containing 40 teeth required in place of the wheel of one tooth, as is shewn by the following formula:— $\frac{50 \times 120 \times 75}{50 \times 15 \times 15} = 40$. Then this 2000 is a standard number, or dividend, but frequently the number of picks are reckoned by the $\frac{1}{4}$ inch, so that in that case 500 would become the standard dividend, and whatever number of picks may be required per $\frac{1}{4}$ inch 500 divided by that number will give the change wheel; or 500 divided by the number of teeth in the change wheel would give the picks per $\frac{1}{4}$ inch of the cloth.

Then comes a question which is often a source of trouble to overlookers. Generally speaking when loom makers send out their wheel lists with the looms they make an allowance of $1\frac{1}{2}$ °/o for shrinkage; but no notification occurs upon the list itself of this allowance having been made, and so confusion is caused in the mind of the overlooker. At any rate what should be done by the overlooker at all times is to determine the exact dividend so that he can vary the allowance for shrinkage as circumstances may require. It has already been shewn that this amount of shrinkage may be anything, and therefore it should never be fixed at one standard. What I should prefer at all times would be a standard number based upon the actual calculation, and the shrinkage allowance varied from time to time according to the quality of the work, and the nature of the material.

Before proceeding to any special arrangements of take-up motion, one or two features in the adjustment of the ordinary motion may be examined, for instance we have the lever carrying the pawl which drives the ratchet wheel A, which, with the long slot at its lower extremity, in which the pin from the sword of the going part works, and the slot in which the pawl itself is carried renders it easy of adjustment with the greatest degree of nicety. This is a necessary condition, as the wheel A must be moved always one tooth and no more. Above the rachet wheel there is usually a fixed pawl which drops into the teeth and prevents any rebound, or recoil; and then there is a second catch shewn in the illustration resting upon the wheel, and having its fulcrum in the front frame of the loom, which serves another purpose. When the loom is brought to a stand by means of the weft fork, when the weft has run out, this fixed catch is lifted by its action so as let the ratchet wheel A run back; the catch seen in the illustration resting upon the wheel A is so contrived, by means of a slot, that it will let the wheel run back two teeth; the object of this is to allow the cloth to return a distance equal to two picks every time the weft runs out, or breaks, so as to prevent any thin place, or inequality, in the cloth. The reason for this arrangement is, that the weft fork being placed at one side of the loom, usually that side where the belt fork handle is placed, the weft must of necessity run out between the period when the shuttle leaves that side of the loom and returns to it, and therefore there must be generally two picks lost whenever the weft does run out; and the weft fork raising the fixed catch and leaving this one in contact with the wheel allows the cloth to run back this theoretic distance so as to avoid the fault mentioned. In ordinary practice this proves sufficiently true for the majority of fabrics, but of course is not absolutely infallible, as the distance over-run by the loom may be anywhere from one pick to three. If the brake gearing is not in good order it may run considerably further, but in any case there is always a margin of one pick on one side or the other, though the average of course must be practically the two picks allowed for.

It will be necessary now to examine one or two other forms of take-up motion, some of which possess a decided advantage, though there are many so-called improvements where the advantages are more imaginary than real. For instance, one difficulty arises in the take-up motion just referred to, in consequence of not being always able to find a wheel containing the exact number of teeth to give the picks required. Suppose, for instance, that 11 picks to the ¼ inch should be required, no wheel can be found to give that exactly, for 500 divided by 11 would give us

$45\frac{5}{11}$, and as it is obviously impossible to have a wheel with that number of teeth, then it is equally impossible, except by the allowance for shrinkage, to weave a cloth with exactly 11 picks to the $\frac{1}{4}$ inch. Here comes in the skill of the overlooker, what he cannot obtain by his wheel he can obtain by a careful adjustment of his warp tension; as already pointed out the tension upon the warp, accompanied by the elasticity of the material, may cause almost any degree of variation in the thickness of the cloth, then herein lies the overlooker's opportunity: if he cannot use a wheel giving the exact number of picks required, then he must adjust the tension of the warp to meet the difficulty; but some of the improvements are intended to obviate this, and by the use of double change wheels enable any exact number of picks to be put into the cloth at will.

To get rid of the difficulty referred to, of not being able to have a wheel which will give the exact number of picks per inch required, other arrangements of positive take-up motions have been devised. Probably the one in most general use is that known as the Pickles' motion, which consists of a train of wheels, two of them being changeable. One of the two is a driven wheel and the other a driving wheel. The arrangement will be best understood by reference to Fig. 141. Commence first at the ratchet wheel and follow the motion throughout. That wheel is moved forward one tooth at every revolution of the crank shaft, and it carries with it a change wheel, marked in the illustration 36. This drives another change wheel marked 60; change wheel 60 carries a pinion communicating motion to a large intermediate wheel which in turn carries a small pinion communicating motion to the beam wheel, and, of course, to the cloth beam at the same time. One peculiarity of this arrangement is that from its first introduction the number of teeth in each wheel of the train has remained unaltered. Let us follow it all through and see exactly how it works out. The ratchet wheel contains 24 teeth, the large change wheel, which for the moment may be considered a fixture, contains 60 teeth; the pinion, or as it is sometimes termed the spring pinion wheel, carried upon the stud of the 60 change wheel contains 24 teeth. The large intermediate, or carrier wheel, contains 89 teeth, the small pinion, upon the same stud, 15 and the beam wheel 90 teeth. Then the circumference of the beam is 60·20 inches.

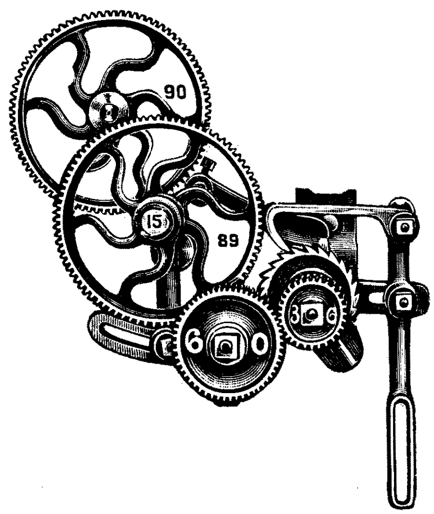


Fig. 141.

The result of all this arrangement is that the change wheel marked 36 in the illustration must run in 9's, or multiples of 9, and whatever number of 9's that wheel contains then the second change wheel must contain that multiple by the number of picks required per $\frac{1}{4}$ inch. For instance, the two wheels represented in the illustration are 36 and 60 respectively; 36 is equal to 9 multiplied 4 times. It is required to have 15 picks per $\frac{1}{4}$ inch or

60 picks per inch, then 15 × 4 will give 15 picks per ¼ inch, or 60 picks per inch, the picks per inch corresponding with the teeth of the wheel. Now suppose the change wheel marked 36 is changed for one containing 54 teeth, which will equal 6 × 9, then to weave a cloth with 15 picks per ¼ inch the second change wheel will require to be 6 × 15 = 90, so that we can be sure always at least of making our calculation within a ¼ of a pick per ¼ inch, or $\frac{1}{16}$th pick per inch. But the change can be made even more fractional than this. One wheel is a driver and the other a driven wheel, then as we increase the size of the driver we increase the rate of speed, and as we increase the size of the driven we decrease the rate of speed. 36 then is the driving wheel, suppose we reduce that by one-half, thus using 18 teeth instead of 36, then we double the power given to us by the change wheel, which is a driven one, and so enable us to reduce the fraction of a pick in a proportionate degree; or we may employ a wheel with 27 teeth and we find the point intermediate occurring between the two. If on the other hand we increase the size of this wheel then we obtain a power of varying the fraction to an infinite degree. Of course we cannot reduce it below a certain point because the number of teeth required would make the diameter of the wheel an impossible one; on the other hand there is a limit in the increased size because of space; but we have one option, which may or may not be resorted to, *i.e.* of increasing the size of the wheel and taking up two or more teeth at each stroke as required, so that our fractional division of picks per inch may be reduced to a point which will positively become absurdity. In many cases such a contrivance as this undoubtedly possesses a value, but any practical man will realise that, with all the nicety of adjustment of the take-up motion, a variation may be made in the cloth by a lack of judgment,

or improper adjustment, in the let-off motion. As already said this chain of wheels has remained unchanged, or practically so, from its first introduction, but there is no reason why a train having two change wheels, one a driving and one a driven, should not be arranged upon some other basis, such for instance as 10, which might be more convenient than 9. It may mean simply an alteration in the diameter of the beam, or in the relative number of teeth in the intermediate wheels, instead of 89 and 15, or the two combined; but whatever advantages may be gained by it would have to be set against the disadvantages of having a special train of wheels, any one of which could not be easily replaced in case of accident.

So far the positive motions described may be termed intermittent in their character, *i.e.* the wheel is driven forward at every stroke of the crank shaft, and whether the movement takes place as the reed comes up to the cloth, or on its return, the principle is virtually the same. The cloth is moved forward a distance equal to one pick at each stroke of the going part. But there is another class of motion which must be referred to and which may be described as a continuous motion. In this case the cloth beam, or more correctly speaking the carrying down beam, in the loom is driven directly from the crank shaft, sometimes by means of spur gearing, or by a combination of spur gearing or worm and wheel motion. One illustration of the latter arrangement is given at Fig. 142, where a pair of bevelled wheels A and B give motion to a worm C, which in turn communicates with the wheel D, and that through a train of wheels, somewhat similar in arrangement to those of the motions already referred to, communicates power to the beam E. After what has been said of positive take-up motions it will be self-evident that change wheels may be introduced anywhere between the worm C and the beam E. Suppose for a moment that the two wheels A and B bear to each other the ratio of 2 to 1, then the wheel D would be carried forward one tooth for every half revolution of the driving shaft of the loom, and the train of wheels between that one and the beam would determine the rate of speed at which the cloth is carried round. Now let us decrease the size of the wheel F, and we increase the speed at which the cloth will be carried down by E, because F is a driven wheel; and in like manner if we increase the size of G we should get the same effect because G is a driving wheel. Then let it be supposed that both wheels are changeable,

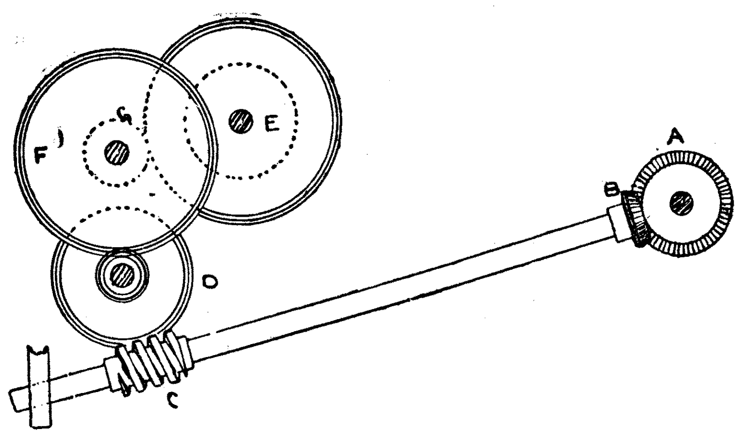


Fig. 142.

it is very evident that by increasing one or decreasing the other we get precisely the same effect, therefore if we change both at the same time we can make any degree of variation, to the most minute fraction of a pick per inch. Then take it for granted that this system of continuous driving from the shaft gives us the power of an infinite degree of variety or change, we must then look for its disadvantages.

As already pointed out in the positive take-up motions, of the ordinary kind, provision is made for an escapement whenever the loom is brought to a stand through the weft having run out, or been broken, therefore in this case a similar contrivance should be provided and that must be applied somewhere between the worm wheel and the beam itself; or what is more to the point, on the loom being turned back the let-off motion is turned back at the same time, thus ensuring even more certainty than in the intermittent motions. One important claim is made for motions of this kind, viz.:—that not only are the changes available extremely ready, and affording a wide scope, down to the most minute fraction of a pick per inch, but more especially the take-up being constant and regular, both the fabric and the warp are maintained at an equable tension throughout, and consequently there can be no defective uneven cloth arising either from the undue straining or slackness of warp in the loom. Theoretically, this is perfectly true, practically other considerations must be dealt with; variation in the thickness of the threads of the weft, the possibility of missing a pick, even with the most perfect escapement that can be devised, and in most cases this escapement is rather a doubtful quantity, and other considerations which are so trifling that they may escape general observation will yet tend to neutralise, in some degree at least, all the efforts to make any positive take-up motion absolutely perfect. I might mention here one item which will have to be referred to later, and which every practical man is well aware of. In working with hemp ropes to the let-off motion any variation in the temperature will cause the ropes to stick a little, and, as a consequence, there will be variation in the tension of the warp, which must of necessity cause variation in the thickness of the cloth. It may be said that positive take-up motions will overcome this difficulty, but even they are subject to variation as already shewn; so that without disparaging for one moment the efforts that have been

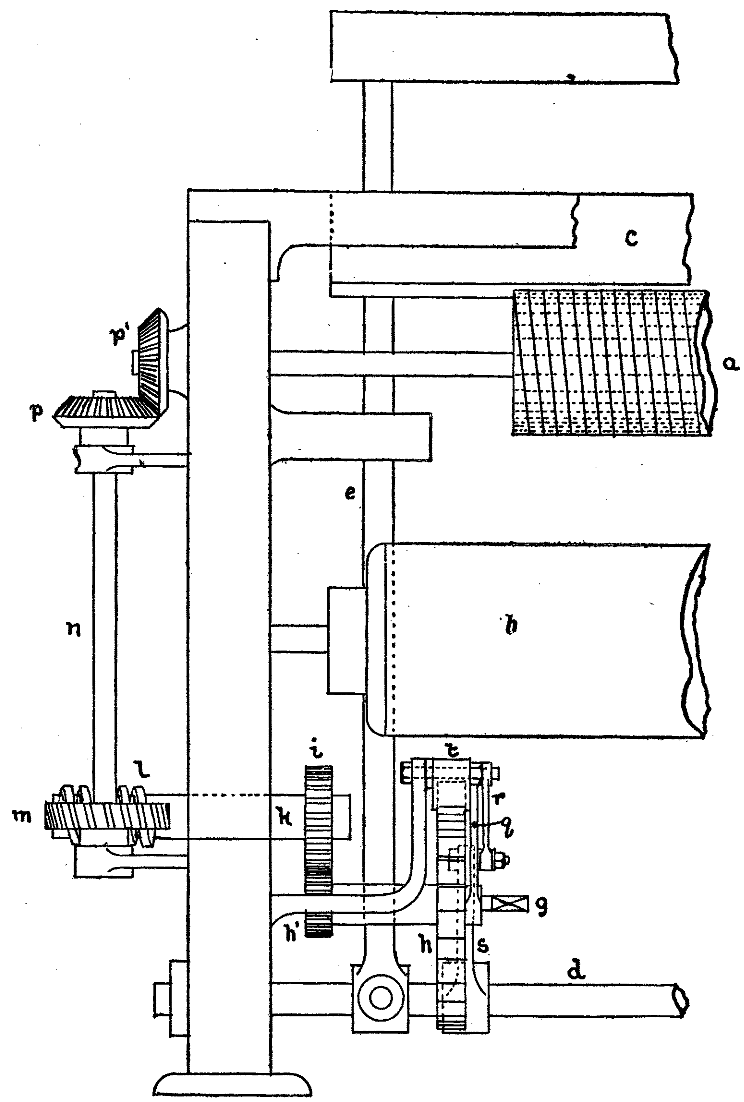


Fig. 143.

made it will not be wise to accept any motion as being perfectly accurate.

The degree of perfection after all is only a comparative one.

An ingenious contrivance of this kind is one patented by the Oldham Velvet Manufacturing Company, Limited, which is represented in Fig. 143, which shews the front elevation and Fig. 144 which shews an end elevation. In this we have the ordinary take-up roller *a*, and the cloth roller *b*. C represents the sley or going part of the loom, and *e* the swords of the going part. On the end frame of the loom a bracket is bolted carrying the shaft *g*, at one end of which is a ratchet *h*, and at the other a pinion wheel *h'* gearing into the spur wheel *i*. The wheel *i* is secured upon a shaft *j*, which in turned is mounted on a second bracket *k* fixed to the loom frame. Upon the other end of the shaft *j* a worm *l* gears into the worm wheel *m* fixed into the lower end of the vertical shaft *n*, so mounted as to revolve in bearings carried by the brackets fixed to the loom frame. The shaft *n* communicates power to the take-up roller *a*, by means of bevelled spur gearing, as shewn in both illustrations, then a pawl lever *q*, mounted loosely upon the shaft *g*, carrying a pawl *q'*, which engages with the teeth of the ratchet wheel moves it forward as desired. The free end of the lever *q* is connected by a link *r* to the end of the arm *s*, which is secured upon the sley shaft, or rocking shaft *d*. So that at each stroke of the going part the lever *q* is moved backwards and forwards, and the pawl is made to turn the ratchet wheel intermittently, in the direction indicated by the arrow upon the wheel, and may be turned one or more teeth at each beat of the going part, according to the number of picks per inch required.

Take now the continuous take-up motions. One of the most perfect and the most recent of the continuous

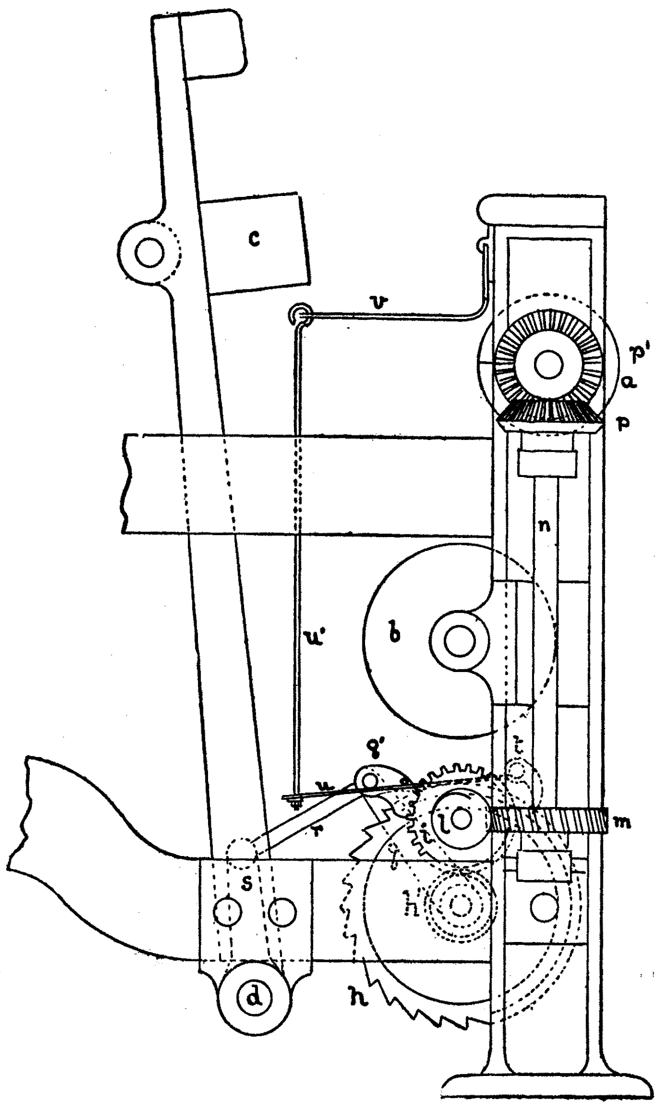


Fig. 144.

take-up motions is that of Messrs. Hutchinson & Hollingworth, as shewn on the loom at Fig. 145, an end elevation of the loom and take-up gearing at Fig. 146, and a front view at Fig. 147.

A and B are respectively the top and bottom chills of the well-known Hollingworth & Knowles' Patent Looms, revolving in opposite directions indicated. These are driven by means of bevel wheels C D on upright shaft E, which is driven from the crank shaft of loom in the ordinary way. The top harness chill A in place of being attached to the top centre shaft as aforetime is mounted on a barrel or sleeve, revolving in bearings in jacquard frame H. This sleeve extends through the bearing to receive the bevel wheel which is keyed on to it. Along side of the top harness chill (A) works the box section chill K, both of them being attached to the sleeve. Through the centre of the sleeve works a horizontal shaft fitted with a sliding catch box capable of being placed in gear with either of the bevel wheels by means of suitable connections from the front of loom, which wheels by reason of engaging with the upright shaft C are caused to revolve in opposite directions. On the opposite end of this horizontal shaft is a pinion N gearing with the intermediate O, which gears with the pattern cylinder wheel P on the end of cylinder which carries the pattern chain. On the bevel wheel end of this horizontal shaft is a rugged chain wheel Q, over which passes an endless chain extending down over rugged chain wheel R working with positive motion gears. Attached to the chain wheel R is a pinion S, into which pinion the change wheels S^1 can be placed by means of radial arms. Attached to the change wheel S^1 is a pinion gearing with the wheel keyed on the horizontal shaft W, on which is a worm X gearing with positive take-up beam wheel Y. On the end of horizontal shaft W is a spline knob Z, which can be drawn out so that the positive beam can be turned

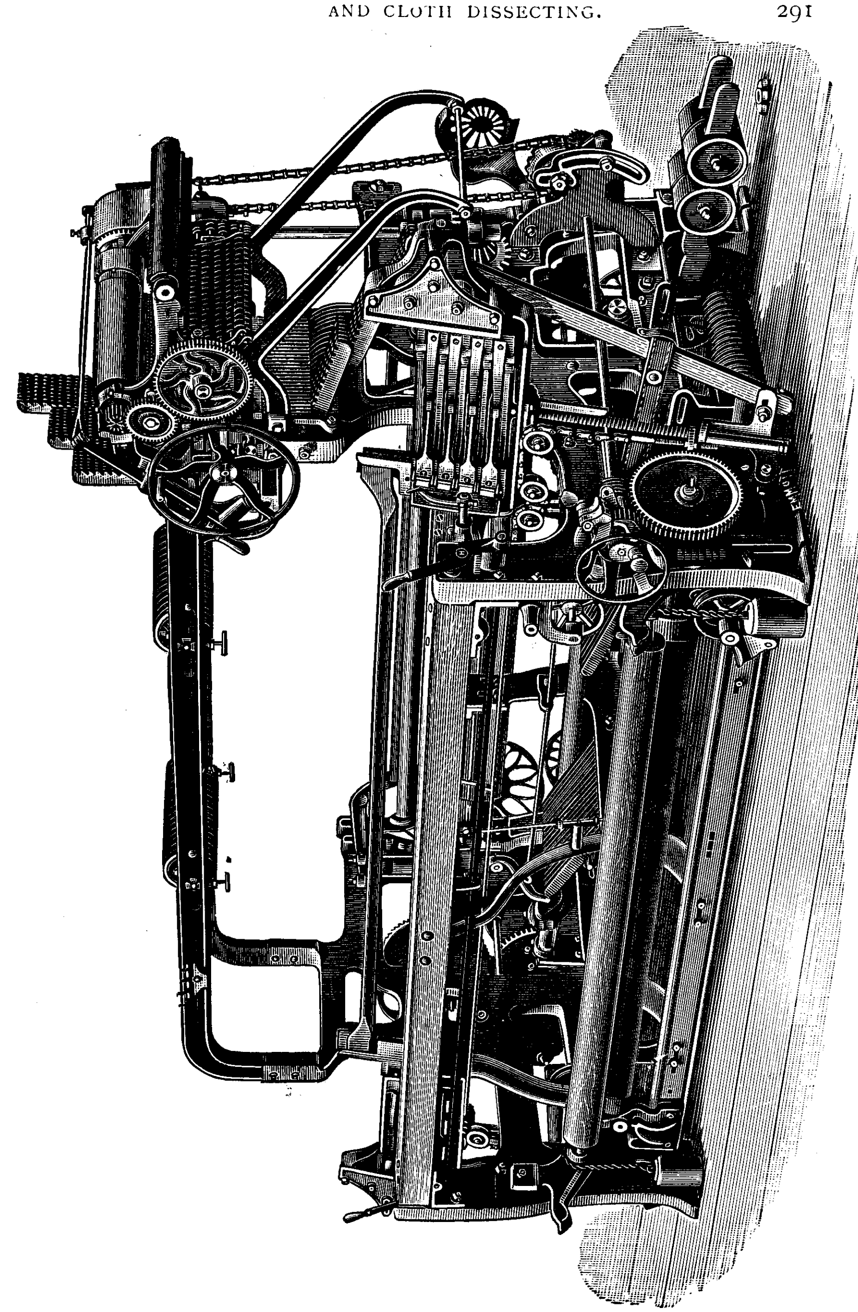


Fig. 145.

by means of hand-wheel for adjusting if required without the horizontal shaft having to move.

When the catch box is placed in gear with the inner bevel wheel the horizontal shaft is caused to revolve in the same direction as the chills A and K, consequently causing the pattern cylinder to revolve in the right direction for forward weaving, also by means of the endless chain and train of wheels, the worm and wheel X Y, the positive take-up beam moves in the right direction for taking up the cloth as it is woven.

When, however, the pattern chain is required to be reversed for finding broken or wrong weft, the catch box is placed in gear with the outer bevel wheel in which case the motion of the pattern cylinder, and likewise the direction of motion of the positive take-up beam, will be reversed turning back the distance equal to the amount of weft which has been taken out.

By the adoption of the motion when the loom is ready for starting again, the take-up beam and pattern cylinder will be at the correct position for the weaving being continued without shewing a faulty place in the cloth.

This motion is so arranged that it can be worked conditionally if required. Working loose on the boss of worm X is a lever carrying catches which fold over and engage with a catch wheel, which is keyed on to the boss of the worm X; this lever has a vertical rod attached to it at the end, which is capable of being lifted every time the lay moves back, by means of an arm attached to lay sword pin, grazing under the pulley on the vertical rod. This rod is also arranged to carry the weights required to give the necessary tension to the woven cloth. These weights can be increased or decreased according to the number of picks required. To effect the change from positive to conditional all that is necessary is to draw out the spline knob Z in which case the worm X and the horizontal shaft W are disconnected,

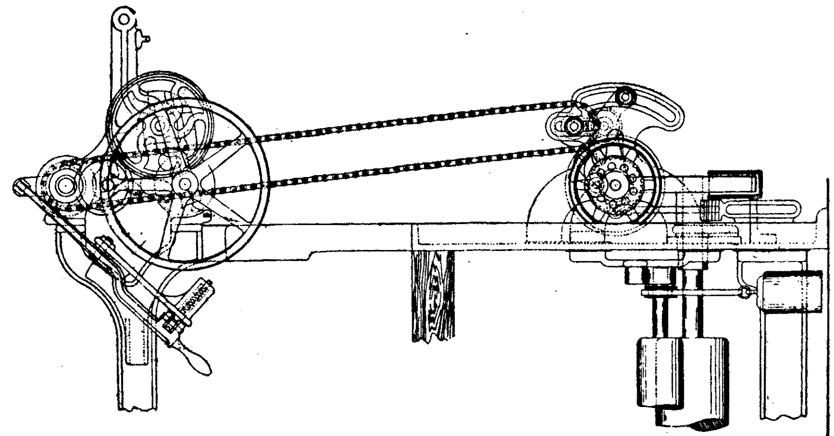


Fig. 147.

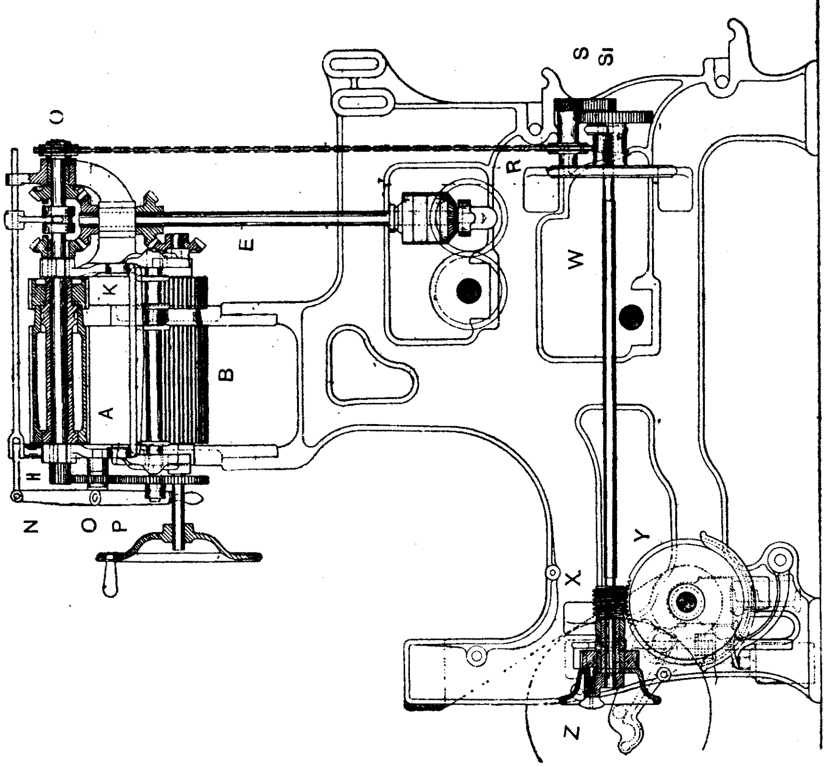


Fig. 146.

the one with the other. Catches are then placed on the teeth of catch wheel, and the necessary weight placed on the vertical rod to give the required number of picks.

As will be seen this is a continuous take-up motion of the most positive kind, and must of necessity be associated with a let-off motion of an equally positive kind, but with an escapement which will prevent the warp getting too

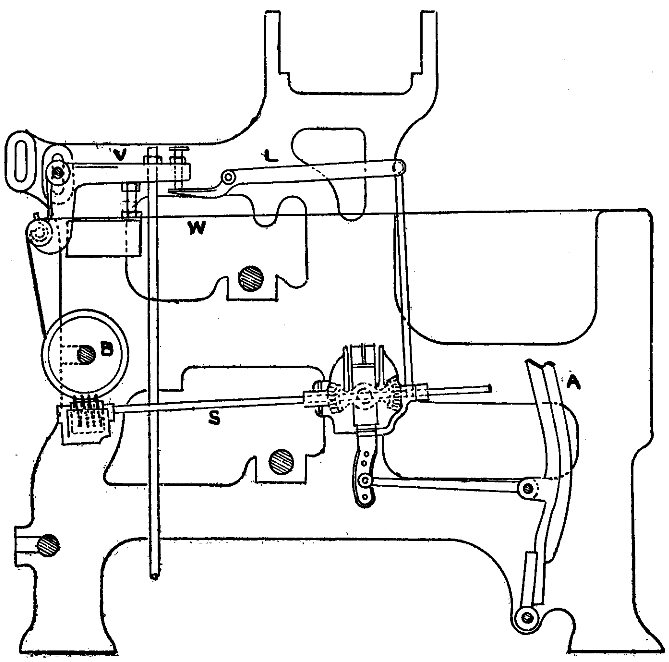


Fig. 148.

tight. This motion is communicated to the warp beam by means of the spurred gearing at the back of the loom, driven upon the shaft. Apart from the positive nature of the motion, and without further discussing the merits or demerits of continuous taking-up, this arrangement possesses the advantage of enabling the weaver to let back the cloth, in the event of broken picks or the weft running out, at the same time that she turns back her cards to find the proper place in her pattern. In many looms the lack of this arrangement proves to be a very serious inconvenience, as the weaver will have to turn the loom over a number of times, and in most cases would carry the cloth forward in so doing, and a separate operation is necessary to restore the fell of the cloth to its proper position, and so run the risk of making cracks or thin places in the fabric.

Now with respect to the letting-off motions a view in outline of the details is given at Fig. 148. A is the lay-sword operating by means of a rod, a T lever under the loom, which operates a couple of pawls on a catch wheel, which will rotate the shaft S, having a worm at the end geared into teeth of the beam head B, and will let off the warp W. This would appear to be a positive and constant motion, and would be so but for the presence of an arrangement for letting off the warp according to the amount of tension. The warp is passed over a back rail which rests in one arm of the back swing lever V, the other end of which acts by means of an adjustable screw on the lever L, which in turn controls a shield on the shaft S, which determines at what rate the worm shall be revolved by the T lever, and consequently at what rate the warp shall be given off.

The details will be better understood by reference to Figs. 149 and 150. In these figures the T lever is marked D, and has two arms D^1 and D^2, each having a toothed segment on its upper surface, which gear with the pawl levers C and C^1, so that as the lever is oscillated by the sword of the going part, the pawls are acting alternately and giving motion to the ratchet wheel A. These pawls are then regulated in their movement by the vibrating roller over which the warp passes. The rod from the lever L in Fig. 148 operates the small lever F in Fig. 150, which is centred on the ratchet wheel shaft H, and

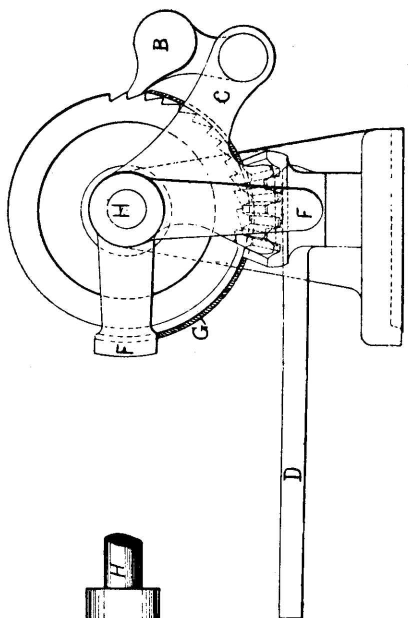


Fig. 150.

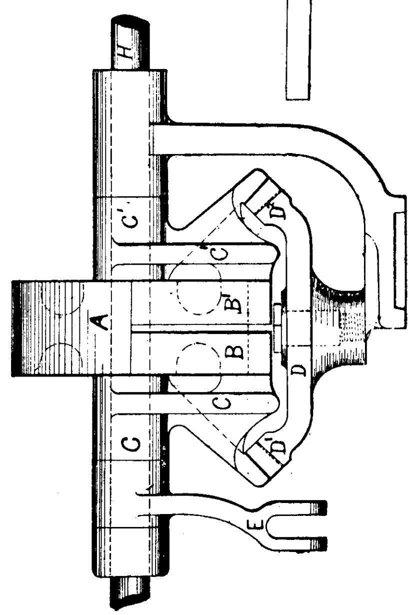


Fig. 149.

which has attached to it the curved shield G, which partly encircles the ratchet wheel, and the nose of which, when the lever to which it is attached is rocked, can pass under the pawls and prevent their engaging with the ratchet wheel. The weight is then so arranged on the vibrator levers that when the warp is at the normal tension the shield is withdrawn and the pawls are free to act, but when the tension becomes excessive, or the reverse, the

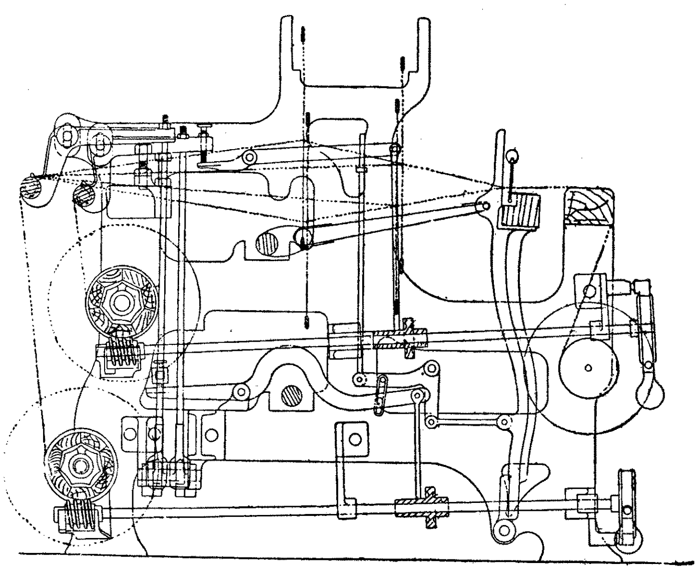


Fig. 151.

vibrating roller is depressed, it will act upon the lever, and so permit the shield to determine the length of stroke to be given by the pawls to the ratchet wheel, and thus regulate the rate at which the warp shall be let off.

A line drawing of the details is given at Fig. 151, where provision is made for two warp beams, and the arrangement of the weighting of the vibrating rollers is shown at Fig. 152. If the details of the Figs. 148, 149, and 150, have been followed those of Figs. 151 and 152 will explain themselves.

The following points may be observed in starting the Hollingworth & Knowles' Open Shed Looms, so far as the let-off motion is concerned. When in other respects the loom is ready for weaving turn the crank so that the lay or going part falls to the back centre; the top let-off lever L, Fig. 148, should be so set as to be slightly

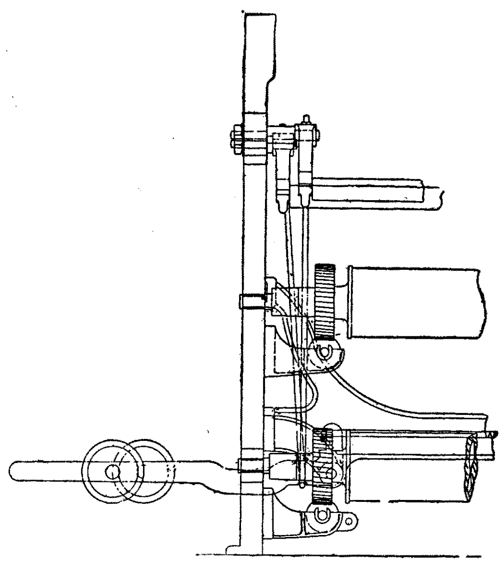


Fig. 152.

inclined by means of set hoop on the rod behind the going part, giving a distance between the opposite end of the lever and the regulating screw on V, of about ¼ inch for woollen goods and about ⅜ of an inch for worsted. The weight lever should then be weighted according to the number of picks per inch.

A very brief glance now at the non-positive take-up motion will be sufficient. The most convenient arrangement is shewn at Fig. 153, where a large ratchet wheel A is placed on the beam head and a lever carrying a pawl is actuated by the going part. A rod B is caused to lift the lever at each stroke of the going part and a weight or series of weights C are placed near the extremity of the lever. On the lower end of the rod B an adjustable nut is placed so that the lever may be lifted any height as desired, though it is not usual to lift it more than one tooth of the ratchet wheel. Then this rod B passes through

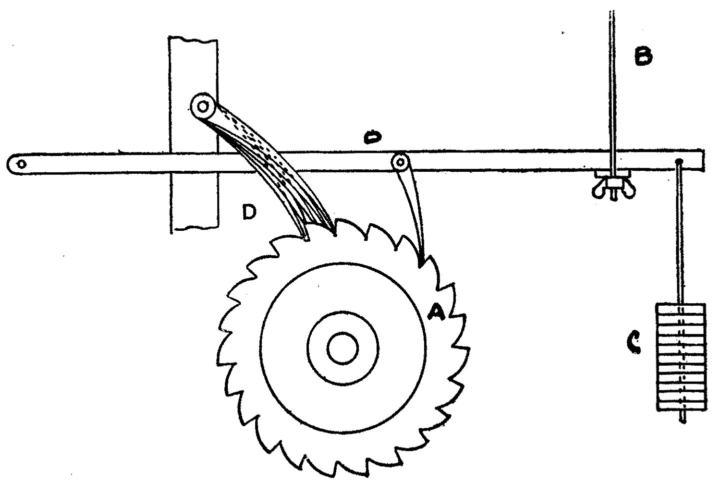


Fig. 153.

a slot on the lever in such a manner that although it always lifts a given height it does not necessarily force it down at each stroke to its lowest point. It will be remembered what was said of a box of weights in Lecture 2, the lever and the weights C take the place of the cord and box of weights in Fig. 31, page 51. As the lever is allowed to drop the weight C, pulling down the lever just at the moment when the reed is in contact with the cloth causes the beam to move forward and take up just so much of the cloth as the reed presses forward. To ensure that this shall be as minute a fraction as possible the teeth on the ratchet wheel are very small, although shown here as being large, and a series of catches D all arranged on the same fulcrum rest upon the ratchet wheel, and are so arranged in their relative lengths that if the wheel is moved forward one fourth or one fifth of a tooth, according to the number of catches employed, one will drop into a tooth and hold it firmly in that position. To assist this a train of wheels is generally used instead of the ratchet wheel being on the beam head as suggested in the drawing.

Now here comes the disadvantage of this system of take-up motion. As the cloth is wound upon the beam the diameter necessarily becomes greater, and as it becomes greater the power of the lever and weight is proportionately diminished, so that at every coiling of the cloth upon the beam the number of picks per inch is gradually becoming more, and consequently a regular increase of the weight C becomes necessary. This is provided for by having a series of small weights which can easily be slipped upon the suspending rod as occasion requires, but it obviously requires the closest attention on the part of the weaver to keep the cloth anything near even in texture. What was pointed out before in reference to the influence of the warp tension upon the number of picks put in a cloth will now become apparent, for as the power of the weight C decreases in carrying the cloth forward the power of the weight upon the warp beam is increasing at the same time, and consequently tending to put more picks per inch in, so that unless provision is made in the mechanism of the loom for neutralising this the cloth will all the time be gradually increasing in bulk. In the loom to which we are referring ample provision is made to meet this contingency. The let-off motion consists of a worm and wheel driven by the going part by means of a rod which carries the wheel forward one or more teeth at each stroke of the going part. In addition to that the back rail of the loom over which the warp passes is placed upon movable bearings so weighted and adjusted, that, as the tension on the warp increases it can act upon the worm wheel in such a manner, that when it has been moved forward a given distance it gives movement of an additional tooth to the worm and so releases the tension, practically as shewn in Fig. 148. This may occur any number of times, but of course it is part of the overlooker's business to so arrange that it shall not occur too frequently, the rate of delivery and take-up should be so adjusted in relation to each other that the escapement shall be brought into play in the most regular manner. Then it becomes the duty of the weaver and the overlooker together to keep a careful watch upon the cloth, first to see that the take-up motion is sufficiently weighted just to give the number of picks required, and that the let-off motion is so adjusted as to move an extra tooth as seldom as possible.

A general survey may now be taken of the several kinds of take-up motion and their influence upon the fabric as well as the faults which may be caused by improper adjustment. Something was said in the first lecture upon this matter and still something more will have to be said in a later lecture, but this is a proper place to make reference to those which are caused directly by the take-up motions. The positive take-up motions perhaps disclose their faults more readily than any others, and are the easiest of adjustment; for instance, the irregularity in the action of the ratchet wheel, caused mainly by an improper adjustment of the take-up catch, is one of the most frequent sources of trouble. The lever, actuated by the going part, and the catch which moves the ratchet wheel forward, should be so adjusted that the wheels move one tooth exactly at each stroke of the going part. Suppose it is carried forward one tooth and a half. At the next stroke it would not necessarily be carried just one tooth and a half, because the pawl may just fail to drop into the third tooth, then of course a wide and narrow space will occur alternately, sometimes it will take too much and sometimes too little, and irregularity must follow. Suppose it takes one tooth and a quarter, the irregularity may then be even greater because the increased stroke would occur at more irregular intervals. A careless overlooker will say always let it take enough; but this is a most dangerous expedient, the enough should be one tooth and one tooth only, there must be no depending upon the tension of the cloth pulling the beam back to compensate for any increased length of stroke, because that would be a variable quantity at all times. Again the adjustment of the holding catches must be carefully attended to; they should be so contrived in the positive, as in the non-positive motion, that whatever is given forward must be held by them. There must be no liability to rebound or give back. Then the slip catch must be carefully adjusted so that every time the loom is brought to a stand by the weft fork or stop rod it gives back the orthodox two picks and no more.

Another matter must not be overlooked in the positive take-up motions, that is, the proper weighting of the cloth beam so as to keep it always in contact with the driving or taking-down wheel. The tension on both sides always being maintained at a perfect equality, otherwise of course one side will be pulling and bearing all the strain whilst the other side is becoming comparatively slack. So that reduced to the simplest form of expression the weights must be so adjusted that there is equal tension all across the piece, and no slipping can possibly occur; otherwise thick and thin places and faults, tending more or less in that direction will be constantly occurring.

Sufficient has already been said as to the relations of the letting-off and take-up motions, and it only remains to emphasize the necessity for having those two motions working in perfect unison to prevent faults constantly arising, in many cases utterly destroying the quality of the cloth.

Although the leading features of both letting-off and take-up motions, so far as principles are involved, have been dealt with pretty fully, it must not be supposed that every form has been explained. So far as take-up motions are concerned there would be comparatively few others to deal with, but as for let-off motions their name is "legion," when it is pointed out that an authority on the subject some time ago asserted that 800 patents had been applied for for letting off motions for looms in ten years, some idea will be formed of the amount of attention which has been given to the subject. Of this large number a very large proportion would never be put on the market, yet those which have reached that stage have been sufficient to bewilder manufacturers as to which would be the best to adopt. Of course, it must not be supposed that all these were supposed to be of universal application, some would be suited for heavy and others for light goods. Some would meet the requirements of one special set of conditions and some would be intended for others; but the mere fact that there is so much room for the exercise of ingenuity shows that the subject is well worth studying and mastering in all its details.

LECTURE 9.

JACQUARDS AND HARNESSES.

Without occupying time in going over the history of the jacquard machine, or tracing more than is necessary for a clear understanding of the development and changes that have taken place in the machine since it was first invented, I will proceed at once to an examination of the general principles involved. In reality the jacquard machine is an extension and development of the witch machine, and its great merit lies in the capability of having a practically unlimited power of pattern production within a very limited space in the loom. In referring to the different forms of dobby, attention has been called to the enormous amount of space taken up when a large number of healds are employed. The jacquard enables us, from the nature and arrangement of the harness, to work with an unlimited number of separate healds, or in other words an unlimited power of pattern production, without taking up too much space in the loom. If the principle of the witch machines used upon hand looms of former days be understood, the jacquard loom of to-day is easily understood. Put briefly, the jacquard machine itself is an extension of the witch machine, where the number of hooks employed for the purpose of raising the separate heald threads may be anything from 100 to 2,000; and in fact for large damask table covers and fabrics of that description several of the largest machines may be employed upon one loom. Not infrequently a fabric is made where every thread has its own separate lifting hook, and yet the harness comes within the compass which causes no inconvenience with the loom. Then taking the harness of the old draw loom and coupling it with the enlarged witch, we have the real jacquard machine of to-day.

A general view of the machine itself is given at Fig. 154, which represents an ordinary single lift machine without the harness attached. In this general view a series of vertical wires are seen to fill the interior of the machine, and in front a perforated bar, or card cylinder, similar to those shewn in the dobbies, but having a much larger number of holes, is also seen. The details of the machine

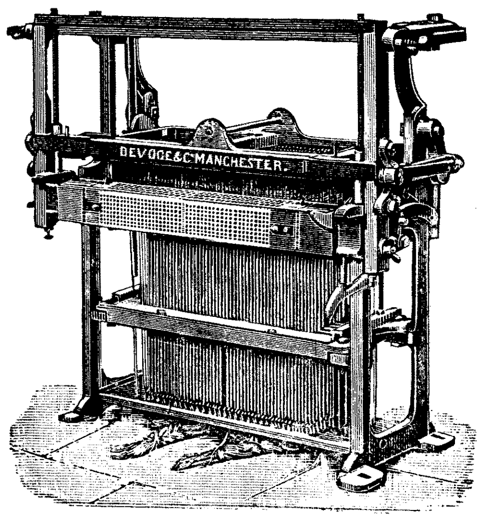


Fig. 154.

will be best understood by referring to the section Fig. 155. In this a series of upright hooks A are seen forming eight distinct rows. Each of those passing through a needle B, the needle is formed after the manner shewn in the figure where a loop is formed through which the upright hook can be passed and a longer loop is formed at the back through which a pin can be passed. This needle or cross-wire, as it is termed, is the medium of operating the harness and the warp threads through the upright hook