# COTTON WEAVING

AND

# DESIGNING

BY

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*REVISED UNDER THE DIRECTION*

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# REVISER'S PREFACE

TAYLOR'S "Cotton Weaving" has for many years enjoyed a reputation among Students who have attended Day and Evening Classes in Textile Weaving and Designing.

It has, however, been found wanting in some important features, and others have needed expansion so as to bring the work up to modern requirements.

A further Edition having been called for, has afforded the opportunity of having these deficiencies remedied by the addition of matters which will put the book in line with the latest improvements in this section of the Mechanical Arts. Chapter I., on preparatory processes, has been entirely rewritten and enlarged. My obligations are many to Mr. H. Nisbet, Weaving and Designing Master here, who has kindly carried out this work. Some chapters have had new and important features added, and many drawings are included for the first time, either as new illustrations, or in place of others which had become obsolete.

For these drawings I am indebted to the same gentleman, who has made this class of work a speciality.

Other chapters have been expanded, and partly rewritten. I should like to say, in conclusion, that while the book was passing through the press the assistance of Mr. Nisbet has been most helpful.

FRED. WILKINSON,
*Director*.

TEXTILE AND ENGINEERING SCHOOL,
BOLTON,
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# COTTON WEAVING AND DESIGNING

## CHAPTER I

### *PREPARATORY PROCESSES*

YARN intended for manufacture into cloth requires to pass through various stages of preparation, the character of which depends upon the class of fabrics to be produced. Thus, some systems of treatment are better adapted for the preparation of yarn for grey cloths (*i.e.* of the native colour of cotton), some for mono-coloured, and others for multi-coloured, fabrics. The choice of a system is often arbitrary, and can only be made from a knowledge of local or special requirements.

The operations involved in the preparation of warps for most fabrics are comprised under not less than five chief divisions, namely—

1. Winding yarn from any of its earlier stages on to warpers' bobbins.
2. Warping.
3. Sizing.
4. Beaming, or winding yarn on to a weaver's beam.
5. Looming, *i.e.* either drawing-in or twisting-in.

Each of these operations may be performed by a variety of machines of distinctly different types that have been specially devised to meet specific requirements, and which are, therefore, better adapted than others for their special purpose. Before introducing the reader to the details of the various types of machines in each division, it will be better to briefly enumerate the different systems of preparation usually adopted in the manufacture of the three classes of goods named above.

## PREPARATION OF GREY WARPS.

Grey warps are prepared by one or other of two systems, namely, (1) Beam warping, for slasher or tape sizing; and, (2) ball or mill warping, for ball or warp sizing; but by far the greater number are prepared by the first-named system.

### 1. *Beam Warping and Slasher Sizing.*

This system comprises the following operations, namely—

1. Winding yarn from cops, ring, or throstle bobbins on to warpers' bobbins, by means of a "spindle" or "cop" winding machine.

2. Beam warping, whereby yarn is transferred, in the form of a wide sheet, from warpers' bobbins on to a large flanged beam.

3. Slasher or tape sizing, whereby yarn is withdrawn from several beams, termed "back" or "slashers'" beams, to be sized, and subsequently re-wound by the same machine on to a weaver's beam by simultaneous operations.

4. Looming, by which the threads of a new warp are placed in a loom ready for weaving.

### 2. *Ball Warping and Sizing.*

This system comprises the following operations, namely—

1. Winding yarn from cops or ring bobbins on to warpers' bobbins.

2. Ball warping, in which a number of threads are withdrawn from warpers' bobbins and condensed into the form of a rope of untwisted strands. This operation may be accomplished by several types of machines. The one usually employed is the old-fashioned warping mill, which coils warp-ends on to a large revolving reel or swift, from which they are subsequently withdrawn and formed into a large ball. Ball warps are also sometimes formed direct from warpers' bobbins; also sometimes from sections formed by a sectional warper; and sometimes by means of a linking or chaining machine.

3. Ball-warp sizing.

4. Beaming, or winding a warp in an even sheet of threads on to a weaver's beam for the loom.

5. Twisting-in or else drawing-in warp-ends in the loom.

If the threads of a new warp are similar in number and counts to those of the finished warp, and are to pass through the shedding harness and reed also in a similar manner, it is more economical to twist the threads of a new warp separately to the corresponding threads of the old warp, and then draw the twisted portion of the warp bodily forward through the healds and reed. If, however, the number of threads and counts are greatly dissimilar, or if a different drafting is required, then recourse must be had to drawing new warp-ends through the harness and reed.

### *Preparation of Mono-coloured Warps.*

Warps of one colour may be prepared from either (1) warp-dyed and sized yarn, or (2) from hank-dyed and sized yarn.

### 1. (*a*) *Warp-dyeing and Sizing.*

The series of operations in this system are identical with those involved in the preparation of grey warps by means of ball warping, but with the additional process of dyeing immediately following the operation of warping, and are as follows :—

1. Winding yarn on to warpers' bobbins.
2. Mill or other system of ball warping.
3. Warp-dyeing and sizing.
4. Winding yarn on to a weaver's beam.
5. Twisting-in or drawing-in.

### 1. (*b*) *Warp-dyeing and Sizing.*

A system by which warps of one colour may be prepared by means of sectional warping, from ball-dyed and sized yarn, has been recently introduced. It comprises the following operations, namely—

1. Winding yarn from cops or ring bobbins on to warpers' bobbins.
2. Mill or other system of ball warping.
3. Warp-dyeing and sizing.
4. Winding yarn from ball warps on to warpers' bobbins by means of a warp-winding machine.
5. Sectional warping and beaming.
6. Drawing-in or twisting-in.

### 2. *Hank-dyeing and Sizing.*

This system involves the following operations, namely—

1. Reeling yarn from cops or ring bobbins into single or multiple hanks. (A standard hank contains 840 yards.)
2. Hank-dyeing and sizing.
3. Winding yarn from hanks on to warpers' bobbins by means of a drum-winding machine.
4. Beam warping.
5. Beaming, or winding yarn from back beams on to a weaver's beam.

6. Drawing-in or twisting-in.

Sectional warping may be substituted in lieu of beam warping.

### *Preparation of Multi-coloured Warps.*

Striped warps are usually prepared by one or other of two systems, namely, (1) Yorkshire dressing, from warp-dyed and sized yarn; and (2) sectional warping, from hank-dyed and sized yarn. Warp-dyeing yields a more uniform tone of colour than hank-dyeing, for which reason some manufacturers prefer to adopt the former system, although the latter system is less costly.

#### 1. *Yorkshire Dressing.*

This system comprises the following operations, namely—

1. Winding yarn on to warpers' bobbins.
2. Mill or other system of ball warping.
3. Warp-dyeing and sizing.
4. Yorkshire dressing, by which the required number of threads of each colour are split off reserve ball warps. The warp-ends thus split off are subsequently passed, in groups of two to four, through the dents of a reed in proper order, according to the required warp pattern, and wound on to a weaver's beam.
5. Drawing-in or twisting-in.

#### 2. *Sectional Warping.*

This system comprises the following operations, namely—

1. Reeling yarn into hanks.
2. Hank-dyeing and sizing.
3. Winding on to warpers' bobbins by a drum-winding machine.

4. Sectional warping, by which a warp is wound in sections upon wooden or compressed paper blocks, with warp-ends in the same relative position that they are required to occupy in cloth. Each section forms a complete unit of the full warp, and when the required number of units are prepared, they are placed together side by side, and compressed upon a mandril; then the yarn is unwound from all sections simultaneously, and wound on to a weaver's beam.

5. Twisting-in or drawing-in.

### *Preparation of Weft Yarn.*

If weft yarn is to be woven in a grey state, it is rarely that it requires to undergo any operation after it leaves the spinner. Grey cops and ring bobbins of weft are usually placed in a shuttle and woven direct; but if they are too large for a shuttle, their yarn is transferred on to wooden or paper bobbins by means of pirn winding.

Cops intended for use as weft are frequently dyed and bleached in that form, and woven without any operation of winding. If, however, weft yarn is dyed or bleached in hanks, it requires to be subsequently wound on to pirn bobbins or paper tubes to fit on a shuttle tongue. Weft is also sometimes woven in a damp condition, with a view to inserting a greater number of picks per inch in cloth than is possible with dry weft.

### *Winding Machines for Warp Yarn.*

Fig. 1 is a diagram showing parts of a "spindle" or "cop" winding machine, which is chiefly employed to wind grey yarn from cops, G, or ring bobbins on to warpers' bobbins, E. It is also sometimes incidentally employed to wind coloured yarn from hanks, O (as represented on the left-hand side of the diagram), when the amount of work required of that kind would not justify the purchase of a "drum" winding machine, which latter is better adapted for that purpose, for reasons that will be explained later.

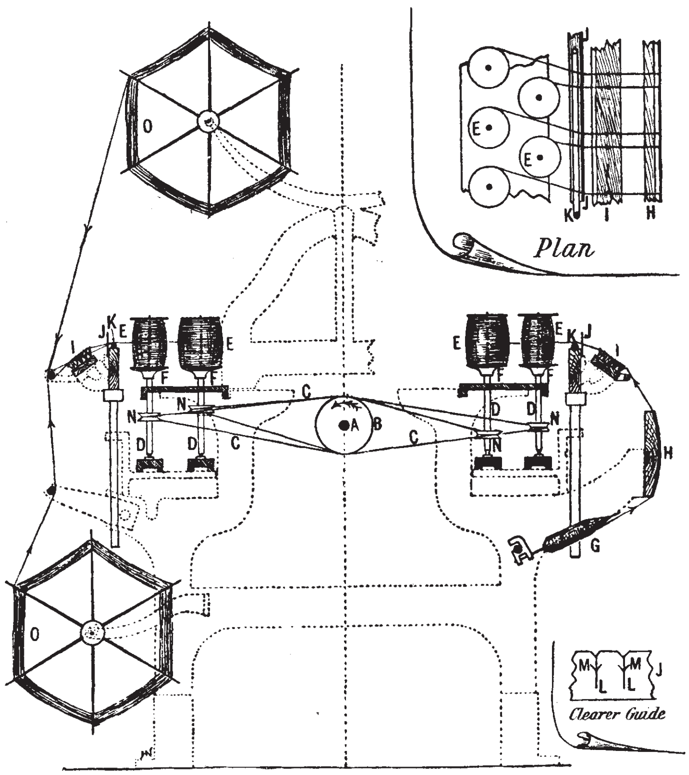



FIG. 1.

As usually made, a "cop" winding machine contains a tin driving drum, B, passing centrally down the machine, and carrying the driving pulleys at one end of the tin drum shaft A. By means of cotton bands, C, the tin drum drives four rows of spindles, D, arranged in two zigzag rows, one on each side of the machine, as shown in part plan (detached). Warpers' bobbins, E, fit loosely upon the spindles, and rest upon metal discs, F, secured to the spindle-shanks, by which bobbins are frictionally rotated. During winding, yarn passes from cops, G, or other source, over a drag-board, H, through a brush, I, and clearer guide, J, thence over a glass rod, K, surmounted on guide-rails, and on to warpers' bobbins, E. The drag-board H is covered with flannel to impart frictional resistance to yarn, and thereby prevent its passing too freely and making soft bobbins. The clearer guide (of which a front view is shown, detached) is a thin metal plate containing a number of vertical slits, L, from near the top of which are two short slits, M, branching upwards at an angle of about 45°. The vertical slits serve to guide threads to their respective bobbins, and also to remove any irregularities, as "slubbings" (*i.e.* thick, soft places consisting of a mass of untwisted fibres). The short slits are intended to prevent operatives from raising threads out of the guides, and so save themselves the trouble and loss of time involved in piecing up broken threads.

Spindle-shanks, D, are furnished with tightly-fitting grooved pulleys, N, termed "wharves," around which driving bands pass. Wharves on each back row of spindles are usually made one-quarter of an inch larger in diameter than those of front spindles, to cause them to revolve at a slower velocity. The object of this is to enable some compensation to be made for the constantly accelerating pace at which yarn is wound, in consequence of the gradually increasing girth of bobbins by additional layers of yarn. When bobbins become about half full on front spindles, a winder removes them to back spindles to be filled.

If bobbins were allowed to fill on front spindles, the velocity at which yarn would travel towards the completion of winding would impart an abnormal degree of tension to it, and thereby make it more liable to break. It is in consequence of the excessive degree of friction to which yarn is subjected in a cop-winding machine that renders it unsuitable for winding yarn that has been previously dyed and sized.

One of the most important parts of a cop-winding machine is the traverse motion to guide yarn between the flanges of a bobbin during winding. These are constructed in great

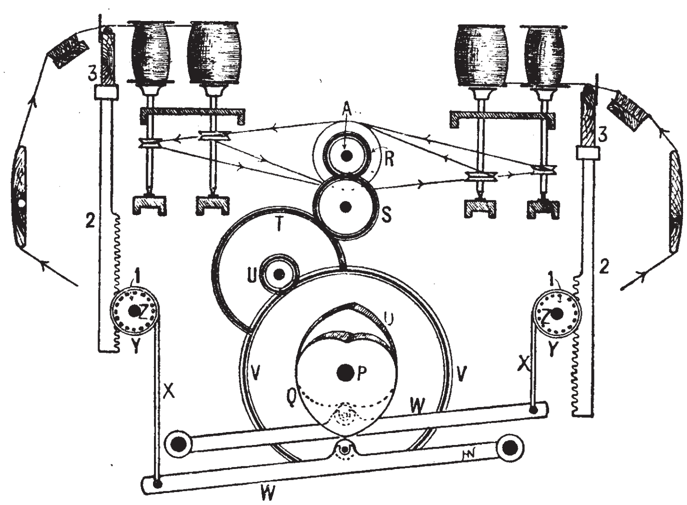



FIG. 2.

variety, but all belong to one of two distinct types, namely, those governed by cams, and those governed by what is termed a "mangle-wheel." They are also constructed to guide yarn at either a uniform or variable pace between the bobbin flanges. If the traverse of yarn is uniform, bobbins will be wound with a uniform diameter; but if a barrel-shaped bobbin is required, the movement of guide-rails must be differential—quicker towards the extremities, and slower towards the centre of their traverse, with the object of placing a greater quantity of yarn upon them. Traverse motions are usually designed on the compensating principle, so that guide-rails on either side move in opposite directions at the same time, and a falling rail helps a rising one to ascend, thereby requiring less motive power to drive a machine.

One of several modifications of a heart-cam traverse motion is shown in Fig. 2. In this motion two heart-cams, P, are set in opposite direction upon a shaft, Q, which is driven by a pinion, R, on the tin drum shaft, A, and a train of wheels, S, T, U, V. The cams operate treadles, W, whereby they fall and rise alternately. The free end of each treadle farthest

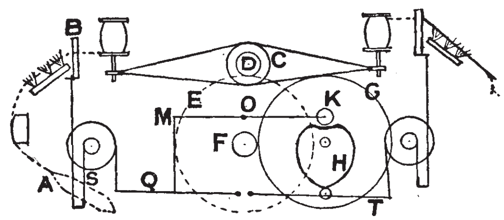



FIG. 3.

from its fulcrum is connected by means of straps or chains, X, to pulleys; Y, secured to shafts; Z, extending one on each side of the machine, and carrying several pinion wheels, 1, at intervals. The latter engage with teeth in vertical racks, 2, which serve as supports to guide-rails, 3. Thus, as treadles are depressed, guide-rails are raised in a positive manner; but their return is effected by gravitation. The character of movement imparted to guide-rails depends upon the conformation of the cams, which may be constructed to give either a uniform or differential traverse to guide-rails, as desired.

Another modification of a heart-cam motion is illustrated in Fig. 3. In this motion a single cam, H, serves to operate both guide-rails, B, by acting upon two treadle bowls, one of which, K, is placed above, and the other, L, below the cam. Treadle bowl K is carried at one end of a lever fulcrumed at O, whilst the other end, M, is connected to a lever, Q. Through the medium of chains and chain pulleys, lever Q operates the guide-rail on the left, whilst the lower treadle, T, operates that on the right.

A traverse motion constructed on the mangle-wheel principle, to wind barrel-shaped bobbins, is represented in Fig. 4,

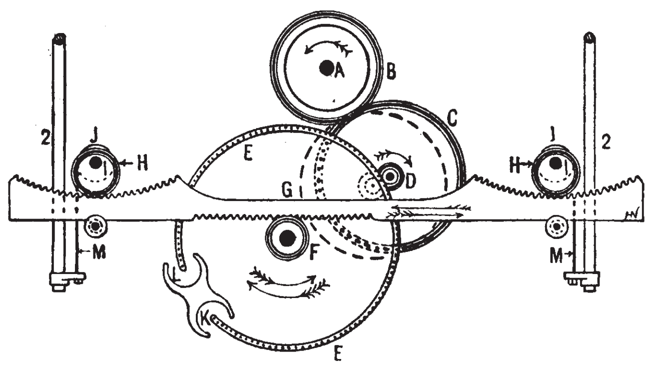



FIG. 4.

A pinion, B, on the tin drum shaft, A, drives wheel, C, which carries a small pinion, D. Wheel C and pinion D are carried by a bracket that permits of a slight concentric movement of those wheels to enable the pinion to engage alternately on the outside and then on the inside of the mangle-wheel E, with which it gears. On the same stud as the mangle-wheel is a pinion, F, which engages with the teeth of a horizontal rack, G, which is formed with a curved rack at each end. The curved racks gear with eccentric wheels, H, fastened to shafts, I, which carry chain pulleys, J, to wind up or let off the chains connected to the supports of guide-rails. When pinion D revolves on the outside of the mangle-wheel, the latter revolves until the gap K arrives at the pinion, which immediately runs inside the mangle-wheel and reverses its direction, until the gap L arrives at the pinion, which then runs on the outside and again reverses the direction of the mangle-wheel. Thus, rack G is slowly moved from one side to the other, and by acting upon the eccentric wheels H at different distances from their axes, their rotation is quicker or slower, according as the racks are in gear with them at a point nearer to, or farther from, the centre of their shafts respectively. On the same shafts as the eccentric

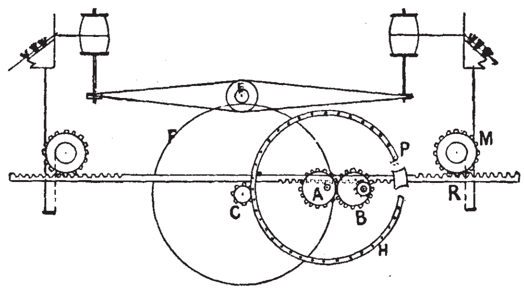



FIG. 5.

wheels are a number of chain pulleys on which are fastened chains, M, connected to the supports, 2, of guide-rails, whereby the latter are raised and lowered in a manner determined by the eccentric wheels.

Another modification of a mangle-wheel motion is shown in Fig. 5. In this motion a wheel, E, on the drum shaft, drives the larger wheel F. The small pinion C turns the mangle-wheel H.

In order to obtain the *unequal* motion of the rack R, to give the barrel shape to the bobbin, a wheel, A, is fixed on the mangle-wheel shaft a short distance from the centre of the wheel. Another wheel, B, is fixed in a similar manner on another shaft, which also carries a wheel which gears into the under side of the rack. The smaller side of the wheel A gears into the larger side of the wheel B, as shown in the diagram, and as the mangle-wheel shaft revolves, the larger part of A will gradually come in contact with the smaller part of B, and

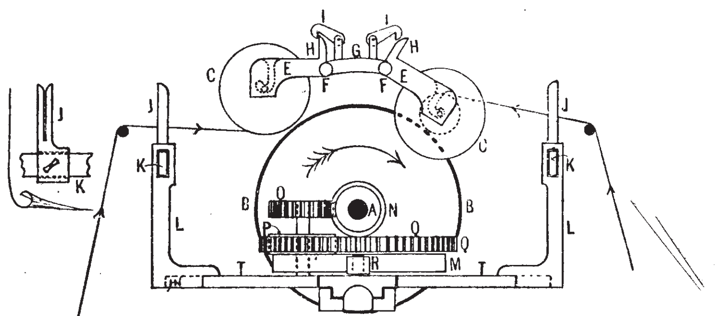
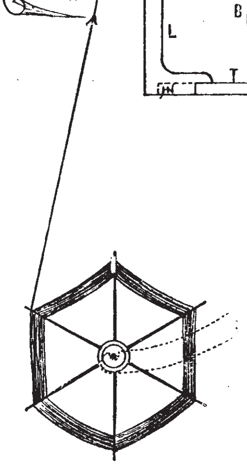



FIG. 6.



this, of course, will cause the rack to move quicker. When the smaller side of A is in contact with the larger side of B, the guide-plate will be guiding the yarn on to the middle of the bobbin; and when the larger side of A is in contact with the smaller side of B, the guide-plate will be putting the yarn on to either the top or bottom of the bobbin.

The small side of the wheel A must be set in gear with the larger side of the wheel B, and the traverse halfway of the bobbin. The pinion C will at the same time be in contact with the middle pin in the mangle-wheel, and the middle of the rack R driving the wheel M.

Fig. 6 is a part elevation, and Fig. 7 a plan, showing the essential parts of a drum-winding machine to wind yarn from hanks, W, that have been previously dyed and sized, on to warpers' bobbins, C. In this type of machine, warpers' bobbins are held horizontally against the peripheries of a series of revolving drums, B, fixed at regular intervals upon a shaft, A, running centrally from end to end of the machine. Bobbins are held in position by spindles, D, contained in frames, E, which

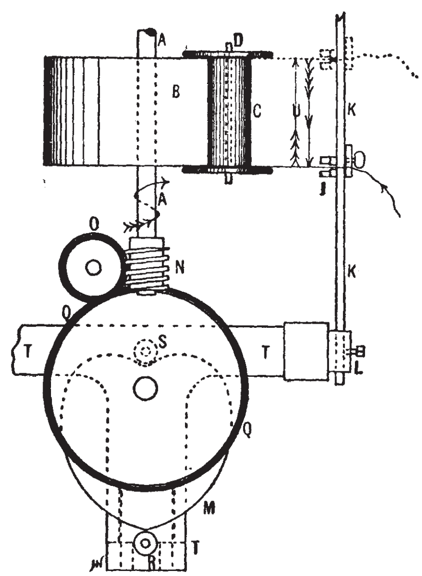



FIG. 7.

are fulcrumed at F to brackets, G, to permit of bobbins rising as they increase in size. Since bobbins are driven by surface contact with drums, the rate of winding is approximately uniform throughout. Projecting from each bobbin frame is a latch, H, to permit of a hook, I, holding a bobbin out of contact with its drum, whilst an operative replaces a full bobbin with an empty one, or pieces a broken thread.

Yarn is guided between the flanges of bobbins at a uniform pace by means of guides, J, carried upon guide-rails, K, supported in brackets, L, and operated by a heart-cam, M. On the end of the driving shaft, A, is a worm, N, which gears with a worm wheel, O, with which is compounded a pinion, P, to drive wheel, Q, to which the cam M is secured. As the cam revolves, it acts alternately upon two runners, R and S, carried upon studs secured to the sliding base, T, of brackets,

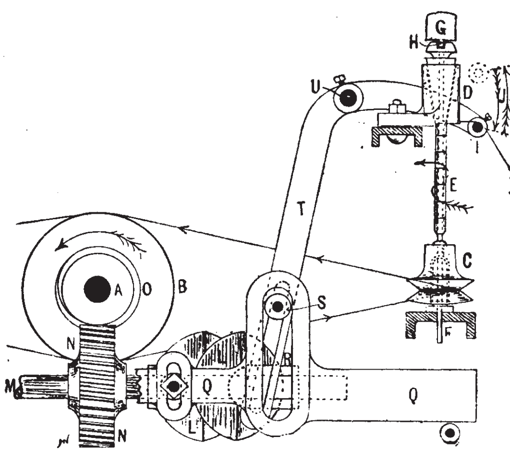



FIG. 8.

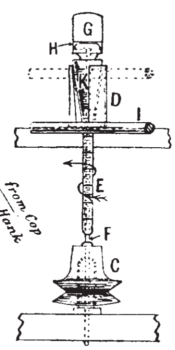



FIG. 9.

L, whereby the latter receive a reciprocal motion, as indicated by arrows, U and V.

*Winding Machines for Weft.*

When weft yarn is in an unsuitable form to be placed within a shuttle, it is usually wound upon paper tubes, or wooden bobbins, by means of one of the many systems of "pirn" winding. The chief parts of the prevailing type of machine used for that purpose are represented in Figs. 8, 9, and 10, which are end and front elevations and plan respectively. Passing centrally down the machine is a tin drum, B, on driving shaft, A, for the purpose of driving a number of wharves, C, arranged at regular intervals on each side of the machine. Fixed immediately above each wharve is a metal pirn cup, D, having a conical interior, for the reception of a pirn bobbin, E. When in position, a long spindle, F, having a heavy head-piece, G, passes through a bobbin tube and enters a rectangular hole in the wharve immediately below. The lower portion of a spindle which enters the wharve is also rectangular in cross-section,

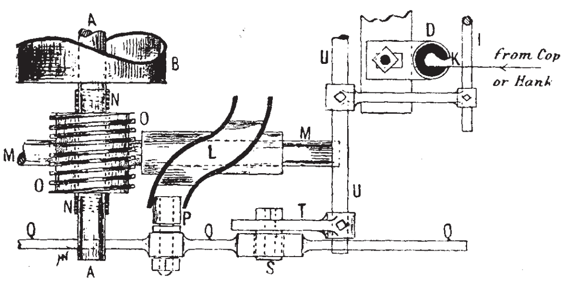



FIG. 10.

and therefore revolves with its wharve. At the same time, bobbins are driven by causing a projection, H, below spindle heads to enter a slot in each bobbin head.

Each thread passes from its source, over several stationary bars, to impart the required degree of tension to it, thence over guide-rail, I, by which it is guided up and down (as indicated by arrows, J) between the extremities of a pirn cup, as it passes through an opening, K, in the latter, and on to its bobbin. In consequence of yarn being built upon a bobbin within a conical chamber, a bobbin, with its spindle, rises automatically as it fills with yarn, and when filled it raises its spindle clear of its wharve, and thus stops automatically.

Guide-rails, I, are usually operated by means of a grooved cam, L, fixed on a side shaft, M, which carries a worm wheel,

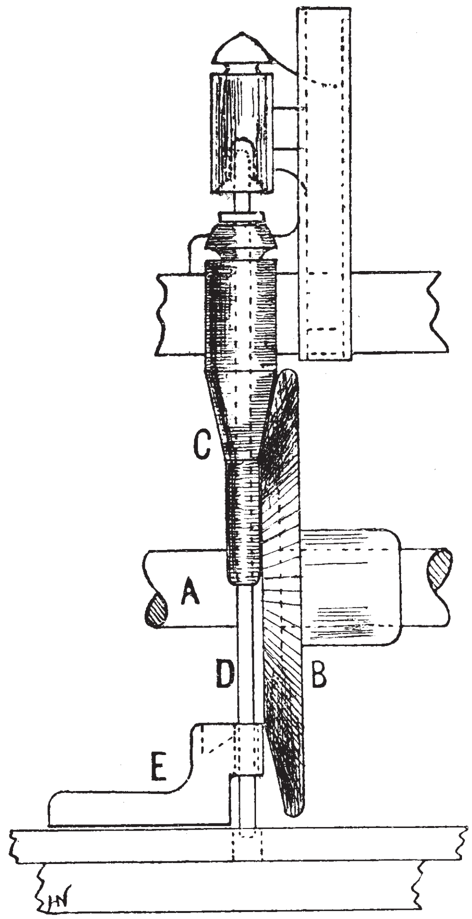



FIG. 11.

N, driven from a worm, O, on the end of a driving shaft, A. The cam acts upon a runner, P, fixed on a sliding rail, Q, in which are formed vertical slots, R, one on each side of the machine. Each vertical slot acts upon a runner, S, secured to lever T, having shaft U for a fulcrum. At regular intervals on shaft U brackets are fixed to support guide-rail I, which rises and falls at a uniform pace in both directions.

In consequence of yarn rubbing against the stationary surface of a pirn cup, it is liable to become burnished, and sometimes injured. Many attempts have been made to overcome that objection by driving bobbins by surface contact with revolving discs, and also by supporting them against conical rollers. Fig. 11 shows one of several methods of driving bobbins by means of bevelled discs, B, fixed at regular intervals upon driving shafts, A, placed one on each side of the machine. In this machine, as in an ordinary pirn cup machine, a bobbin, C, rises automatically until filled, when its spindle, D, withdraws from a hole in the bolster, E, and slides down a short incline, thereby stopping a bobbin by carrying it from the disc.

## WARPING.

The three methods of warping in use are mill warping, beam warping, and sectional warping. The oldest form is mill warping, but this has been largely superseded in almost all cases, except for coloured goods, by the beam warping machine.

In beam warping bobbins are placed in a creel. This is a frame constructed to hold from 400 to 500 bobbins, and is the shape of the letter V, as this is the most convenient and easiest for unwinding. The 400 to 500 threads, A, are taken through an expanding reed, B (Figs. 12, 13, and 14). The ends are then passed over a tin measuring roller, D, and under tension-rollers, 15 and 18, which keep the yarn taut, and also pull it back when it is required to turn backward to find a broken thread, or otherwise. Each thread is then passed separately underneath a small bent wire drop-pin, 22. Each

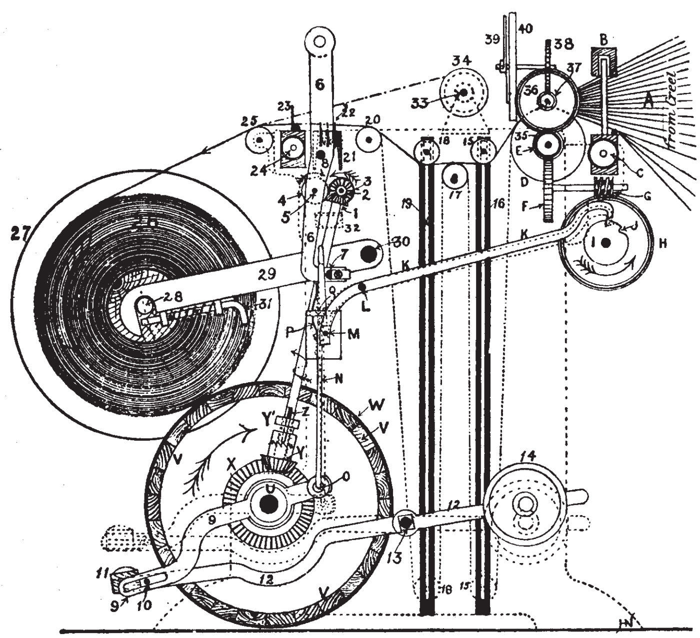


FIG. 12.

thread bears the weight of one of these wires, and should the thread break when the machine is in motion, the wire falls between two rollers, 3 and 4, which latter is mounted so that a wire causes it to move forward and, by releasing a "trigger" motion at Q, as it is called, the machine is automatically stopped. This is the principle of Singleton's stop-motion, which is the one most commonly used. In front of the stop-

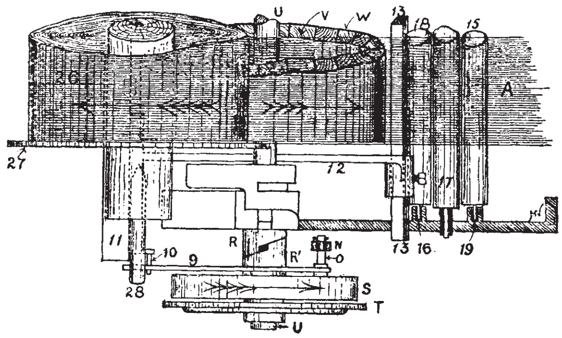



FIG. 13.

motion wires the yarn is passed through an expanding comb, 23, which regulates the width of the slashers' or "back" beam, 26. This beam is driven by friction; the beam rests on a drum, V, and as the drum revolves, the beam is driven in such a manner that yarn is wound at a uniform pace throughout, although the beam is gradually increasing in diameter. One of these machines will supply about 80 to 90 looms weaving medium counts of yarn. The creel is usually made to hold 504 bobbins, but any lesser number of ends may be put on a beam.

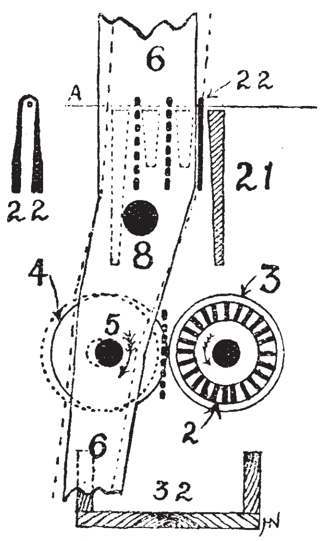



FIG. 14.

After leaving the warping machine the beams are taken to the slashing frame, where a sufficient number of beams are put together to form the warp for the loom.

**Mill warping.**—This system of warping is still in use for warps used in the Bradford mixed goods trade, and for many classes of coloured cotton goods in Lancashire, although slashed warps are fast superseding the system for the former trade, and sectional warping is replacing the system for the coloured trade. Mill warping is also in general use in silk manufacture. Those spinners who supply warps to Yorkshire

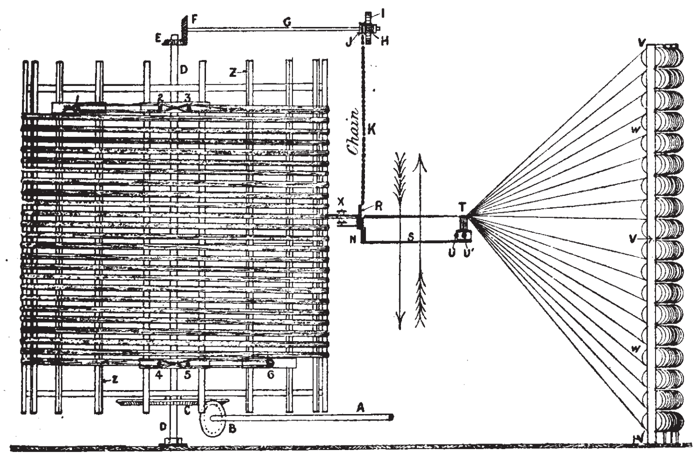



Fig. 15.

worsted manufacturers have usually supplied them in the ball, unsized. The warps are "mill" warped, and the manufacturer has them sized to his own orders by cotton warp sizers, who usually combine this business with dyeing and finishing in the Bradford district. Slashed warps are now being used in the Bradford trade to a considerable extent, the warps being in most cases slashed in Lancashire and sent on beams.

A warping mill consists of a large reel, Z (Figs. 15 and 16), of from six to twenty yards circumference, which is made to revolve. This reel is fixed upright in suitable framework, and the warper's bobbins, W, are placed in a creel, V, by the side of the reel. The ends are taken from the bobbins, and drawn separately through the eyes of a row of needles, T, which constitute what is termed a "heck." This heck is so constructed that one-half of the eyes can be raised above the other half, to form a lease. The heck slides up and down the framework Y of the mill, and thus forms a traverse and distributes the warp as the reel revolves. At the

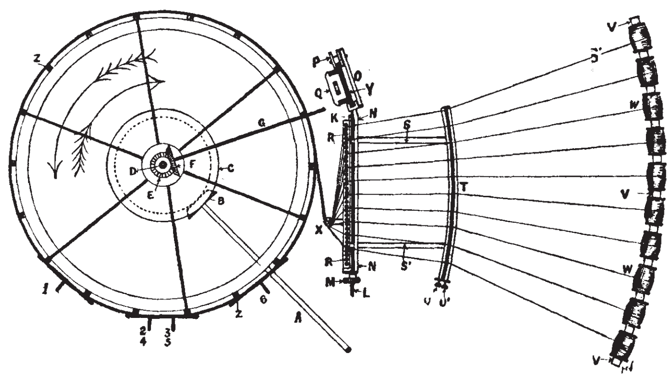


FIG. 16.

commencement of a warp, the bunch of ends is taken from the "heck" and fastened to a peg, 6, at the bottom of the reel. As the reel revolves the heck slowly rises, and so causes the warp to be wound on the reel spirally, without overlapping. The heck is moved up and down a sufficient number of times to give the required number of ends in the warp, when the warp is cut off and unwound, and made up either in the form of a ball or a chain. The length of a warp is determined by the number of revolutions made by the mill from the commencement, until it is reversed at the other extremity.

## SECTIONAL WARPING.

Sectional warping is a system chiefly employed in the production of coloured striped warps, from yarn previously dyed and sized in the hank, and subsequently wound upon warpers' bobbins by a drum-winding machine. It is also sometimes employed in the production of grey warps for ball sizing. As its name implies, the operation consists of preparing a warp in sections, termed "cheeses," each of which is a complete unit, and virtually a transverse section, of the full warp. When the required number of sections for a warp have been made, they are compressed between flanges side by side upon a mandril of a running-off machine, and their yarn run from them simultaneously on to a weaver's beam. Sometimes a sectional warper works in conjunction with an automatic stop-motion similar to that of a beam warping machine, in which case bobbins are contained in a V-shaped creel. They also sometimes work without a stop-motion. In that case bobbins are contained in a curved creel similar to that employed in conjunction with a warping mill, whereby the threads are better under the observation of the operative warper, and broken threads may be more readily detected. One of the most important considerations in sectional warping is the production of sections of uniform diameter and length of yarn; otherwise, warp-ends would be of varying degrees of tension; also, waste of material would result from irregular lengths of yarn on the sections.

The principal parts of a well-known type of sectional warping machine are shown in Figs. 17, 18, and 19. Warp-ends, A, are withdrawn from a curved creel, and passed separately through needle eyes of a leasing heck, B, thence through a

V-reed, D, over a tin measuring roller, F, and on to a section block, O, which is compressed between two flanges, N, O, upon a shaft, Q, by which it is turned. Flange N is removable to permit of a full section being replaced by an empty one. Another flange, 24, is keyed upon the section shaft, Q, and driven by means of friction bowls, 20, 20′, placed one on each

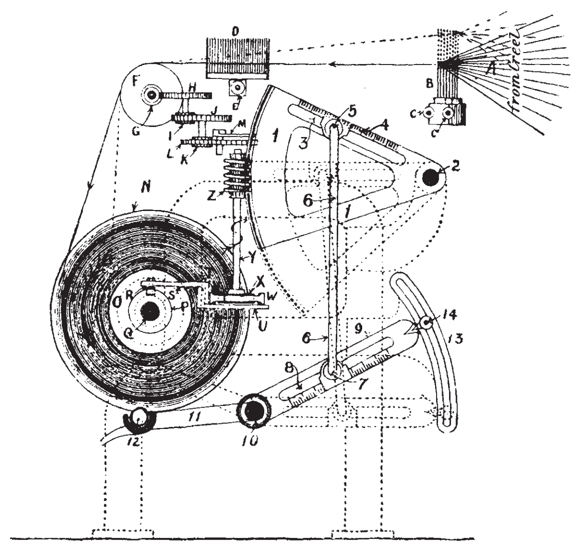


FIG. 17.

side, and turned by driving shafts 16, 16′, each of which contains a wide loose pulley, 17, 17′, a narrow fast pulley, 18, 18′, and a toothed wheel, 15, 15′, which are in gear. Thus, if driving strap 19 is placed in a central position (as indicated) it runs on both loose pulleys, without effect; but if placed upon the fast pulley 18, it will turn the section *forward*, and wind yarn on the front, as shown, and if placed on fast pulley 18′, it will turn a section *backward*, and wind yarn at the back.

This arrangement enables sections to be made with one-half of a full repeat of a warp pattern, either alone or in addition to several repeats (provided the pattern is a symmetrical one), so that when all sections are placed in their proper position for running their yarn on to a weaver's beam, two halves of a pattern will join together without a break. A uniform rate of winding yarn is maintained by causing friction driving bowls, 20, 20′, to automatically recede from the section shaft at a pace

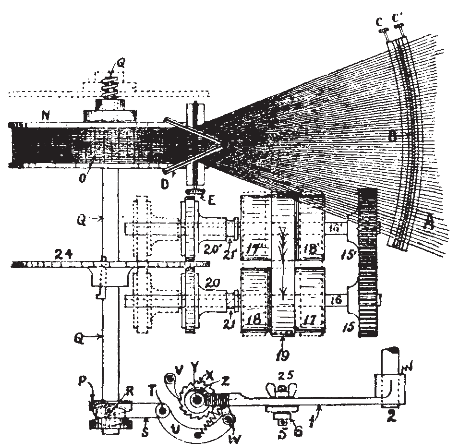


FIG. 18.

exactly corresponding to that at which a section increases in diameter, thereby gradually retarding the velocity of the section shaft.

A presser roller, 12, carried at the end of a lever, 9, 11, fulcrumed on shaft 10, bears against yarn during winding, to wind it more compactly, and also to ensure uniformity of diameter of sections composing the same warp. During the winding of the first or "trial" section, the presser, which is suitably weighted, is free to recede at such pace as corresponds with the increasing diameter of that section; but for subsequent sections, the presser is under mechanical control, and may only recede at a prescribed pace, which should, however, exactly coincide with its recession during the formation of the first section. The movement of the presser is governed by means of a toothed quadrant or sector, 1, communicating with presser

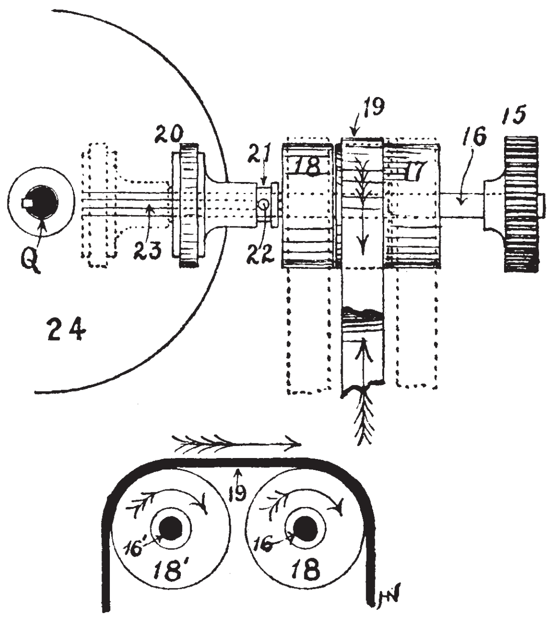



FIG. 19.

lever, 9, by a connecting rod, 6. The position of rod 6, in relation to the fulcrum 2 of the sector and the fulcrum 10 of the presser lever, determines the velocity at which the presser recedes. A cam, P, on the end of section shaft Q, imparts an intermittent rotary motion to a short vertical shaft, Y, by means of lever S, U, and pawl W. Surmounting shaft Y is a worm, Z, gearing with the teeth of sector 1 which slowly rises as a section revolves, thereby causing the presser to recede, at a prescribed pace. The number of revolutions of the section

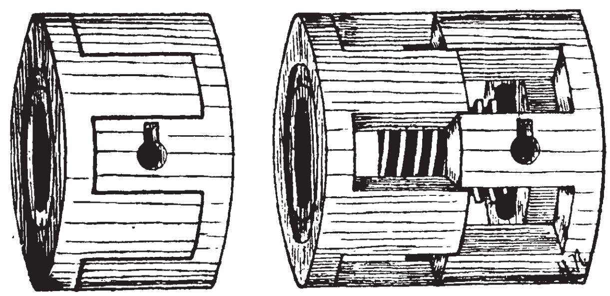


FIG. 20.

shaft is indicated upon a dial; also, the length of yarn wound is indicated upon a dial, by fingers operated by a train of wheels driven from worm G, on the end of tin measuring roller shaft

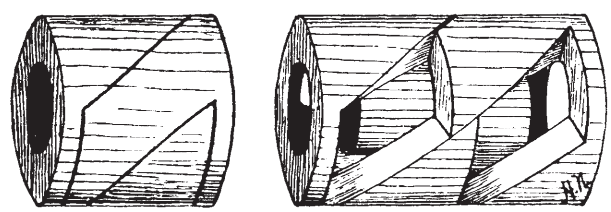


FIG. 21.

F. The two indicators, therefore, serve as a check upon each other.

Section blocks are made in different widths from $3\frac{1}{2}$ inches upwards. Some are constructed so as to permit of expansion and contraction, as shown in Fig. 20. Pressers are also constructed on a similar principle, as shown in Fig. 21.

## SIZING.

The chief systems of sizing are slashing, dressing, ball-sizing, and hank-sizing.

The object of sizing is to strengthen the yarn by saturating it with a starchy substance, which lays the fibres, thus making it weave with less breakages. Other objects are to impart "feel" to the cloth, and to give it additional weight. For light sizing, in which the object is simply to strengthen the yarn, and not to increase its weight, only 10 to 15 per cent. is added to the weight. When 30 or 40 per cent. is added it is termed medium sizing, and for heavy sizing often 100 per cent. or more is added to the weight. The materials used for light sizing are: wheat flour, sago, farina or potato starch, rice flour or starch, maize.

Potato starch, or farina, is obtained from the tubers by reducing them to a pulp and mixing well with water. The water carries away the starch, and when allowed to stand the starch falls to the bottom of the vessel and the water can be drawn away. Farina is much used in all kinds of sizing, on account of its cheapness and the thickness of the paste it produces when boiled with water.

Sago is much used in light sizing, for which it is specially adapted. It is obtained from the pith of the sago palm, and made into flour by treating with water and drying on hot plates.

Maize is a starch obtained from the Indian corn, and is sometimes used for lightly sizing the finer counts of cotton yarns.

For light sizing it is not necessary to use anything but wheat flour, farina, or sago, and a small quantity of softening material, usually tallow or wax. Wheat flour is fermented

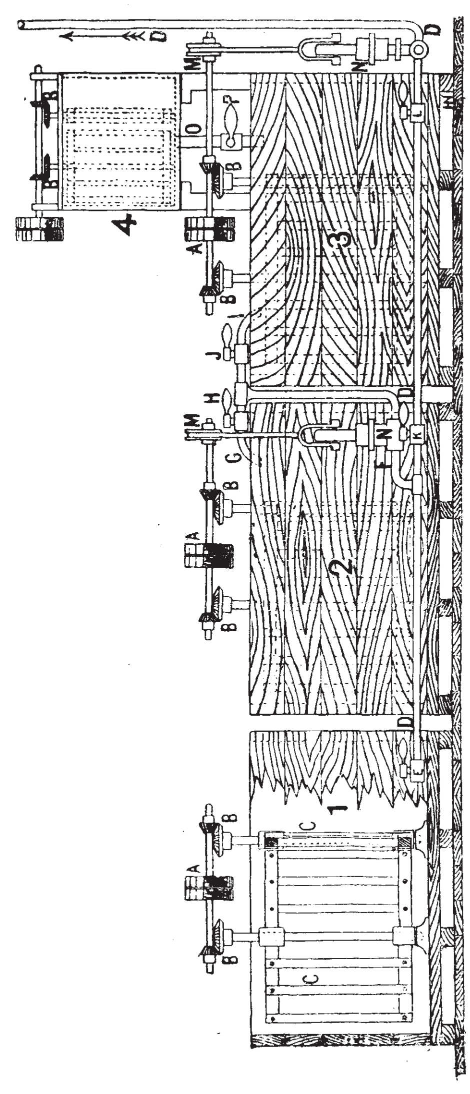


FIG. 22.

before using by mixing it well with water (about equal weights of each) and leaving it for several weeks, occasionally stirring to keep the particles in suspension. When flour is fermented new bodies are formed, which have a powerful influence in preventing mildew. The fermenting cistern, 1 (Fig. 22), is usually a large vessel 8 feet by 4 feet by 4 feet, in which are two revolving "dashers," C, to stir the flour and water when fermenting. Another similar cistern, 2, is used for storing called a "storage and diluting" cistern, into which the mixture is pumped after a few days, and left to further ferment. A force-pump, N, is used for pumping from this to the mixing cistern, 3, where the softening and weighting materials are added, after being boiled together in pan 4.

Softening materials are used to render the yarn more pliable. The articles mostly used for this purpose are tallow, wax, and soap, cocoanut and palm oil.

The following mixtures are suitable for light sizing. They can be made to give a greater or less percentage, according to the specific gravity of the mixture. For testing the specific gravity or density of the liquid, the Twaddell's hydrometer is used. This instrument registers in degrees the density of the mixture, or the amount of matter in solution.

For light sizing—

| | |
|---|---|
| Wheat flour . . . . . . . | 280 lbs. |
| Tallow . . . . . . . . | 16 ,, |

Another mixture is—

| | |
|---|---|
| Sago . . . . . . . . . | 100 lbs. |
| Farina . . . . . . . . | 100 ,, |
| Tallow . . . . . . . . | 10 ,, |
| Soap . . . . . . . . . | 4 ,, |

For sizing with sago, cocoanut oil is often used as a softening material. A mixture of these two gives as good a size as anything for pure sizing.

Another mixture used for fine counts is—

| | |
|---|---|
| Farina | 100 lbs. |
| Wax | 5 " |
| Tallow | 4 " |
| 1 gall. water to 1 lb. farina. | |

Almost every manufacturer uses different proportions of ingredients. Many use wheat flour, farina, and sago mixed in various proportions, whilst a flour and farina mixture in the proportions of 2 : 1 is considered by some to give the best results. Farina and sago are also often mixed for light sizing in the proportion of two parts farina to one part sago. Wheat flour carries through better than farina or sago, and is therefore more generally used for the heavier kinds of sizing.

Any of these mixtures may be altered as regards strength, or otherwise, by increasing or diminishing their density. If a mixture twaddles 10 degrees at a given temperature, it may be strengthened for heavier cloths or higher picks by increasing the proportion of solid matter in the mixture until it twaddles 15 degrees at the same temperature.

For adding weight to the cloth china clay is the chief ingredient used. This material is found in deposits in Devonshire and Cornwall, and is used in large quantities for the purpose of weighting and filling cloth, more especially those manufactured for export to the Eastern markets.

For what is termed "medium" sizing, viz. adding about 30 to 50 per cent. to the weight of the cloth, the following materials are used in various proportions, the proportion given being an example—

| | |
|---|---|
| Flour | 100 lbs. |
| Clay | 30 to 40 lbs. |
| Tallow | 15 lbs. |
| Chloride of magnesium | 1 gallon. |
| Chloride of zinc | ½ " |

It will be noticed here that chloride of magnesium and chloride of zinc are introduced along with the china clay. Chloride of magnesium is a very powerful softener as well as a weighting material, and one of its uses is to prevent the gritty feel which the addition of clay alone would give to the cloth. It has a great affinity for water, and has thus the power of attracting moisture to the cloth in which it is used. It is this which really constitutes its softening effect.

Chloride of zinc is used to prevent mildew, which is a species of vegetable growth which often occurs in sized cloth which has been left damp, or which attracts moisture.

As chloride of magnesium attracts moisture, it is necessary to use an antiseptic which will counteract the tendency of the cloth to mildew. Chloride of zinc possesses valuable properties as an antiseptic, and therefore it is often used where chloride of magnesium is used in the size as a softening and weighting material.

If china clay is used for medium sizing without using chloride of magnesium, it is necessary to greatly increase the proportion of tallow or other softeners in the mixture. Thus, for every 100 lbs. of flour, 40 lbs. clay, and perhaps 25 lbs. tallow would be used.

Chloride of calcium has a similar effect to chloride of magnesium, but is scarcely as powerful. It is used by many in light-sizing mixtures to prevent the yarn becoming too brittle.

For heavy sizing the proportions of clay and mineral ingredients are increased. In some classes of low shirtings, over 100 per cent. is added to the weight of the yarn. The adhesive material mostly used is wheat flour, as it carries the added materials better than farina or sago; but farina is sometimes used for sizing up to 100 per cent. Sometimes two parts clay to one of flour is used for very heavy sizing.

For 100 per cent. sizing about the following proportions may be used :—

| | |
|---|---|
| Flour . . . . . . . . | 100 lbs. |
| Clay . . . . . . . . | 130 ,, |
| Tallow . . . . . . . . | 14 ,, |
| Chloride of magnesium . . . . . | 5 gallons |
| Chloride of zinc . . . . . . | 2 ,, |

Colouring matters are used in size to give the yarn any desired tinge. Blue is the most common, as it neutralizes the yellowness of the cloth given in heavy sizing. Only a very small quantity is required. Sometimes yellow is used to give a brownish appearance to American yarn, making it appear more like Egyptian. Numerous other materials are used for various purposes in sizing. "Gloy" has been found useful for strengthening warps for very heavily picked cloths.

Fig. 23 will show the principle of the slashing machine in its most usual form. The warpers' beams are placed in the creel 1, at the back of the machine. In the diagram there are six beams, 1 to 6, so that if each one contains 500 ends there would be 3000 ends in the warp. The warp passes over roller A, and into the size-box. The small roller B in the size-box is of copper, and is called the immersion roller. The warp is passed under this, and its depth in the size mixture is regulated by it. The warp then passes between two pairs of rollers, C, D, and E, F (of which D and F are covered with flannel), to squeeze the surplus size from the yarn. The size is kept boiling in the size-box by the injection of steam. When the warp comes from the rollers E, F, it passes over a large drying cylinder, M, and, after passing almost completely round it, over a smaller cylinder, N, and then round the fan P and over guide-roller Q. The warp then passes through the dividing rods R (which divide the warp into the same portions that come from each warpers' beam), thence over guide-roller S and tin

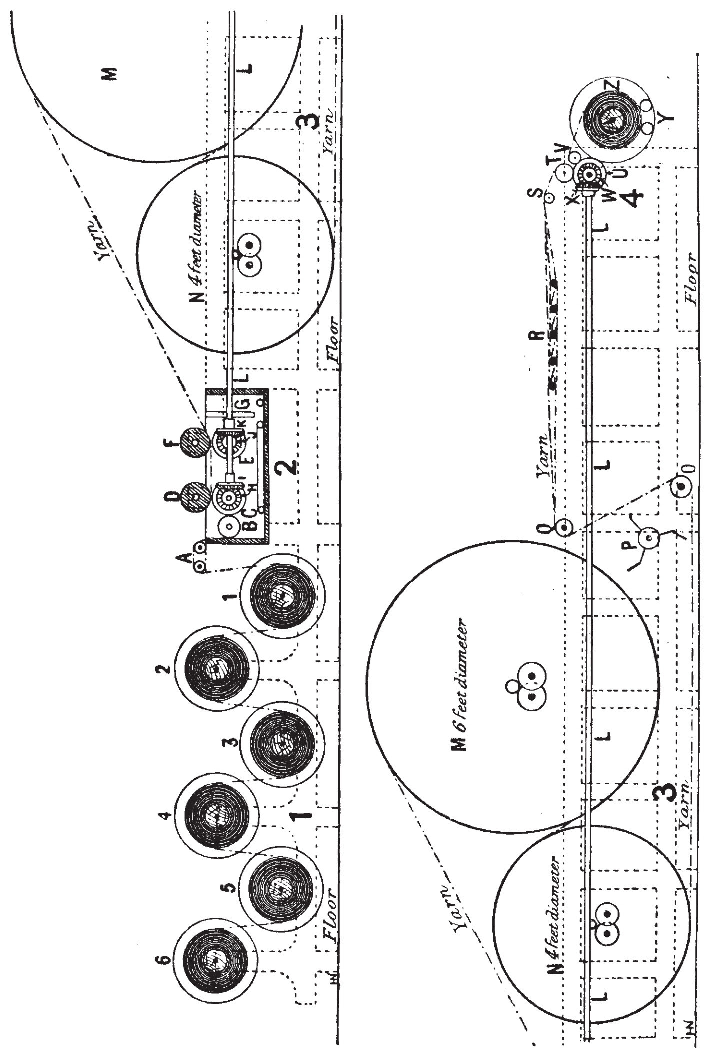

M
N 4 feet diameter
Yarn
Floor
M 6 feet diameter
N 4 feet diameter
Yarn
Floor

FIG. 23.

measuring roller T, between drawing rollers U, V, and finally on to a weaver's beam, Z. This end of the machine is called the "headstock," and comprises the measuring mechanism, dividing rods, and winding-on arrangement.

The position of the immersion roller in the size has some effect upon the amount of size retained on the warp, as by sinking the roller lower in the box the yarn will remain longer in the size, and will therefore absorb more. This roller is also mounted so that it can be lifted out of the size altogether when the machine is stopped. The larger cylinder is usually 6 feet to 7 feet diameter, and the smaller one about 4 feet diameter, and both are heated with steam.

Some machines have a revolving brush between the size-box and the cylinder. This brush is usually driven from the fan shaft, and its object is to lay the projecting fibres, and so strengthen the yarn. Brushes are only used in some fine-weaving districts, and not always there. The brush gives the threads a round, smooth feel, and prevents them sticking together. Under the brush which brushes the yarn a smaller brush is placed, running at a slower speed than the one above it; the lower brush is placed a short distance into the upper one, and serves the purpose of cleaning it as it revolves.

The marking mechanism in the slashing frame usually consists of a tin roller wheel, B (Fig. 24), driving the wheel D, called the "stud wheel"; a screw or worm, E, on this stud drives the bell wheel F. The marking hammer L is situated immediately above a vessel containing colouring matter, and is lifted by a cam, P, driven from the tin roller, and dropped suddenly on the warp, marking it to the required lengths.

The length between each mark is regulated by the wheels used. The tin roller wheel being the driver, if this is divided into the product of the stud wheel and bell wheel, it will give the number of revolutions of the tin roller for each mark, and this multiplied by the circumference of the roller will give the length of the mark. The formula will stand thus—

$$\frac{\text{stud wheel} \times \text{bell wheel} \times \text{circumference of roller}}{\text{tin roller wheel}} = \text{length of mark.}$$

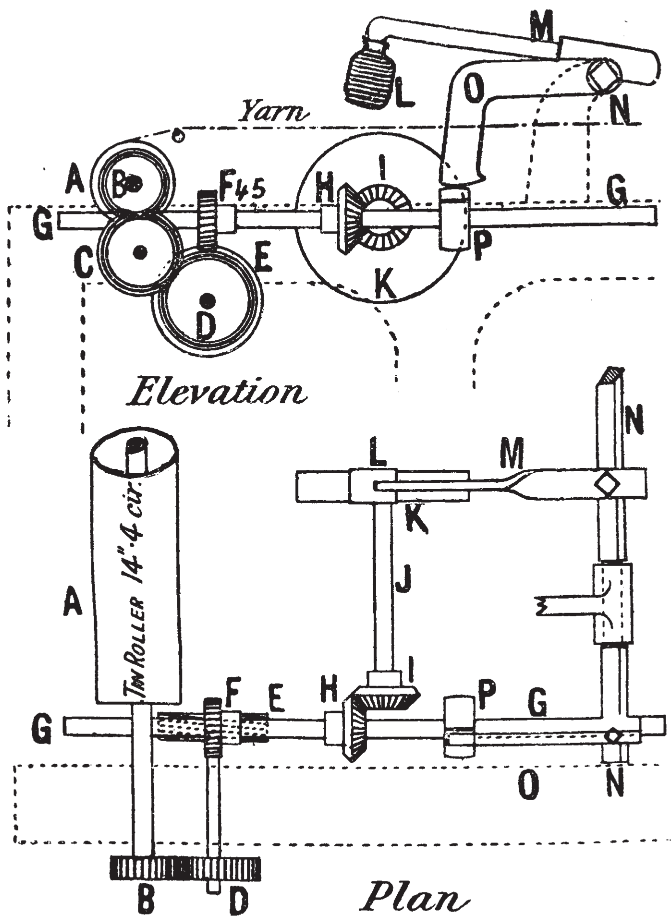



Fig. 24.

If the stud wheel contains 90 teeth, the bell wheel 45 teeth, the tin roller wheel 60, and the roller is 14·4 inches circumference, the length of the mark will be

$$\frac{90 \times 45 \times 14{\cdot}4}{60} = 972 \text{ inches}$$

There are other marking motions in use for marking short lengths for dhooties and scarves of various kinds, some being constructed so as to mark scarves of two different lengths in

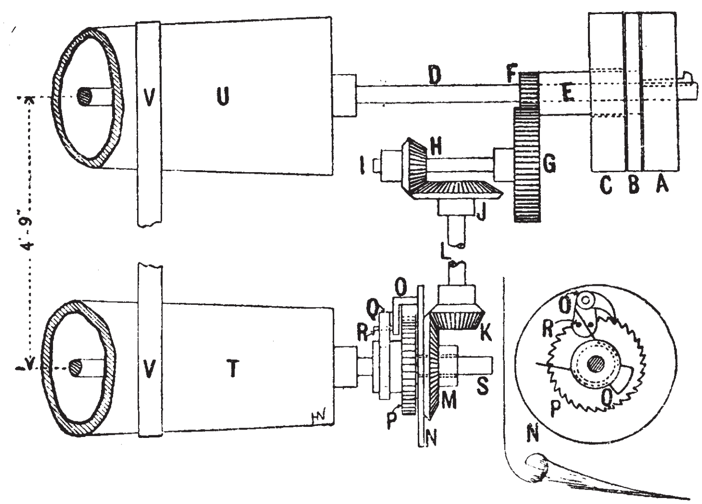



Fig. 25.

succession—say one scarf is marked 2 yards long, and the next one 4, the two being repeated.

A "slow motion" arrangement is used for keeping the machine moving very slowly whilst the weaver's beam is changed. If the machine is stopped completely, the warp becomes marked where it rests on the drying cylinders. Fig. 25 shows the principle of this arrangement. There are three pulleys, A, B, C, on the driving shaft D. Between the fast and loose pulleys A, C, the slow motion pulley B is placed. When the belt is moved from the fast pulley to the slow motion, the wheel F is set in motion and drives another wheel, G, and this, through the bevel wheels H, J, K, M, causes the catch O to drive the ratchet wheel P on the driven cone shaft T. As the motion of the driving catch O is slower than the cone T when driven by the fast pulley, the catch O will begin to work when the strap is moved from the fast pulley to the slow motion pulley, and the speed of the machine is reduced to the point where the catch O overtakes the driven cone T.

Hot-air drying has been employed in place of cylinder drying, but is not much used. In this system of drying the warp passes from the size-box to hot-air chambers. The air is heated with steam pipes and driven through the chambers by fans. Combinations of cylinder and hot-air drying have also been used, but with little success.

In a slasher sizing machine, yarn is withdrawn from back beams and finally wound upon a weaver's beam at a uniform pace, notwithstanding the gradually increasing diameter of the latter as it fills with yarn. It follows, therefore, that the velocity of a beam must gradually diminish from the commencement of winding. In order to meet such requirement a beam is driven negatively by means of a frictional driving motion, one of which is shown in sectional elevation in Fig. 26. This motion consists of a tooth wheel, A, whose sides are extended beyond its proper teeth to form inner flanges, which latter are turned at right angles to form an outer rim. Two outer flanges, B, interlock with the rims of wheel A, as shown at C, so that wheel A and flanges B always revolve at the same velocity. Enclosed within each chamber between the inner flanges of A and outer flanges B is a sheet steel disc, D, encased within two flannel washers, E, and secured to a hub which rotates on a hollow beam shaft, O, in which is cut a channel or

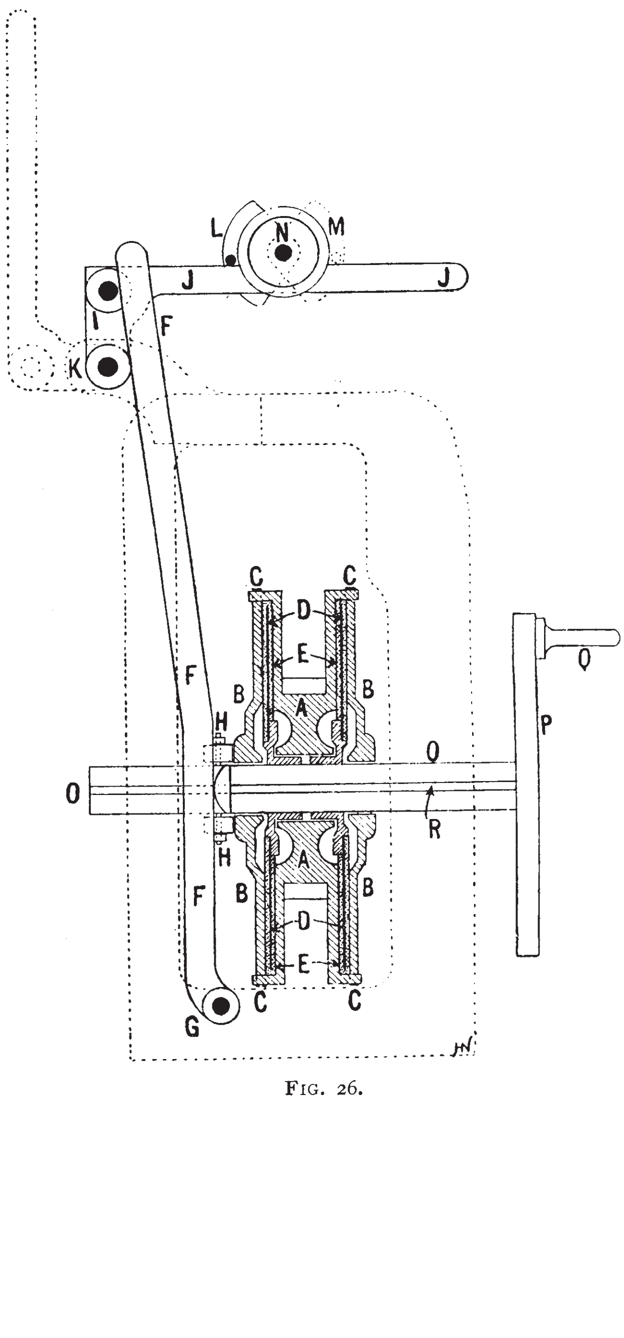



FIG. 26.

key-bed, R. The hubs of steel discs D being furnished with a key that enters the channel R, are free to slide upon shaft O, which they rotate at the same velocity. The hub of wheel A revolves freely upon the hubs of discs D; also, the hubs of flanges B revolve freely upon shaft O; therefore, by compressing the flanges and discs together, any degree of friction, within certain limits, may be induced. Pressure is applied to the flanges by means of a vertical lever, F, fulcrumed at G, and elbow lever J fulcrumed at K. A stud, I, in lever J bears against lever F with a force that may be regulated by means of an adjustable weight, L, N. On the inner end of shaft O, which receives one of the beam gudgeons, is a disc, P, furnished with a stud or peg, Q, to which is attached a rope or strap that encircles and grips one end of the weaver's beam, which is thereby turned. As a beam becomes filled and its velocity diminishes, the slippage between discs D and the driving flanges increases, because the velocity of the driving flanges remains undiminished.

### *Automatic Supply of Size to a Sizing Machine.*

There are numerous devices for the purpose of ensuring a continuous and automatic supply of size to the size-box of a slasher sizing machine. One of these is represented in Figs. 27 and 28. From the last mixing beck 3 (Fig. 22) size is pumped into a storage beck, 5, whence it is withdrawn and forced by a ram, N, along feed pipe Q, which is coiled within a steam-heated chamber, U. From the steam chamber it returns along pipe T, through regulating valve Z, and into the size-box, in a boiling state. Within a separate chamber of the size-box is a floating copper roller, X, connected at one end by means of rod Y to a tap which regulates the flow of size through valve Z, on the principle of a ball tap.

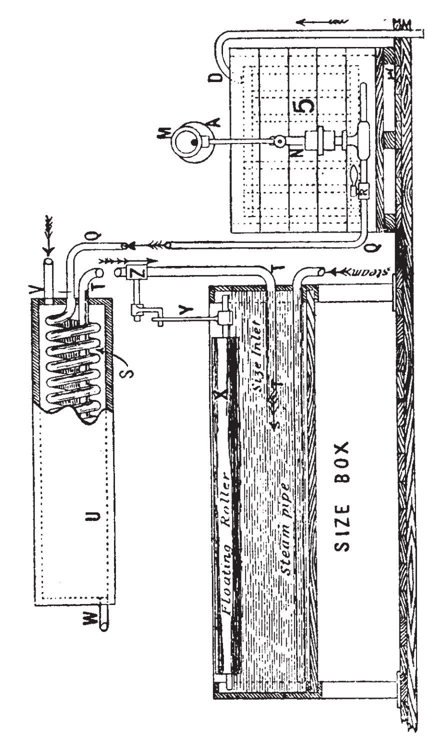

SIZE BOX
Floating Roller
Steam pipe
Size inlet
Steam

FIG. 27.

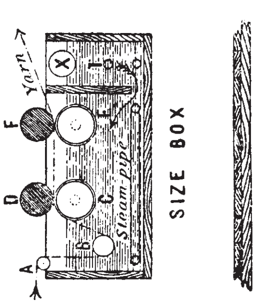

SIZE BOX
Steam pipe
Yarn

FIG. 28.

**Scotch dressing** is another system of applying size to the yarn. This is a much slower method than slashing, and is chiefly suitable for very fine yarns. In this machine the weaver's beam is placed above an expanding reed, R (Fig. 29),

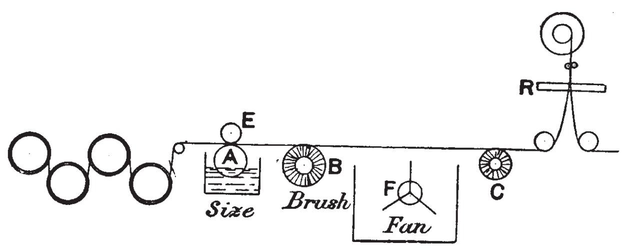



FIG. 29.

and to prevent the ends being crowded the warper's beams are divided, one-half the ends being placed at each end of the machine. The warp is passed through a pair of rollers, A E, the top one being very heavy. The lower roller of the pair is immersed some distance in the size, and takes the size up to the yarn. After emerging from the rollers or "squeezers," the yarn passes through a revolving brush, B, and over a fan in a hot-air chamber, F, then through another brush, C, round a guide-roller through the expanding reed to the weaver's beam. The opposite half of the machine is a duplicate of this. By this process the yarn is greatly strengthened. The brushing lays down all the projecting fibres, and makes the thread round, preventing any caking of the size on the threads. The production, of a machine of this kind, is much less than that of a slashing frame, as only about five beams a day can be dressed,

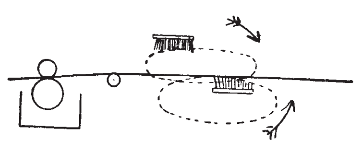


FIG. 30.

whilst about fifteen beams could be slashed in the same time. Instead of the circular brush B, sometimes flat brushes are used. These are made to work on both sides, as shown at Fig. 30. The dotted lines show the movement of the brushes.

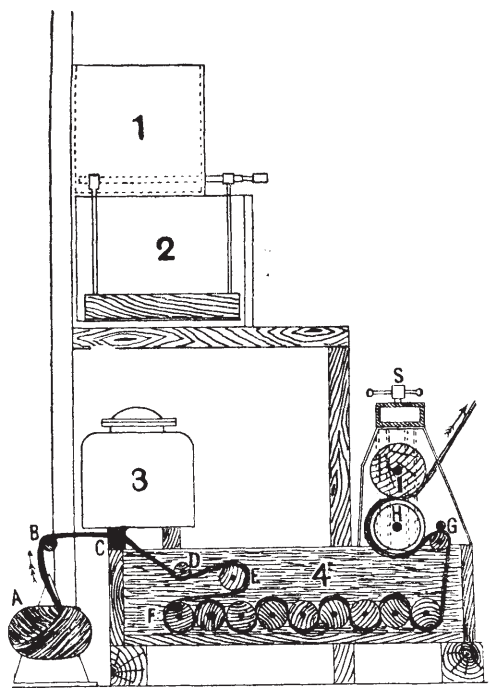



FIG. 31.

The warp is brushed in the opposite direction to that in which it is moving.

### *Ball-warp Sizing.*

Fig. 31 is a sectional elevation of a sizing machine for ball-warps. One or more warps, A, are placed upon cones, and their yarn guided over rollers, B, C, into a large size-box, 4, containing a series of rollers, between which yarn passes until it emerges at guide-roller G, when all excess of size is removed by rollers H, I. From the squeezing rollers, yarn is conducted to a drying machine (Fig. 32), consisting of a series

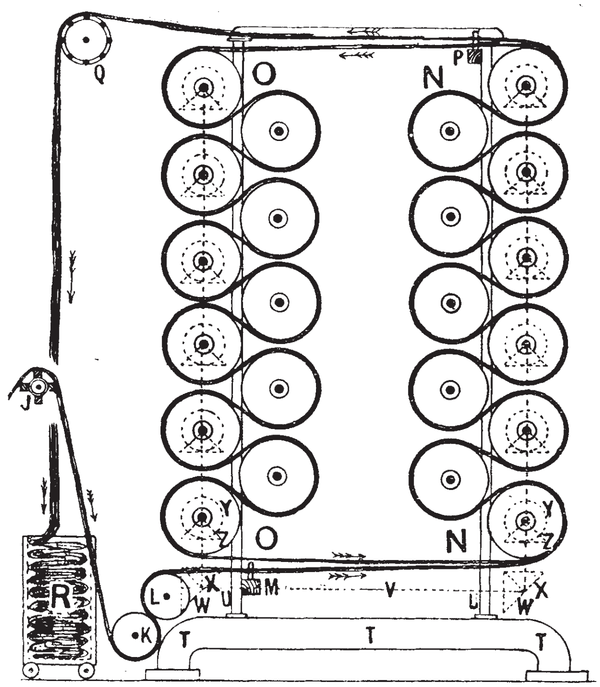



Fig. 32.

of steam-heated cylinders arranged in two vertical zigzag rows, O, N, the outer rows of which are driven from vertical shafts containing a series of bevel wheels, Z, gearing with bevel wheels Y at one end of the cylinder shafts. By this means yarn is subjected to little tension, and its elasticity is better

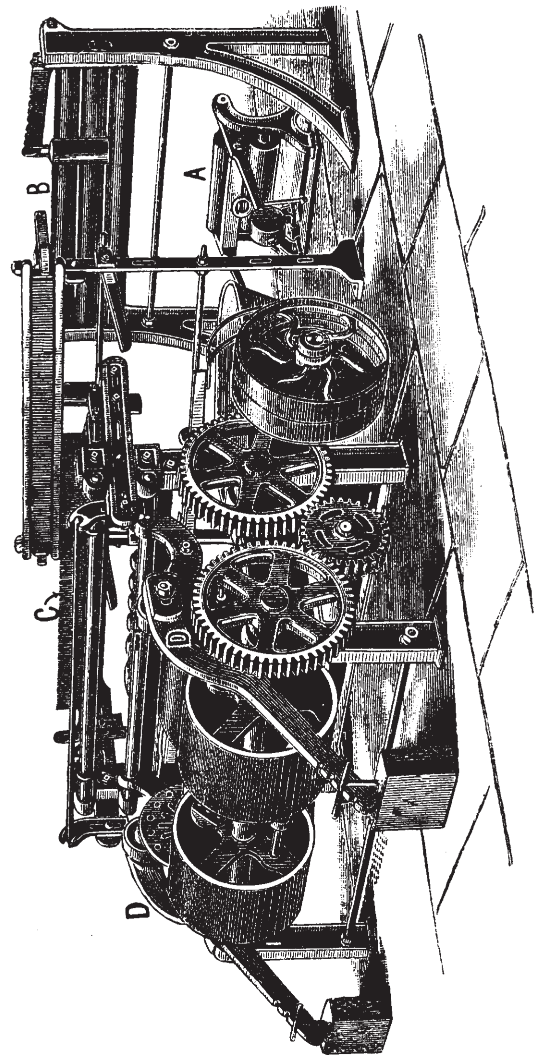



Fig. 33

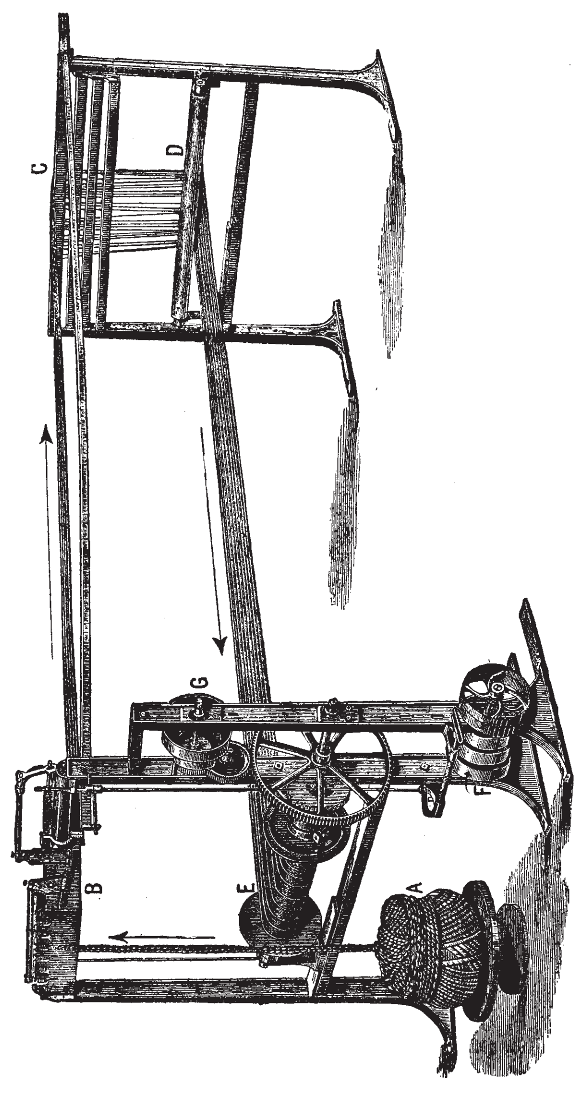



Fig. 34.

preserved. After drying, the warps are deposited in box crates, R, to be subsequently re-balled, ready for beaming or winding on to a weaver's beam.

### *Beaming.*

Beaming machines exist in great variety, but they may be classed under the heads of (1) press beaming, and (2) tension beaming machines. An example of the first-named type, as made by Butterworth and Dickinson, Ltd., is illustrated in Fig. 33. If beaming is accomplished from back beams prepared by a beam warping machine, a creel or stand capable of holding several beams is situated in the rear of the headstock of the beaming machine; but if beaming is from ball-warps, yarn from the latter is passed in a circuitous manner under and over tension and guide rollers A, B, for the purpose of tautening and separating warp-ends, which are finally passed through the dents of an expending comb, C, and on to a weaver's beam. By causing weighted levers, D, to bear upon the beam-ends during winding, a hard and compact beam is made.

A tension beaming machine of the type known as a Yorkshire dressing machine, as made by Hattersley & Sons, is shown in Fig. 34. Yarn from a warp, A, or from several sections of warps, is conducted under and over the bars of a tension ladder, B, thence around dividing bars, C, between tension rollers, D, and finally through a wraith or coarse reed on to a weaver's beam, E; but if Yorkshire dressing proper is adopted, warp-ends are passed through the dents of a reed in groups of two to four, and disposed according to pattern (if any) before passing on to a weaver's beam ready for weaving in the loom. By means of stepped speed pulleys, F, G, the velocity of a beam may be retarded at intervals, to compensate for the gradually increasing diameter of a beam, and thereby maintain a uniform rate of winding.

# CHAPTER II

## *HAND AND POWER LOOMS*

THE three principal movements in weaving are shedding, picking, and beating up the weft. By shedding is meant opening

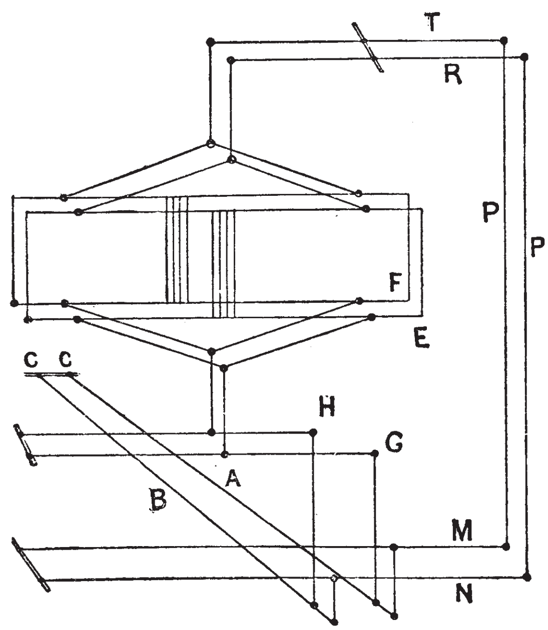



FIG. 35.

the warp threads to allow the shuttle containing the weft to pass over certain ends and under others. In the common hand loom the shed is made by the weaver operating treadles with his feet. Fig. 35 shows the method of connecting the shafts or staves with the treadles for weaving a plain cloth. There are two treadles, A and B, placed underneath the loom, and centred at C. The stave E is connected to the treadle A through the lever G. The stave F is connected to the same treadle through the "tumbler" T and the lever M. When the treadle A is pressed down it will take the stave E down, and the stave F up. For the second pick, the stave F is connected to the treadle B through the lever H, and the stave E is connected to the same treadle through the "tumbler" R and the lever N. Therefore, when the treadle B is pressed down, it will take the stave F down and stave E up. By alternately pressing first one treadle and then the other, we get each stave up for one pick and down for the next, alternately, as required for weaving plain cloth. The levers M and N are usually called "long lams," the levers G, H "short lams," and the top levers R, T "tumblers." The cords PP connect the long lams and tumblers together at the side of the loom.

In mounting this loom for weaving a three-shaft twill, three treadles are required, one treadle for each pick in the pattern. Supposing one stave to be down and two up for each pick. The stave required to be taken down for the first pick must be connected to the first treadle through a short lam, and the two staves required to be taken up must be connected to the same treadle through their long lams and tumblers. Each pick in the pattern must be gone through in this manner. A separate treadle is required for every pick in the pattern, unless the same pick is repeated, in which case one treadle will do for more than one pick. It is not advisable to break the regularity in the order of treading in order to save a treadle; but in diaper patterns and similar weaves the effect of a point draft is obtained by reversing the order of treading.

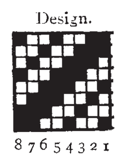



FIG. 36.

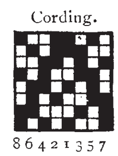



FIG. 37.

Figs. 36 and 37 show the design and cording plan respectively for a twill cloth requiring eight treadles.

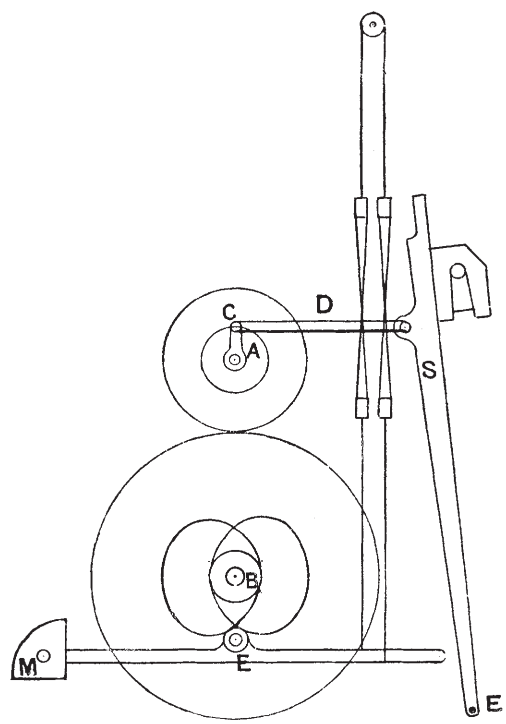



FIG. 38.

The hand loom is practically obsolete in the cotton trade, but it is still extensively used in silk manufacture, where power looms, as at present constructed, are not found advantageous for weaving the finer classes of goods.

The chief shedding motions in power looms are tappets, dobbies, and jacquards.

There are various kinds of tappets, the simplest and best for plain or twill weaving being those sh‑.wn at Figs. 38 and 39. The former is \.ne more general arrangement. In this the tappets are placed under the loom, inside the framework. In the arrangement shown at Fig. 39 the tappets are placed *outside* the loom, and thus a larger amount of floor space is taken up by the latter than the former.

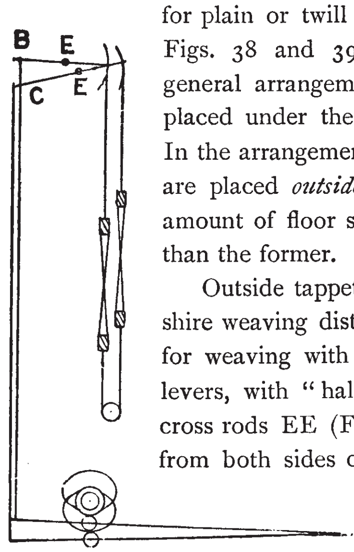



FIG. 39.

Outside tappets are mostly used in the Yorkshire weaving districts, and are commonly made for weaving with about eight shafts. The top levers, with "half moons," are centred at the cross rods EE (Fig. 39), and the heald is lifted from both sides of the loom. The top levers are very useful for equalizing the shed, as the connection with the upright rod can be altered without difficulty.

In a power loom there are two horizontal shafts, the top shaft A (Fig. 38) and the bottom shaft B. The former is used for working the slay, by means of the crank C, and the connecting rod or "crank arm" D (Fig. 38). The bottom shaft is used for "picking," and for this purpose it is necessary that the shaft should revolve at one-half the speed of the top or crank shaft. The toothed wheel on the bottom shaft must therefore contain twice the number of teeth in the wheel on the crank shaft which drives it. As a plain cloth contains two picks to the round, and the bottom shaft makes one revolution for two picks, the tappets are fixed to the bottom shaft. Each tappet acts upon treadle bowl E, and therefore the size of the bowl will require to be taken into consideration in shaping the tappets. For weaving plain cloth four staves are usually taken, in order to prevent overcrowding the healds on each stave, the ends being drawn through the staves in the order 1, 3, 2, 4. As the staves are fastened together in pairs, this is the same as two staves.

The kind of movement to be given to the staves is very important, especially in quick-running looms. The staves should be moving quickest when they are level, and their speed should gradually decrease as the shed opens. It is obvious that a movement of this kind will put as little strain as possible on the warp, and therefore cause the fewest breakages. The depth of the shed should only be sufficient to allow the shuttle to pass, therefore the "lift" or stroke of the heald is dependent upon the depth of the shuttle used. The shed when opened should remain open only long enough to allow the shuttle to pass through.

*Example.*—What lift should a tappet have to make a plain cloth, the other arrangements in the loom being as follows: Sweep of slay $5\frac{1}{2}$ inches, distance of healds from cloth 8 inches, heald connected to treadle 24 inches from fulcrum, distance from fulcrum to centre of treadle bowl 16 inches, size of shuttle $1\frac{1}{2}$ inch broad, $1\frac{1}{4}$ inch deep?

Assuming that the tappets are under the loom, as in Fig. 12, the treadle bowl E is 16 inches from M, and the heald connected 24 inches from M. If slay moves back from cloth $5\frac{1}{2}''$, and the shuttle is $1\frac{1}{2}''$ broad and $1\frac{1}{4}''$ deep, it follows that the shed must be $1\frac{1}{4}''$ deep, or a little over, at a point $4''$ from the cloth ($5\frac{1}{2}-1\frac{1}{2}=4$). Then if the heald is $8''$ from cloth, the stroke of heald may be obtained—$4 : 8 :: 1\frac{1}{4} : 2\frac{1}{2}''$ stroke of heald, and as $24''$ treadle $: 16 :: 2\frac{1}{2} : 1\frac{2}{3}$ lift of tappet required.

To obtain the proper shape of the tappets for a plain cloth, the lift or stroke of the tappets to give the required lift to the healds must be obtained. If the lift of the heald is required to be 4 inches, and the centre of the treadle bowl E (Fig 38) is situated 12 inches from the fulcrum of the treadle M, the heald being connected to the treadle at, say, 18 inches from the fulcrum, the lift or stroke of the tappet will be obtained as follows :—

$$\begin{array}{rl} \text{As} & 18 : 12 :: 4 \\ & \quad\;\; \underline{4} \\ & 18 \;)\; 48 \;(\; 2\tfrac{2}{3} \text{ lift of tappet} \\ & \quad\;\; \underline{36} \\ & \quad\;\; 12 \end{array}$$

In some makes of looms the staves are connected to the treadles at a point between the fulcrum and the treadle bowl,

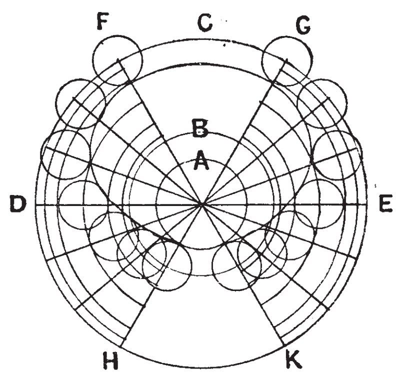



FIG. 40.

the fulcrum being at the front of the loom. This necessitates a larger lift of tappet than lift of heald. The tappets in this case are very large, and are preferred by some manufacturers.

**To construct a tappet for a plain cloth from the following dimensions.**—Lift of tappet, 4 inches. Distance from centre of shaft to nearest point of contact with treadle bowl, 2 inches; dwell one-third of a pick. Diameter of treadle bowl, 2 inches.

At a radius of 2 inches describe the circle A (Fig. 40).

This circle represents the distance from the centre of the shaft to the nearest point of contact with the treadle bowl.

At a radius of 3 inches describe the circle B. One inch added for radius of treadle bowl.

At a radius of 7 inches describe the circle C. Four inches added for lift.

The circle B represents the centre of the treadle bowl when the inner circle of the tappet is acting upon the bowl.

The circle C represents the centre of the bowl when pressed down by the tappet.

The pattern being a plain one, the circle must be divided into two equal parts, and each half-circle will then represent one pick. By the line DE divide the circle into two equal parts. Then, as the healds must have a pause or dwell equal to one-third pick when at the top and bottom of their stroke, divide each half-circle into three equal parts by the lines FK, GH. Divide FH and GK each into six equal parts, and divide the space between the circles B and C into the same number of unequal parts, the largest being in the middle, gradually decreasing towards the circles B and C.

From the corners of these unequal spaces, and with the radius of the treadle bowl in the compasses, describe circles representing the position of the treadle bowl at different parts of its movement.

Draw the curved line touching the extremities of the treadle bowl. This gives the outline of the tappet.

As previously stated, the movement of the heald must be quickest when the shed is nearly closed, and must gradually decrease in speed as the shed opens. The unequal spaces into which the lift of the tappet was divided give this eccentric movement to the heald. The curve of the tappet will approach nearer to a radial line as the shed closes, and the heald approaches the centre of its stroke. Referring to Fig. 40, it will be seen that the treadle bowl is at rest from F to G and from H to K, or one-third of a pick at both the top and bottom of the stroke. Therefore the time allowed for change, or for moving the heald from top to bottom, or *vice versâ*, is equal to two-thirds of a pick. If a dwell equal to half a pick is required, it can be obtained by dividing the pick into four equal parts and taking the middle two parts for dwell. If two-thirds dwell is required, divide the pick into six parts and take four parts for dwell.

It is usual to give the tappet which operates the back heald a slightly larger lift than the tappet which operates the front heald. The difference required can be easily calculated. In looms with the fulcrum of the treadles at the front, and the healds connected to the treadles between the fulcrum and the treadle bowls, some of the required extra lift is obtained by connecting the back heald to the treadle at a point further from the fulcrum than the front heald is connected. In looms with the fulcrum of the treadles at the back of the loom, and the tappets acting between the heald and the fulcrum, there will be a greater difference between the size of tappets in proportion to the lift than in the former case.

Tappets for twills, and other simple weaves, having more than two picks to the round, are usually placed upon a counter-shaft, but outside tappets are usually worked loose upon the bottom shaft.

The following example will illustrate the principle of constructing twill tappets :—

Draw a tappet for a 3 up and 1 down twill. Distance from centre of shaft to nearest point of contact with treadle bowl 3 inches, lift 3 inches, bowl 2 inches diameter, dwell $\frac{1}{2}$ pick.

At a radius of 3 inches describe the circle A (Fig. 41). At a radius of 4 inches describe the circle B (one inch added for treadle bowl). At a radius of 7 inches describe the circle C

(3 inches added for lift). There being four picks in the pattern, divide the circles into four equal parts by the lines DE, FG. Then each quarter-circle represents one pick, and the tappets must be made to make one revolution for four revolutions of the crank shaft. As the dwell of the heald (when the shed is open) must be equal to half a pick, or half a revolution of the crank shaft, divide the first pick into four equal parts by the points O, L, M; make DP equal to DO, and

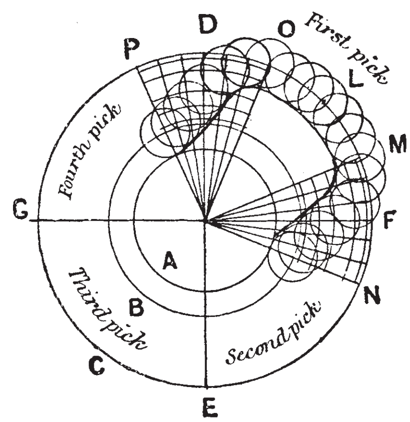



FIG. 41.

FN equal to FM, and rule lines from P, O, M, N to the centre. The distance OM represents the half-pick dwell, and the distances OP and MN represent the half-pick which will be allowed for changing the heald from bottom to top of its stroke, and *vice versâ*. Divide OP and MN into six equal parts, and the lift of tappet, or the distance between the circles B and C, into six unequal parts, the largest in the middle and gradually decreasing towards the two circles. From the corners of the unequal spaces describe the small circles representing the treadle bowl at different parts of its stroke, and draw the outline of the tappet touching the extremities of these circles.

A tappet of this shape acting upon a treadle bowl two inches in diameter will take the heald down for one pick and allow it to go up for three picks. The heald will be held stationary for exactly half a pick when at the bottom of its stroke, and will begin to rise slowly, and gradually increase in speed as it approaches the centre of its stroke, and will gradually decrease in speed as it approaches the top of its stroke. The downward movement will be an exact counterpart of this. In this kind of tappet it will be noticed that the heald, when it gets to the top (if it is required up for more than one pick), remains stationary until it is required to come down. Thus the heald remains at the top while the circles revolve from N to P.

For this twill there will be four treadles, each treadle being operated by a tappet of the same shape; but the tappet operating each succeeding treadle will be placed one quarter of a revolution later than the previous one.

The size of the treadle bowl has a very appreciable effect upon the shape of the tappet, more especially when there are several picks to the round. The movement imparted to the *centre* of the treadle bowl will be the exact movement given to the heald as far as regards dwell and eccentricity, and as the tappet acts on the treadle bowl at a distance of 1 or 2 inches from the centre, the required amount of dwell and eccentricity must be given to the centre of the bowl, and the shape of the tappet obtained accordingly. It will be noticed at Fig. 41, that to give a dwell of half a pick to the centre of the treadle bowl, a slightly longer dwell is on the tappet at the inner circle; and as the size of the treadle bowl increases, this hollowing out of the tappet must be increased in order to keep the dwell of the heald the same.

Fig. 42 is a drawing of a tappet for a 3 down, 1 up, 1 down, 1 up (six to the round) twill. Centre of tappet shaft to nearest point of contact with bowl 4 inches, lift of tappet 2 inches, bowl $1\frac{1}{2}$ inch diameter, dwell one-third of a pick.

To construct this tappet :—At a radius of 4 inches describe the circle A. At a radius of $4\frac{3}{4}$ inches describe the circle B.

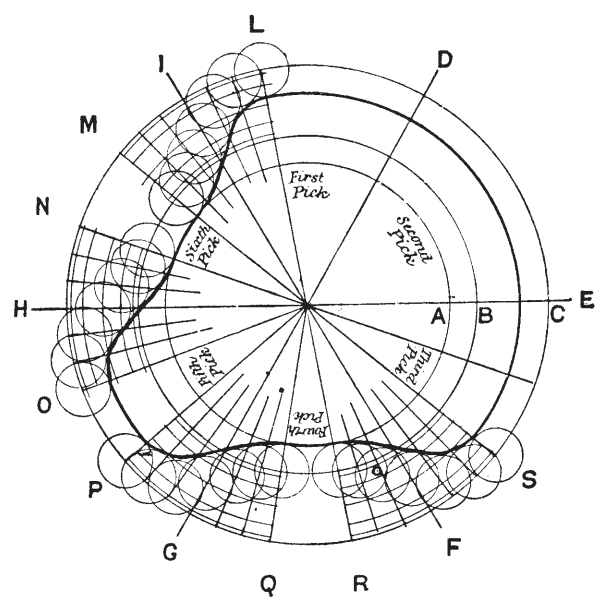



FIG. 42.

At a radius of $6\frac{3}{4}$ inches describe the circle C. As there are six picks to the round, divide the circles into six equal parts by the lines D, E, F, G, H, I. As there is one-third pick dwell, divide each pick into three equal parts, and take the middle one for dwell. Rule the lines L, M, N, O, P, Q, R, S to the centre, and divide the spaces allowed for change into six equal parts, and the distance between the circles B and C into six unequal parts, as in the previous examples. From the corners of the unequal spaces describe the circles representing the movement of the treadle bowl, and obtain the shape of the tappet accordingly. It will be noticed that at point L the treadle bowl begins to dwell, and remains stationary until it reaches the point S, when it begins to go up. The heald will thus be down

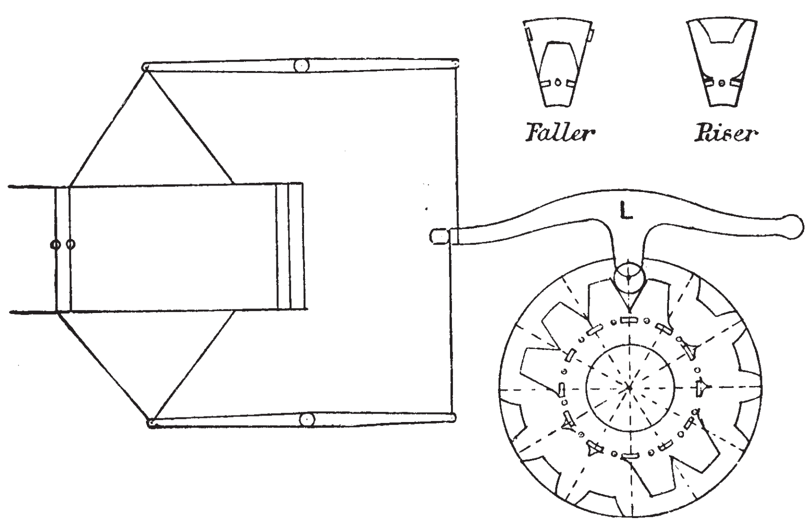



FIG. 43.—Woodcroft's Tappet.

for the first, second, and third picks, up for the fourth, down for the fifth, and up for the sixth.

**Woodcroft's Section Tappets** are much used in weaving heavy goods, such as velveteens and corduroys. They are made with various numbers of sections to the round. A single tappet plate of one twelve picks to the round is given at Fig. 43. Sections are sometimes made in two kinds only. These are termed "risers" and "fallers," according as they raise or depress a heald respectively. Each heald requires one plate and lever L, and as the tappets revolve, the lever L is moved up and down. When the lever L is lifted, the heald is moved downwards. A difference in the character of the shed produced by these tappets as compared with ordinary tappets

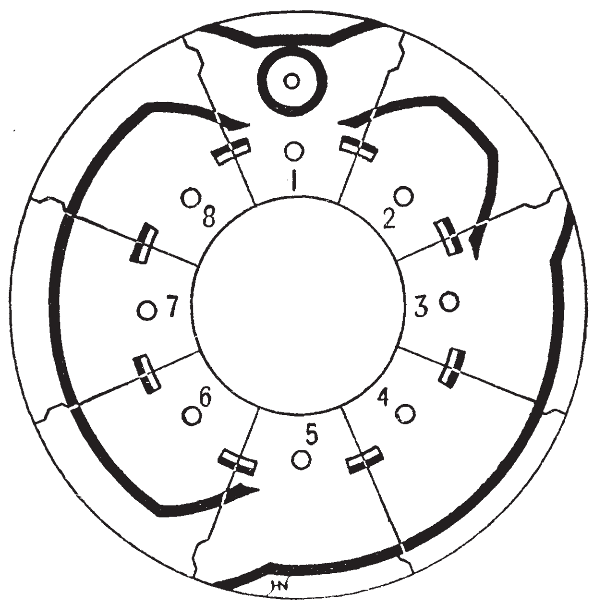



FIG. 44.

Woodcroft Section Tappet.—Sect. 1, riser (heald-up); sect. 2, faller (heald-down); sect. 3, left-hand riser; sect. 4, neutral riser; sect. 5, right-hand riser; sect. 6, left-hand faller; sect. 7, neutral faller; sect. 8, right-hand faller.

will be noticed. When the lever L is lifted for two or more picks in succession, it comes down about half-way each pick. This is unavoidable in section tappets consisting only of "riser" and "faller" sections, which must join together exactly wherever inserted, thereby causing all the healds to come towards the centre of the shed after every pick. If there are twelve sections to the round, any pattern repeating on three, four, six, or twelve picks may be woven.

It is sometimes considered an objectionable feature of section tappets (as represented in Fig. 43) that they cause all healds to be brought level after every pick, thereby producing jerky shedding. This objection, however, has been overcome by the construction of eight distinct varieties of sections, as shown in Fig. 44, whereby healds may remain either up or down for several picks in succession on the "open-shed" principle, as with ordinary box-plate tappets cast in one piece.

## OSCILLATING TAPPETS.

Another form of shedding device, which embodies certain features of ordinary rotary tappets and dobbies, is that known as the oscillating or rocking tappet, an example of which is shown in Fig. 45. This type of shedding motion consists of a series of plates, B, cast with upper and lower projecting ridges, C, D, and fulcrumed on shaft A, upon which they oscillate in a manner indicated by arrows, E. A movement in either direction represents one pick. On each side of the rocking shaft A, and oscillating with the tappets, is a pattern chain, F and F′, composed of bowls and bushes threaded upon spindles, G. Pattern chains, which represent odd and even picks respectively, are rotated alternately and intermittently, one spindle for each pick, thereby causing elbow-levers H to be raised or depressed, according to whether a bowl or a bush is presented underneath them respectively. The vertical arms of H act upon loose plates, I (termed "duck-bills"), which are fulcrumed upon short studs, J. Grooves may thus be formed between either the upper or lower ridges of tappet plates, and the upper or lower edges of "duck-bills," which grooves, by acting upon treadles K, governing healds, will operate the latter in a manner determined by the pattern chains.

Oscillating tappets are situated at one end of a loom, above the crank shaft, from which they are driven by wheel gearing

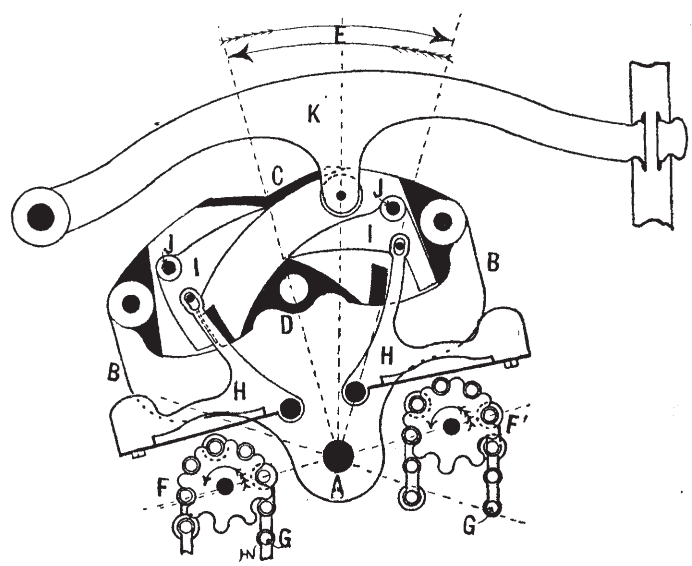



FIG. 45.

and suitable connecting arms. They are chiefly employed on looms weaving fustians and similar heavy and strong fabrics.

In plain looms with under tappets, the healds are generally connected round a top roller or cone, so that when the tappet is pressing one stave down, it is also taking the other stave up. The shedding is thus positive. For weaving twills, satins, and such weaves, either spring, roller, or pulley top motions are used.

Where spring tops are used, the tappet pulls the heald down, and the spring pulls it up again. Of course, the speed at which the heald moves upward will be controlled by the shape of the tappet exactly as it is in its downward stroke, but in the up stroke of the heald, the tappet is only acting negatively. With roller tops the movement is positive, as the rollers are so constructed that as one stave is taken down by the tappets another is taken up. If two staves are taken down, two will be taken up, and the tappets must be constructed so as to allow

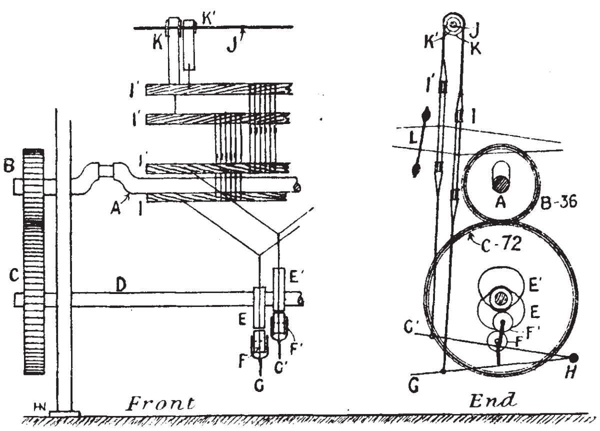



FIG. 46.

this. It is very important also that the tappets should be of the proper shape, and the exact counterpart of each other, so that any one stave is allowed to go up at exactly the same speed, and with the same amount of eccentricity in its movement, as any other stave which is being taken down by the tappets. Fig. 46 shows the top roller arrangement for plain cloth. Straps are connected to the staves over the rollers K, $K^1$; so that when one stave is taken down by the tappet, the other is taken up.

For three staves the arrangement of rollers as shown at Fig. 47 is used. The diameter of B must be twice that of A.

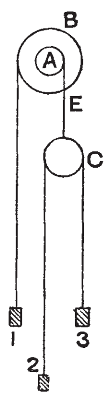


FIG. 47.

Sometimes a pulley is used at C, but when it is a roller, it is fitted into slots at the ends so as to allow of its being lifted. The diameter of C is immaterial, but the reason for B and A being as 2 : 1 is that when the first heald is taken down, either the second or third must be taken up the same distance. Suppose the first stave is pulled down a distance of 4 inches, the strap E, being fastened to the roller A, which is half the size of B, will be taken up only two inches; and as the tappets are constructed so as to allow only one heald to go up each pick, if this heald is the second one, the third being immovable, the second will be taken up 4 inches, or the same distance that the first was taken down. If the strap E were fastened to B, the stave would be taken up eight inches instead of four. This arrangement of rollers is suitable for a 2 and 1 twill; either 2 down and 1 up, or 1 down and 2 up.

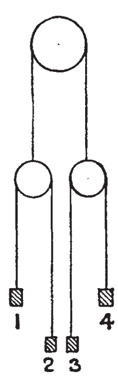


FIG. 48.

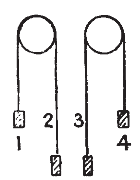


FIG. 49.


*Draft*

For four staves the arrangement shown at Fig. 48 is used. The relative size of the rollers in this case is immaterial. If the first stave is pulled down by the tappet 4 inches, and the second is the one allowed to go up, it will be taken up the same distance. If the first is being pulled down 4 inches, and the third is the one allowed to go up, the other being immovable, the strap A is pulled down 2 inches, and B lifted two inches, and the third stave will be lifted 4 inches. If any one of the four healds is pulled down, another will be lifted the same distance. This motion can be used for either a 3 and 1 twill or a 2 and 2 twill, or any four-stave pattern with the same number of staves going up as are going down each pick. The arrangement shown at Fig. 49, in which the top roller is dispensed with, is sometimes used for a 2 and 2 twill. It will not work a 3 and 1 pattern. The principle of this will be understood by carefully following the movement of staves in weaving a 2 and 2 twill. The draft used with Fig. 49 must be 1, 3, 2, 4, or the first end must be drawn through the first stave, the second end through the third stave, the third end through the second stave, and the fourth through the fourth stave. If

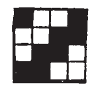


FIG. 50.

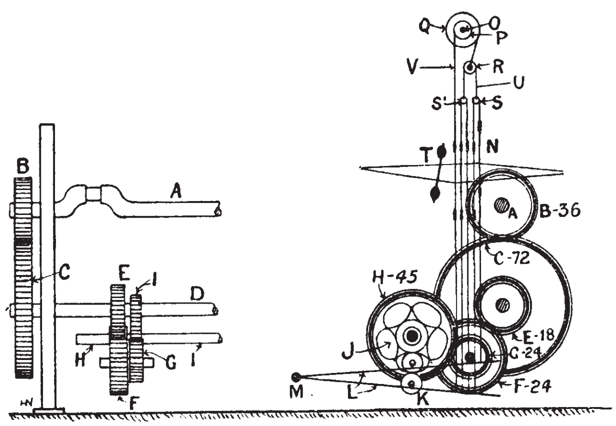



FIG. 51.

the pattern is the one shown at Fig. 50, in which the first and second ends are down for the first pick, it is obvious that to effect this the first and third staves will be down for that pick, and the second and fourth staves will be up. For the second pick the second and third ends are down, and as these are drawn through the third and second staves respectively, these staves must be down for the second pick. As the third is already down, it is only necessary to take the second down, which will pull the first up as required. The changes in this pattern will be easily understood from the following :—

1st pick : 1st and 3rd staves down, 2nd and 4th staves up.
2nd pick : 3rd and 2nd staves down, 5th and 3rd staves up.
3rd pick : 2nd and 4th staves down, 1st and 3rd staves up.
4th pick : 4th and 1st staves down, 3rd and 2nd staves up.

Fig. 51 shows a top-roller device for five healds, with bottom heald staves connected to treadles that are operated by tappets, J, fixed upon a shaft underneath, but a little in front of healds, and driven by a train of wheels from a pinion, B, on the end of the crank shaft A.

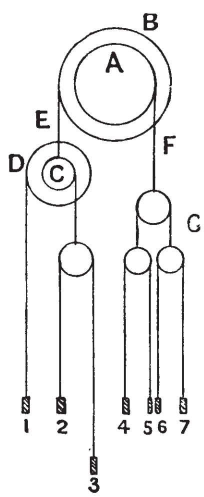


FIG. 52.

An arrangement for seven staves is given at Fig. 52. The two pulleys A and B, on the same centre, are in the ratio of 3 : 4, and the pulley D must be twice the diameter of C, the relative size of the remaining pulleys being immaterial. If the first stave is pulled down, say, 6 inches, and the seventh stave is the one allowed to go up; then the strap E will be pulled down 2 inches, and the strap F taken up $1\frac{1}{2}$ inches, the strap G 3 inches, and the stave 6 inches, which is the same distance that the other stave was pulled down. It will be the same with any other healds in the set. If one stave is taken down, any other one left loose by the tappet will be taken up the same distance. Instead of the pulleys A and B, a lever may be used with its two arms in the ratio of 3 to 4, the four staves being connected to the shorter arm, and the three staves to the longer arm.

In some looms the positions of tappets and roller heald-motions are inverted: tappets being fixed above, and roller motions below, healds. In such cases the roller motions are known as "stocks and bowls," which terms, however, more correctly describe those devices consisting of a combination of levers and bowls, or rollers, and not those consisting of rollers upon shafts. In either case, they are based upon the same

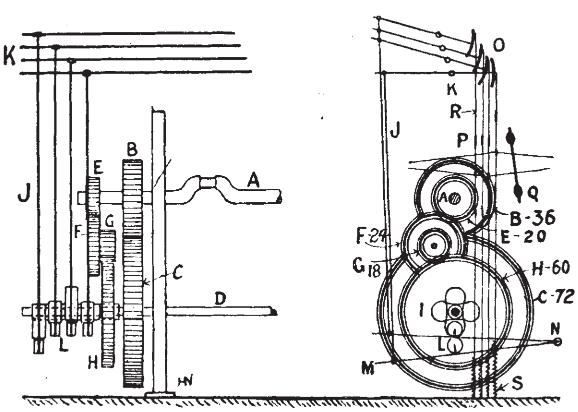



Fig. 53.

principle of leverage, and act in an exactly similar manner to each other. These devices are very limited in their scope, as regards variety of weaves for which they are suitable, and may only be employed for weaves of a regular character, in which the number of healds up and down is the same for every pick. Of course, any number of healds in a set may be up or down as required, but when once that number is selected, and healds are tied up accordingly, it may not be changed without re-tieing up.

Fig. 53 shows a front and end elevation of what is known as the Yorkshire shedding motion, in which tappets are cast upon a sleeve slid upon one end of the second motion or picking shaft D, to operate treadles, M, fulcrumed at N. Connecting rods, J, connect treadles, M, with quadrant jacks, O, secured to cross-bars, K. These serve as fulcra for the jacks, which are connected to upper heald staves, P, by means of straps and cords, R, whilst bottom heald staves are attached by cords to springs, S, for the purpose of pulling healds down, after being raised by the tappets.

## PICKING.

As soon as a warp-shed is sufficiently opened by the healds, the shuttle, containing weft, is propelled through it. That operation is termed "picking," and may be accomplished by either of two types of picking motions known as "over" and "under" picking motions. The "over-pick," also known as the "cone" and Blackburn pick (Fig. 54), is in most general use, especially for narrow and quick-running looms weaving light and medium-weight fabrics; whilst the "under-pick" (Figs. 56 and 57), of which there are many modifications, is chiefly confined to medium and broad looms, which require a picking motion capable of developing greater force. A shuttle is propelled by a picker made of hide, which is connected by means of a leather strap to the picking stick A (Fig. 54). The upright shaft B is the fulcrum of the lever. The cone C is the short arm of the lever which receives the force from the picking tappet D. The tappet is so shaped that as it revolves it gives a sudden quick movement to the cone-shaped stud, and therefore to the shuttle. It is obvious that as the shuttle must move from one side of the loom to the other, and back again, for two revolutions of the crank shaft, the picking tappets must be placed on a shaft whose speed is one-half that of the crank shaft; therefore the bottom shaft in the loom on this account is made to move at the required speed, and the picking tappets are placed on this shaft at opposite sides of the loom.

The chief requirement in a good pick is that as little force as possible shall be wasted in the loom. The relative positions of the tappet shaft and cone should be such that the force is exerted as nearly as possible in the direction of the dotted line E at right angles with the upright shaft B. It is impossible to effect this throughout the whole course of the stroke, but it is obvious that if this is approached as nearly as possible, the pick will be smooth, and the wear and tear reduced to a minimum. A very considerable amount of power is wasted if the direction of the force is too much downward.

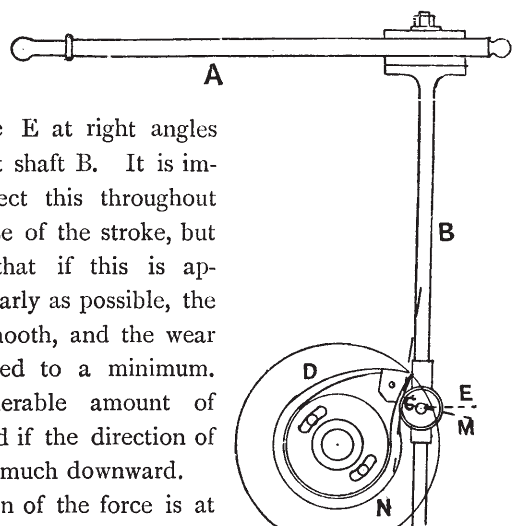


FIG. 54.

The direction of the force is at right angles to a line drawn tangent from the cone at the point of connection with the picking tappet. Thus in Fig. 54 the direction of the force is indicated by the dotted line M, which is at right angles to the dotted line N, drawn tangent to the cone at the point of connection with the tappet.

The intensity of the force depends on the length of the stroke of the tappet and on the suddenness of the curve of the working face. If in two looms the length of tappet is the same, but in one the portion of a revolution occupied in making the stroke is less than in the other, there will be a greater intensity of force in the loom with the quicker stroke. In Fig. 55 the portion of a revolution occupied in making the stroke is indicated by the angle AB. If this angle is increased, the force of the pick will be lessened, and if the angle be decreased, the force of the pick will be augmented. It will be understood from this that if the picking tappets are short the pick is liable to be harsh. If a fair length of tappet is given, a smoother and better-timed pick can be made. The curve on the picking tappet gradually approaches a radial line as it nears the end of the stroke, but the combined influence of the change in the position of the cone and the backward movement of the slay causes the shuttle to move quickest in the early part of its movement in the box.

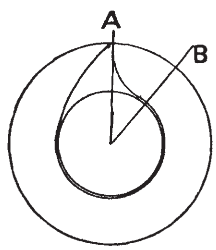



FIG. 55.

There is a relation between the length of the shuttle-box and the length of the picking tappet. If the tappet is a short one, the shuttle-box must be short; and if a longer tappet is used—the leverage of the picking arm and other parts being the same—the shuttle-box will be longer.

It is obviously inadvisable to have too short a tappet, as the movement of the shuttle in the box must in that case be extremely sudden, in order to have the necessary force.

An underpick motion is given at Fig. 56. A picking treadle, A, centred at C, is pressed suddenly down by the picking bowl B, which is fastened on to the wheel on the bottom shaft in the loom. A strap, E, connects the treadle and the picking lever. In Fig. 57 this connection is shown. The strap from the treadle is fastened to the quadrant, and as the treadle is pressed suddenly down, the picking lever H is moved forward. The shape of the curve E, which the picking bowl strikes, regulates the character of the movement given to the lever H, and it is well not to have the curve too small and sudden, or the pick will not be satisfactory. The curve on the treadle in Fig. 88 (p. 120) is perhaps better than the one in

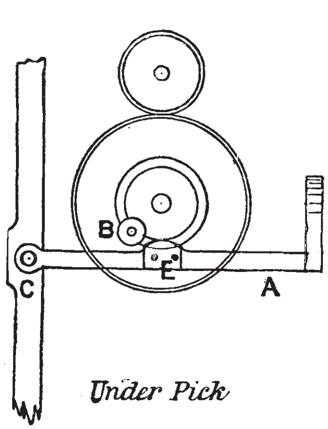



Fig. 56.

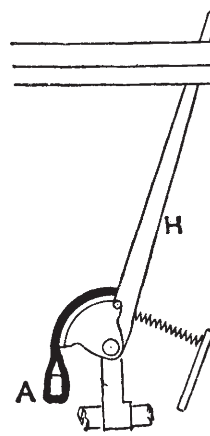



Fig. 57.

Fig. 56, as it is longer, and is therefore not liable to be so jerky.

There are numerous other picking motions, which chiefly differ in the mechanism for actuating the picking lever.

**Beating up the Weft** is the third primary movement in weaving. This movement is performed by a crank on the top shaft in the loom and a connecting rod or crank-arm which connects the crank and the slay together. This is shown at Fig. 38, where the crank C and crank-arm D give a reciprocating movement to the slay S. The slay moves upon a rocking shaft, E, as a fulcrum, and when the crank is at the front centre the slay-swords should be perpendicular, or nearly so. Sometimes the fulcrum is taken a little forward, but it is never advisable to have the slay over the perpendicular when in contact with the cloth.

The movement of the slay should be eccentric. It is obvious that when the slay is at the back of its stroke its movement should be sufficiently slow to allow time for the shuttle to pass through the shed; and that when beating up, the speed of the slay should be sufficient to knock the weft firmly into the cloth. A crank and crank-arm give the kind of movement required.

The eccentricity of the slay's movement depends upon the length of the crank and crank-arm, and upon the position of the crank-shaft in relation to the point of connection of the crank-arm with the slay. The position of the crank-shaft in relation to the connecting pin varies in different makes and widths of looms. We shall see that the position of the shaft and the direction in which the loom runs have an important bearing on the force exerted by the slay in beating up the weft. For ordinary looms the usual position of the shaft is a little below the level of the connecting pin when at the front centre, and when the shaft is in this position the movement of the slay is the most even and least eccentric. To obtain this position of the crank-shaft in a diagram, first draw the line SA (Fig. 58) to represent the slay-sword when the reed is in contact with the cloth; this we will assume is perpendicular. We will suppose SA to be 24 inches, S being the rocking shaft and A the connecting pin which connects the crank-arm with the slay. Suppose the loom we are dealing with to have a 3-inch crank and a 12-inch crank-arm. Describe the arc AN from the centre S, and mark off on the arc a distance from A equal to twice the length of the crank. As the crank is 3 inches long, mark off the point B, 6 inches from A. This point B represents the position of the connecting pin when the slay is at the back of its stroke.

From A, rule the line AX in such a position that the arc AB makes the least possible departure from it. It will be found that this necessitates AX cutting the arc AB at a point a little past the middle of the arc. With the length of the

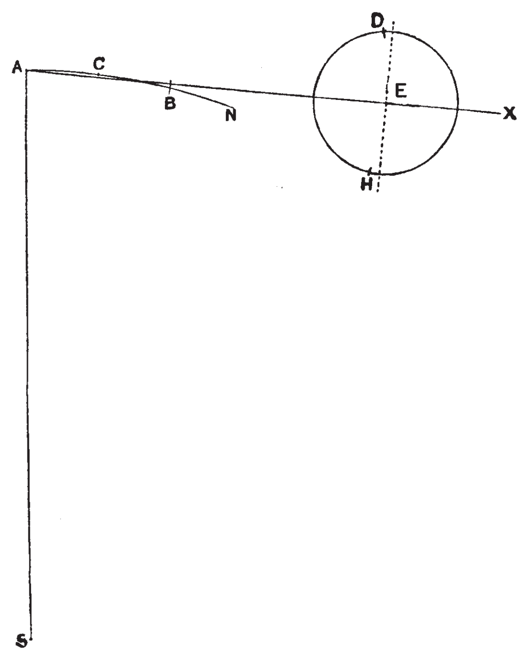



FIG. 58.

crank and crank-arm, viz. 15 inches, in the compasses, from A as a centre cut the line AX at E, and this gives the position for the crank-shaft which will give the least possible eccentricity to the slay. This will be obvious, as the nearer the connecting pin moves on the straight line AX, the less will be the eccentricity of the slay.

That the movement of the slay in the back half of its stroke is slower than in the front half can easily be proved by taking the length of the crank-arm in the compasses, and, after bisecting the arc AB at C, from C marking off the points D and H on the crank circle. It will be seen that both these points are somewhat inside the top and bottom centres of the crank indicated by the dotted line, and therefore the slay moves from C to A and back, the front half of its stroke, in less time than it moves from C to B and back to C. The reason for this eccentricity or unevenness in the movement of the slay is that when the crank is moving from the back centre to the top centre the crank-arm is oscillating and opening an angle with AX while the slay is moving forward, and therefore while the

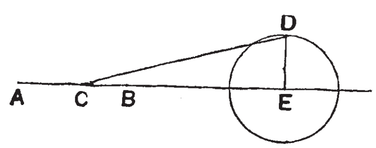



FIG. 59.

crank is making this quarter of a revolution, the connecting pin of the slay will move something less than from B to C; and while the crank is moving from the top centre to the front centre, the crank-arm is straightening or closing the angle while the slay is moving forward, and thus the connecting pin will move a greater distance than from C to A while the crank is making this quarter of a revolution. When the crank moves from front to bottom centre the angle is opening while the slay is moving backwards, and therefore the pin will move a little more than from A to C; and when the crank moves from bottom to back centre the angle is closing while the slay moves backwards, thus retarding the velocity of the slay.

This will be better understood from Fig. 59, where CD is the crank-arm, and ED the crank at the top centre. A is the position of the connecting pin when at the front of its stroke, and B its position when at the back of its stroke. The dimensions are as in Fig. 58—viz. 12-inch arm, 3-inch crank—and for simplicity we will assume the connecting pin moves on the straight line AE. From A to B is 6 inches, and therefore it is obvious that AC is something over 3 inches, and that the connecting pin moves this distance whilst the crank is making the quarter of a revolution from top to front centre. The distance AC can be obtained as follows. It is obvious that CDE is a right-handed triangle, and therefore $CD^2$ is equal to $CE^2 + ED^2$. Therefore $CD^2 - ED^2 = CE^2$, and having obtained the length of CE, we can subtract this from AE, which leaves the length of AC. The formula will stand thus—

$$CD^2 - ED^2 = CE^2$$
$$12^2 - 3^2$$
$$144 - 9$$
$$\therefore 135 = C\,E^2$$
$$\text{and } CE = \sqrt{135} \text{ or } 11{\cdot}6189$$
$$\text{length of } AE = 15{\cdot}0000 \text{ inches}$$
$$11{\cdot}6189 \text{ inches}$$
$$AC = 3{\cdot}3811 \text{ inches}$$

The answer may be obtained in one calculation as follows :—

$$AE - \sqrt{CD^2 - ED^2} = AC$$
$$\text{or} \quad 15 - \sqrt{12^2 - 3^2}$$
$$15 - \sqrt{144 - 9}$$
$$15 - \sqrt{135}$$
$$15 - 11{\cdot}6189 = 3{\cdot}3811$$

We thus see that the connecting pin moves 3 inches $+ 0{\cdot}3811$

inch while the crank is moving from the top to front centre. It will also move the same distance while the crank moves from front to bottom centre.

When the crank is moving from the bottom to the back centre, the connecting pin will move 3 inches − 0·3811.

$$\begin{array}{r} 3\cdot0000 \\ \underline{0\cdot3811} \\ 2\cdot6189 \end{array} \text{ inches,}$$

and the same distance when the crank moves from back to top centre.

It is often necessary in comparing looms to obtain the distance travelled by the connecting pin for a smaller movement of the crank than a quarter of a revolution.

Suppose it is desired to find the distance travelled by the connecting pin while the crank moves through 30 degrees to the front centre.

Take a 4-inch crank and 12-inch crank-arm. In Fig. 60,

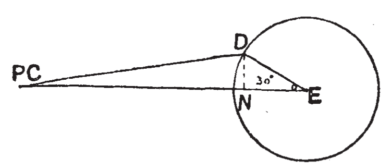



FIG. 60.

ED is the crank, 4 inches, and DC the crank-arm, 12 inches, the angle O = 30 degrees. P is the position of the connecting pin when at front of its stroke.

To find the distance CP. From a table of natural sines we can obtain the sine of an angle of 30 degrees, viz. sin 30° = 0·5, and therefore, knowing the length of ED, viz. 4 inches, we can obtain the length of DN, it being 0·5, or half of ED, in an angle of 30 degrees.

Having two sides of a triangle, we can obtain the third side thus:

$$ED^2 - DN^2 = EN^2 \text{ and}$$
$$CD^2 - DN^2 = CN^2$$

Having obtained the length of CN and EN, we can easily obtain CP by subtracting CF from the length of crank and crank-arm together. Working out the problem in figures we get—

$$ED^2 - DN^2 = EN^2$$
$$4^2 - 2^2 = EN^2$$
$$16 - 4 = EN^2$$
$$12 = EN^2$$
$$\therefore\ EN = \sqrt{12} \text{ or } 3{\cdot}4641. \quad \text{And}$$
$$CD^2 - DN^2 = CN^2$$
$$12^2 - 2^2 = CN^2$$
$$144 - 4 = CN^2$$
$$140 = CN^2$$
$$\therefore\ CN = \sqrt{140} \text{ or } 11{\cdot}8321$$
$$\text{and } 11{\cdot}8321 + 3{\cdot}4641 = 15{\cdot}2962$$

Therefore CE = 15·2962 inches, and subtracting this from PE, which is 16 inches ($12 + 4 = 16$), we get $16 - 15{\cdot}2962 = 0{\cdot}7038$ as the distance CP, which is the distance moved by the connecting pin for the 30 degrees movement of the crank.

The complete formula is as follows:—

$PE - [\sqrt{ED^2 - DN^2} + \sqrt{DC^2 - DN^2}] = CP$, or distance moved by the connecting pin for the given number of degrees through which the crank moves, ND being obtained from a table of sines.

To find the distance moved by the connecting pin while the crank moves through 5 degrees—say, from 30 degrees to 25 degrees in beating up.

To solve this it will only be necessary to subtract the length of CE when the crank is forming an angle of 30 degrees from the length of CE when the crank forms an angle of 25 degrees. In the previous example we found that for 30 degrees, CE = 15·2962 inches, and therefore proceeding in the same manner for 25 degrees, we get from table of sines, sin $25° = 0{\cdot}4226$, and 0·4226 of 4 inches 1·69; therefore ND = 1·69 inches, and

$$\begin{aligned} 4^2 - 1{\cdot}69^2 &= EN^2 \\ 16 - 2{\cdot}856 &= EN^2 \\ 13{\cdot}144 &= EN^2 \\ \therefore\ EN &= \sqrt{13{\cdot}144} \text{ or } 3{\cdot}626 \\ \text{and } 12^2 - 1{\cdot}69^2 &= CN^2 \\ \therefore\ 144 - 2{\cdot}856 &= CN^2 \\ 141{\cdot}144 &= CN^2 \\ \therefore\ CN &= \sqrt{141{\cdot}144} = 11{\cdot}88\,; \end{aligned}$$

therefore CN = 11·88 inches, and CE will equal 11·88 + 2·626, or 15·506 inches, when the crank is forming an angle of 25 degrees.

| | | |
|---|---|---|
| | 15·506 | length of CE for 25 degrees |
| | 15·296 | length of CE for 30 degrees |
| inches | 0·210 | distance moved by pin whilst crank moves through 5 degrees, from 30 degrees to 25 degrees, in beating up. |

In this manner it is easy to calculate the distance travelled by the pin for any number of degrees moved by the crank, and by comparing the velocity of the slay in different looms, the force of the beat up can be compared.

*The force exerted by the slay varies as the square of its velocity.* Thus, if in two looms where the *weight* of the two slays and the tension on the two warps are the same, the velocity of the slay in one loom is twice that of the other at a certain point in the beat up, the force of the former slay at that particular point will be four times the force of the latter, $1^2 : 2^2 :: 1 : 4$.

We can thus compare the force exerted by the slay in different looms at any point of the beat up.

The force of the beat up is chiefly exerted upon the pick when the crank is nearly at the front centre, and the force exerted will also depend considerably upon the tension on the warp; but the slay is doing some work in beating up from the moment the reed begins to move the pick forward.

Possibly the most reliable method of comparing the force of the beat up in different looms is to calculate the time occupied by the slay in moving through a specified distance at the front of its stroke in beating up. This necessitates a rather different calculation to the preceding examples, but is equally as simple.

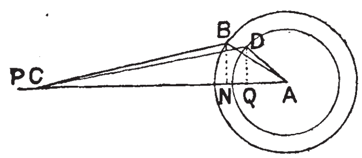


FIG. 61.

Suppose it is required to compare the force exerted by the slay in beating up (say the front 1 inch of its stroke) in two looms, one with a 12-inch crank-arm and 3-inch crank and the other with an 11-inch arm and 4-inch crank. The weight of the slays, the speed of the looms, the tension on the warps, and the timing of the primary movements, the same in each case.

In Fig. 61 the smaller circle represents the 3-inch crank and the larger one the 4-inch crank. CP = 1-inch, CB = 11-inch arm, and CD = the 12-inch arm. It is obvious that if we can obtain the two angles made by the cranks, viz. $\angle$ CAB and $\angle$ CAD, we shall be able to get the time, or fraction of a revolution, occupied in moving the slay from C to P. As we know the three sides of the triangle we can obtain the angle enclosed by any two sides, and what is required in this case is to obtain the angles BAC and DAC. In triangles of this kind where there is no right angle, we can obtain the cosine of the angle as follows :—

$$\frac{CA^2 + AD^2 - DC^2}{2CA.AD} = AQ, \text{ the cosine of angle DAC,}$$

and $$\frac{CA^2 + AB^2 - BC^2}{2CA.AB} = AN, \text{ the cosine of angle BAC.}$$

The proof of this formula is given in Euclid, Book 2.

Having obtained the cosines of the two angles, we can find the angles themselves by referring to a table of sines and cosines.

Then as AP = 15 inches,

CA = 14, AD 3 inches, DC 12 inches, BA 4 inches, BC 11 inches; and reducing the formulæ to figures, we get:

$$\frac{14^2 + 3^2 - 12^2}{2 \times (14 \times 3)} = \frac{196 + 16 - 144}{84} = 0{\cdot}7262 \text{ cosine,}$$

and by referring to a table of sines, we find that cosine 0·7262 = angle $43^\circ\ 26'$, therefore angle DAC = $43\frac{1}{2}^\circ$, about. Also

$$\frac{14^2 + 4^2 - 11^2}{2 \times (14 \times 3)} = \frac{196 + 16 - 121}{112} = \frac{91}{112} = 0{\cdot}8125,$$

and by referring to a table of sines and cosines, we find cosine 0·8125 = angle $35\frac{2}{3}^\circ$.

We thus find that to move the connecting pin 1 inch to the front of the stroke, in the loom with 11-inch arm, the 4-inch crank will move through $35\frac{2}{3}^\circ$, and in the loom with the 12-inch arm the 3-inch crank will move through $43\frac{1}{2}^\circ$ for the same movement of the slay. Assuming the force exerted by the latter to be 1, the force of the former will be as $35\frac{2}{3}$ squared : $43\frac{1}{2}$ squared : : 1 : *Ans.*

It may be as well here to give a short explanation of the system of obtaining angles by sines and cosines.

As the crank moves forward it is obvious that the line DQ will become shorter, and as the angle becomes larger the line DQ will increase in length. In trigonometry, the ratio between the length of the line DQ and the radius AD is called the *sine* of the angle, and if the radius is 1, the length of DQ will be the value of the sine. In an angle of 30° the sine is exactly $\frac{1}{2}$ the radius, and the relation between the radius and the sine for every angle is known, and arranged in "tables of sines." The length of AQ will also vary with the angle, and the length of this line is called the "cosine" of the angle QAD. The *cosine* of an angle of 30° is therefore the same as the *sine* of an angle of 60°. When the sine is known it is easy to obtain the cosine as follows :—

Cosine $= \sqrt{1 - \sin^2}$. Thus for an angle of 30°, cosine $= \sqrt{1 - 0{\cdot}5^2}$, or $\cos^2 = 1 - 0{\cdot}5^2$, therefore $\cos^2 = 1 - 0{\cdot}25$, or $\cos^2 = 0{\cdot}75$, $\therefore \cos = \sqrt{0{\cdot}75}$ $= 0{\cdot}866$. By reversing, the sine may be obtained from the cosine.

The value given to the sines and cosines must not be taken for the *actual* length of the lines; they are simply the ratio to the radius. Thus in an angle of 30°, if the radius is 1 inch the length of the sine will be $\frac{1}{2}$ inch and the cosine 0·866 inch. If the radius is 2 inches, the actual length of the sine will be 1 inch and of the cosine 1·732 inches.

TABLE OF SINES AND COSINES.

| **Angle.** | Sine. | Cosine. | Angle. | **Angle.** | Sine. | Cosine. | Angle. |
|---|---|---|---|---|---|---|---|
| **0°** | **0·00** | **1·00** | **90°** | 24° | ·4067 | ·9135 | 66° |
| 1° | ·0175 | ·9998 | 89° | **25°** | **·4226** | **·9063** | **65°** |
| 2° | ·0349 | ·9994 | 88° | 26° | ·4384 | ·8988 | 64° |
| 3° | ·0523 | ·9986 | 87° | 27° | ·4540 | ·8910 | 63° |
| 4° | ·0698 | ·9976 | 86° | 28° | ·4695 | ·8829 | 62° |
| **5°** | **·0872** | **·9962** | **85°** | 29° | ·4848 | ·8746 | 61° |
| 6° | ·1045 | ·9945 | 84° | **30°** | **·5000** | **·8660** | **60°** |
| 7° | ·1219 | ·9925 | 83° | 31° | ·5150 | ·8572 | 59° |
| 8° | ·1392 | ·9903 | 82° | 32° | ·5299 | ·8480 | 58° |
| 9° | ·1564 | ·9877 | 81° | 33° | ·5446 | ·8387 | 57° |
| **10°** | **·1736** | **·9848** | **80°** | 34° | ·5592 | ·8290 | 56° |
| 11° | ·1908 | ·9816 | 79° | **35°** | **·5736** | **·8192** | **55°** |
| 12° | ·2079 | ·9781 | 78° | 36° | ·5878 | ·8090 | 54° |
| 13° | ·2250 | ·9744 | 77° | 37° | ·6018 | ·7986 | 53° |
| 14° | ·2419 | ·9703 | 76° | 38° | ·6157 | ·7880 | 52° |
| **15°** | **·2588** | **·9659** | **75°** | 39° | ·6293 | ·7771 | 51° |
| 16° | ·2756 | ·9613 | 74° | **40°** | **·6428** | **·7660** | **50°** |
| 17° | ·2924 | ·9563 | 73° | 41° | ·6561 | ·7547 | 49° |
| 18° | ·3090 | ·9511 | 72° | 42° | ·6691 | ·7431 | 48° |
| 19° | ·3256 | ·9455 | 71° | 43° | ·6820 | ·7314 | 47° |
| **20°** | **·3420** | **·9397** | **70°** | 44° | ·6947 | ·7193 | 46° |
| 21° | ·3584 | ·9336 | 69° | **45°** | **·7071** | **·7071** | **45°** |
| 22° | ·3746 | ·9272 | 68° | Angle | Cosine | Sine | Angle |
| 23° | ·3907 | ·9205 | 67° | | | | |

We see from Fig. 61 that in a loom with a 4-inch crank and 11-inch arm, the velocity of the slay is much greater when beating up than with the 3-inch crank and 12-inch arm.

The effect of the length of the crank-arm on the velocity of the slay can easily be shown by a diagram or by calculation. If the length of the crank-arm be altered without altering the length of the crank, there will be found a somewhat quicker movement of the slay at the beat up in the loom with the shorter arm. The difference is not so great when the crank-arm is a long one in proportion to the crank. The chief cause of the difference in the velocity of C in Fig. 61 is the difference in the length of the *crank*. It is obvious that the longer the crank the greater the angle which it will cause the arm to make, and therefore the greater will be the acceleration of the velocity of C when the angle is closing and the slay moving forward. Likewise, it is obvious that the shorter the arm the larger will be the angle to close, but the *principal* thing to notice is that an increase in the length of the *crank* causes an increase in the velocity of the slay *owing to the extra distance which it has to travel in each revolution;* so that even if the crank-arm were lengthened in exact proportion to the increase in the length of the crank, so as to keep the angle to be closed in beating up the same, there would still be a considerable increase in the velocity of the slay, caused by the extra distance it has to travel. This lengthening of the crank has obviously much more to do with the increase in velocity of the slay than the shortening of the arm has.

The longer the crank the further back from the cloth will the slay be taken, and assuming that the shed is open for the shuttle when the crank is at the bottom centre, a long crank is obviously more suitable for a wide loom, as, having to move further back, it will allow a longer time for the shuttle to pass through the shed than a short crank would; therefore the wider the loom, the longer the crank is required to be to allow time for the shuttle to pass.

The time allowed for the passage of the shuttle may also be increased by using a short arm so as to increase the eccentricity of the slay.

The longer the crank, the greater the velocity of the slay, therefore a long crank is suitable for *heavy* work, as it stores

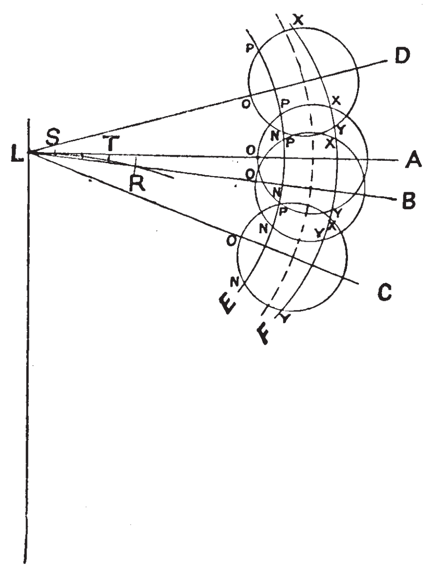



FIG. 62.

up more force in the slay than a short one. The force may also be increased by shortening the crank-arm, thus increasing the eccentricity of the slay.

The position of the crank-shaft in relation to the connecting pin has some effect upon the *eccentricity* of the slay's movement. Fig. 62 shows this, but to see clearly the effect it would be advisable to make an accurate drawing to a large scale.

Four positions of the crank-shaft are shown. The one on the line A is just a little below the level of the connecting pin, so that the pin moves as nearly as possible on the line A when making the front quarter of its stroke. The circle on the line B is the position where the pin moves as nearly as possible on line B when at the back quarter of its stroke; D is any higher plane, and C any lower one. Divide the stroke of the connecting pin LR into four equal parts, and from S, with the crank-arm in the compasses, cut the circles with the arc E, and from T cut the circles with the arc F. It will be found that in the circle A, OP is slightly longer than in any of the other circles; therefore this is the position where the beat up is slowest. It will also be found that in the circles B and C there is scarcely any difference in OP, therefore sinking the crank-shaft from within reasonable limits makes very little difference; if anything, there is a slight decrease in the size of OP as the plane is lowered, but it is very slight, and the increase in the velocity of slay would also be very slight. On the other hand, by raising the crank-shaft to D a considerable increase in the velocity of the slay in beating up takes place, as it will be found that in this circle OP is much less than in the others.

At the back of the stroke it will be found that in the plane B the distance XY is least; therefore there is here the least dwell of the slay at the back of its stroke with the shaft in this position. This is because the pin moves as nearly as possible on the line B whilst the crank is at the back part of its stroke. As the crank is raised or lowered the dwell at the back increases slightly.

Reversing the direction of the loom makes a difference in the beat-up.

It will be found that in the circle A, OP and ON are about equal, therefore there will be scarcely any change in the velocity of beat-up by reversing the loom; but as the shaft is lowered ON will be found to become less than OP, and therefore a quicker blow is given by reversing the loom if the shaft is in this position. If the shaft is raised, as in the case of circle D, it will be found that ON becomes *greater* than OP; therefore with the crank above A, reversing the direction of the loom will cause a slower and weaker beat-up.

In the diagram, Fig. 62, the crank and crank-arm are the same length for each position, the centre of the shaft being indicated by the dotted arc.

*Timing of the Primary Movements.*

The primary movements, shedding, picking, and beating up, are timed differently in relation to each other in weaving different classes of fabrics. For plain cloths, or other cloths

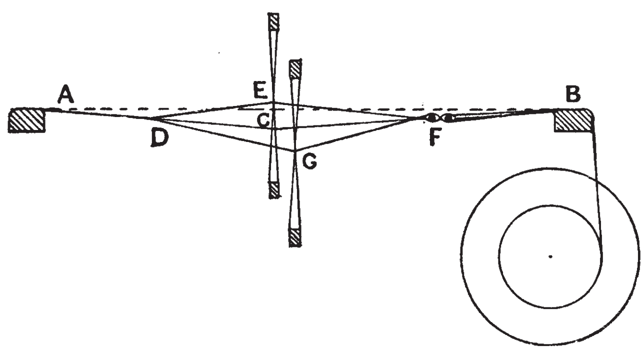



FIG. 63.

where a good cover is required—that is, where the warp has to be spread—the crank should be set about the top centre when the healds are crossing each other. At Fig. 38 the loom is timed in this manner. When so timed it is obvious that the shed will be considerably or altogether open when the reed is in contact with the cloth. By sinking the centres of the healds below a line drawn from the temple to the back rest, the upper portion of the shed is always slack, and if the pick is beaten up in a crossed shed, the loose ends of the warp are spread between the taut ones. In Fig. 63 the straight line AB is drawn from the front carrier A to the back carrier B. The centres of the healds when level are on the line ACB, the point C being a little way below the line A B. When one stave is lifted a certain distance and the other goes down the same distance, it is obvious that the upper portion of the warp will be slacker than the lower portion, because the line ADEFB is shorter than ADGFB, and when the reed beats up with the warp in this position the slack ends are spread between the taut ones, thus giving a good cover to the cloth and preventing the reed marks from showing. Each set of ends alternately becomes slack.

Another advantage of beating up when the shed is crossed or partly open for the succeeding pick is that the pick is held more firmly in position than when the shed is not crossed, and therefore the picks can be got in better.

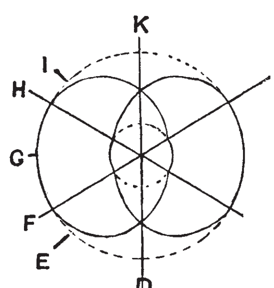


FIG. 64.

In twilled cloths the boldness of the twill is somewhat affected by the warp being spread, and these cloths are often preferred when made without the healds having been sunk.

If the dwell on the tappet is equal to one-third of a pick, as in Fig. 64, the line D will mark the point of the tappet when the crank is at the top centre. When the crank has made one quarter of a revolution and is at the front centre with the reed in contact with the cloth, the point E will be acting on the treadle bowl. It will be seen that here the shed is almost fully open. When the crank is at the bottom centre the point G will be acting on the bowl, and the shuttle should just be entering the shed. When the point H of the tappet is acting on the bowl the shed will be commencing to close, and the shuttle must be just leaving the shed. When the point I is acting on the bowl the crank will be at the back centre, and when the crank reaches the top centre the healds will be again level.

If the dwell on the tappet is more than one-third pick, and at the commencement the crank is set on the top centre with the healds level, the shed will keep open longer for the shuttle to pass through, and would be more open when the crank reached the front centre. It will be obvious that for a wide loom a longer dwell is required than for a narrow loom.

By having the shed fully open before the shuttle enters the shed, the warp is spread and a good cover put on the cloth, but all this dwell is taken off the time which would otherwise be allowed for opening and closing the shed, and therefore means extra strain on the warp.

If it is not necessary to spread the warp, the shed need not be fully open until the shuttle is entering the shed. In this case the greatest possible amount of time is allowed for opening and closing the shed, thus putting as little strain as possible on the warp.

### *Speed of Tappets.*

As previously stated, the bottom shaft in the loom, being the one used for picking, revolves at one-half the speed of the crank-shaft, and therefore plain cloth tappets may be fastened on the bottom shaft. Tappets of more than two picks to the round are usually fixed on a counter-shaft, S (Fig. 65), in looms with inside tappets. Sometimes the wheel E is geared directly into the wheel C on the bottom shaft, but usually a carrier-wheel, D, is used to convey the motion from the bottom shaft.

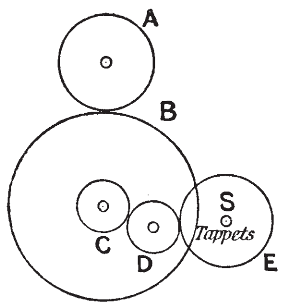



FIG. 65.

The number of teeth in the carrier wheel has no effect on the speed of the tappets, as it is used simply to fill up the space between the bottom and counter-shafts.

If the wheel on the crank-shaft A contains 45 teeth, and the wheel B 90 teeth, C 40 teeth, and E 60 teeth, the tappet-shaft S will be making one revolution for three revolutions of the crank-shaft; therefore these wheels will do for three-end twill tappets. This may be proved by multiplying the drivers together and the drivens together, and dividing one by the other, thus—

$$\frac{90 \times 60}{45 \times 40} = 3$$

It is usual to place two or three wheels on the bottom shaft of the loom, so that any one of them may be geared into the carrier wheel D, each giving the required speed for different tappets. If a 40 wheel, a 30 wheel, and a 24 wheel are placed on the bottom shaft in such a manner that they can be moved along the shaft and any one of them be geared into the carrier wheel, any 3, 4, or 5 pick tappets can be driven with these wheels. We have seen that a 40 wheel at C gives three picks to the round.

Suppose the 30 wheel at C is geared into the carrier wheel, we get—

$$\begin{array}{r}\text{drivens}\\ \text{drivers}\end{array} \frac{90 \times 60}{45 \times 30} = 4,$$

or the relative speed of the tappets and crank-shaft are as

1 : 4; therefore these wheels may be used for any tappets with four picks to the round.

If the 24 wheel is at C, we get:

$$\frac{\text{drivens } 90 \times 60}{\text{drivers } 45 \times 24} = 5,$$

and thus we get the proper rate of speed for tappets five pick to the round.

Some loom makers use the wheel E as a change wheel. With a 24 wheel C and a 36 wheel E we get three picks to the round, thus—

$$\frac{\text{drivens } 90 \times 36}{\text{drivers } 45 \times 24} = 3$$

With a 24 wheel C, a 48 wheel E gives 4 picks,
With a 24 wheel C, a 60 wheel E gives 5 picks,
With a 24 wheel C, a 72 wheel E gives 6 picks.

*Example.*—Find the number of teeth for the wheel C on the bottom shaft to drive tappets seven picks to the round, wheel on tappets 63 teeth.

$$\frac{90 \times 63}{45 \times 7} = 18 \text{ wheel. } \textit{Ans.}$$

Woodcroft's tappets, as a rule, are driven directly from the crank-shaft. As these tappets are usually of a large circumference, a large wheel on them is of no disadvantage, although sometimes intermediate wheels are used.

If the tappets are twelve to the round, and the wheel on the tappets contains 192 teeth, a driving wheel of 16 teeth will be required on the crank-shaft.

$$\frac{192}{16} = 12 \text{ picks to the round}$$

For driving outside tappets, as in Fig. 39, a driving wheel on the crank-shaft and two intermediate wheels are generally used.

The tappets are placed on the bottom shaft outside the loom, but they are loose upon the shaft, and can, of course, be made to revolve at a different speed to the shaft, either in the same or in the opposite direction. This system of driving the tappets is shown at Fig. 66. The wheel A, on the crank-shaft, drives the wheel B, on an intermediate stud; the wheel C, on the same centre, drives the tappet wheel D.

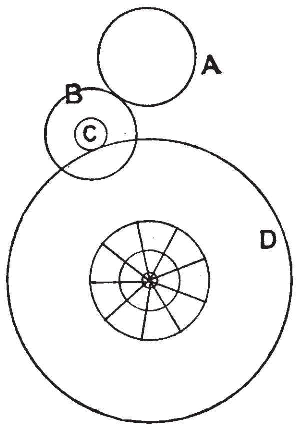


FIG. 66.

To find the wheel on the crank-shaft, or the first driver, the other wheels being as follows: first driven wheel, B, 36 teeth; second driver, C, 12 teeth; tappet wheel, D, 120 teeth.

Multiply the two driven wheels together, and divide by the given driver multiplied by the picks to the round, thus—

$$\frac{36 \times 120}{12 \times 9} = 40 \text{ first driver, A.}$$

To find the second driver for eight picks, the other wheels being: first driver, A, 20; first driven, B, 40; second driven, D, 60.

The given driver multiplied by the picks to the round, $20 \times 8 = 160$; the drivens multiplied together, $40 \times 60 = 2400$; $2400 \div 160 = 15$ wheel required.

To find either of the driven wheels, multiply the two drivers and the picks together, and divide by the driven given wheel, thus—

*Example.*—Find the wheel for the tappets, D, for 10 picks to the round, the other wheels being : first driver, 16 teeth ; first driven, 32 teeth ; second driver, 20 teeth.

$$\frac{16 \times 20 \times 10}{32} = 100 \text{ wheel required}$$

To find both intermediate wheels, multiply the given driver by the picks to the round, and as the product is to the teeth in the tappet wheel, so is the required driven to the required driver.

*Example.*—Find the two intermediates for 10-pick tappets, if the wheel on the crank-shaft has 18 teeth, and the wheel on the tappets 120 teeth. The $18 \times 10 = 180$, and therefore the two required wheels must be in the proportion of 180 to 120, the former being the driven wheel. Thus a 36 driven and a 24 driver will give the required speed to the tappets. That this is correct may be seen from the following :—

$$\frac{18 \times 24}{36 \times 120} = 10 \text{ picks}$$

That the required wheels must be in this proportion will be apparent from the fact that if the wheel B has ten times the number of teeth in A, then B is revolving at the speed at which the tappets are to move; therefore if the wheel C has the same number of teeth that D has, the speed of the tappets will remain the same.

## FAST- AND LOOSE-REED LOOMS.

One of the most important motions in the power loom is that by which the loom is stopped automatically when the shuttle is caught in the shed or for some reason does not enter the shuttle-box. A motion of this kind has always been considered necessary since the introduction of the power loom. If the shuttle be caught in the shed as the reed is beating up, it is obvious that great damage to the warp must result unless the loom is brought to a sudden stop or the reed thrown out.

The oldest form of protector is the "stop rod." In this the reed is fast, and if the shuttle is caught in the shed or flies out, the loom is brought to a sudden stop before beating up. Fig. 67 will illustrate the principle of this motion. If the shuttle enters the box safely it presses back the swell S, which projects inside the box and is held there by a spring. As the swell is pressed back it raises the lever B above the frog F as the slay beats up. If the shuttle for any reason does not enter the box, the swell is not pressed back, and as the slay moves forward in beating up, the lever B catches the frog F, which is moved a little and applies the brake G, and also knocks off the loom handle H, which removes the belt on to the loose pulley. Before the application of the brake to this motion the frog was fixed to the framework of the loom, and it will easily be understood that the concussion caused many breakages. A stop rod protector was patented in 1791, but the brake was not applied until 1840 or thereabouts.

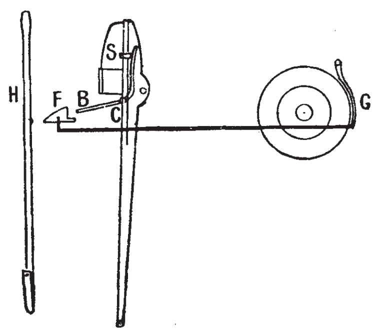


Fig. 67.

The loose reed is a better way of preventing damage to the warp by the shuttle being caught. If the shuttle is caught in the shed it throws out the reed and stops the loom. Its action will be understood from Fig. 68. A rod, C, runs underneath the shuttle-race at the back of the slay, and the finger B is fastened to it. The reed is held in position by a board, A, which is also connected to the rod C, as shown in the diagram. If the shuttle is caught in the shed, it presses back the reed and the board A, and lifts the finger B to the upper side of the frog F, and as the slay moves forward it throws the board A further back and the reed out at the bottom, and the lever H is brought into contact with the loom handle, and the loom is stopped. If the shuttle passes safely through the shed, the reed is not pressed back, and the finger F comes under the frog as the slay gets to the front of its stroke, and holds the reed comparatively fast. The disadvantage of the loose reed is that the reed is not sufficiently firm to put a large amount of weft into the cloth, but improvement is being made in this respect, and loose-reed looms are to-day made for weaving fabrics for which it was formerly necessary to have fast reeds.

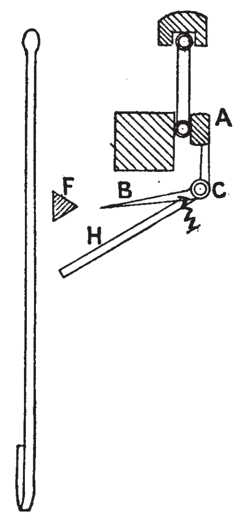


FIG. 68.

The invention of the loose reed is generally attributed to Mr. James Bullough. It was invented about 1842.

## THE WEFT FORK STOP MOTION.

One of the most useful adjuncts to the power-loom is the motion for stopping the loom when the weft breaks or runs out. Fig. 69 will explain the principle of this useful contrivance. The grid A is placed at the side of the reed between the reed and the shuttle-box, and the fork is so placed that as the grid moves forward the prongs of the fork pass through it.

When the weft comes between the fork and the grid it raises the end of the fork E, out of the way of the hammer H, which is moved forward every two picks by a cam or lifter, D, on the bottom shaft of the loom. If the weft breaks or runs out the fork will of course pass through the grid, and it is so balanced that the hook E will be caught by the hammer and the loom

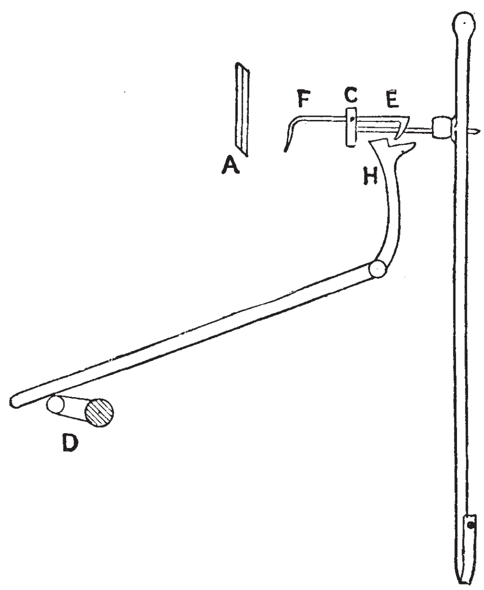



FIG. 69.

handle knocked off. The invention of the Weft Fork Stopping Motion is claimed by several persons, but it was perfected about the year 1842, when the brake was applied to it. The action of this brake is illustrated at Fig. 70. When the handle is pushed sideways in starting the loom it lifts the rod R and the lever L, and thus takes the brake off. When the handle is knocked off by the weft fork being caught, the lever L drops and the brake is applied. The brake power can be regulated by altering the position of the weight on the levers.

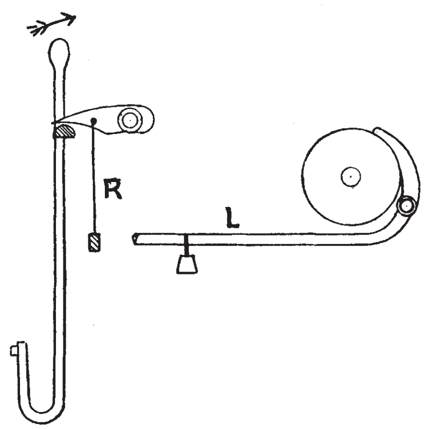


Fig. 70.

In looms with change boxes at both sides the weft fork is often placed in the middle of the loom. It is obvious that when several shuttles are used there will always be some weft threads opposite the grid in the ordinary weft fork motion, and this renders it inoperative in this class of looms. It is therefore necessary to have a fork to feel for each pick separately.

## TAKING-UP OR COILING MOTIONS.

There are two distinct classes of taking-up motions—the positive, and the negative or drag motion. In the former the cloth is taken up a small but regular distance each pick, and the number of picks per inch can be regulated to a fraction. Fig. 71 is the common form of positive take-up motion. A ratchet wheel or "rack wheel," A, is moved forward one tooth every pick by a click or catch, M, operated by a projection, G, on the slay sword. As the slay moves forward the rack wheel is moved one tooth, and the holding catch or detent N prevents it from going back. There are five wheels in the train, and the names usually given to them are as follows: A, rack wheel; B, change wheel; C, stud wheel; D, stud pinion; E, beam wheel. The emery taking-up roller is marked F. The cloth, as it is woven, is drawn forward by the emery roller and is wound upon the cloth roller, which is pressed against the emery roller by weighted levers, and is turned by friction.

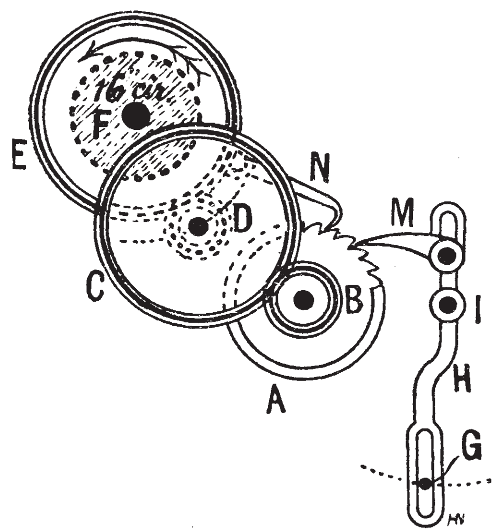



FIG. 71.

The speed at which the emery beam roller is turned regulates the number of picks per inch, and as changes are constantly required in most weaving mills, the wheel B is usually taken as a change wheel. As this wheel is a driver, a smaller wheel will make the emery roller move slower, and therefore more picks will be put in the cloth, and a larger wheel will drive the emery roller quicker, and as a consequence a smaller number of picks will be put in. If the rack wheel has 50 teeth, the stud wheel 120 teeth, the stud pinion 15 teeth, and the beam-roller wheel 75 teeth, the beam roller being 15 inches in circumference, and if the change wheel used has 25 teeth, the number of picks per quarter-inch will be 20.

This may be proved by multiplying the drivers together and by the circumference of the emery beam roller in quarter-inches for a divisor, and multiplying the drivens together for a dividend: the quotient will be the number of picks per quarter-inch.

| Drivers. | Driven. |
|---|---|
| 25 | 50 |
| 15 | 120 |
| 125 | 6000 |
| 25 | 75 |
| 375 | 22500)450000(20 picks per |
| 60 quarter-inches in beam | 45000 quarter-inch |
| 22500 | 0 |

When the cloth is taken out of the loom, rather more than this number of picks will be counted, as there is not the same tension as when the cloth is being woven. It is usual to allow about $1\frac{1}{2}$ per cent. for this shrinkage.

For the purpose of easy calculation the dividend of the loom is obtained; that is, the change wheel required to give one pick per quarter-inch. By using this as a dividend and dividing by the number of picks required in a quarter-inch, the quotient will be the change wheel required; and, *vice versâ*, by dividing by the change wheel, the number of picks given by that wheel can be obtained.

To find the dividend of a loom—

Multiply the rack, stud, and beam wheel together for a dividend, and the stud pinion and the number of quarter-inches in a circumference of the emery beam for a divisor, and the quotient will be the mathematical dividend. Add $1\frac{1}{2}$ per cent. to this for the practical dividend.

With the wheels given in Fig. 71 the dividend will be as follows:—

15 stud pinion
60 quarter-inches in circumference of beam

900

50 rack wheel
120 stud wheel

6000
75 beam wheel

900)450000(500 mathematical dividend
4500

00

500
7 = $1\frac{1}{2}$ per cent. for shrinkage

507 **practical dividend.**

Having the dividend, it is only necessary to divide by the picks to obtain the change wheel required, or to divide by the teeth in the change wheel to obtain the picks which it will give, thus—

picks $\frac{507}{13} = 39$ change wheel    change wheel $\frac{507}{20} = 25\frac{1}{3}$ picks.

The following are the wheels used by various loom makers:

| Rack wheel. | Stud wheel. | Stud pinion. | Beam wheel. | Circumference of beam in inches. | Dividend. |
|---|---|---|---|---|---|
| 50 | 120 | 15 | 75 | 15 | 507 |
| 60 | 120 | 15 | 75 | 15 | 609 |
| 50 | 146 | 14 | 90 | 15 | 794 |
| 50 | 100 | 12 | 75 | 15 | 528 |
| 60 | 100 | 12 | 75 | 15 | 634 |

*Example.*—Find the dividend of a loom with a rack wheel 60 teeth, stud wheel 100 teeth, stud pinion 12 teeth, beam wheel 75 teeth, beam 15 inches circumference.

$$\frac{\overset{\text{rack}}{60} \times \overset{\text{stud}}{100} \times \overset{\text{beam wheel}}{75}}{\underset{\substack{\text{stud}\\\text{pinion}}}{12} \times \underset{\substack{\text{quarter-inches}\\\text{in beam}}}{60}} = 625 \text{ mathematical dividend}$$

$$\underline{\phantom{62}9} = 1\tfrac{1}{2} \text{ per cent.}$$

$$634 \text{ practical dividend.}$$

It is not possible by changing one wheel only to obtain any number of picks or fraction of a pick, as will be seen from the following examples :—

$$\text{picks } \frac{507}{40} = 12{\cdot}67 \qquad \text{picks } \frac{507}{41} = 12{\cdot}12$$

$$\text{picks } \frac{507}{42} = 12{\cdot}07$$

For the lower number of picks the motion does fairly well, but for the higher numbers of picks the changes cannot be made with sufficient exactitude by changing a single wheel. Even in the lower picks it is now required to make the smallest fractional changes.

An improved arrangement of wheels is now largely adopted. This is Pickles' motion. Fig. 72 shows the train of wheels. The change wheel B is in this case a driven wheel, and therefore if a larger wheel is used it will give a larger number of picks in the cloth, and if a smaller wheel is used it will give a smaller number of picks; so that if the wheels are so proportioned that the change wheel B has the same number of teeth that there are picks per quarter-inch, it will always remain so, whatever size the wheel is. If a 20 driven wheel gives 20 picks, a 30 will give 30 picks, and so on.

The wheel A is also changed, and this is usually called the "standard" wheel. This is a driver wheel, and therefore a smaller wheel gives more picks, and *vice versâ*. The wheels are so proportioned that if A, the standard wheel, has nine teeth, each tooth in B, the change wheel, represents one pick and therefore, this wheel being a driven, the number of teeth in it will also represent the number of picks per quarter-inch. If an 18 standard wheel is used, it is obvious that the emery beam will be driven twice as fast, therefore each tooth in the change wheel B will then represent half a pick per quarter-inch. With a 27 standard each tooth in the change wheel B will represent one-third of a pick. With a 36 standard each tooth in B will represent a quarter of a pick per inch.

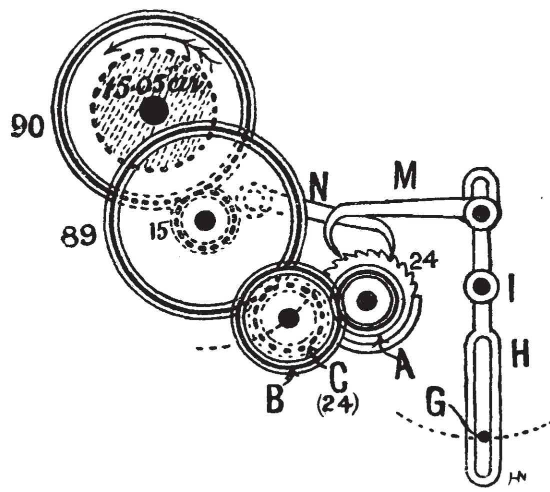



FIG. 72.

The wheels mostly used are those in the diagram, and supposing we have a 36 standard and a 45 change wheel, and taking the emery beam as 15·05 inches in circumference, we get—

$$\frac{\overset{\text{B}}{24 \times 45 \times 89 \times 90}}{\underset{\text{A}}{36 \times 24 \times 15 \times 60{\cdot}20}} = 11{\cdot}088$$

$$\begin{array}{rl} \cdot 166 = & 1\tfrac{1}{2} \text{ per cent. for shrinkage} \\ \hline 11{\cdot}254 & \text{picks per quarter-inch.} \end{array}$$

Thus with a 36 standard a 45 change wheel, B, gives $11\frac{1}{4}$ picks per quarter-inch, or each tooth in the change wheel gives a quarter of a pick per quarter-inch.

By changing these two wheels any fraction of a pick can be obtained. Thus if $13\frac{1}{2}$ picks per quarter-inch are required, the wheels used would be an 18 standard and a 27 change wheel. For $13\frac{2}{3}$ picks a 27 standard and a 41 change wheel would be used, and so on.

The following examples will fully illustrate the principle of this motion :—

| Picks per quarter-inch. | Standard wheel. | Change wheel. |
| --- | --- | --- |
| 20 | 9 | 20 |
| $15\frac{1}{2}$ | 18 | 31 |
| $14\frac{1}{3}$ | 27 | 43 |
| $14\frac{2}{3}$ | 27 | 44 |
| $13\frac{1}{4}$ | 36 | 53 |
| $13\frac{3}{4}$ | 36 | 55 |
| $12\frac{1}{5}$ | 45 | 61 |

It is not always customary to change the wheels in the above manner, as a different value is often given to each tooth in the change wheel by altering the standard wheel, otherwise than by multiples of nine.

Any number may be made the basis of a train of wheels of this kind; there is no reason why it should be nine more than any other number, and in adapting looms from the ordinary five-wheel motion to this principle, it is not necessary to get all new wheels, as some of the old ones may be made to form part of the train.

There are several kinds of negative or drag take-up motions. One of the older forms is that given in Fig. 73. A lever, AB, centred at C is weighted on the arm B. A small cam, D, on the crank-shaft presses down A every pick and lifts the catch E, which operates the ratchet wheel F.

As the weights drop they act as a drag upon the ratchet wheel. A small pinion on the same centre as the ratchet wheel drives the wheel G on the cloth beam. The cloth in a negative motion is wound directly on to the cloth beam, and thus there is no risk of damaging the finer fabrics, as is the case when an emergy beam is used, as in a positive motion. The number of picks put in the cloth is regulated by the weights on the lever B; the greater the weight the less the number of picks, and *vice versâ*.

The action of a negative motion is as follows:—As the slay beats up, the cloth between the cloth beam and the reed is slackened a little, and the weights on the lever at that moment act as a drag upon the ratchet wheel F. The holding catch is usually a double one, and will hold the ratchet wheel when taken forward the space of half a tooth.

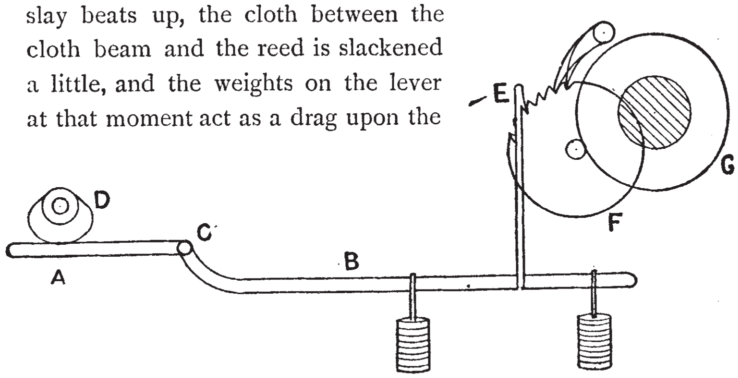


FIG. 73.

By increasing the drag upon the ratchet wheel, a slighter blow from the slay will enable the weights to act, and thus less weft is put into the cloth. If a loom is regulated so as to put a certain number of picks per inch into the cloth of a given count of weft, and weft of a finer count is then used, it is obvious that the number of picks per inch would be increased. If the weft varies in thickness the negative motion compensates for this somewhat, by putting more picks in where it is thinner, and thus a more even thickness of cloth is produced than where a positive motion is used.

As the cloth is wound on the beam the circumference of the latter gradually increases, and consequently there would be a gradual alteration in the amount of weft put into the cloth, owing to the difference in leverage. It is necessary, therefore, to count the cloth and adjust the weights at intervals in order to keep the number of picks regular.

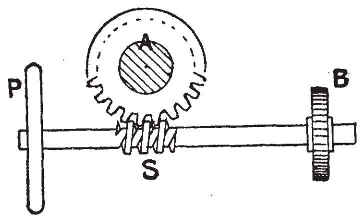



FIG. 74.

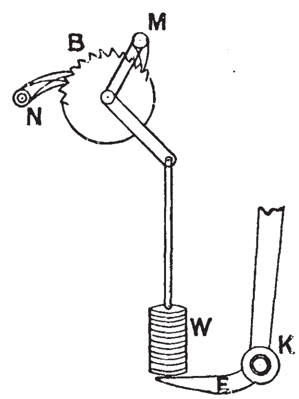



FIG. 75.

Another kind of negative take-up motion is shown at Figs. 74 and 75. This is now more generally used than the other kind. The cloth beam A is driven by a screw, S. The ratchet wheel B is fastened to the screw-shaft, and the method of operating the ratchet wheel will be seen from Fig. 75, which is another view of the mechanism. A short lever, E, is attached to the rocking shaft K, and as the slay moves backwards from the cloth the weights W are lifted a little, and when the slay moves forward, the weights, acting through the catch M, will take the ratchet wheel forward a tooth, or half a tooth, as the case may be. There is usually a double-holding catch N, which will hold the wheel if taken forward half a tooth. When the ratchet wheel has made one revolution, the wheel on the cloth beam will only have been moved one tooth by the screw, so that the required slow movement of the cloth beam is obtained by very simple means. There is a hand wheel, P, for unwinding the cloth readily. The negative motion is used principally in weaving the heavier classes of cotton fabrics and those in which there is a large number of picks per inch, such as velvets, and similar fabrics. Its advantages are that the cloth is wound directly on to the cloth beam, and cannot therefore be injured by an emery beam, and that it makes the cloth of a more even thickness, as it compensates for any variation in the thickness of the weft; and its disadvantages as compared with a positive motion are that it requires frequently adjusting (less frequent, of course, when a very large number of picks are put in, as in velvets), and that it does not put a perfectly regular number of picks in the cloth, as a positive motion does. This latter is the chief objection to it, as even in the lighter makes of common velvets a positive motion is preferred on account of its giving a more evenly picked cloth. In silk looms, where it is absolutely necessary to dispense with an emery beam, a very large cloth beam is used, and the cloth is wound directly on to the cloth beam although the take-up is positive. The cloth beam is sometimes over a yard in circumference, so that it will hold a fair length of cloth without making much difference in the number of picks. The cloth is taken off the beam frequently, or the gradual change in the thickness of the cloth beam would cause the piece to get too thin. This would, of course, not do for cotton goods.

Another ready method of obtaining any required pick in a positive motion is used in the East Lancashire districts. Seven wheels are used, as in Pickles' arrangement, but the ordinary wheels of a 507 dividend (or other dividend) are used, and in addition the two wheels B and C, as in Pickles' (Fig. 72), are introduced. The wheel B, the driven wheel, is called the standard in this arrangement; and suppose it is required to put 15 picks per quarter-inch in the cloth with the rack wheel 50 teeth, stud wheel 120, stud pinion 15, beam wheel 75, beam 15 inches circumference. The standard used is a 24—this, it must be borne in mind, is in this case a driven wheel. Then by multiplying the dividend of the five-wheel motion, viz. 507·5, by 24, the teeth in the standard, and dividing by the picks per quarter-inch required, we get the product of the two drivers, A and C, thus—

$$\frac{507{\cdot}5 \times 24 \text{ standard B}}{15 \text{ picks}} = 812$$

This 812, then, is the product of the two drivers, and any two convenient wheels which, multiplied together, give this number can be used—thus $\frac{812}{28} = 29$. Therefore the two drivers may have 28 and 29 teeth respectively. The two wheels are found by experiment. If the dividend of the five wheels is 609 a 20 standard wheel is used, and the same drivers as in the preceding case will do. If it is required to change only one wheel, and to have the arrangement such as to give an exact number of picks, or half-picks, or quarter-picks, in the quarter-inch of cloth, by taking the two drivers A and C of such numbers that their product amounts to 507, the number of teeth in the driven wheel B will always equal the number of picks per quarter-inch exactly. Thus $\frac{507}{13} = 39$. Therefore if the drivers A and C have respectively 13 and 39 teeth, every tooth in the driven wheel B will represent one pick per quarter-inch.

Suppose half-picks are required exactly, the method of obtaining the wheels is as follows:—Multiply the 507·5 by 2, which equals 1015, then find two convenient wheels which, multiplied together, produce this number; $35 \times 29 = 1015$, and the two drivers A and C may be 35 and 29. This will cause every tooth in the driven wheel B to represent half a pick exactly.

Thus with a 35 wheel A, and a 29 wheel C, a 31 wheel B will give $15\frac{1}{2}$ picks per quarter-inch, the other wheels being the same as in an ordinary 507 dividend motion.

The following examples will prove this:—

$$\frac{50 \text{ rack} \times 31 \text{ B} \times 120 \text{ stud} \times 75 \text{ beam wheel}}{35 \text{ A} \times 29 \text{ C} \times 15 \text{ pinion} \times 60 \text{ quarter-inches}} = 15{\cdot}27$$

$$\begin{array}{rl} \text{and } 15{\cdot}27 & \\ 0{\cdot}23 & = 1\tfrac{1}{2} \text{ per cent. shrinkage} \\ \hline 15{\cdot}50 & \text{picks.} \end{array}$$

When quarter-picks are required exactly, by changing one wheel only—multiply 507·5 by 4, and the product of the two drivers A and C must equal this. Then every tooth in the driven wheel B will represent a quarter-pick per quarter-inch.

There are many methods of letting off the warp positively, but none are likely to succeed in displacing the older and quite satisfactory method of levers, ropes, and weights. The very fact of making the let-off positive, causes too great a rigidity in the hold of the warp, which is detrimental to the yarn. The frictional let-off is not likely to be replaced in cotton goods weaving unless it be in some of the heavier kinds of fabrics. Where it is a question of putting in as much weft as possible, the positive let-off has an advantage.

## CHAPTER III

### *DROP-BOX LOOMS*

WHERE more than one weft is used in a fabric, it is, of course, necessary to change the shuttle automatically. Sometimes two or more different counts of weft of the same colour are used, and sometimes different colours of weft. Checks of all kinds extra weft spots, and others are the chief classes of fabrics which require change boxes.

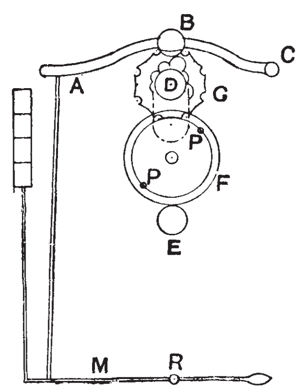


FIG. 76.

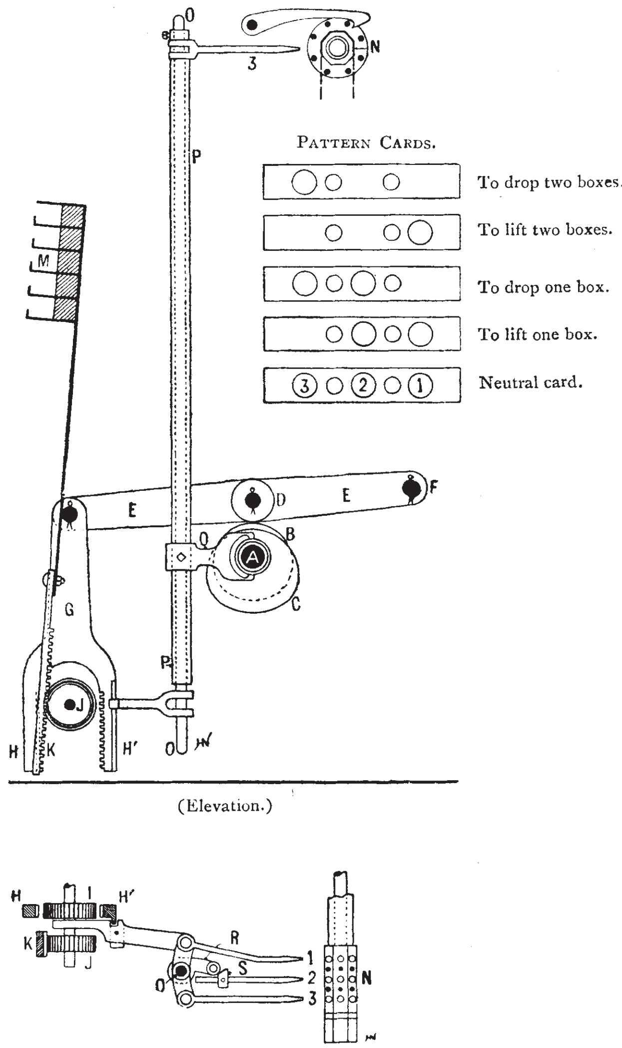
The oldest and commonest form is the Diggle's chain motion illustrated at Fig. 76. The number of boxes used in this motion is either 2, 3, or 4. It would be possible to use more, but it is not usually done with this arrangement for operating them. A lever, AC, is centred at C (Fig. 76), and the friction bowl B on this lever is moved upwards by a chain, composed of links fastened together on pins, which work round a barrel, D. These links are of different sizes, according to the number of boxes used. The smallest link leaves the top box in a line with the shuttle-race, and the other links are of such a size as to raise either the second, third, or fourth boxes (assuming that there are four) into this position. The general method is to raise the boxes one at a time, and drop them all together, but this is not compulsory. It will be seen that the motion of the boxes is not positive downwards—that is, the boxes drop by their own weight, and are not mechanically forced down, as in Wright Shaw's or Whitesmith's motions—and it will be well understood that there will thus be a limit to the speed at which the loom can be run. The method of turning the barrel D which carries the chain is as follows. A wheel, E, on the crank-shaft drives a larger wheel, F, above it. On the face of this wheel, F, is a rim and two projections, PP, or, it may be, only one projection. These projections or pins gear into the star wheel G, which is fastened to the barrel carrying the chain, and therefore when the star wheel is turned one tooth, or one-eighth of a revolution, it will move the chain a space of one link. The wheel E on the crank-shaft often has one-fourth the number of teeth contained in the wheel F; therefore, if there are two pins or projections, PP, in the circumference, the star wheel will be moved one tooth every two picks, and the boxes may be changed so often by making the chain accordingly. The lever M, which is centred at R, has the boxes attached to one end, and the other end may be pressed down by the foot when it is required to lift the boxes for any purpose when the loom is stopped. Supposing the wheel E to have 15 teeth and F 60 teeth, if there are two projections, PP, on the face of F, the shuttle may be changed every two picks, but if there is only one projection or pin, there may be a change every four, or a multiple of four picks.

The chief disadvantage of this motion in the form given at Fig. 76 is that the chain becomes very cumbersome if a long pattern is required. To obviate this, the projections PP are, in an improved motion, made so that they can be withdrawn from gear with the star wheel. This is effected by a clutch motion which is subsequently described in connection with the "pick-and-pick loom." With this improvement, each link in the chain may be made to represent any number of picks, the number being regulated by a small chain of metal cards, and thus larger patterns may be made without the long heavy chains which are required in the ordinary "Diggle."

The Diggle's chain principle, although suitable for some types of looms, is not an ideal motion, as the downward movement of the boxes is negative. The boxes have nothing to force them down but their own weight and the weight of the levers connected with them, and this necessitates the loom being run at a slower speed than is the case with some of the positive drop-box motions. Of this latter kind Wright Shaw's motion is one of a great variety of different types, and has been in use for a long time.

## WRIGHT SHAW'S DROP-BOX.

The principle of this motion will be understood from the diagram, Fig. 77. The essential feature of this invention is a forked rack, G, suspended from the free end of a treadle lever, E, fulcrumed at F, and carrying a bowl or runner, D, near the centre. At one end of the second motion or picking shaft, A, of the loom, are two cams, B and C, either of which may be brought underneath the treadle bowl at will, so as to raise the treadle and forked rack once during each revolution of the picking shaft, corresponding to two picks. Passing midway between the two prongs, H, H′, of the fork is a short shaft, upon which are secured two toothed wheels, I and J. Wheel I is so placed that the teeth on either side of the rack may be put into engagement with its teeth just before the fork rises, so as to turn




(Elevation.)

(Part Plan.)

FIG. 77.

the wheel in either direction; or the rack may occupy a neutral position when rising, in which event the wheel remains stationary. In any case, the racks are always clear of the wheel when descending. Immediately in front of wheel I is another similar wheel J, whose teeth are in permanent engagement with those of a rack, K (an extension, L, of which supports the shuttle-boxes, M). Thus, if rack H′ is put into gear with wheel I, boxes will be depressed as the rack rises; but if rack H operates, the boxes will be raised. One box, or two boxes, only, may be either raised or dropped at one change, according to which rack and which cam is put into operation. The smaller cam moves one box, and the larger cam two boxes, either up or down.

The selection of racks and cams is made by pattern cards (detached) which pass over an octagonal prism, N. The cards are presented separately, once in two picks, to three selecting needles, 1, 2, 3. The two outer needles, 1, 3, are attached one at each end of a double arm secured at the top of a long vertical shaft, O, the bottom of which communicates with the forked rack G. Thus a depression of boxes is effected by a blank part of a card pressing against needle 1, and an elevation of boxes by pressing back needle 3. Shaft O is loosely contained within a long tube or sleeve, P, which carries a short arm, R, at the top, and a forked clutch, Q, which acts upon the boss of cams, B and C. If it is desired to move two boxes, needle 2 is pressed back, thereby causing an inclined piece, S, secured to it, to act upon arm R so as to slightly turn the sleeve P, and move the larger cam C under the treadle bowl at a time when the short side of the cam is uppermost, as indicated in the diagram, Fig. 77. At one point, the larger and outer cam is slightly lower than the smaller one, and can be readily moved under the bowl.

The various changes which can be made by this motion may be seen by referring to the cards at Fig. 77. When there is a blank opposite the first needle only, the rack H′ is pushed to the left and the boxes are moved "down one." When there is a blank opposite the third needle only, rack H is moved to the right and the boxes are forced "up one." When there are blanks opposite the first and second needles, they are pushed backward, thus moving rack H′ to the left, and also forcing the larger cam under the treadle bowl, in which case the boxes will be moved "down two." When there are blanks opposite the second and third needles, they are pushed backward, and the boxes are "raised two." When there are three holes in the card, the racks, when lifted, miss the wheel, and there is "no change" in the boxes. It will be seen that the boxes may be moved either up or down, a space of one or two boxes only at a time. There may be more than three boxes, as many as five being regularly used; but if there were five, it would not be possible to change from the first box to the fourth or fifth. The greatest change which can be made is from the first to the third, fourth to second, and so on.

## WHITESMITH'S DROP-BOX.

The principle of Whitesmith's motion is probably the best for any number of boxes. It is usually made for four, and the change may be made with certainty from one box to any other. The arrangement for working four boxes in a loom is illustrated at Figs. 78, 79, 80. The principle will be best understood by referring first to Fig. 80. The four different positions of the boxes are here shown. The boxes are connected to the ring or strap of an eccentric at the point E, and at A the position of the parts is shown when the boxes are at their lowest point. The eccentric, F, on the shaft has a lift of one box, and therefore by causing it to make half a revolution intermittently every two picks, the boxes would be alternately lifted and dropped a space of one box, as will be seen by referring to C (Fig. 80), where it has made half a revolution from its position at A. It

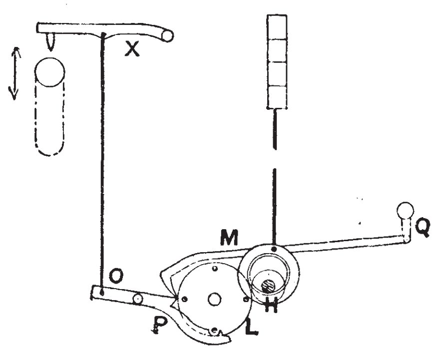



FIG. 78.

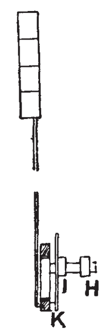



FIG. 79.

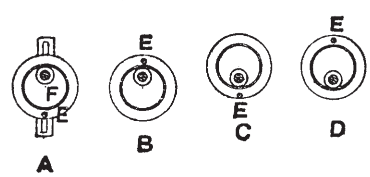



FIG. 80.

will be seen that E is one box higher at C than at A. Starting again from the first position, as at A, by turning the outer ring halfway round and leaving the eccentric stationary, there will be a lift of two boxes. This is shown at B (Fig. 80). Again starting with the first position, as at A, if we turn the outer ring halfway round, and at the same time turn the eccentric F half-round, we lift a space of three boxes—that is, from the first to the fourth box.

The position of E in this case is shown at D (Fig. 80). We thus see how from the bottom box any other of the four can be reached. By turning the eccentric halfway we lift one box, by turning the ring halfway round we lift two boxes, and by turning both ring and eccentric halfway round we lift three boxes. If we are at the third box, as at B (Fig. 80), and we wish to reach the second box or one lower, by turning the eccentric half a revolution and the ring half a revolution we shall get the position required. It will thus be seen that any one of the four boxes may be reached at will. At Fig. 79 another view of the eccentrics and boxes is given. The wheel H is keyed to the shaft on which the eccentric is fixed, and riding loosely upon this shaft is another wheel, I, of the same size, to which a fork, K, is attached. This fork fits on to a pin at the back of the ring, and thus by turning the wheel I the ring can be moved independently of the eccentric. If the wheel H is moved it moves the cam, and if the wheel I is moved it moves the ring. Referring now to Fig. 78, the wheel H is shown. This wheel is driven by a wheel, I (Fig. 79), twice its size. On the face of the wheel L there are four pins, and by lifting the lever OP at O, the pulling hook M is dropped round one of the pins, and the hook being moved forward by the crank Q will cause the wheel L to make a quarter of a revolution and the wheel H to make half a revolution, and therefore the eccentric is moved half a revolution. On the same stud as the wheel L there is another wheel exactly the same size and with four pins; this wheel (which cannot well be shown in the diagram) gears into the wheel I shown in Fig. 79. There is also another pulling hook which works along with M. This second pulling hook is operated by another lever like OP. There are two levers, X, which are lifted by the cards, and by lifting X, either, or both, of the pulling hooks may be dropped, and either of the wheels I or H (Fig. 79) turned half a revolution, but always in the same direction.

The wheel L and its companion are prevented from turning too far by a strong friction arrangement.

This motion may be adapted to work six boxes, or even more. For six boxes there is another eccentric inside the first eccentric, which can be worked independently; this will, of course, require a third pulling hook, and so on.

Many loom-makers have patented arrangements on the same principle, which do away with the pulling hooks M, and it is probably in this direction that the motion may be improved.

The Whitesmith principle is simple, and positive throughout, and it is difficult to see why it is not in more general use. It is generally admitted by those who have had practical experience of drop-box looms on this principle that it is the best. There are other drop-box motions, but the foregoing are the chief kinds.

## CIRCULAR-BOX LOOMS.

These are not used in the cotton trade to anything like the extent they are in the woollen and worsted trades, especially in Yorkshire. It is remarkable that this should be the case, as it is claimed for circular boxes that they can be run at a higher speed than any other kind. Circular boxes are usually made for six shuttles, generally to move only one box at a time, but they are made to skip one box, although the arrangement is by no means so simple or satisfactory as in a well-made loom on Whitesmith's principle, where the changes are made from one box to another almost noiselessly. At Fig. 81 the mechanism of a circular-box motion is shown. There are two hooks, A and B, which act upon pins outside the boxes. When the hook

A is pulled down the boxes will be turned one to the right, and when B is pulled down they are turned one to the left. A lever, EF, is connected with the lower part of each hook, and another lever, M, is lifted every two picks by means of a cam, C. The cards lift or drop the L lever QS at S, and so the hook H can either be lifted or left down by the lifter M, and the boxes can be turned one in either direction. A disadvantage of circular boxes is that they cannot be used in fast-reed looms on account of the difficulty of operating the stop rod from the back of the boxes. They are therefore only used for weaving the lighter classes of fabrics.

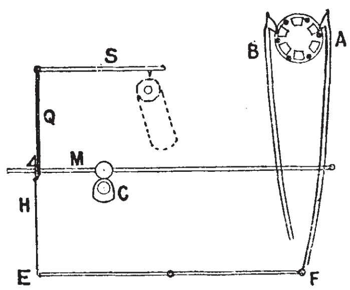


FIG. 81.

## PICK-AND-PICK LOOM.

The majority of box looms are made with movable boxes at one side of the loom only, so that single picks of any colour cannot be put in the cloth at will. As it is very desirable in many fabrics to use single picks of a colour or count of weft, it is necessary to have movable boxes at both sides of the loom, and where this is the case it is usual to have picking mechanism which will allow of several picks being made in succession from either side of the loom. If the matter be carefully thought over, it will be easily apparent that even with drop boxes worked quite independently of each other at both sides of the loom, if the picking mechanism is of the ordinary kind—viz. to pick once from each side alternately—it would be impossible to obtain that variety of changes in the shuttles which is in many cases necessary. In a loom with two boxes at each side worked independently, it would be impossible to obtain single picks alternately of two colours or counts. But by being able to pick twice in succession from each side this can be done. By going through all the changes possible with a given number of boxes, the advantage of this kind of picking arrangement will be very apparent, in the command it gives over any shuttle in the series for any pick. It is therefore necessary to have the picking mechanism aforementioned in order to allow of all the boxes being emptied at one side if required. A loom of this character is called a "pick-and-pick" loom; the picking motion is sometimes called a "pick at will" motion. The loom which we take as an example is one on the Diggle's chain principle. There are two chains, placed at one side of the loom for convenience. Both chains are on one barrel, A (Fig. 82). The chain for working the boxes at the right-hand side of the loom operates the lever B, and the left-hand chain operates the lever C, the fulcrum of both levers being at D. When these levers are lifted they lift the levers E and F, and when E is lifted it lifts the boxes at the right-hand of the loom, and when F is lifted it lifts the left-hand boxes. The connection of the left-hand boxes with the lever F is shown at Fig. 83. The shaft G is placed under the loom, and the left-hand boxes are connected to the lever H, which is fast to the shaft G. The lever F is also fast to the shaft G, but the lever E rides

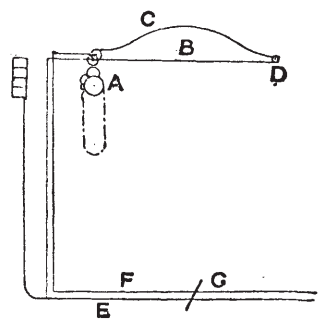


FIG. 82.

loosely upon this shaft, which merely serves as a fulcrum for E. From these two figures it will be clearly understood how the boxes may be worked independently at both sides of the loom by two chains placed side by side upon the barrel A.

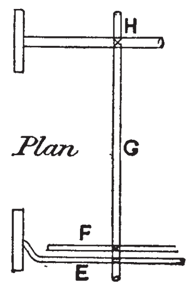


FIG. 83.

In order to make each link in these chains represent any number of picks, and thus prevent long cumbersome chains, the mechanism shown at Figs. 84 to 87 is employed. The barrel A in Fig. 84 is the same as barrel A in Fig. 82, and carries the chains for lifting the levers B and C. At the end of the barrel the star wheel I is fixed, and this star wheel is turned by the pins J. These pins are worked by a clutch motion shown at Fig. 86, by which they can be withdrawn from gear with the star wheel as desired.

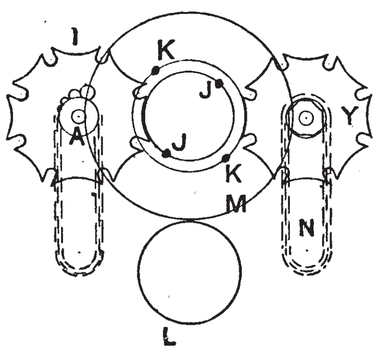


FIG. 84.

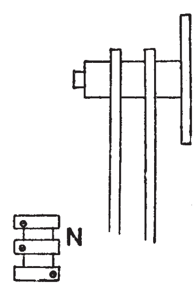


FIG. 85.

The pins KK are fixed, and turn one tooth of the star wheel Y every pick, the wheel M having twice the number of teeth contained in L, which is on the crank shaft of the loom. The star wheel Y is fast to the end of a small octagonal barrel, which carries a pattern chain N composed of small metal cards, and we have seen how this barrel is turned one division every pick. Above this pattern chain N a finger, O (Fig. 86), is placed and is lifted up against a spring every pick by the cam P on the face of the wheel M. When the finger is up, the pins JJ are taken inside the wheel M, as shown at Fig. 86. The cam P only raises the finger a sufficient length of time to allow the barrel Y to be turned round, and if there is a blank in the cards opposite the finger O when it is let down by the cam it will still keep the pins J inside the wheel, and will thus prevent

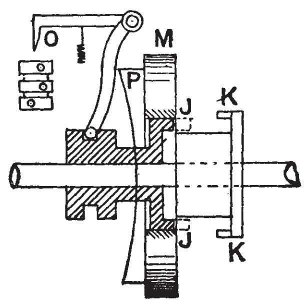



FIG. 86.

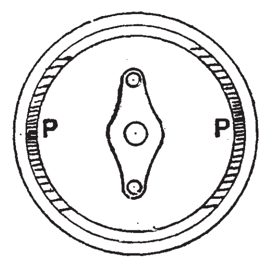



FIG. 87.

either of them from engaging with the star wheel I, and will leave the boxes unchanged. This can be repeated any number of picks. If a change is required in the boxes, a hole is placed opposite the finger O, and when it is let down the pins J project through the wheel M (as indicated by the dotted lines in Fig. 86), and the star wheel I will thus be turned one tooth, and the chain can make the change required in the boxes.

Fig. 87 is another view of the cam-shaped projection P, which raises the finger every pick, and Fig. 85 is another view of the chain barrel A. The letters in the six Figs. 82 to 87 inclusive refer to the same parts in each case.

In this way the chains on A are rarely required to be very long, as one link may be made to represent any number of picks from one upwards. Of course a separate card on Y is required for each pick, but these are very small, only about $1\frac{1}{2}$ inch in length, and a large pattern can be made with very little trouble.

When a Jacquard is used on one of these looms it is sometimes necessary to work the pattern from the Jacquard cards. This can be done in a very simple manner by covering the hole in the barrel carrying the cards N with a metal plate, which is held over the hole by a spring. When a change is required in the boxes, a Jacquard hook pulls the plate from over the hole, and allows the finger O to drop, and thus causes the star wheel I to be engaged by the pins J.

The picking mechanism in a pick-and-pick loom may be either over or under pick. In the former the picking tappets are sometimes moved on the shaft by a clutch arrangement. In the latter the top of the picking treadle is movable. As the under pick is perhaps the best adapted for this loom, we will describe it.

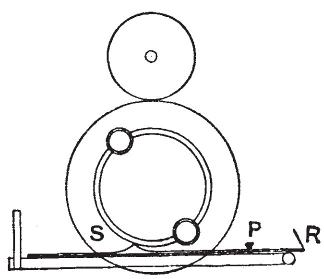


FIG. 88.

Fig. 88 is a side view of the loom, and the top of the picking treadles consists of a metal plate with the "shoe" S of such a shape as to give the required force and character to the pick. This metal plate works round a pivot, P. The treadles at both sides of the loom are the same in this respect. At the back of the loom a rod, R, is connected to the extreme ends of the loose plates or the treadles, and when one plate is *on* the treadle, the other is fixed *off* its treadle, as shown in Fig. 89. The consequence is that when the picking bowls come round (there are two bowls on the bottom shaft at each side of the loom) the loom will pick always from that side where the loose plate is *on* the treadle, and at the other side, where the plate is *off*, the bowls will pass over the treadle without touching it. By moving the rod R sideways, the plates may be moved alternately off and on their treadles.

If the loom has four boxes at each side, it may be necessary to pick four times in succession from one side of the loom, and by a simple arrangement the picking can be regulated at will. The mechanism for moving the rod R sideways is shown at Fig. 90. Inside the loom framework a lever, L,

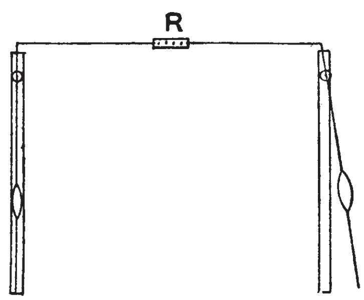



FIG. 89.

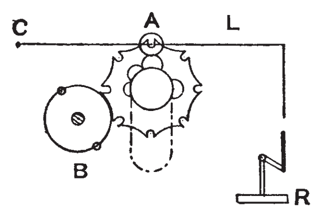



FIG. 90.

is centred at C, and by a combination of levers is connected to the rod R, which is the rod referred to in the previous diagrams. A strong spring keeps the plates right for picking from one side, but when it is required to pick from the other the lever L is lifted, which moves the rod R sideways and moves the plate off one treadle and on the other. A chain is used for lifting the lever L, and the star wheel A is turned by two pins on the wheel B on the bottom shaft of the loom, or by one pin if on the crank shaft, thus causing the star wheel to be turned one division every pick. The loom may thus be made to pick four times from the right side, three from the left, twice from the right, and so on, of course always taking care that the shuttles are there to be picked.

# CHAPTER IV

## *DOBBIES*

THE tappet shedding motion is the simplest and most perfect for a small number of shafts. They may be made to work an indefinite number of shafts, but it is seldom that above eight or ten are worked with ordinary tappets, and about sixteen with Woodcroft's or other plate tappets.

With dobbies, a higher number of shafts may conveniently be worked, but it is not only for this reason that dobbies are so extensively used. They are extensively used for weaving twills, satins, and other simple weaves, on four or five shafts. The chief advantage they possess is that any number of shafts within their capacity may be used without extra trouble or cost; whereas ordinary tappets have to be made specially for each pattern; whilst section tappets, and oscillating tappets, are inconvenient.

Dobbies are made to weave up to 40 or more shafts, but 16 and 20 are the commonest numbers. Most dobbies now used are on the double-lift principle; indeed, the single-lift dobby or witch machine is almost obsolete in cotton weaving. The chief kind of double-lift dobby is the "Hattersley" or "Keighley" dobby. The principle of this machine was invented by Messrs. Hattersley & Hill, of Keighley, Yorkshire; hence its name. Since the original patent rights have expired, almost all loom makers have their own particular form of this dobby, embodying many more or less minor improvements on the original. The principle of this dobby will be understood from the lecture diagram, Fig. 91. The dobby is placed at one side of the loom, and is therefore in a convenient position for being attended to. The upright rod R is connected to a crank on the bottom shaft of the loom, and therefore the rocking lever AB, centred at C, will make one complete movement to and fro, every two picks. The knives D and E slide

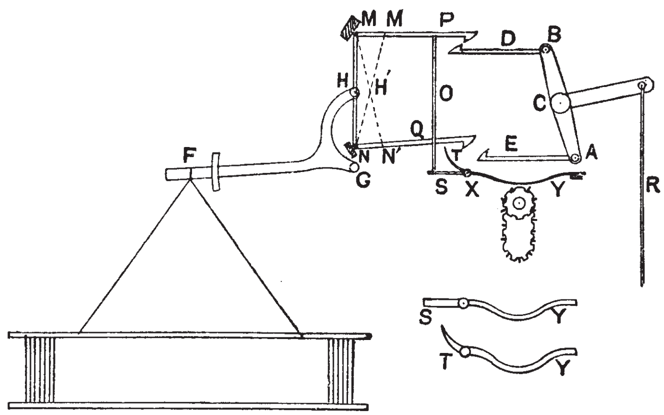



Fig. 91.

along, always retaining a horizontal position, one going inward as the other comes outward.

The shaft or stave is connected to the jack lever FGH at F, and the upright MN is fastened to this lever at H, the fulcrum being at G. The upright MN has two hooks, P and Q, connected to it at opposite ends, and suppose that when the knife D is in its innermost position, as in the diagram, the hook P is dropped on to the knife; when the knife begins to move it will take the top of the upright MN with it until MN assumes the position indicated by the dotted line M'N, and the stave is lifted. If it is required to lift the same stave for the succeeding pick, the bottom hook is then dropped on to the knife E, which at that moment will be in its innermost position just commencing its outward movement, and is taken forward by it until the upright MN assumes the position indicated by the dotted line MN′; and it will easily be seen that as the top of the upright is moving back from M′ to M whilst the bottom of the upright is moving forward from N to N′, the centre of the upright H remains stationary at H′, with the exception of a slight movement caused by the knife going further back than the hooks, and thus the stave remains up all the time. The character of the shed is, therefore, what is termed "open shed"—that is, if a stave is required up for several picks in succession, when it is lifted it remains up until it is required to come down again. This is what is meant by "open shed" as compared with "centre shed," the characteristic of which is that the lifted stave, instead of remaining up, is let down halfway every pick and taken up again if required.

The method of dropping the hooks is as follows:—Two levers, S, T, of different shapes are employed for each pair of hooks; these levers are centred on a rod, X. One of the levers, viz. T, is bent from the fulcrum to touch the bottom hook, and the lever S projects straight out from the fulcrum, and an upright needle O rests upon it, the top hook resting upon the upright needle. When the lever SY is lifted a little at Y it will drop the top hook, and when TY is lifted at Y it will drop the bottom hook.

In a 16 shaft dobby the parts shown in the diagram are duplicated sixteen times—that is, there are sixteen uprights MN, each with two hooks, sixteen levers SY, sixteen like TY, and sixteen of other parts. The levers SY and TY are operated by lags pegged so as to lift the staves to give the required pattern. These lags work round a cylinder or barrel, which is turned round the space of one lag every two picks intermittently. Each lag operates the hooks for two picks, one row of pegs operates the top hooks P, and the other row of pegs the bottom hooks Q. The method of pegging the lags will be understood from Fig. 92, where two lags are shown with

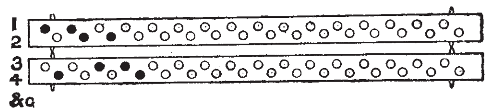



FIG. 92.

the pegging for a two and two twill. Of course care must always be taken that the pegs are put opposite the proper levers, as when only a portion of the jacks are used, say eight, it is often preferred that the staves be connected to eight jacks in the middle of the machine.

Double jacks are often preferred, as the cords connecting

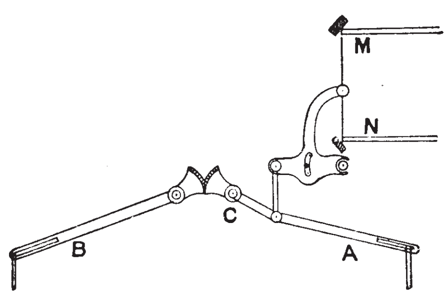



FIG. 93.

the stave to the jacks are shorter and have a straight lift. This is shown at Fig. 93. The lever A is centred at C, and when either end of the upright MN is taken forward it lifts the lever A, which at the same time causes the lever B to lift an equal distance. Thus the stave gets a straight lift from both sides, and there is less liability of the cords stretching, and less vibration of the heald.

The Keighley dobby is decidedly the most popular one at the present time, but what is known as the "Blackburn" dobby is preferred by some. This is a double-lift dobby, which gives a centre shed—that is, the staves which are required up for a number of picks in succession are let down halfway every pick and taken up again. The principle of this dobby is illustrated at Fig. 94. The staves are lifted by the

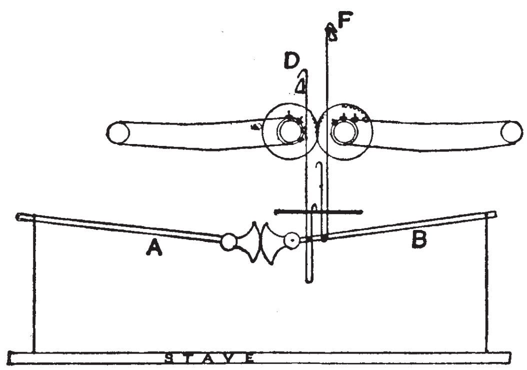



FIG. 94.

two jacks A and B; when B is lifted it causes A to lift the same distance. There are two hooks, D and F, for each double jack, and the lags are divided into two parts, all the odd numbered picks being fastened together, and the even picks forming another chain. The pegs in the lags press back the hooks, the back part of each of which forms a spring, so that when the hook is pressed back it leaves the stave down.

The knives lift alternately. When one is going up the other is going down, and when one hook of a pair is lifted, as in the diagram, a lag operates the other hook, and if the same stave has to be lifted for the next pick, the hook is left over the knife, and the second hook will be taken up whilst the stave is being let down, and will catch it halfway and take it up to the top again. This is the advantage of all double-lift machines over single-lift. The staves which are required up for a certain pick are being taken up whilst those which were up for the previous are coming down. A saving of time is thus effected, and the looms can be run quicker than with single-lift machines. The knives are worked from the bottom shaft, as shown in Fig. 95.

Another thing to be borne in mind is that in a single-lift machine all the staves come to the bottom every pick, and therefore the character of the shed is different from that of a double-lift. In double-lift machines there are the "open-shed" like the Keighley dobby, and the "centre shed" like the Blackburn dobby. It is important to remember these points, as the cover and appearance of the cloth is affected by the beating-up being done in different kinds of sheds.

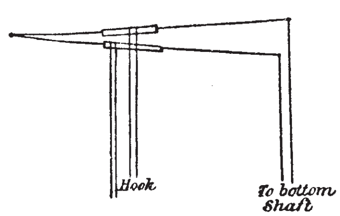



FIG. 95.

The loom crank is usually set at the top centre, or thereabouts, when the rising and falling staves are level, so that the shed will be partly open for the next pick by the time the loom crank gets to the front centre. In single-lift dobbies the beat-up is made when the shed is closed, and so the warp has not the same chance of being spread as with the timing of double-lift dobbies. This difference in the character of the shed when the beat-up is made is caused by the fact that in a double-lift machine the knives, being in the middle of their stroke, are moving at their quickest speed when the shed is closed, and in a single-lift the knife is almost stationary when the shed is closed. The same thing occurs in Jacquards, and the matter may be better understood by a reference to the chapter on Jacquards.

Dobbies can be made "positive" in various ways. Keighley dobbies are made with a pin fixed on the upright MN (Fig. 91) at the point H. A wire is hooked on to this pin and connected to an L lever at the side of the loom opposite the dobby; this is connected to a lever at the bottom of the loom. By connecting the bottom of one stave to this lever the stave will be pulled down as the upright M N is taken forward, and so the knife whilst taken one stave up is pulling another down, rendering the dobby positive. This, of course, will only do for certain simple patterns, such as twills, satins, and similar weaves, and would not do for patterns where different numbers of staves are lifted every pick. Positive dobbies are not much used in the cotton trade.

The ordinary form of dobby is non-positive, the stave being kept down by springs in some form or other. One reason which may be urged against ordinary springs, or "jack boxes," is that the pull on the heald increases as the stave is lifted and the spring opened. It is obvious that this is just the reverse of what is required, as the stave is lifted positively, and the pull on it may therefore conveniently be decreased as it is lifted, and the healds would last longer. The use of the spring is to keep the stave down, and therefore it should exert its greatest force when the stave is at the bottom. A simple method of accomplishing this has long been in use. Something on the same principle has been used on hand looms for generations, and very cheap and convenient undermotions of this kind have long been available for power looms; but, strange to say, cotton manufacturers have been very slow at adopting them. An undermotion of this kind is illustrated at Fig. 96. The spring is fixed at A, and a wire hook connects the spring with the quadrant at B. It will easily be seen that as the stave lifts, the direction of the pull of the spring is gradually moved over the centre of the quadrant at C. If the stave were lifted until the spring was in a direct line from A

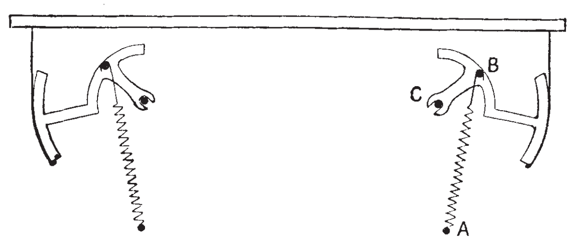



FIG. 96.

to C, the pull on the stave would be *nil*, as all the force would be exerted on the fulcrum. Each stave is connected at both sides in the same manner, the springs and other parts are all arranged in a very compact manner, and the cost is very small.

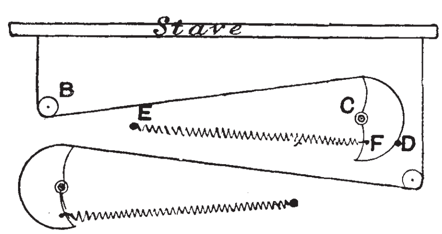



FIG. 97.

Another form of undermotion on the same principle is much used in Yorkshire in the woollen and worsted trades. This is illustrated at Fig. 97, and is known as Kenyon's undermotion. In this the springs are arranged horizontally, and therefore longer springs can be used. The quadrant is centred at C, and a strap is fast to the quadrant at D. The spring is connected with the quadrant at F. The strap passes from the quadrant under the bowl B, and thence to the stave. Another quadrant serves in the same manner for the opposite side. The spring is fastened to a bar at E, and as the stave is lifted, the pull of the spring is gradually moved over the centre C, and therefore the pull on the heald gradually decreases as it is lifted.

## CHAPTER V

### *MISCELLANEOUS*

When two or more pieces are woven in one width and afterwards cut or torn apart, if there are not a few leno ends to divide each piece the warp threads have nothing to stop them from coming out at the cut sides. In light fabrics this is a greater disadvantage than in heavy and finely picked ones, such as velvets, and therefore in the former it is usual to weave a

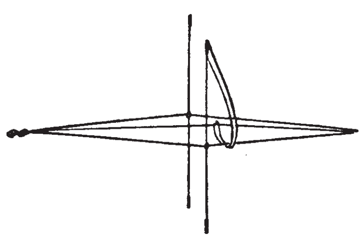


Fig. 98.

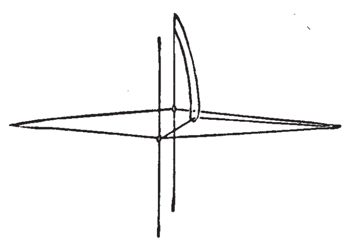


Fig. 99.

few ends leno to keep the edge firm. There are various kinds of motions for effecting this object, one of the oldest being that illustrated at Figs. 98 and 99. This is for an ordinary plain loom, and the crossing end is taken through the back stave and through a loop from the top of the front stave. This loop is often formed of a small fine pliable chain, as it wears longer than worsted. Fig. 98 shows the back stave lifted, and Fig. 99, the front stave up, when it will be seen that the crossing end is brought up on the opposite side from the previous pick.

Another, and perhaps a better, method, is Shorrock and Taylor's patent, shown at Figs. 100 and 101. For a plain loom the two straps A and B are fastened to a drum on the top roller of the loom. In these straps are the small eyes C and D, and through these eyes the crossing ends are taken. The "standard" ends, round which C and D are crossed, are drawn through the fixed eyes EF, immediately above the small bobbins MN. The straps pass round the bobbins and up to the elastics X, which are fastened to a hook, L, at the top of the loom. The top roller is rocked to and fro by the ordinary staves, and when rocked in the direction against the elastics the crossing

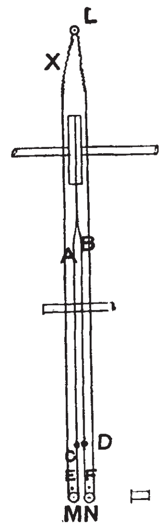



FIG. 100.

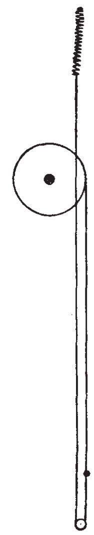


FIG. 101.

threads are brought up inside as shown at Fig. 100, and as the roller rocks back the elastics pull the eyes C and D completely round the bobbins and take the crossing threads up the other side of the "dummy" or "standard" ends, EF. The selvedge formed is thus like that shown at Fig. 102.

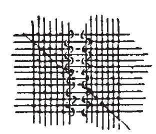


FIG. 102.

There are many patents taken out every year for split motions, but the simple old forms still keep their place.

Another invention of a totally different kind may be mentioned. In this, the weft is cut between the two cloths every pick as it is being woven, and the loose end is then turned round and taken into the cloth at the next pick, thus forming a practically perfect selvedge; indeed, it would be impossible for any one to find out the difference without being told or making a very close examination. For about half an inch at the inner side of the cloth there are double picks, but this is scarcely noticeable. The practical utility of this invention is yet to be proved, and one thing to militate against its general adoption is its cost, which is several pounds per loom, whereas some of the ordinary split motions cost only a few shillings per loom. With Jacquards or dobbies it is an easy matter to arrange an ordinary doup heald to form a split, but the arrangements before mentioned are used for plain looms, where it is not so easy to get the required lift. The twist used must be very strong, as no slackener is used. Usually it is a three- or four- or six-fold cotton thread.

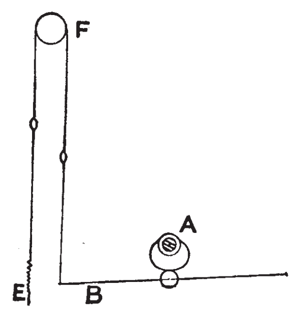


FIG. 103.

Another kind of selvedge motion is that used for producing a plain selvedge on a loom weaving satteens with tappets. The fact of the ordinary satteen being five picks to the round, and a plain selvedge being a necessity, causes either the tappets to be made ten to the round, working the plain selvedges by tappets on the same shaft, or the selvedge ends must be worked from another shaft. In what is known as Smalley's satteen motion the former principle is acted upon: the tappets are ten to the round, and the plain is worked from the same shaft.

A more ordinary form is that shown at Fig. 103. A small tappet, A, is fitted on the bottom shaft (or picking shaft), and this acts upon a lever, B, to which the bottom of one set of harness threads containing, say, the odd-numbered ends of the plain is connected, the other, or even-numbered, ends of the plain being connected to the elastic E, the bowl F at the top being used for working round. When the tappet presses down the lever B, it will take half the plain ends down and the other half up, and the elastic will pull back again as the tappet allows it. In this way a plain selvedge is obtained in a five-shaft satteen.

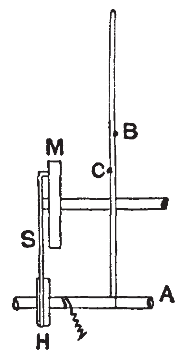


FIG. 104.

Another method of effecting the same purpose is shown at Fig. 104. A shaft A is placed under the loom, and this shaft is made to rock to and fro to work the mails B and C alternately up and down. The picking shaft of the loom has a crank M fastened to it, and a strap S is taken from this crank to the small drum H on the shaft A, and is wrapped round it. As the crank M revolves it will pull the shaft A in one direction until the crank gets to the top, and when the crank has passed the top of its stroke the spring X will pull the shaft back to its original position, and thus the required reciprocating motion is given to the shaft A and to the mails B and C.

## *Double-beat Slay.*

A double beat is sometimes required to be given to each pick of weft. This is done in weaving some of the heaviest kinds of sackings, carpets, and similar fabrics. Fig. 105 shows how this is effected. AB is the slay, and is movable about B as a centre; EC is in two pieces, viz. ED and DC, and these are fitted loosely on a pin at D. It will be obvious that when the crank occupies either position QP or QP′, the slay will be at the front of its stroke, and as the crank is moving from P to M it will pull the slay back a little, and in moving from M to P′ a second beat-up will be made. Whilst the crank is moving from P′ to P the shuttle is passed through the shed. It is

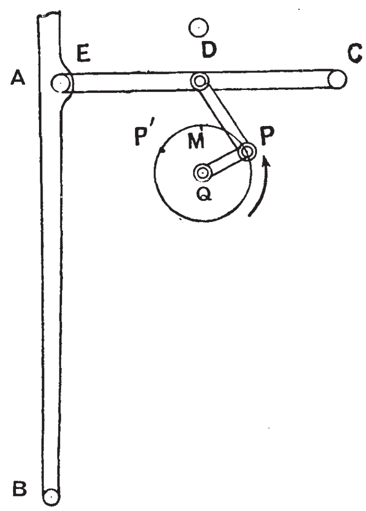



FIG. 105.

obvious that a beat-up of this kind will enable the weft to be beaten well up into the cloth, and more to be put in than with a single beat. The force exerted is often so great that the looms have to be very firmly fastened into the floor on which they stand, or they would move.

# CHAPTER VI

## *JACQUARD WEAVING*

THE Jacquard machine was the invention of a Frenchman of that name, who exhibited the machine about the year 1800. It was introduced into this country about twenty years later. The chief advantage of the machine is that a large number of warp threads can be operated separately, and a larger figure be produced than with a shaft harness. The chief ideas in the machine are that each mail is connected separately to its hook, and the use of perforated cards to leave any hook over the griffe if it is required to be lifted, or to push it away from it if the hook is required to be left down in the shed.

The original Jacquard machine was a single-lift, and although many minor improvements have been made in it, the main features are practically the same to-day as in the earliest machines introduced into this country. At the present day the single-lift is comparatively little used in cotton manufacture owing to the increased speed at which double-lifts can be worked, but it is still preferred in silk manufacture for several reasons. One reason is that the character of the shed when beating up in a double-lift machine is essentially different to that produced by a hand-loom, where of course a single-lift is always used, and as hand-loom fabrics have a finer touch and appearance than power-loom fabrics, the object is to imitate the hand-loom production as nearly as possible. The cause of this difference in the character of the shed when beating up will be explained later in this chapter. Another reason is that silk-looms could never be run at any speed higher than that of which a single-lift machine is capable, and therefore the advantage of increased speed of the double-lift is of no use.

Double-lifts, owing to the counterpoise and the division of the work on to two knives, are undoubtedly steadier in working, and this is an argument decidedly in their favour. Single-lifts are still used in the manufacture of figured lenos, as no shaking motion has yet been successfully adapted to enable the crossing ends to cross with a double-lift machine.

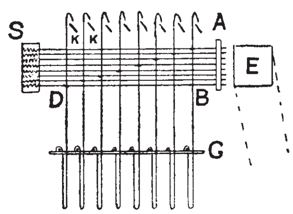


FIG. 106.

A single-lift Jacquard for weaving a pattern which occupies 400 ends in a repeat consists of 400 hooks and 400 needles, with an extra row of eight hooks for selvedges, or other auxiliary use. The hooks are arranged in eight rows with 51 hooks in a row. A cross section of this Jacquard is shown at Fig. 106, where the uprights are the hooks and the horizontal wires the "needles." A is the "needle board," and this is a perforated board through which the needles pass. The bottom needle B is twisted or looped round the back hook D, and the connection of the other needles and hooks is shown. At the back of each needle a small spring made of fine brass or steel wire is placed. These springs are held in position in the "spring-box" S. There are, therefore, 408 springs required for the 408 needles. The hooks rest on the grate G, but in some makes of machine the grate is not used and the hooks rest upon a "bottom board." In this case the hooks are very liable to turn round, and thus cause annoyance. To prevent this, flat hooks have been used, and the needle loop was shaped so as not to permit the hook to turn within it. The eight knives form the griffe. These knives are all fastened together, and are moved up and down from the crank-shaft of the loom. The illustration shows the knives at the bottom of their stroke, and at this point, or immediately after the griffe begins to move upwards, the card on the perforated cylinder E is pressed against the needles, and if there is a hole in the card, the needle directly opposite the hole will pass through it and into the perforation in the cylinder, and the knife will take up the hook to which this needle is connected. If the card is blank opposite any needle it will press back the hook, and as the knife lifts, the hook is left down. Thus it is possible to lift any of the 408 hooks in the machine for any pick. When the cylinder is taken away from the needles the hooks are forced back into their original position by the small springs in the spring-box S.

It will be noticed that the knives are leaning a little, and the reason for this will be apparent, as if they were not leaning they would catch the tops of the hooks in coming down, and would break or bend them. The sloping position enables the knives in coming down to press back the tops of the hooks and so get under them, ready for the next card to be pressed against the needles. The knives should come down low enough to be quite clear of the hooks, and therefore in this machine there is a considerable dwell when the shed is closed.

The harness for a straight-over pattern is mounted as shown at Fig. 107. In order to prevent confusion the connection of the cords to the machine is not shown, but the numbers on the line A represent the hooks in the machine to which the cords are to be attached. The "comber-board" or "cumber-board" B is a frame into which perforated slips are fitted. These slips are perforated to different degrees of fineness, the fineness being regulated by the number of ends per inch required in the cloth to be woven. The lingoes, L, are metal weights, and serve the purpose of keeping the mails down. MM are the mails, through which the warp threads are drawn in the order shown by the numbers, beginning at the back left-hand corner. The draft in straight-over patterns is always taken in this way in Jacquard weaving, although it is not compulsory. The harness is built

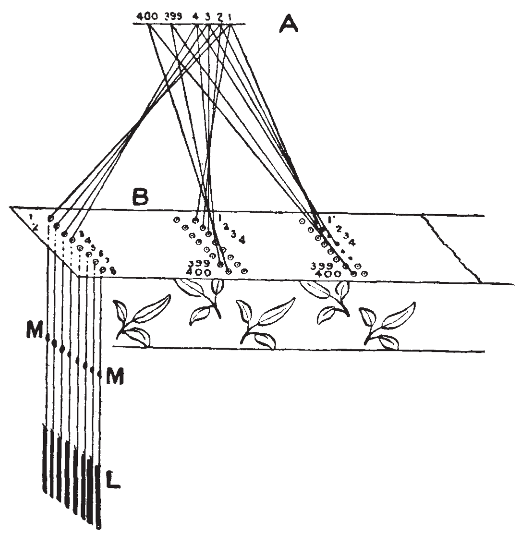



FIG. 107.

with linen thread, and the method of tieing the lingoes to the hooks will be understood from the diagram.

When one lingoe has been connected to each of (say) 400 hooks, the first pattern is complete. Supposing there are 100 ends per inch, the pattern will occupy 4 inches, and therefore if cloth is required 28 inches wide in the harness, there must be seven lingoes attached to each hook, making seven patterns, or seven repeats of the pattern, in the width of cloth. Thus when one lingoe has been tied to each hook, beginning with the first and ending with the 400th, another is connected to each hook, beginning again with the first; and when this is done other patterns are formed in the same manner until the required number is complete.

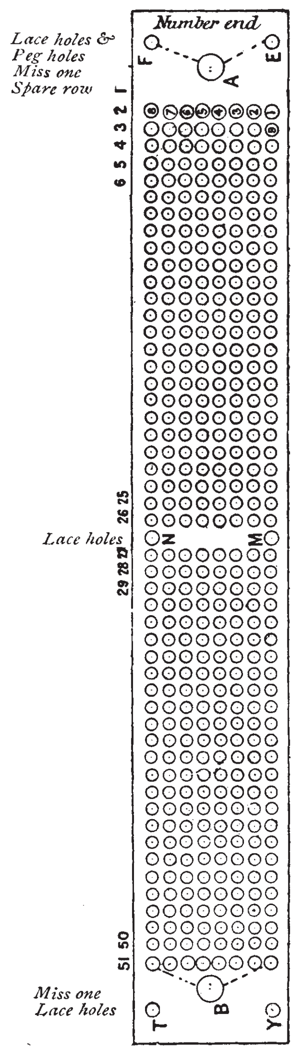



Fig. 108.

It is important to have a clear understanding as to which is the hook which lifts the first end in the draft. This hook is the one connected with the bottom needle in the last row on the 25-side of the machine. As we stated previously, a 400s machine has 400 hooks arranged in 50 rows of 8, or 8 rows of 50 hooks, and in addition there is always a spare row of hooks, making 51 rows in all. As it is necessary to lace the cards in the middle as well as at the sides, a space has to be allowed for the lace holes, and therefore the machine is divided into two parts by a space between the 26th and 27th rows.

end in the draft. This is the hole which operates the bottom needle in the last row on the "25-side" of the Jacquard machine, which, as was previously stated, is the hook from which the draft begins.

Following out the operation of cutting the card. When the 26th row has been cut, the lace holes MN (Fig. 108) are cut, and then the cutting is again straight-forward to the 50th row. The piano machine is so constructed that with the same stroke of the treadle which cuts the 51st row the peg hole D is also cut, and then follows a stroke without cutting, after which the two lace holes T and Y are cut. This makes 56 strokes of the foot for each card.

It is usual, in order to economise space, for the Jacquards with straight, or "Norwich," harnesses to be placed on the loom, so that on one loom the cards hang over the weaver's head, and on the next the cards are at the back of the loom. In both cases the harnesses are built the same way, but in one case (cards over weaver's head) the thread operated by the bottom needle on the "25-side" will be at the back of the comber-board, at the left hand; and in the other case (cards behind loom) the same thread will be at the front of the comber-board at the right-hand side.

As previously stated, the single-lift Jacquard for cotton weaving is not often employed except for special purposes, such as figured leno weaving. The advantage possessed by the double-lift Jacquard as regards speed is so very considerable that its adoption for ordinary forms of cotton weaving has become universal; and the advantage of speed is not the only advantage it possesses, as will be pointed out shortly.

A double-lift machine with one cylinder for a 400 end pattern consists of 800 hooks and 400 needles. Each needle is twisted or bent round two hooks, as shown at Fig. 111. The hooks are connected together in twos by neck cords, which are usually strong whipcord, as will be seen from the illustration. It will be seen that the bottom needle is bent round the back pair of hooks, the next needle round another pair, and so on. Each needle has a spring behind it, as in a single-lift machine.

There are two griffes, which work oppositely—that is, as one goes up the other comes down. The griffes (or knives) are worked by a double crank on the bottom shaft of the loom, so that each griffe moves from the bottom to top of its stroke in one pick, and from top to bottom in another pick.

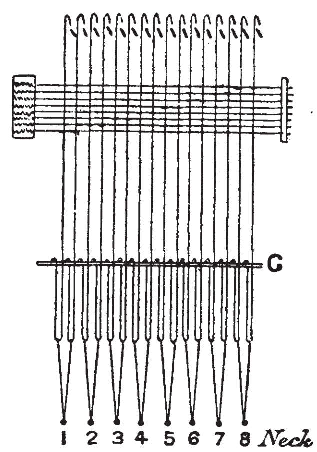


Fig. 111.

The principle of the double-lift will be understood from Fig. 112. One knife, A, is at the top, and the other knife, B, is down. One hook of the pair is lifted, and therefore the ends in the mails connected to the neck cord at C will be lifted. Suppose now it is required to lift the same ends of warp for the next pick: a card is pressed against the needles, and if there is a hole in the card opposite the needle E, it will leave the needle and the hook N where they are, and as the knife B is lifted, the hook N will be taken up as the hook M is coming down. The hooks will cross at about the middle of their stroke, and the weight of the ends and lingoes on the cord C will at that moment pass from the hook M to the hook N. In the diagram the cord attached to the hook N is slack, but when this hook is lifted the cord will gradually tauten until it bears all the weight, when the cord from the hook M becomes slack. We thus have the ends for the second pick lifted whilst the ends which were up for the previous pick are coming down. This is where the advantage of the double lift lies. In a single lift the knife must lift the hooks up and then come down to the bottom before another card can operate the needles, whereas in a double lift the card for a second pick can be brought against the needles as soon as the ends which were up for the previous pick are ready to come down.

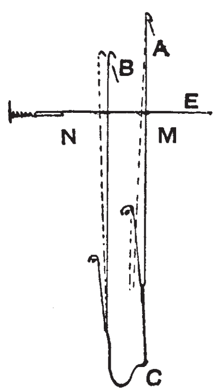


FIG. 112.

It is obvious that in the position shown in Fig. 112, when one knife is up and the other down and the needle pressed back by the card, that the hook M will also be pressed back, as shown by the dotted line. The bend of the hook over the knife, therefore, must be sufficient to prevent the hook being pushed off the knife, and it will be noticed that the hooks in this class of machine are bent more than the hooks in a single-lift machine. The hooks rest on the grate G, Fig. 111, and the shape of the hook at this point acts as a spring to straighten the lifted hooks after the pressure of the card has been taken off the needles. A machine of this kind can be run at a speed of about 160 or 170 picks a minute, as compared with the 130 or 140 picks of a single-lift.

A double-lift machine on another principle is illustrated at Fig. 113. This is a two-cylinder machine, and to weave a pattern repeating on 400 ends this machine requires 800 hooks and 800 needles. The cylinders work at opposite sides. The hooks are placed as shown in the diagram, the hooked parts facing each other in pairs, and by following carefully the manner in which the needles are twisted round the hooks it will be seen that there are really two single-lift machines placed together, alternate rows of hooks representing each machine. There are two griffes, as in the double-lift single-cylinder machine, and the griffes are worked in the same manner.

The cylinders work alternately, the cards being laced in two sets, all the odd numbers being together in one set and the even numbers forming another set. Immediately one knife is at the top and the other at the bottom, one cylinder is pressed against the needles, and it will be noticed that the hooks which each cylinder operates have the hooked parts in the direction of the cylinder. When the hooks operated by one cylinder are at the top the other cylinder is pressed against the needles, and thus the work done by one cylinder in Fig. 111 is divided between two in this machine. The advantage of this machine is in the lessened speed of the cylinders. The vibration caused by the cylinder working at a high speed in a single-cylinder machine is so great that the limit is reached at about 170 picks per minute, whereas a double-cylinder machine can be run up to 200 or sometimes even more picks per minute, though perhaps 180 is a more advantageous speed. The top set of

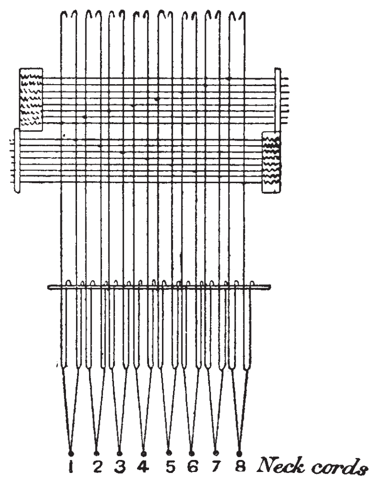



FIG. 113.

needles project a little further through the needle board to compensate for the difference in leverage on the hooks.

Besides the advantage of speed, double-lifts have an advantage in the counterpoise obtained by one set of hooks going up as the other comes down. This causes a more even motion and steadier working. Another advantage possessed by double-lifts is that the beating up of the weft is effected in a crossed shed, thus enabling more weft to be put in than in a single-lift, where the beat-up is done with a closed shed. This beating up in a crossed shed also spreads the warp better, and prevents the reed marks from showing, for the same reason as was given when referring to the spreading of the warp in the tappet loom.

In silk weaving a single-lift machine has an advantage in imitating more closely hand-woven goods, as hand-loom weavers usually beat up in a closed shed. This causes the weft to be put in straighter—that is, less wavy, which is very desirable in silk fabrics.

The cause of this difference in the shed when beating up in the two kinds of looms will be understood by following the relative positions of the griffes and the loom crank throughout its revolution.

In a single lift the time allowed for opening and closing the shed must be used to the best advantage; that is, as much time as possible must be given for this purpose. On this account it is necessary to pick the moment the slay is sufficiently far back to allow the shuttle to enter the shed—that is, when the slay is half-way back, or the crank at the bottom centre. The griffe is worked by a crank on the top shaft of the loom, and there is no actual dwell of the griffe or of the ends when the shed is open; therefore the shed must be opened a little wider than would otherwise be necessary for allowing the shuttle to pass through.

The shed must be sufficiently open to allow the shuttle to enter when the loom crank is at the bottom centre. This regulates the timing of the other parts. Fig. 114 will make this quite plain. The shed must be nearly fully open when the crank is at the bottom centre to allow the shuttle to enter; and when the loom crank is at A the griffe must be nearly at the top. When the crank is at B the griffe will be at the extreme top, and when the crank is at the top centre, or C, the griffe will be as near the bottom as it was to the top when the loom crank was at A. As was previously pointed out, the griffe must go further down than the hooks to allow another card to operate the needles, and therefore it is when the loom crank has arrived at C that the knife is leaving the hooks resting on the grate, or bottom board. The griffe will be at the

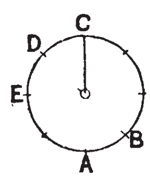



FIG. 114.

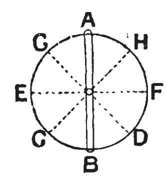



FIG. 115.

extreme bottom when the loom crank is at D, and when the griffe is up at the hooks again the crank is at the front centre, or E. Thus the shed has the fraction of a revolution between B and C to close in, and between E and B for opening. The shed remains closed for the quarter of a revolution, C to E.

In a double-lift the warp is much more leniently dealt with. As we have said, the shed must be open for the shuttle to enter when the loom crank is at the bottom centre. Therefore the griffes should be in their extreme position—one up and one down—when the crank is at the bottom centre.

The timing of the parts in a double-lift will be seen at Fig. 115. The cranks that work the griffes are on the bottom shaft, which of course makes a revolution every two picks. These cranks will be perpendicular when the shed is fully open; therefore when the loom cranks are at the bottom centre the cranks which drive the griffes must be in the position AB. If they are so set they will be in the position CD when the loom crank reaches the back centre, and in the position EF, or horizontal, when the loom crank arrives at the top centre, when the shed will be closed. We have thus a closed shed when the crank is at the top centre, as in a single-lift; but in this case when the shed is closed the griffes are moving quickly, whereas we have a quarter of a revolution dwell after the loom crank reaches the top centre in a single-lift. This causes, as we shall see, a difference in the shed when the slay beats-up, or is at the front centre. When the griffe cranks are in the position GH, the loom crank will be at the front centre, and thus the shed will be partly opened for the next pick when the reed comes in contact with the cloth.

Jacquards are made in various sizes. 100s, 200s, 300s, 400s, and 600s, are the most common. 100s are arranged in rows of four; 200s and 400s are in rows of eight; 300s and 600s in rows of twelve.

There are two distinct kind of harness mounting, the London and Norwich systems. In the former the Jacquard is placed with the narrow end towards the front of the loom, thus causing the cards to fall at the side. In the Norwich system, or "tie," the machine is placed with the broad side facing the front of the loom, thus causing the cards to hang either over the weaver's head or at the back of the loom. On this system, as there are eight rows in a machine, by taking the comber board eight rows deep the harness becomes what is called a straight neck. With the London system, the end of the machine facing the weaver, there must be a twist in each pattern in the harness. There is not much to choose between the two systems. Some prefer the London tie, as they say the twist in the harness causes the harness threads to support each other, and so last longer. The Norwich system is the more common, especially in the cotton trade.

Fig. 116 shows the method of tying up the harness on the Norwich system for a bordered fabric, such as handkerchiefs. In these goods it is usually preferred that both borders should point inwards, as in the sketches Figs. 116 and 117.

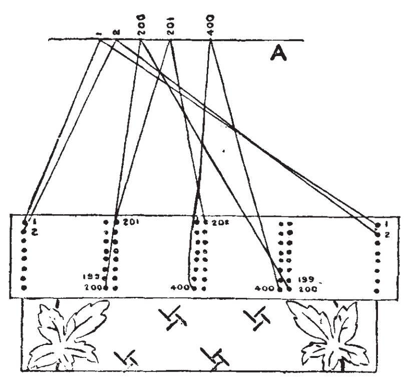



FIG. 116.

The hooks to which the harness threads are attached are numbered on the line A, and it will be seen that the draft begins in the left-hand corner at the back of the comber-board, the lingoes being numbered in the order of the draft. The cords are tied up just as for an ordinary straight-over harness for the first 400, or one full pattern of the machine, but then, instead of commencing with the first hook again, the 201st lingoe is tied to the 201st hook, and the second half of the pattern is repeated. This forms the middle of the handkerchief, and it must be repeated over a sufficient number of times to give the required width of cloth after allowing for the trimming and border. In

Figs. 116 and 117 nothing but a border and middle are shown, but sometimes a trimming of another small weave is required outside the border, and this, which is usually on a small number of hooks, is repeated over in the same way as the middle. In Fig. 118 only two repeats of the middle are shown; but supposing that the harness had 100 ends per inch, and that the handkerchief was required to be twenty-four inches wide exclud-

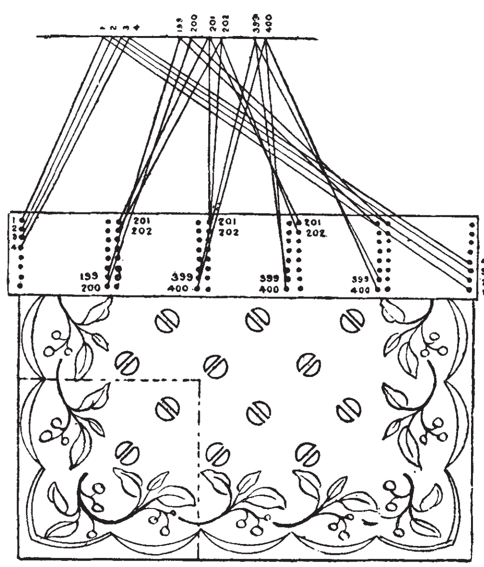


Fig. 117.

ing the border, there would be twelve repeats of the middle required. When the middle has been repeated over a sufficient number of times, the other border must be tied up, and to obtain the reverse position of the figure the draft must be reversed. By tying the next lingoe to the 200th hook, and going backwards with the draft, it can easily be seen that the same figure will be woven at this side of the harness as at the opposite side; the only difference will be that the figure will point to the left, as will also the twill in the ground, if it is a twill. This system of tying up is compulsory in the Norwich system, as it is usual to keep the harness straight—that is, the harness threads from each of the eight rows in the Jacquard each form a separate row in the comber-board. We have thus eight rows in the machine and eight rows deep in the comber-board, and it would not do to have a thread taken from the

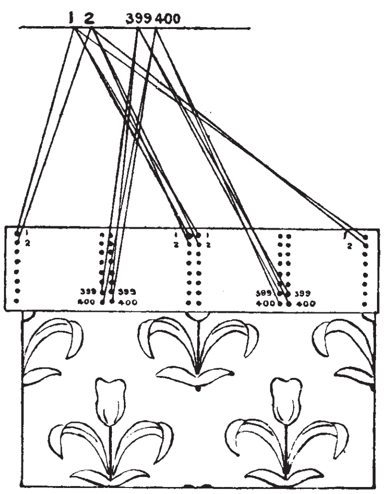



FIG. 118.

front of the comber-board at one border and from the back of the comber-board at the other border to the same hook.

If the harness is a "London tie" it necessitates a half-turn in each pattern, as the machine is at right angles to the comber-board. Therefore the draft may be continuous, as shown at Fig. 117, where, after the middle has been repeated a sufficient number of times, finishing with a thread from the 400th hook at the front of the comber-board, the next one is taken from the 200th hook through the back of the comber-board, and the border will finish with a thread from the first hook going through a hole at the front of the board—just the reverse to the other side.

Bordered goods are often made with two borders at each side, and sometimes the borders are repeated a few times. The number of hooks taken for the border and middle respectively vary according to requirements. Sometimes, in a 400 machine, 300 will be taken for the border and 100 for the middle, and so on. The cross-border must of course be designed, and the cards cut. The number of cards in a set in these goods is often very large, as the middle must be repeated over the required number of times, and there will be as many cards used in the set as there are picks in the handkerchief.

In designing for the mounting given at Fig. 117, the design would be made on 400 ends: 200 for the border and 200 for the middle, and the cards would be cut just in the ordinary manner. The cross-border would also be designed in such a manner as to harmonize with the side borders. The portion to be designed is enclosed by the dotted lines.

Centre ties or point ties are another class of harness in regular use. This is really the two borders of a bordered harness joined together. Fig. 118 shows how the tying up is done for a pattern of this kind. The first 400 threads are connected as usual, the draft being from back to front. When the 400th has been reached, the draft is reversed until No. 1 is arrived at again. The same effect is obtained as in a point of V draft in a shaft harness. The pattern must be of such a character that one half is the exact reverse of the other. This kind of harness is used for weaving large damask figures, and it is obvious that the effect produced is really that of a figure on 800 ends, or twice the size of the machine. Designs of this character are of course rather stiff, but are suitable for damasks, and similar fabrics.

## CROSS-BORDER JACQUARDS.

The object of a cross-border Jacquard is to save the expense of cards in handkerchiefs and other bordered goods. As pointed out previously, the portion of the handkerchief between the two cross-borders is usually repeated over for a considerable number of times, often from twelve to twenty times. This often means using a few thousand cards, which might be

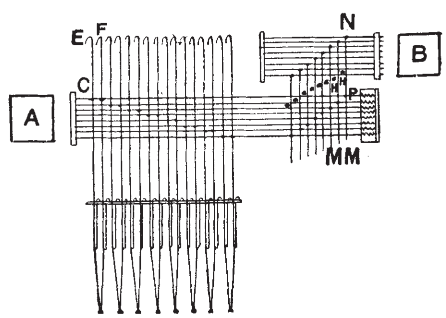



FIG. 119.

saved if the border and middle cards could be laced separately and changed automatically. On the hand-loom it is usual for the weaver to change the cards by hand when required, substituting the border for the middle cards and *vice versâ*, but in the power-loom this is of course out of the question, and usually the total number of picks in the handkerchief have each a separate card. The cross-border machine illustrated at Figs. 119 and 120 is the invention of Messrs. Crossley and Davenport.

The machine is double-lift, as will be seen from the connection of the neck-cords. The border cards are put on one cylinder, B, and the middle cards on another, A. When the cylinder A presses back a needle, say the top needle C, it will press back the pair of hooks EF, as in an ordinary double-lift single-cylinder machine, and as long as this cylinder is worked every pick the machine is to all intents and purposes a double-lift single-cylinder machine. When this cylinder is stopped and the cylinder B is worked every pick, the cards on the cylinder B have exactly the same effect on the ends as those on cylinder A; for when the top needle in this set of needles is pressed

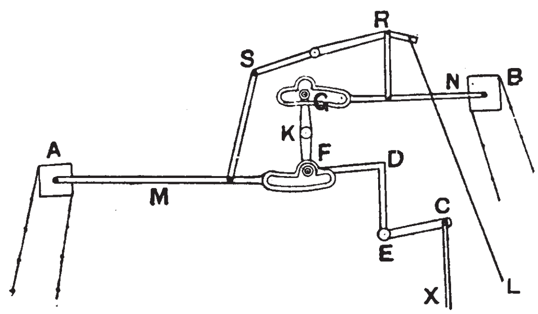



FIG. 120.

back, it will force backward the pair of hooks EF, exactly as operating needle C by the other cylinder did. Only one spring-box is used, as the upright wires MM pass through loops, P, in the long needles, and small iron bars, HH, act as fulcra for the wires MM. The tops of these wires are fastened to the short needles N, as indicated in the diagram, and thus when the needle N is pressed back it moves the needle C in the opposite direction and operates the hooks EF.

The cylinders can be changed by pulling the cord L in Fig. 120. When the parts are in the position shown in this illustration, the cylinder A will be pressed against the needles every pick. The cylinders are driven from the crank shaft, the rod X goes to the crank shaft, and a reciprocating motion is given to the L lever CD centred at E. The rocking lever FG is centred at K, and the reciprocating motion is transferred from CD to FG. It will be seen that one end of the lever FG is in the diagram inside the bend in the slot on M, and the other end of the lever FG is in a position to move about its centre, K, without moving the cylinder B. Thus as the crank shaft of the loom revolves it will give motion to the cylinder A, but not to B. By pulling the cord L, however, the bend on the slot on N takes hold of the top of the rocking lever G, and at the same time, through the lever SR, M is lifted, and the end F of the rocking lever moves freely in the slot without moving the cylinder A. The disadvantage of this motion is that the change is not made from the cards automatically, certainly not an impossible piece of mechanism to contrive. There are other cross-border motions, but this is only given as an example.

## DOUBLE-SHED JACQUARD.

Double-shed Jacquards are used chiefly in weaving heavy goods where a very large and deep shuttle is required to hold a reasonable quantity of weft. The principle of this machine will be easily understood from Fig. 121. A is connected to the crank shaft of the loom and moves the end of the lever BC up and down, the fulcrum of the lever being at E. The bottom board or plate F is therefore moved up and down, and in doing so the griffe G is made to move oppositely, the bottom plate coming down as the griffe goes up, and *vice versâ*.