JUTE AND LINEN WEAVING

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JUTE AND LINEN WEAVING

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THIS WORK IS DEDICATED

TO THE MEMBERS

OF THE

DUNDEE CHAMBER OF COMMERCE

PREFACE TO THE SECOND EDITION

PRACTICALLY all the original matter is reproduced in this edition; any small parts which have been omitted have been replaced by illustrations of more modern machinery. The additional matter embraces 108 new illustrations with the corresponding text; it includes the two distinct types of automatic weft supply mechanism, the chain linking machine, terry towel motions, warp stop motions, individual motor drives, improved types of box motions and jacquards. In nearly every chapter there has been inserted one or more new illustrations of modern weaving machinery.

We desire again to express our best thanks to all those who have been kind enough to assist us in this work, and to the publishers and printers for the excellent manner in which they have done their part.

T. WOODHOUSE.
T. MILNE.

September 1914.

PREFACE TO THE FIRST EDITION

DURING the last twenty years several important works on weaving have been presented to the public, but these have almost invariably been devoted to the various sides of the subject as applied in the structure and the production of woollen and cotton fabrics. It is true that these two fabrics are the most important of the whole group of textiles, and as such demand the greatest measure of attention from a literary as well as from a technical point of view. Teachers and students of these branches have therefore been fortunate in having within their reach a number of valuable works of reference bearing directly upon their particular branch of the textile industry. Those persons, however, engaged in the study and the manufacture of jute, linen, and of silk, have not been so fortunate in the above respect, and the scarcity of text-books bearing particularly upon the weaving of the two former fibres has induced us to compile the present work.

While the book is intended principally for those associated with the jute and the linen trades, we hope that several portions of it will be found useful for students in the other branches of weaving; indeed, it is practically impossible to compile a treatise on any branch of weaving which does not overlap, more or less, one or more of the other branches of the subject.

We do not claim that the work is complete in every respect; still we think that no important feature of the subject has been overlooked. Should, however, such omission be observed by any reader, we hope that we shall have our attention drawn to it. It has been our endeavour to put the matter in a readable form, and we hope to have contributed somewhat to the elucidation of the more abstruse problems of weaving by treating the principles underlying picking and beating up in a manner entirely different from the stereotyped form.

Should the present issue receive the favourable support of the weaving public, we hope to supplement it by a re-publication in book form of a series of articles, at present under course of publication in *The Textile Manufacturer*, upon the mathematical and the designing parts of the subject.

We trust our labours will enable present and future students to pursue their course of study under more pleasant conditions, and that this work may be the means of encouraging practical men to study more closely the theoretical side of their occupation.

We take this opportunity of thanking the publishers for their uniform kindness towards us, and also the various firms of machine makers and manufacturers to whom we have been indebted for particular information.

T. WOODHOUSE.
T. MILNE.

May 1904.

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CHAPTER I

INTRODUCTORY

It must not be inferred from the title given to this work that it is intended to discuss the principles or processes applied in the construction of only those fabrics composed entirely of linen or of jute. At the present time it is not unusual to find fabrics composed of two or even more materials, as in damask tablecloths, tapestries, etc., where the fibre originally employed was entirely linen in the former case, and cotton, or even silk, in the latter. Cotton warps have been used in conjunction with linen wefts for the production of union fabrics similar to those mentioned above for a period now extending over many years, and, previously, linen warps and cotton wefts were interwoven in the same kind of textures. In so far, therefore, as cotton is introduced into the construction of these unions, it will be necessary to consider yarns made from this fibre.

The origin of linen weaving undoubtedly dates far back into ancient history — in this country alone it was a recognised industry over three hundred years ago,—and the cloth itself is one of the best known and most ancient of textures. Jute weaving, on the other hand, is comparatively a new industry, but rapid developments in this particular branch have taken place since the introduction of the jute fibre into Scotland about the year 1830. The machinery for the manufacture of this fibre is now so near perfection, and the handling of it so excellent, that many types of fabrics composed of jute compete successfully with those made from other fibres. Rugs, towels, upholstery cloths; Brussels, Wilton, Scotch, and other carpets, may be mentioned as typical examples. Besides these (which are in many cases made entirely of jute) there are many types of fabrics which depend, more or less, upon the jute fibre as one of their constituents. The great bulk of this fibre, however, is made into the commoner classes of cloths, such as hessian, bagging, tarpauling, and sacking.

CHAPTER II

COUNTS OF YARN

In the building-up of any class of fabric one of the first considerations is the method of classing the sizes or grists of the yarn of which it is to be composed. The three fibres mentioned being so intimately related, the methods of counting these yarns are herewith given:—

Jute and Heavy Linen or Flax Yarns

90 ins. or $2\frac{1}{2}$ yds. = 1 thread, or the circumference of the reel.
120 threads or 300 yds. = 1 lea or cut.
2 cuts or 600 yds. = 1 heer.
6 heers or 3600 yds. = 1 hasp or hank.
4 hanks or 14,400 yds. = 1 spyndle.

The size or grist of the above yarns is determined by the weight in pounds (avoirdupois) per spyndle of 14,400 yds. Thus, if 14,400 yds. of yarn weigh 8 lbs., it is termed 8 lb. yarn, and so on.

Fine Linen or Lea Yarns

90 ins. or $2\frac{1}{2}$ yds. = 1 thread, or circumference of the reel.
120 threads or 300 yds. = 1 lea.
10 leas or 3000 yds. = 1 English hank.
12 leas or 3600 yds. = 1 Scotch or Irish hank.
20 English hanks or $16\frac{2}{3}$ Scotch or Irish hanks, or 60,000 yds. = 1 bundle.

The size of lea yarn is reckoned by the number of leas of 300 yds. each in 1 lb. (avoirdupois). Examples:—If 20 leas weigh 1 lb., it is termed 20's lea yarn, or simply 20's yarn. If 50 leas weigh 1 lb., it is called 50's yarn. It is usual to apply the former of these yarn tables to all jute yarns, and also to dry-spun linen or flax yarns, and the latter table to wet-spun linen or lea yarns.

From the foregoing tables it will be seen that the jute and heavy-linen yarns have a standard length and a varying weight; whereas the finer linen yarns have a standard weight and a varying length. The two distinct methods of counting are a little confusing to the beginner, for in the former case the thicker the yarn the higher is the count, whereas in the latter case the thicker the yarn the lower is the count. Both, however, may be reconciled as follows:—Referring to the jute and heavy-linen yarn table, it will be seen that there are 48 cuts or leas of 300 yds. each in one spyndle of 14,400 yds. From this consideration, and the fact that the counts of the finer linen yarn are based upon the number of leas of 300 yds. each in 1 lb., the following rule is deduced. Rule:—The leas per spyndle

(48) divided by the weight in pounds per spyndle will give the leas per pound, and therefore the lea count. And, *vice versa*, the leas per spyndle divided by the lea count, or, in other words, the number of leas per pound, will give the weight in pounds per spyndle. Thus :—

$$\frac{48 \text{ leas}}{6 \text{ lb. per spyndle}} = 8\text{-lea yarn (8 leas per pound).}$$

And—

$$\frac{48 \text{ leas}}{8 \text{ leas per pound}} = 6 \text{ lb. per spyndle.}$$

Cotton Yarn Table

54 ins. or $1\frac{1}{2}$ yds. = 1 thread, or circumference of the reel.
80 threads or 120 yds. = 1 rap, or wrap.
7 raps or wraps or 840 yds. = 1 hank.

The size or count of cotton is determined by the number of hanks of 840 yds. each in 1 lb. (avoirdupois)—that is, 10's cotton contains 10 hanks per pound, and so on. Cotton is made up in bundles of 5 and 10 lbs. each, usually the latter. A 10-lb. bundle of 15's cotton should therefore contain $15 \times 10 = 150$ hanks.

Since the counts of both cotton and fine linen yarns are both based upon a given number of yards per pound, it follows that their counts will vary in inverse proportion to these lengths. Thus the counts of cotton will be to the counts of linen as the yards per hank of cotton (840) are to the yards per lea of linen (300) inversely :—

300	:	840	=	1	:	2·8
yards per lea.		yards per hank.		cotton.		linen.

This must be so, since the linen basis of length is contained 2·8 times in that of the cotton basis. Similarly, linen

counts may be converted into cotton counts. For instance, the equivalent cotton count of 28's linen would be :—

840	:	300	=	28's	:	10's
yards per hank.		yards per lea.		linen count.		cotton count.

$840 \times 10 = 8400$ yds. per pound in 10's cotton.
$300 \times 28 = 8400$ yds. per pound in 28's linen.

CHAPTER III

REELING, BUNDLING, AND SETTING

Reeling is resorted to for three principal reasons—viz. easiness of transport, storage, and bleaching and dyeing. In the reeling of jute and linen yarns the machine registers automatically the revolutions of the reel. One hundred and twenty of these revolutions, or 120 threads (see yarn table), make one cut or lea of 300 yds. The yarn is leased, according to its size or count, in heers, cuts, or half-cuts, and tied together by means of a "band," the quantity in the band varying from two to twelve cuts. No rule is uniformly observed in the making up of jute yarns, some spinners leasing all sizes which are to be wrought in the natural state in heers, six of these heers in each band, thus making a proper hank equal to twelve cuts. Although a standard hank contains twelve cuts, it is evidently impossible, on account of the limited space on the swifts, to adhere rigidly to this number when making up very heavy yarns. It is also considered advisable to group smaller quantities together when the yarn is intended to be bleached or dyed, and the following table may be taken as a guide in such cases :—

Up to 5 lb.	6 heers in band	$\frac{1}{4}$ spyndle.
5 to 10 lb.	6 cuts „	$\frac{1}{8}$ „
11 to 24 lb.	4 cuts „	$\frac{1}{12}$ „
26 to 36 lb.	3 cuts „	$\frac{1}{16}$ „
Over 36 lb.	4 half-cuts in band	$\frac{1}{24}$ „

The yarn is then made up into bundles as near as possible of 56 lbs. each. Linen yarn, as mentioned before, is also reeled upon the 90-in. reel,[1] but is made up somewhat differently from jute. The coarse yarn up to about 8 lea is made up into half-hanks (6 cuts of 300 yds. each), and $33\frac{1}{3}$ of these go to make one bundle, or 60,000 yds. Fine yarn is made up into hanks of 12 leas each ($16\frac{2}{3}$ of these = 1 bundle). One or more of these bundles, depending upon the size of the yarn, are tied together and form what is called a "bunch" or "lump." The following is generally adopted :—

Up to 14 lea	$1\frac{1}{2}$ bundles	= 1	bunch.
16 to 28 lea	3 „	= 1	„
30 to 60 lea	6 „	= 1	„
Above 60 lea	12 „	= 1	„

Cotton is reeled on a 54-in. reel and tied up in hanks of 840 yds. each, or multiples of this, and is made up, as before mentioned, in 5 and 10 lb. bundles.

The Reed.—Although serving the double purpose of beating-up the weft of the fabric and determining the fineness or coarseness of the texture so far as the warp is concerned, the reed will be considered at present only from this latter point of view. The porter or sett of any fabric is determined by the reed through which the warp yarn is drawn. Originally in Scotland the sett for linen fabrics was based on the Scottish ell of 37 ins.; and according to the number

[1] *Fine linen yarn above 80s is often reeled on a 54-in. reel, 100 threads or half a lea being placed in each band.*

of hundreds of splits in this measure, the reed was termed a 600, a 1400, a 1700, and so on, usually written 6^{00}, 14^{00}, 17^{00}, etc. In the jute and linen industries, however, the reed is now reckoned by the number of porters of 20 splits each in 37 ins., and for convenience in ascertaining the sett of any reed or fabric, a measure or gauge is used which between its extreme points is one-twentieth part of this width, or 1·85 ins. The number of splits in this gauge determines the sett or porter of the reed. Thus, if the gauge or measure covers ten splits, it is called a 10-porter

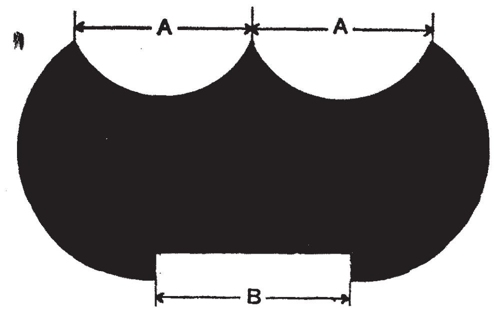
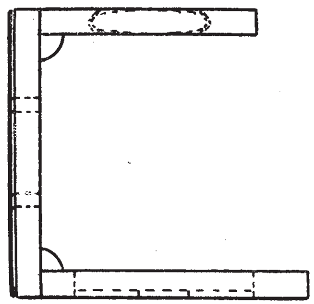


FIG. 1.

reed, and so on. As 10 splits × 20 times the measure = 200 splits on 37 ins., then 200 splits ÷ 20 splits per porter = 10 porter.

The measure shown in Fig. 1 is divided into two equal parts A, each $\frac{37}{40}$, or 0·925 of an inch, and, neglecting the shrinkage which has taken place between the reed width and the cloth, the reed or porter of plain cloth will be the number of threads contained in one part A. In plain cloth it is understood that two threads pass through each split of the reed. In jute cloths the shots of weft are rarely counted by the porter measure, the number per inch being generally taken, and for this purpose an inch gauge is introduced as seen at B in Fig. 1. The practice of counting the shots per inch also obtains in Scotland for coarse linen fabrics. But for the finer classes of linen goods it is customary to use what is commonly called the "glass." This consists of an ordinary magnifying glass fixed in a framework of brass, and so arranged that when placed on the cloth, the threads, etc., in a given space may be readily seen and counted.



In Fig. 2 a glass is shown (in side elevation at D) in position for counting, the support, or the bottom part, being cut away as shown in the plan at E. When arranged in this way four different measures, through which the shots, threads, or splits may be counted, are obtained. In this case the measurements are: F, $\frac{37}{40}$ of an inch; G, $\frac{1}{2}$ in. (sometimes $\frac{37}{80}$ is used instead of $\frac{1}{2}$ in.); H, $\frac{1}{4}$ in.; and J, $\frac{37}{200}$ of an inch. By this latter measure, $\frac{37}{200}$ of an inch,

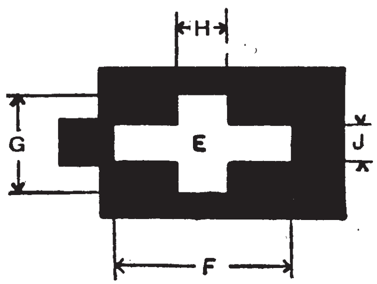


FIG. 2.

the sett of the reed in hundreds is readily determined. This space being contained 200 times in 37 ins., it follows that the splits in this space multiplied by 200 will give the reed. Example :—5 splits in glass × 200 = 1000 splits in 37 ins., or 10^{00} reed. If the threads in the cloth be counted, the number will be the reed in hundreds. Example :—10 threads in glass × 200 = 2000 threads in 37 ins., and 2000 threads ÷ 2 threads per split = 1000 splits, or 10^{00} reed.

In some parts of Ireland it is customary to take 40 ins. as the basis instead of 37 ins., the reed being reckoned by the number of hundreds of splits in this width. In this case the aperture of the counting glass is contained 200 times in 40 ins. It is therefore one-fifth of an inch in size. This glass is generally used for the reed only, that on the 37-in. basis being usually used for the picks or weft. (The latter is known as the 37-in. counting glass in linen.) In some districts the reeds are reckoned by the number of splits per inch, while the number of threads in each split is indicated by a small figure immediately after that of the reed.

Thus, taking a 10's reed as an example :—

10's reed 1's = 10 threads per inch.
10's reed 4's = 40 threads per inch, and so on.

It is surprising that this system, which is so simple and so easily understood, has not been more widely adopted.

CHAPTER IV

WARP WINDING

In the preparation of yarn for the loom, the first process is generally that of warp winding, although in some few cases, where warps are made direct from the spinning bobbins, this is not necessary. Where, however, the warp yarn is to be dressed or starched, or the warp prepared by means of the linking machine, it is essential for economic reasons that the yarn be rewound on to larger bobbins, or on to spools, to suit the enlarged banks necessary for these preparatory processes. It may be mentioned here that these spools, rolls, or cheeses have practically displaced the ordinary bobbins in connection with dressing. This is chiefly due to their greater capacity, seeing that as much as one spyndle of 14,400 yds. of 8-lb. yarn is being regularly placed on one spool. This of course enables the machine to be run much longer without stoppages for refilling than is the case when the ordinary bobbins are used. Other advantages obtained from the introduction of these spools are a lower percentage of waste, a reduced initial cost, fewer breakages, and greater facility for transport. When warp yarns are received in the hank it is necessary that they be also rewound for the process of warping or dressing.

Roll or Cheese Winder.—Figs. 3 to 7 are introduced for the purpose of illustrating the roll winder as made by Messrs. Robertson and Orchar, Limited, Dundee. Figs. 3 and 4 show respectively in elevation and plan the winding mechanism of the machine. The four pulleys C, C^1, C^2, C^3 are all connected by means of a single belt D, arranged as

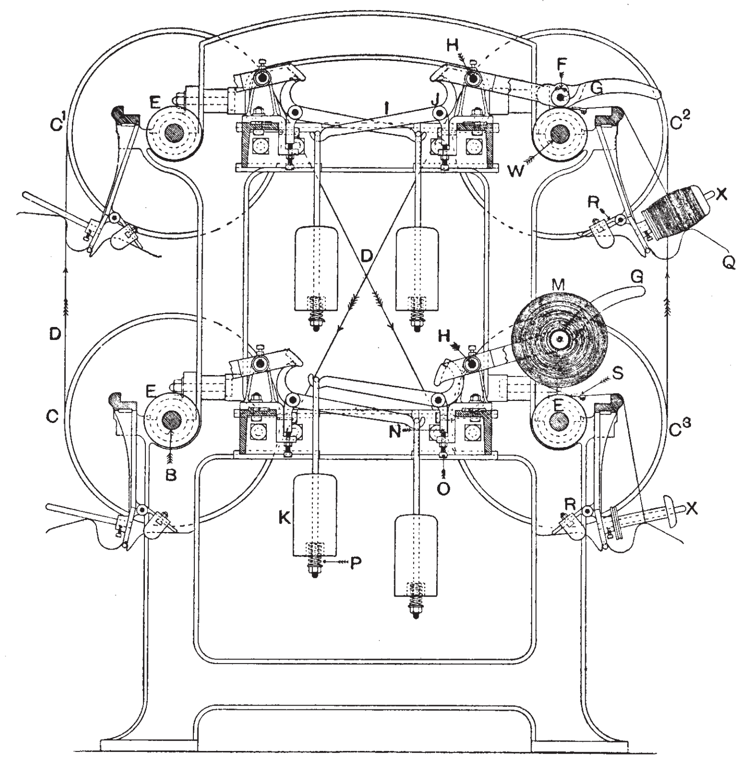


Fig. 3.

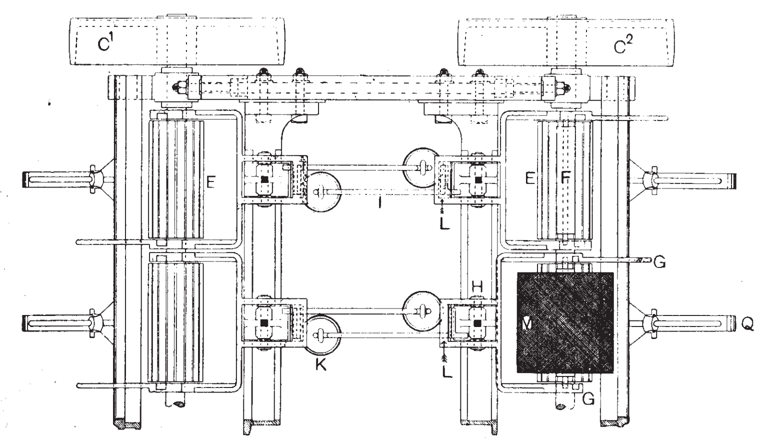


Fig. 4.

shown, to give a similar inward motion to all the fluted spool drivers E. Pulley C receives its motion from shaft B and the driving pulley A at the opposite end of the machine. Spools F (usually of wood for jute yarns, although made of paper for finer yarns) revolve on suitable spindles, and are driven by rolling contact with spool drivers E; they are carried by the two long arms of bracket G fulcrumed at H, and are kept in firm contact with the spool drivers by means of lever I fulcrumed at J, and weight K. As the spool or roll fills, the long arms of the bracket G rise gradually, and the short arms fall gradually—naturally through a shorter distance—until the extreme positions are reached. During the above movement the oblique surface of G's shorter arm bears upon and depresses the curved arm of lever I, and thus raises the corresponding straight arm and the weight K. These movements continue until the spool has reached the desired dimensions, at which time the curved and shorter arm of lever I should slip over the top of the oblique surface at the rear end of lever G, and thus by means of weight K raise the long arm of G and the spool M slightly until the latter is clear of the spool driver E. Each roll is thus automatically stopped when its required diameter is reached. This diameter may be varied at will between 6 and 9 ins. by raising or lowering the bracket N, in which the lever I is fulcrumed. This adjustment may be quickly and accurately accomplished by means of a set-screw and lock-nut O. The spiral spring P, which is supported by a washer and a nut on the end of the rod depending from lever I, and enters a recess in the weight K, is introduced to prevent vibration in the lever I when the weight K is allowed to drop back into its original position. Spinning bobbins are placed on the pins X as shown, and are tensioned

by means of the spring Q and the weighted lever R. Since

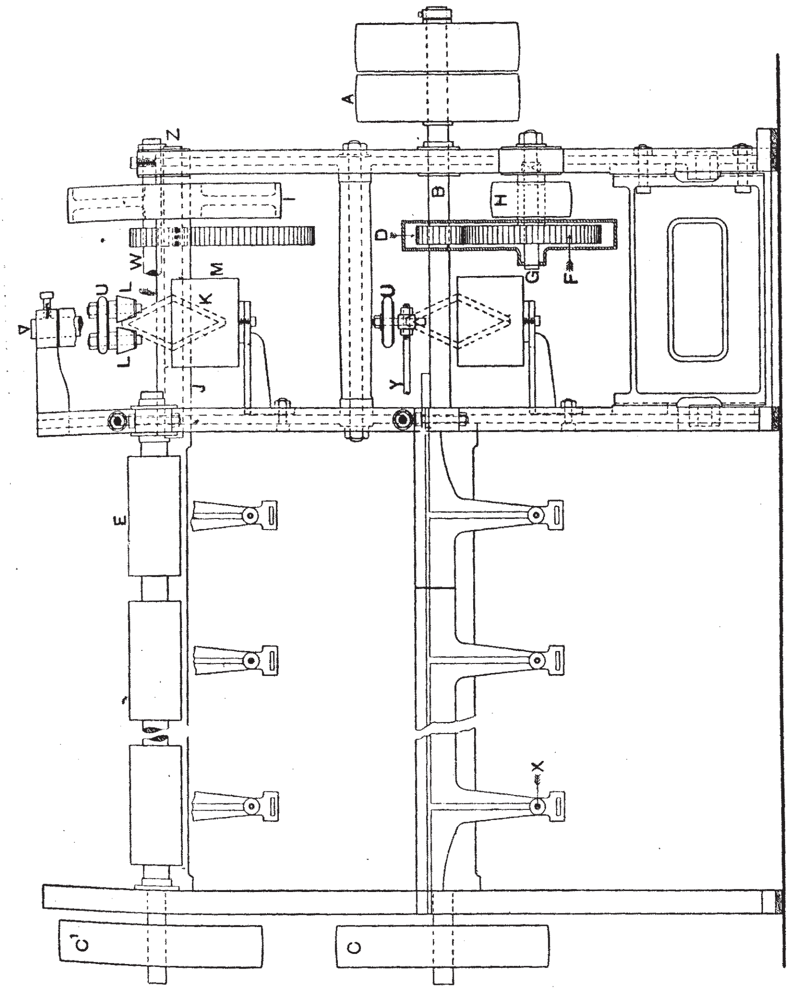


FIG. 5.

it is essential that the pressure should decrease as the bobbin empties, the lever R is so centred that it gradually

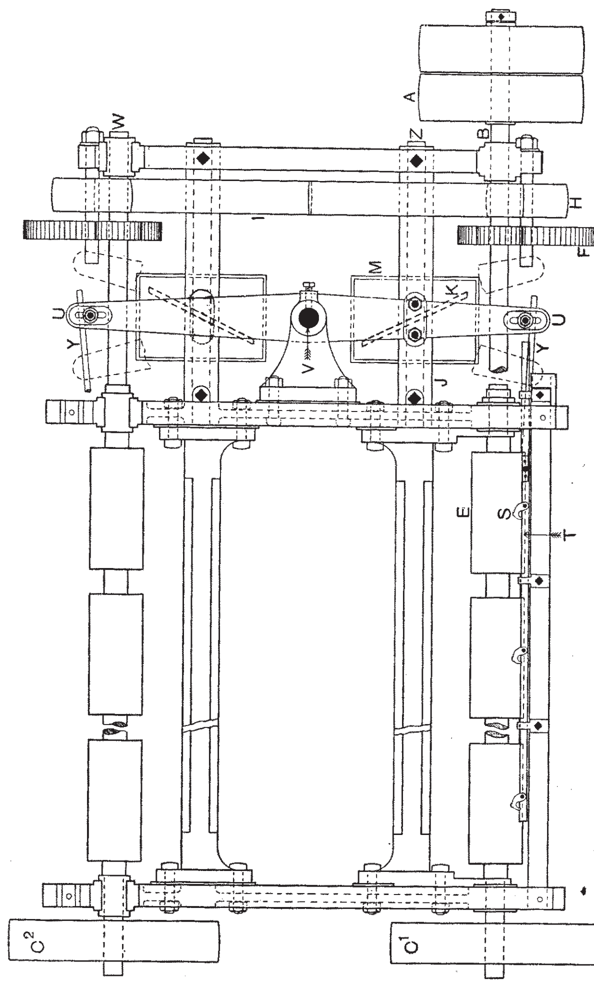


Fig. 6.

approaches a vertical position, and reduces its pressure on

the spring Q as the diameter of the bobbin decreases. The rapid traverse necessary for building the yarn on spools without flanges is imparted directly by the yarn

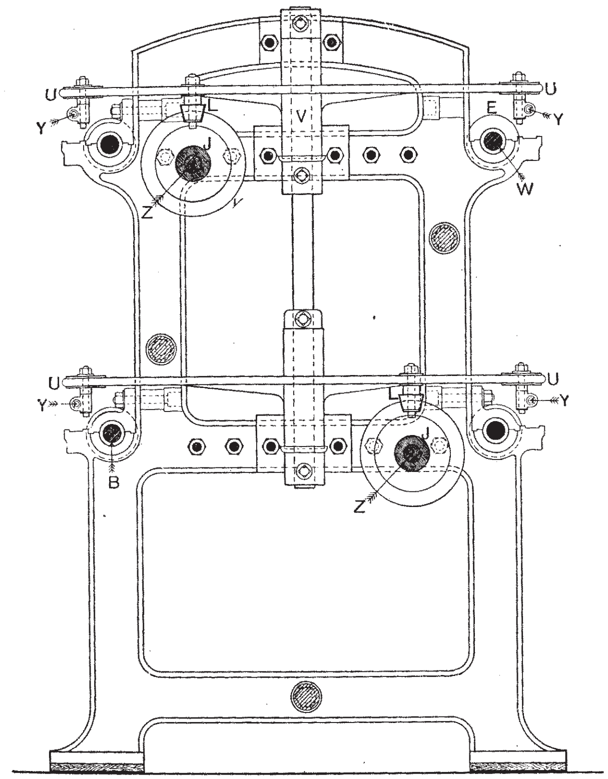


Fig. 7.

guide. This motion will be understood by reference to Figs. 5 and 6, which show respectively the side elevation and plan of the machine, and Fig. 7, which shows in end elevation the camshaft frame. The yarn guide or hook S,

Fig. 6, is rigidly fixed to the traverse rod T, which is supported by and slides in guides fixed at suitable places on the framework of the machine, and which is attached by the connecting rod Y to the traverse lever U. This latter, being centred at V, imparts an equal but opposite movement to the traverse rod T at the opposite side of the machine. Motion is conveyed to this lever as follows:—Keyed on the driving shaft B is a driving pinion D of 24 teeth, gearing with a wheel F of 75 teeth, which revolves on the stud G. Compounded with wheel F, and therefore revolving with it, is the pulley H of 7-in. diameter, which drives by means of a belt, not shown in the drawing, the pulley I of 18 in. diameter on the camshaft J, this shaft being in reality a sleeve on the stud Z. Fixed to the same shaft J is a cam or worm plate K, which has a left-handed thread for half its circle, and a right-handed thread for the other half, seen in plan in Fig. 6, in elevation in Fig. 7, whilst the path of its travel is shown in Fig. 5. This cam K revolves between the anti-friction cones L bolted to the traverse lever U, and thus imparts through U the necessary quick traverse to the rod T and the yarn guides S. The traverse, and therefore the length of the rolls, may be varied at will between 7 and 9 ins., by adjusting the studs in the slots at each extremity of the lever U. The cam K is constantly lubricated by causing it to revolve in an oil bath M. An arrangement, similar in all respects to that already described, but driven from the shaft W, conveys motion to the traverse rod T for the under tier of spools on both sides of the machine. The capacity of the machine is usually 80 spools, 40 on each side.

All roll winders for the jute and heavy-linen trade are similar in construction, and each possesses satisfactory parts for the three chief requirements of such machines,

e.g. a uniform speed of yarn, a quick traverse, and an automatic method of lifting any roll from the driving drum when the roll has reached the desired diameter. The first requirement is obtained directly by the surface speed of driving and the constant speed of the shaft which carries the spool drivers; the second is invariably obtained by means of some form of cam or split pulley, while the third is obtained by ingenious and sometimes simple methods.

Fig. 8 illustrates in elevation and plan the automatic stop mechanism as well as the tension device employed by Messrs. Douglas Fraser and Sons, Arbroath, and the detached figure is a front view of the faceplate A over which the yarn runs from the bobbin B. The faceplate itself provides a simple yet effective method of preventing the yarn jerking as it passes from side to side of the roll. When the thread is stretched from the bobbin B to either side of the faceplate it clearly forms the hypotenuse of a triangle, the other sides of which are formed by half of the straight line which joins the two extreme edges of the faceplate, and the vertical position of the thread. These sides are shown respectively by the dotted lines, C, D, and E in the detached figure. By cutting away the ends of the faceplate as shown in the plan view, the lengths C and E are kept more uniform, and hence the yarn is subjected to less strain as it is rapidly withdrawn from the bobbin.

Taking the tension device first, it is clear from the solid and dotted positions of F, which turns about point G, that the greatest pressure of the drag F on the bobbin will be when the latter is full, because the weighted roller H, when in the dotted position, has a tendency to fall. As the bobbin empties, the moment of the force decreases

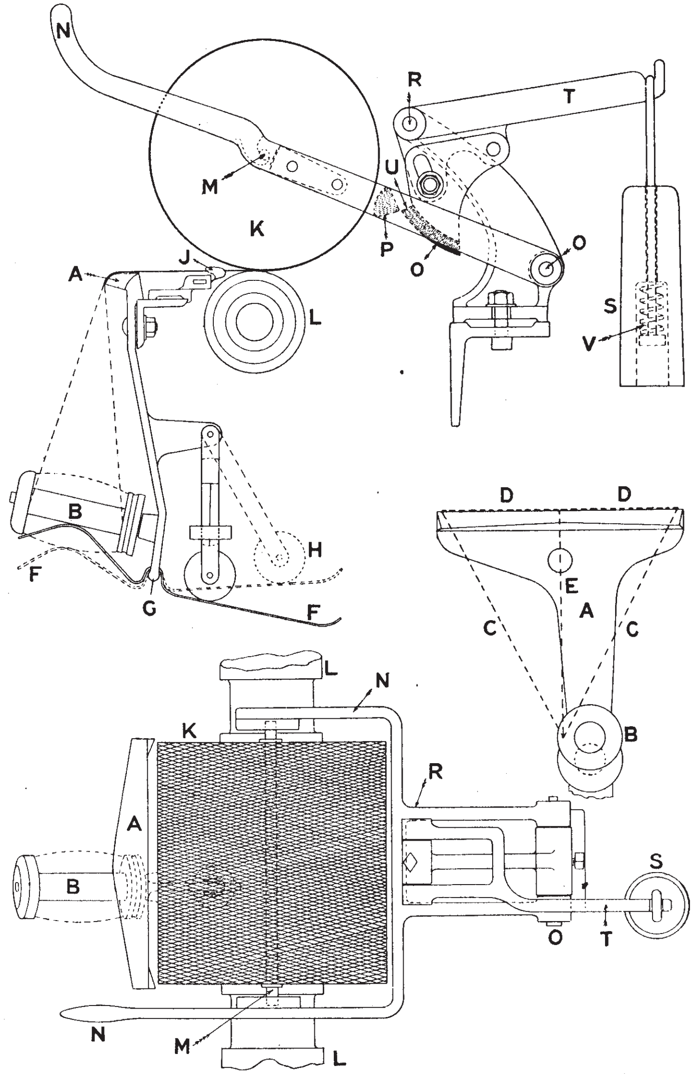


Fig. 8.

gradually, until finally the roller and its support reach the vertical position, when the force disappears. Thus the pressure on the bobbin gradually diminishes as the yarn is withdrawn.

In the elevation the yarn is shown passing over the breastplate A, through the yarn guide J, and between the roll K and the roll driver L. The roll itself is shown full, but it is wound as usual upon either a wooden or paper tube, through the centre of which passes the iron pin M; the whole is supported by the lever N, fulcrumed at O. Extending between the two arms of lever N is a bar P, the section of which is of the form shown in dotted lines; the contact between the upper surface of P and the lower curved surface of Q (also shown in dotted lines) fulcrumed at R is obtained by means of the weight S on the end of lever T. But as the roll fills, the arm N, and therefore the triangular bar P, rises until it reaches the position shown in the drawing, when the pressure is removed from the upper surface of P, and surface U of part Q slips under part P, thus raising slightly lever N and breaking the contact between the roll driver L and the roll K. A spiral spring V is also utilised in the weight to minimise vibration when the weight S drops to force part U under part P.

Roll winders are now almost invariably used for grey yarns, but bleached or dyed yarns are usually wound on to bobbins, because the bobbin flanges serve as a protection against dust and dirt, which would otherwise stain and perhaps spoil the bleached or dyed yarns.

Bobbin Winders. — There are two distinct systems of bobbin winding:—

(*a*) That which arranges the yarn on the bobbin in a convex form, the finished product being usually termed a "barrel-shaped bobbin"; and (*b*) That which lays the yarn perfectly horizontally between the two flanges of the bobbin, and thus builds a bobbin with sides which are parallel.

The threads in both systems are parallel with respect to the section or the flanges of the bobbin, but are built convexly and parallel respectively to the barrel or core of the bobbin. The convex build is used only for comparatively heavy yarns such as jute, whereas the parallel or drum-wound bobbin is invariably used for linen yarns.

Figs. 9 and 10 show respectively the side and end elevations of a bobbin-winding machine of the former type as made by Messrs. Charles Parker, Sons, and Co., Dundee. Motion is conveyed by the pulley A to the shaft B, which extends from end to end of the machine. Fixed at regular intervals on this shaft are fluted friction wheels C, two of which are necessary to drive one bobbin. Bobbins D revolve on suitable pins carried by the arms E, the latter being centred in the brackets F. Projecting from one of each pair of arms E is a diamond-shaped piece G, somewhat similar to part P, in Fig. 8, which supports the pressing lever H, the weight of which through G and E keeps the bobbin pressed hard against the friction wheels C, these latter causing the bobbin to revolve. As the bobbin fills, it is gradually forced away from the centre of the friction wheel C until the diamond piece G gets outside the inner curve of the pressing lever H. Immediately this point is reached the outer curve of H begins to act on the inside of G, and thereby throws out the bobbin, until G is caught in the recess near the outer end of the lever H. The yarn passes as shown from swifts or reels J over traverse fingers K. These latter are fixed to rods L and receive suitable traverse through the heart-shaped cam and the connections shown. Cam M is driven by a

worm on shaft B, through the worm wheel N on the

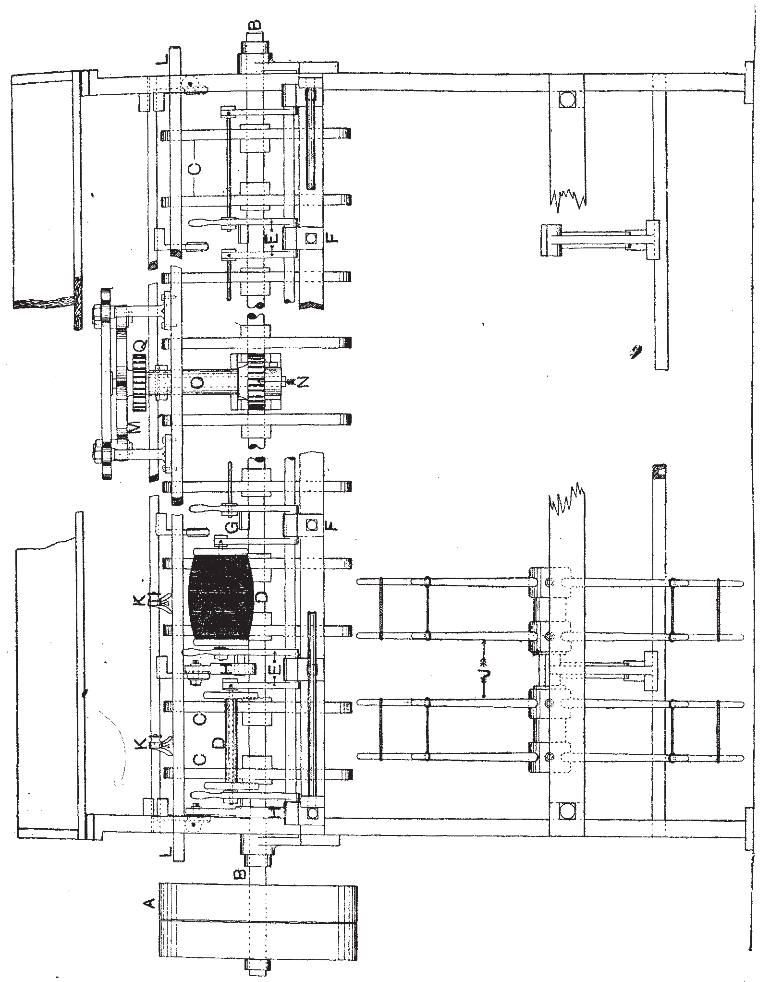


Fig. 9.

vertical shaft O, and pinions P and Q. The diameter of the bobbin may be increased or decreased by adjusting the lever H at its fulcrum R. The yarn is tensioned by suspending a weight from a band passed round the axis of the

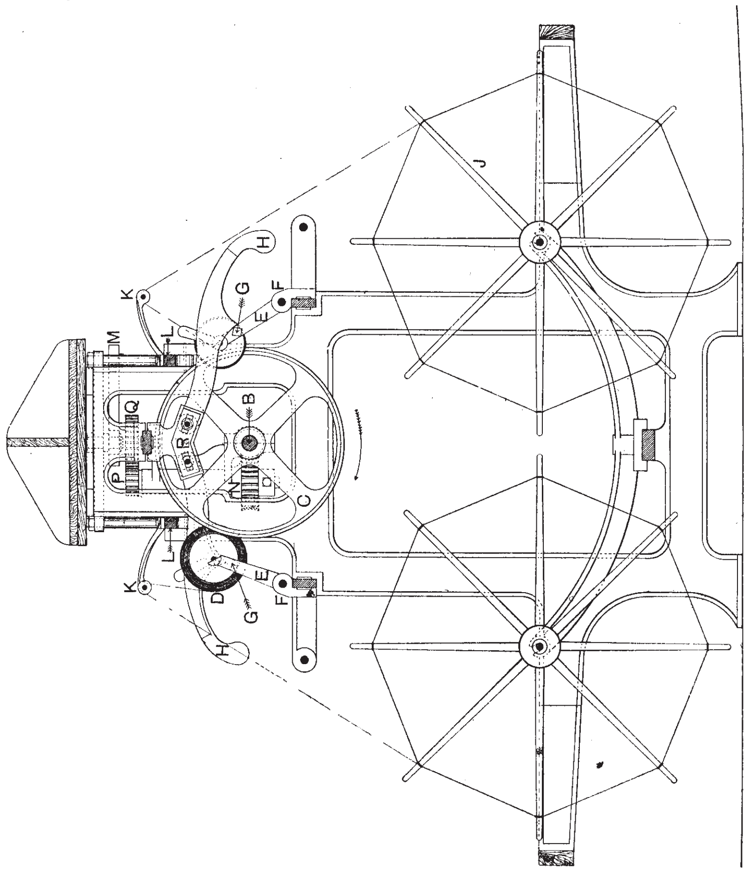


Fig. 10.

swift. The usual capacity of the machine is twenty-four bobbins each side.

Parallel Drum Winder.—A drum winder is perhaps the

simplest of all textile machines, and practically every textile machinist of repute undertakes its manufacture. Still it is probable that no two makers will build machines which are identical in detail, although all such machines possess the same main features.

Figs. 11 and 12 illustrate end and partly sectional elevation and side elevation respectively of a standard drum-winding machine. The main shaft A traverses the machine from end to end, and carries at regular intervals cast-iron drums B, about $9\frac{1}{2}$-in. diameter by 5-in. face, on which the bobbins rest, and by which they are rotated while they are being filled. The breadth of the drum depends, naturally, upon the traverse required for the particular size of bobbin, that is, the distance between its flanges which the drum just fills. Motion to the corresponding shaft on the other side of the machine is conveyed by means of crossed belts from pulleys CC to similar pulleys on the other shaft. Each flanged bobbin D is supported horizontally by a metal spindle E, which is suitably hinged to one arm of the bobbin holder bracket F, so that the spindle may be swung out readily for the removal of a full bobbin, or for the replacing of an empty one. Bobbin-holder F, of which a detail view is shown in Fig. 12, is free to move vertically in slotted guides G, and recesses are formed near the top of the guides for the free outward movement of the spindle when the bobbin-holder is in a certain position.

The following parts are provided for retaining the bobbin-holder in this position when necessary, and also for preventing it from rising too rapidly with the bobbin as the latter is being filled with yarn. Incidentally this aids in producing a firmly wound and well-filled bobbin. Mounted centrally behind each bobbin-holder is a rectangular lever H, the horizontal arm of which may be weighted as desired to resist the rising of the bobbin,

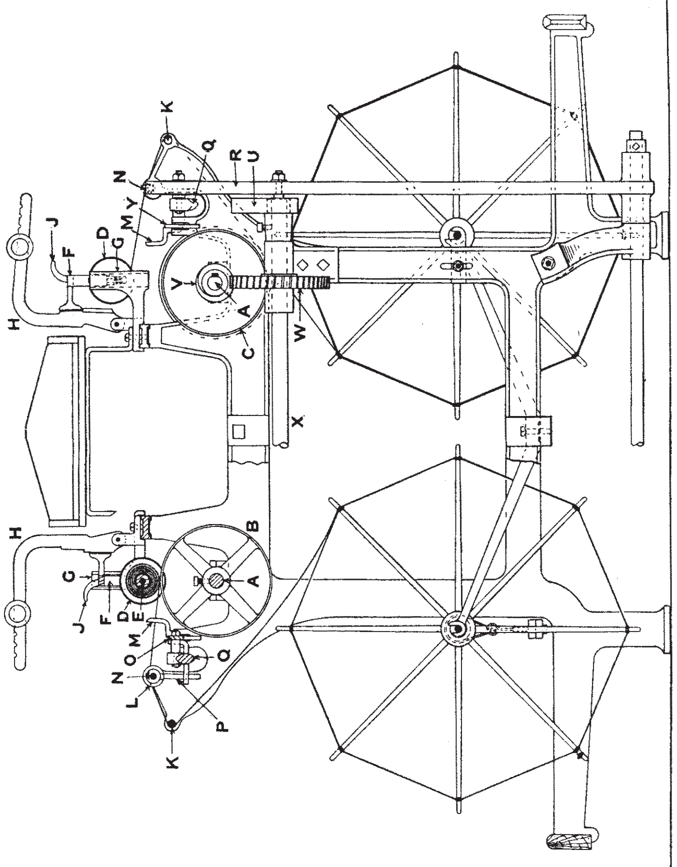


Fig. 11.

while the vertical arm is provided with a frictional face about 2 ins. long by $1\frac{1}{2}$ ins. broad, the top of which forms a projecting ledge to support the bobbin-holder

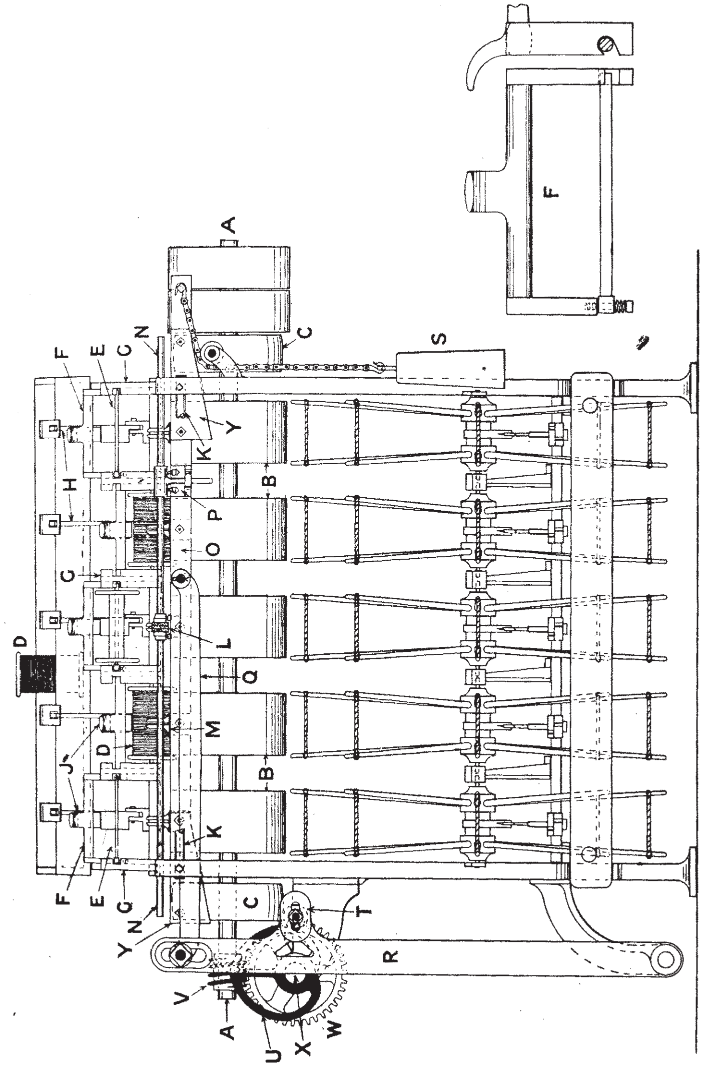


Fig. 12.

(see right-hand view, Fig. 11). Contact between lever H and its corresponding bobbin-holder is obtained by means of an arm which projects rearwards from the cross arm of each bobbin-holder (see Fig. 11), and which is provided with a similar friction face at its extremity. A curved projection J on each holder is provided, by means of which the bobbin may be raised at will into the top position for the repairing of broken ends, or for the removal of the full bobbin. Advantage is taken of the same projection for lowering the bobbin again so that the yarn may come into contact with the drum B.

As in all winding machines which wind from hanks, the yarn is extended for winding purposes on the usual form of swifts. These swifts are supported as shown, and, in order to apply the necessary degree of tension to the yarn, straps or bands are passed over the nave, and more or less weight attached according to the character and strength of the yarn. If it is linen yarn it is passed through a cleaning guide L, after having been led over guide rod K, and then through the traverse guide M. One cleaning guide only is shown, but each is composed of two or more layers of heavy, coarse flannel or felt, in the form of washers, which are pressed together between collars mounted on rod N. The latter is caused to move in unison with the guide bar O by means of the flexible connection P, so that the cleaners L are constantly in line with their respective guides M. Besides being instrumental in removing dirt and slubs from the yarn, the washers are beneficial in breaking up many bad spinning splices, and so preventing trouble in subsequent processes.

Like many machines of this class the traverse mechanism is negative in character. Traverse bar O, which carries the various yarn guides M, is attached by means of connecting rod Q to lever R at one end, and by chain to weight S at the other end. The tendency of the weight S is to move bar O to the right, and so keep the anti-friction roller T in lever R in constant contact with the heart-shaped cam U. As the shaft A revolves, worm V causes worm wheel W and cam U to revolve, and so move lever R and bar O to the right positively, against the action of the weight S, while the latter returns all again to the left after the peak of the cam has passed the anti-friction roller T. Shaft X extends across the machine, and a cam similar to U, but set diametrically opposite to it, is fixed at the other end, and performs similar functions for the other side of the machine.

A novel feature of the above machine is the simplicity of the method by which the friction of the yarn being wound is distributed over the whole depth of the guides M. It is well known that a comparatively soft material, such as yarn, if guided continually over the same surface at a high speed, will in time cut a groove into the hardest of metal. For this reason it is very desirable that the frictional action of the yarn should be distributed over as large a surface as possible, and, as the movement of the yarn itself would involve further friction elsewhere, the makers have preferred to move the guides gradually up and down as they are traversed from end to end of the bobbin. This they accomplish by bolting an inclined plate Y to each end of the traverse bar O; these plates cause the bar to rise in its guide slots as it travels to the right, gravity causing it to fall as it moves to the left. Since the line of the yarn from guide rod K to the bobbin is constant, and since the guides M rise and fall with the bar O as indicated, it follows that the bearing point of the guide upon the yarn will change continuously throughout one complete traverse.

The motion of the yarn guide must be perfectly constant and regular from flange to flange of the bobbin, so that the same quantity may be laid on the bobbin in each unit space, and thus build the sides parallel to the shaft. This equal distribution is determined by the outline of the cam U, which is formed to give exactly equal lateral movements to the guide bar O in equal units of time. It will be observed that as the drive is on the yarn direct, and as the layers of yarn are parallel to the core of the bobbin, the speed of the yarn passing on to the bobbin will be uniform throughout. This is a point worthy of consideration, more especially when tender yarns are being dealt with. In the case of the barrel-shaped bobbin, referred to in Figs. **9** and 10, the shape of the cam must be such that the traverse fingers K will move more slowly when guiding the yarn on to the centre of the bobbin than when approaching the flanges, and so build more yarn in the centre than towards the ends. This drive is usually considered as one in which the speed of the yarn is constant; but, although its speed at any given part between the two flanges is the same for every layer in that part, it varies slightly from point to point in each cycle of the thread guide.

CHAPTER V

WEFT WINDING

BROADLY speaking, there are only two methods of winding (pirn and cop) employed in the preparation of jute and linen yarns for the shuttle. The former is by far the older

method of the two, and is simply a power-loom development of the winding employed in the hand-loom industry. It is now practically restricted to linen weaving, and even in this branch, especially in the wider fabrics and the heavier sizes of yarns, it is gradually being displaced by the newer system of cop winding. For fine and tender yarns, however, it is not likely to be wholly superseded.

In pirn winding the yarn is wound in a conical form upon a wooden pirn or core which remains with the yarn throughout the weaving process. The wind of the yarn is parallel—that is, the successive rounds of yarn lie practically parallel to each other, a slow traverse being given to the guide finger in order to obtain this condition. Throughout the entire process the linear velocity of the yarn remains constant; this is of great importance in the winding of fine or tender yarns, and it explains the reason of the priority of this system for such yarns. Moreover, the tendency to produce waste is not so great as in cop winding. It is sometimes held that in the weaving process cops cause more waste than pirns; this is true in many cases, but the fault is more often due to defective administration than to the system of winding. This, however, is more than counterbalanced by the fact that cops are more economical from the points of view of time and space, besides making more level selvages than pirns. As a pirn empties it is impossible to avoid a gradual increase of tension on the weft thread, whereas a cop will unwind from beginning to end with exactly the same tension throughout. For this reason pirns are very much restricted in length, whereas cops can be made any practicable length without causing any increase of tension while weaving. In the winding of a cop the yarn is built in a conical form on a bare spindle which is withdrawn after the winding is completed, leaving the yarn to retain the form of a cop as best it may. It is, however, capable of remaining stable because of the cross method of winding employed, each succeeding layer of yarn crossing the previous one at a sharp angle—a result obtained by means of a rapid traverse given to the guide finger. The linear velocity of the yarn, however, is variable, and this is the feature which makes the system unsuitable for the winding of tender yarns.

There are several different varieties of pirn winders in use, the chief difference being the method employed to obtain the differential speed of the winding spindle in order that the velocity of the yarn shall be constant whether it is being wound at the base or near the apex of the cone. In some machines the spindles are driven positively by toothed gearing, the variation of speed being obtained by the introduction of elliptical and eccentrically set wheels into the train of gearing by which the spindles are driven. In others, the spindles are driven negatively, and the variable speed obtained by what is practically a gradual and continual changing of the diameter of a driven wheel. Both systems are extensively used, and a pirn winder of the latter type as made by the Anderston Foundry Company Limited, Glasgow, is illustrated in Figs. 13 to 15. Fig. 13 shows the machine in front elevation. Keyed on driving shaft A, which makes about 240 revolutions per minute, is a driving drum B of 16-in. diameter. From B the drive is taken to the far side of the machine by means of a short open belt C, and to the near side by a crossed belt C^1 as indicated. Pulleys D are now made with removable outside flanges to permit of the belts being put on tightly. At regular intervals along shaft E driving discs F are fixed and impart their rotary movement to the faceplates G of the spindles H. Because

of the weight of H and G, and of the fact that the latter

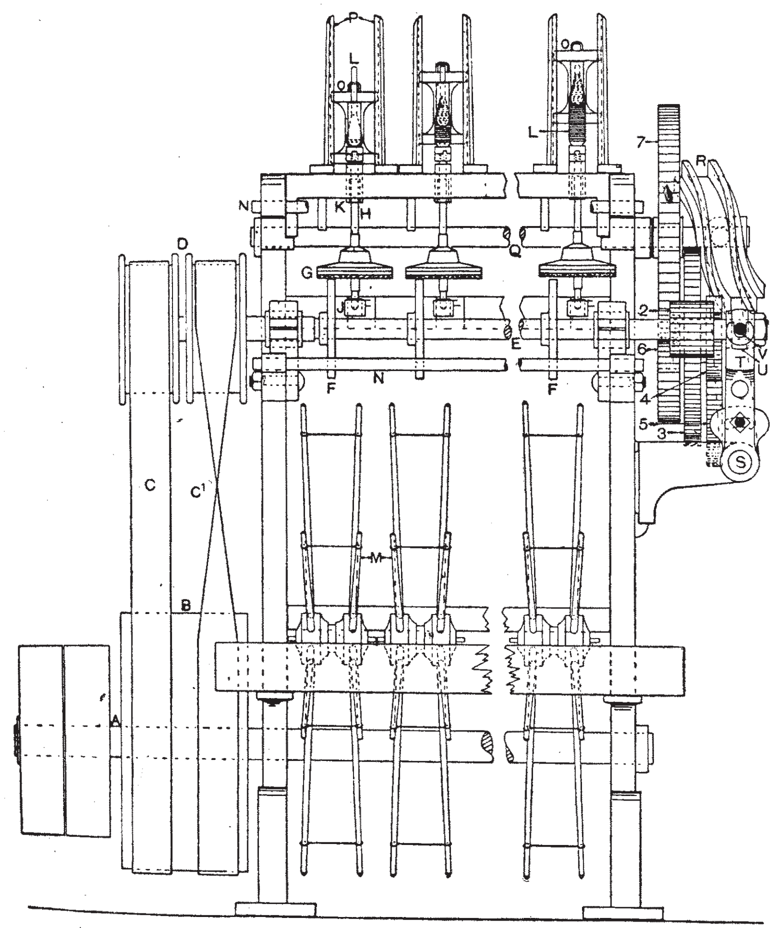


FIG. 13.

are faced with leather, sufficient grip is created between faceplates G and discs F to ensure a steady and constant drive of the spindles H. The latter are supported vertically by footsteps J and loose collars K, and have a cap screwed on the upper end, by which the pirn L is rotated. The yarn is taken from the reels M (supported and paced or tensioned as shown in Fig. 14), is passed over guide rods N, and thence by a suitable guide finger X (see Fig. 15) is guided on to the pirn. On the upper rod N flannel discs are usually fixed, between which the yarn passes. These aid in regulating the tension on the yarn, besides cleaning it and removing many impurities. The firmness of a pirn depends principally upon the tension imparted to the yarn while winding, and upon the weight of the cone builder O which rests upon the yarn during the process, gradually rising in the slotted guide posts P as the pirn fills.

Since the relative diameters, and therefore the circumferences, of the base and top of the cone are as 3 to 1, it is evident that each layer of yarn at the base is three times the length of each round at the top. If the speed of the spindle were constant it is obvious that the velocity of the yarn would vary as the guide finger rose and fell. To avoid this the spindle is speeded up as the finger rises, and reduced in speed as the finger falls in exact proportion to the gradual decrease and increase respectively of the diameter of the cone on which the yarn is passing. This is accomplished as follows:—Keyed on shaft E, Fig. 13, at the gearing end of the machine (elevation and plan of the end being shown in Fig. 14), is a pinion 2 of 26 teeth, which, through intermediate wheel 3 of 100 teeth, wheel 4 of 34 teeth, wheel 5 of 84 teeth, and wheel 6 of 30 teeth, drives wheel 7 of 100 teeth on camshaft Q. The latter carries the positive cam R shown in both figures. Rocking shaft S stretches across the machine at this end, and

carries at each extremity a forked lever T which controls the corresponding disc shaft E through collar U and

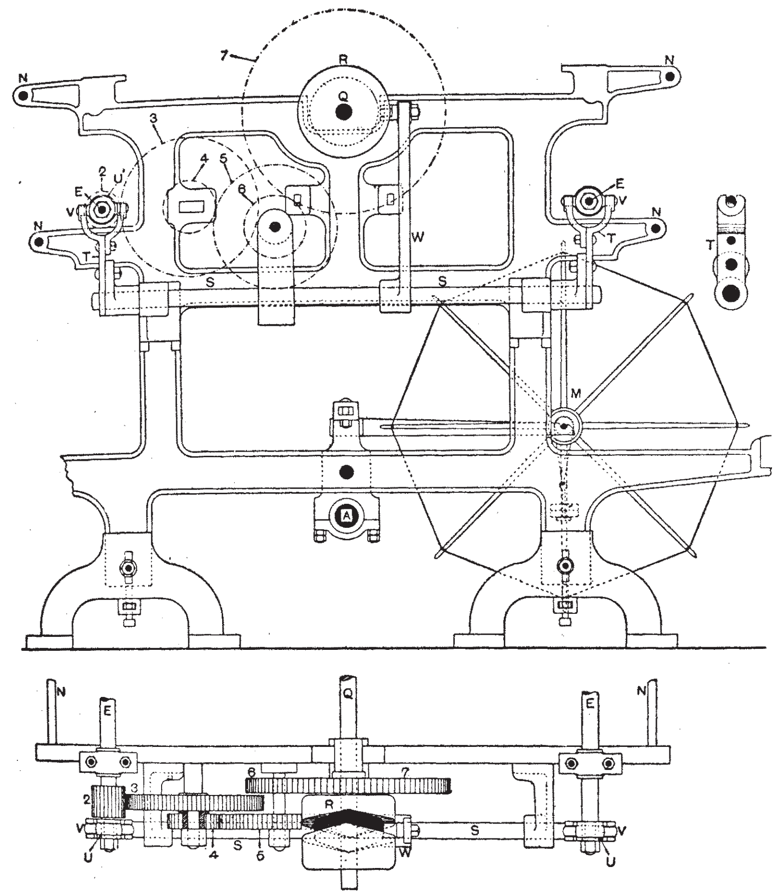


FIG. 14.

suitable projecting studs V. Keyed near the centre of shaft S is a third lever W provided with a stud and anti-friction roller at its upper end. This stud projects into the groove of the cam R, and is moved to and fro as the latter rotates with shaft Q. The oscillating motion of lever W is conveyed through shaft S to forked levers T, which by their connection to disc shafts E cause the latter to move backwards and forwards while rotating. This end-long movement of shaft E (about $1\frac{1}{2}$ ins.) is continually altering the driven diameter of the faceplates G, and therefore the speed of the spindles H and the pirns L. As shaft E travels to the right of the figure, discs F approach the centre of the spindles H and reduce the effective diameter of plates G, causing the spindle speed to be increased, while at the same time the guide finger X, Fig. 15, is gradually rising to the top of the cone. Conversely as shaft E travels to the left of the figure, discs F approach the edge of the plates G, thereby increasing their effective or driven diameter and reducing the spindle speed, while the guide finger X gradually guides the yarn to the base of the cone. From this it is obvious that shaft E and the guide finger X must move in unison, and to ensure this a second cam Y on shaft Q imparts motion to the guide fingers. These latter (see Fig. 15, which is a sectional elevation of the machine) consist of a double-armed lever fulcrumed at Z in the cone builder O. In virtue of gravitation and the pull of the yarn, the heel of the pendant arm of X continually presses against a travelling plate 8 which extends from end to end of the machine, and is fixed at these points to suitable sliding bars 9, these latter being in turn connected by rods 10 to levers 11, which are fulcrumed at 12 and carry at 13 suitable studs and rollers for cam Y to work against. Both bars 9 are connected by a strong spring 14 which keeps both levers 11 in touch with the cam and ensures their

working together. As cam Y rotates, levers 11, bars 9 and plates 8 are pushed or pulled to one side, the pendant arm of X is pushed forward or allowed to recede, and the finger X is raised or lowered respectively. When the pirn L has been filled to the desired height it is automatically stopped by the following arrangement. Lever 15, ful-

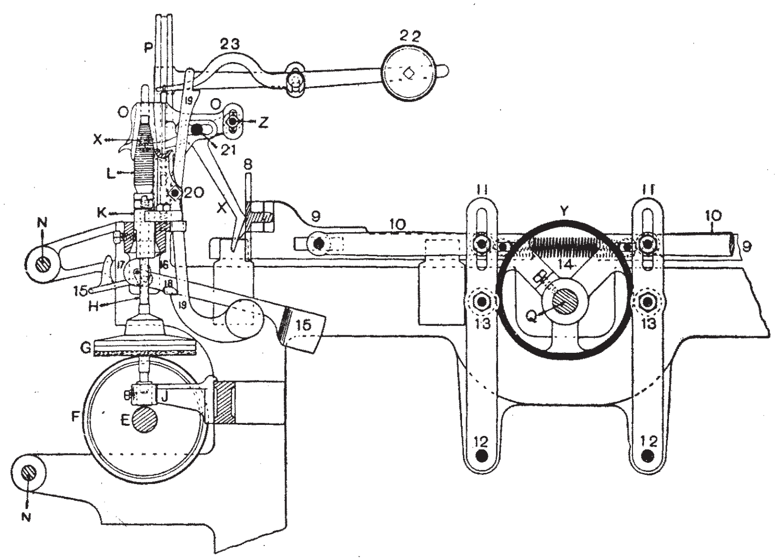


Fig. 15.

crumed in bracket 16 in line with the spindle H, is weighted at its extreme right, while at a point a little to the left of its fulcrum it supports a small disc 17, which is held just in touch with the under-side of the loose collar K by means of the projecting piece 18 resting on the catch of lever 19 fulcrumed at 20. These two are kept in contact by reason of the position of the weight at the lower end of lever 19, but as the cone builder O is raised by the filling of the pirn, stud 21 comes in contact with, and gradually presses forward, the upper end of lever 19 until the lower end relieves the piece 18, when the heavy end of lever 15 falls and the short arm raises disc 17. This carries with it collar K, which lifts spindle H and faceplate G clear of the driving disc F. The height to which the pirn may be filled is regulated by the position of stud 21 in the cone builder O. Counterbalance weight 22 and lever 23 permit of very fine or tender yarns being relieved of practically the whole weight of the cone builder O.

Pirns vary very little in size, the usual dimensions being from $5\frac{1}{2}$ to $6\frac{1}{2}$ ins. long by 1 in. diameter. Cops vary more considerably and lend themselves more readily to variation both in length and diameter. In the jute and linen trades generally 8 to 10 ins. long by $1\frac{1}{4}$ to $1\frac{3}{4}$ ins. in diameter may be taken as regular sizes. These dimensions, however, are altered to suit the various kinds of fabrics, and also the different diameters of yarns.

Cop machines vary very little in principle, and Fig. 16 gives a general idea of the arrangement of the mechanism in the latest cop winding machine as made by Messrs. Charles Parker, Sons and Co., Dundee. The main shaft G is driven by belts or by motor, and upon this shaft, which runs the whole length of the machine, a number of skew bevel wheels A (corresponding to the number of spindles on that side of the frame) are keyed. Bevel wheel A imparts a continuous motion to the bevel pinion B, which rests on a bush C in the rail D. Pinion B revolves loosely on spindle E, but a projecting key in the socket of clutch F fits into a key-way in the spindle, and by this connection the two parts revolve together when desired. Three projecting pieces (one only shown in black) are cast upon the upper face of pinion B, and corresponding recesses are

formed in the lower part of clutch F. The above-mentioned key-way, fully $\frac{1}{16}$ in. deep, extends over the entire

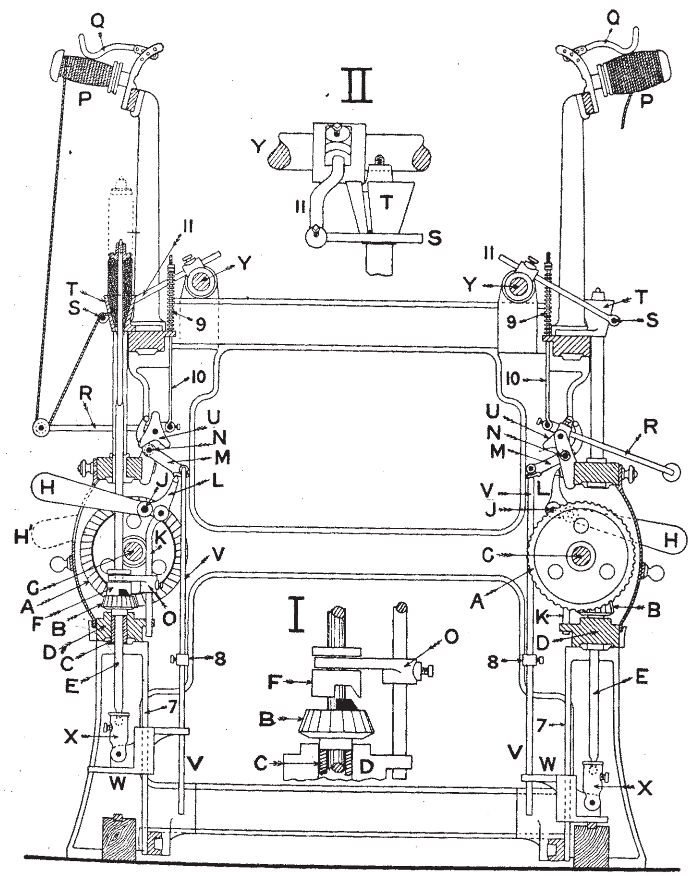


FIG. 16.

length of the round part of the spindle E, and by means of this slot the spindle may slide easily up or down the key in the socket of clutch F. Since the pinion B is driven positively, and the clutch F connected to the spindle in the manner indicated above, it is evident that, when the pinion and clutch are in contact, as shown on the left side of the drawing, the spindle will be rotated; but if the clutch be raised to the position illustrated in inset I, the spindle will cease to rotate. The two parts, B and F, are placed in contact by raising the clutch lever H to its highest position, and thus forcing down the short arm L, the rod K, and the clutch fork O. The clutch lever H, fulcrumed at J, remains in this position, and pinion B and clutch F are retained in contact by means of a step or recess formed on the straight arm of lever M, fulcrumed at N; this recess engages with the extreme upper end of arm L of the clutch lever. The spindle E will therefore rotate so long as the parts retain the positions shown on the left side of the illustration. If, however, through any cause, the clutch lever H should fall to the dotted position H^1 (the position shown also on the right), it is clear that the rod K would rise, and would consequently lift the clutch fork O; the latter would in turn raise clutch F clear of the pinion B, and thus cause the spindle E to stop. It is desirable that the spindle should stop not only when the cop has reached the proper length, but also whenever a thread breaks or becomes slack, and parts are provided to accomplish this in both cases. The spinning bobbins P are placed on suitable supporting pins, and the yarn is tensioned by means of weighted levers Q. On the right-hand side a full bobbin is on the pin, while on the left the thread from a partially emptied bobbin is shown passing under the porcelain guide at the end of the sensitive lever R, then over the oscillating guide finger S, and through the slot of the cone T. As the spindle rotates, the yarn is drawn

forward, and accumulates on the spindle in the form demonstrated by the sectional cop—the particular inclination of the nose of the cop being determined by the angle of the cone. The angle contained between the two sloping sides of the nose varies usually from 22° to 26°, that is, the inclination of the nose from the centre line of the cop is 11° to 13°. Sensitive lever R is set-screwed in a lug which projects from the three-lobed part U, the latter being suitably fulcrumed; hence if the yarn breaks, or runs too slack, the sensitive lever R will fall, and will cause the upper lobe to come in contact with and to press forward the upper or curved arm of lever M, thus raising the recess on the end of the lower arm of lever M clear above the upper point of the short arm L of lever H. The heavy lever H then falls, rod K is lifted, and so is fork O and clutch F, the combined movement resulting as stated in the stoppage of the spindle. To stop the spindle when the cop has reached a predetermined length a rod V is provided, which is secured by the upper end to lever M, and which passes freely through a lug projecting from the back of the footstep bracket W. The front portion of W supports the spindle footstep X, and, as the cop fills, spindle E, footstep X, and bracket W are raised together, the latter being maintained in its proper vertical plane by sliding on the rectangular guide 7. The distance between the upper and inner arm of the bracket W and the collar 8 on rod V determines the length of the cop, and the collar 8 is adjustable so that cops of any practicable length may be wound. As the cop is gradually filled, the footstep bracket W slides up guide 7, and also up rod V, until the upper face of W reaches the lower face of collar 8; any further upward movement of W causes collar 8 to rise, and ultimately the rod V raises lever M and releases the upper part of L, thus allowing H to fall, when the spindle is immediately stopped. The two lower lobes of U prevent the lever R from rising too high or falling too low by coming in contact with the projecting fulcrum N, while the arm L strikes a flat part on the bracket which supports lever M, and thus limits the fall of lever H. In the right-hand figure the levers R and H are in their lowest positions and in contact with the parts which are used to arrest their downward movements.

When the collar 8 is raised by W, the cop will be of the dimensions indicated by the dotted lines. The spring 9 on the end of rod 10 attached to the rear end of sensitive lever R tends to relieve any sudden strain which is thrown on the yarn.

The necessary traverse to the yarn is imparted by the upward and downward movements of guide finger S, which is set-screwed to the traverse lever 11 ; the latter is in turn set-screwed to a suitable holder on the rocking shaft Y. Care should be taken to see that the traverse lever 11 and guide finger S allow the thread to reach the bottom of the slot in cone T as illustrated in inset II., as otherwise the nose of the cop will not be built satisfactorily. Inattention to this point is one of the chief causes of soft-built cops, and of cops breaking down in the shuttle while weaving.

The rocking shaft Y receives its motion from the main shaft G, Fig. 17, by means of an eccentric 2 keyed on shaft G, eccentric rod 5, and arm Z. The latter is provided with a slot so that the degree of oscillation of rod Y may be varied. In order to increase the diameter of the cop, slightly raise the position of traverse lever 11, Fig. 16, by adjusting the nuts 3 and 4 on the eccentric rod 5, Fig. 17, and increase the traverse of the same lever to the necessary extent by moving the stud 1 in the arm Z nearer to the

shaft Y. A decrease in the diameter may, of course, be obtained by an opposite adjustment. This shift will alter every spindle on the same row, but should it be desired to change only one spindle, this may be done by lengthening or shortening, as far as possible, traverse lever 11, when a corresponding decrease or increase respectively in diameter will be obtained. (The apparent departure from the principles of leverage is due to the position of S with respect to T, and to the fact that the flexibility of the yarn causes the latter to lag considerably behind the movement of the traverse lever 11, and consequently to receive a much reduced traverse.) The increased diameter can also be got by adjusting the position of the traverse lever 11 on the shaft Y, so that the finger S will travel further up the cone T. This, however, as already mentioned, produces an unsatisfactorily built cop, as the diameter should not be increased without a proportionate increase being given to the traverse.

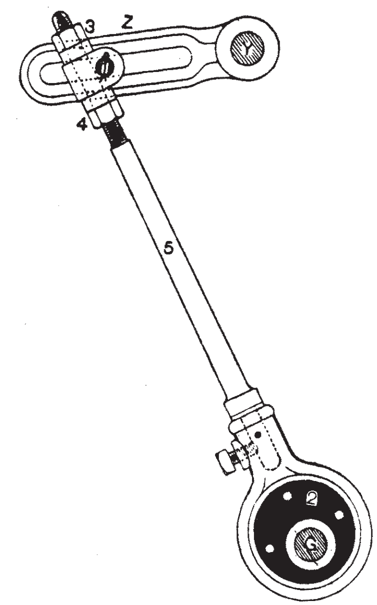


FIG. 17.

CHAPTER VI

WARPING, BEAMING, AND DRESSING

THERE are at least seven different methods employed in the preparation of jute and linen yarns for the loom, irrespective of those used for pattern work and for short lengths generally. These are :—

1. That by which the chain is made in one or more parts on a warping mill, and then beamed on to a weaver's beam.

2. By which the warp is made in one or more parts on a linking machine, and then beamed on to a weaver's beam.

3. By which the yarns are run direct from a bank on to a weaver's beam, and are either left dry or are starched or dressed in the process.

4. By which a definite proportion, say, $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{5}$, $\frac{1}{6}$, etc., is run and dressed on to each of 2, 3, 4, 5, 6, etc., warping beams, and then all beamed dry on to a weaver's beam.

5. By which similar proportions indicated in No. 4 are run dry on to warping beams, and then all dressed and run simultaneously on to a weaver's beam.

6. By which the yarn is chained in definite proportions of the total number of threads as in No. 4, then dyed in the chain form, beamed on warper's beams, and then ultimately dressed and run simultaneously on to a weaver's beam as in No. 5.

7. By which the warp is beamed on to small sectional beams, each of which constitutes a distinct section of the complete width of the weaver's beam. They are then either woven direct from the sections or transferred to an ordinary weaver's beam.

The warping mill is still largely employed in the preparation of all kinds of pattern warps, and for the production of short lengths of warps which are made up of fancy yarns or coloured yarns, say for carpeting and similarly striped goods. It is also much used for preparing warps intended to be delivered and to be woven by manufacturers in various districts where spinning is not practised, and particularly for export. It is, however, being gradually displaced, except for short lengths, by the more modern linking machines.

Warping machines are in most cases driven by hand, although in some few cases they are driven frictionally by power. Fig. 18 illustrates, in elevation and plan, the ordinary type of hand-driven warping mill. It is built upon, and revolves about, a vertical axis or centre post A, from which project radial bars B ending in uprights C—the latter being kept rigid and equi-distant by stay rods D. The mill is driven by a grooved hand wheel E, round which, and also round the lower end of uprights C, an endless band F is passed. The circumference or "round of the mill" is usually from 10 to 13 yds., and is for warping calculations divided into spokes, a spoke being the distance between any two uprights C. Thus a 10 yds. mill may have 24 spokes; 11 yds. mill, 26 spokes; 12 yds., 28 spokes; 13 yds., 30 spokes, and so on. The number of spokes, however, may vary in mills of the same circumference. Sometimes this circumference is arranged for a given number of ells (37-in. measure). The total height of the mill varies from 6 ft. to 7 ft. 6 ins., giving about 5 ft. to 6 ft. 6 ins. clear working space. In warping, the yarn is "laid" or wound on the mill in a spiral form

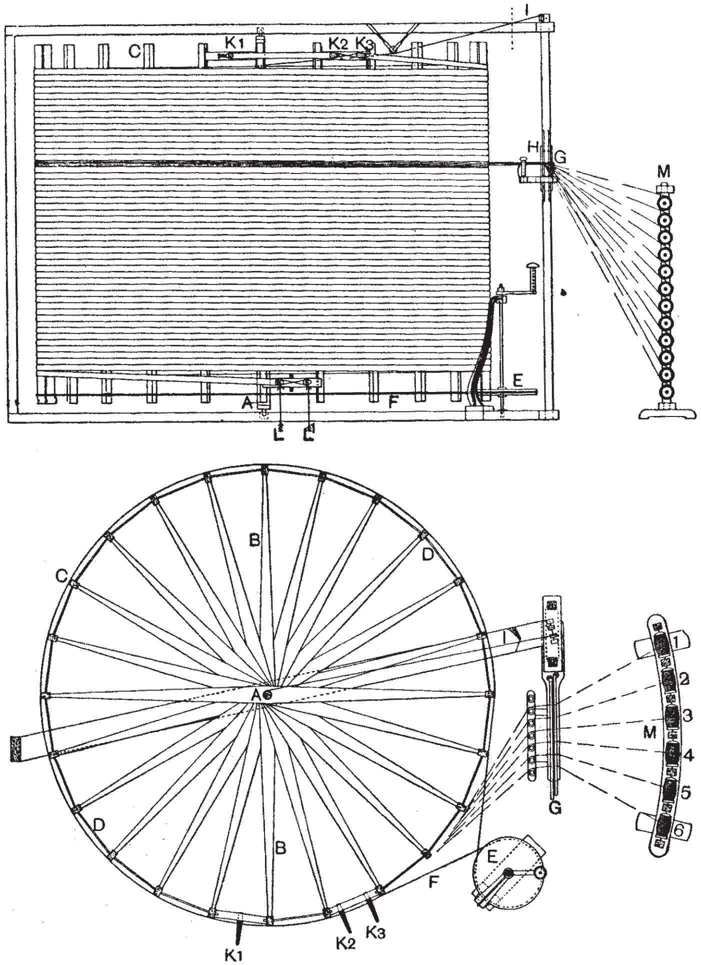


Fig. 18.

by lowering and raising the "heck" or guide reed G

while the mill is revolving. This lowering and raising of the guide reed is accomplished by suspending the "heck-box" H (to which the guide reed is fixed) to a cord or band I; the band is then passed over and under a series of pulleys fixed to the frame and to the heck, and finally attached to the centre post of the mill. According to the direction in which the mill is driven, a definite length of cord is either given off or taken on by the centre post at each revolution, thus lowering or raising the guide reed.

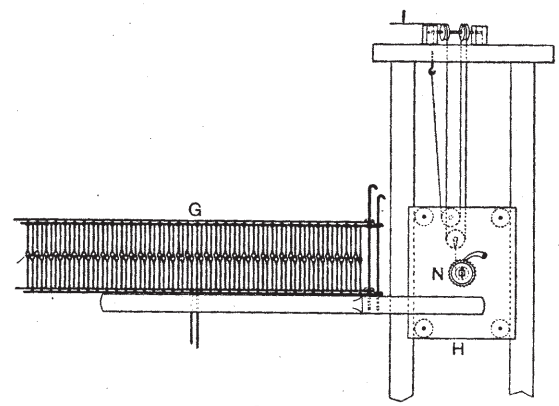


Fig. 19.

By reference to Fig. 19 it is seen that cord I passes over four pulleys before being taken to the centre post, thus dividing the part given off in one revolution of the centre post into four equal portions, and therefore allowing the heck-box to fall only one-fourth of the length given off. The reverse action, of course, holds good when taking up.

To calculate the fall of the heck for one revolution of the mill (neglecting the thickness of the cord), multiply the diameter of the centre post, say 2 ins., by 3·1416, and divide by the number of cords by which the heck-box is suspended — in this case four. Then $\frac{2 \text{ ins.} \times 3\cdot1416}{4 \text{ cords}}$ $= 1\cdot5708$ ins.; that is, from the centre of one round of yarn to the centre of the next round will be 1·5708 ins. If the working height of the mill be 78 ins., then 78 ins. $\div$ 1·5708 ins. $=$ 49·6, or practically 50 rounds. Supposing the mill to be 12 yds. in circumference, then 50 rounds $\times$ 12 yds. each $=$ 600 yds. of chain which may be laid on if necessary. Any shorter length may be obtained by changing the position of forks L, which may be fixed at any suitable point on the mill.

The "bank" or "bobbin creel" M (Fig. 18) is a wooden frame in which the necessary and most convenient number of bobbins are placed for the making of the warp. In ordinary work these are usually spinning bobbins, winding being dispensed with. The capacity of the bank is usually 72 bobbins, although the number generally employed varies between 45 and 65, and is, if possible, a measure of the total number of ends required. Thus, suppose it were required to warp a chain of 256 splits or 512 ends (a split meaning two threads or ends, plain cloth), the warper would place 64 bobbins in the bank, this being the greatest number between 45 and 65 which is a measure of 512. In selecting the number of bobbins care has to be taken that it will give a suitable number of "bouts" in which to run the chain (the term bout means a full traverse of the mill from forks K to forks L, and back again to K). In the above case we should have four bouts. 64 ends $\times$ 2 $=$ 128 ends in one bout; 128 ends $\times$ 4 bouts $=$ 512 ends in the chain. For practical reasons this would be too much to put on the mill at one time, and it is therefore usual to take the chain off in parts. In the case under notice two bouts would be run on to the mill, and then taken off by linking them; then other two bouts would be warped and removed in the same way. When it becomes necessary to take the chain off in three parts, there may be either six or nine bouts in the chain. Each part should, of course, have the same number of bouts, so that the process of beaming may be carried out under satisfactory conditions. Before proceeding to describe the operation of warping, it is necessary to give a short description of the heck or guide reed G, Fig. 19. In appearance it resembles a coarse iron camb (rather than reed) of two leaves, with thirty-six eyes on each leaf, and set so that the eyes of one leaf are midway between those of the other. The threads of yarn from the bobbins pass through these eyes, and as the heck rises or falls are guided on the mill in a spiral or screw form, as already stated. Each leaf of the heck, with the corresponding half of the yarn, may be raised at will, and the lease formed by each alternate thread being passed over and under, or under and over, respectively, as shown on the forks K, Fig. 18. The operation of warping is as follows:—After bringing the heck to a suitable level, the warper begins with the top bobbin of row No. 1, and takes each in succession in that row; then proceeds in a similar manner with No. 2 and succeeding rows. The first thread is passed through an eye in the back leaf of the heck; the second thread through an eye in the front leaf of the heck; and so on, back and front alternately, until all are entered; the ends are then tied together, and the heck raised until it is level with the forks K. The warper then divides the yarn equally by raising the back leaf of the heck, and passes the yarn thus divided over the first and second forks; divides the yarn again by raising the front leaf, and passes the yarn over the third fork, thus forming the "thread-by-thread" or drawer's lease. This done, the mill is driven round in the proper direction, the heck meantime falling, until the necessary number of rounds is on; this, of course, being determined by the length of the chain and the circumference of the mill. Suppose, for example, that the warp is to be 540 yds. long, to be made on a 12 yds. mill, and to be keeled or marked for five cuts; then

$$\frac{540 \text{ yds.}}{12 \text{ yds.}} = 45 \text{ rounds of mill.}$$

Having placed forks L, L^1 at the proper point, the warper proceeds to form the "pin" or beamer's lease—*i.e.*, he or she divides the total number of threads in the chain (512) into a given number of equal portions, such number depending on the width of the beam for which the chain is intended. In this case 72 divisions or pins will be taken, and as this lease is formed on reaching forks L, L^1, and again immediately on turning back, or twice in every bout, it follows that it will be formed $4 \times 2 = 8$ times during the warping of the chain. Then $\frac{72 \text{ pins}}{8 \text{ times}} = 9$ pins or divisions into which the threads in the bank will require to be divided. $\frac{64 \text{ threads in bank}}{9 \text{ pins required}} = 7$ threads and 1 over, or

$$\begin{array}{lr} 8 \text{ pins with } 7 \text{ threads each} = & 56 \\ 1 \text{ pin with } 8 \text{ threads} \ldots\ldots\ldots = & 8 \\ \hline & 64 \text{ threads.} \end{array}$$

The general formula for the number of threads per pin is obtained by dividing the total number of threads in the warp by the total number of pins in the width between the flanges of the beam. In this particular case:—

$\frac{512 \text{ threads}}{72 \text{ pins}} = 7\frac{1}{9}$, the average number of threads per pin.

Having formed this lease, the mill is driven in the opposite direction. But before proceeding to the top the warper marks or "keels" the yarn at the proper points for cutting when woven. This is done by counting off the proper number of rounds from the bottom and marking the yarn in black or other coloured ink. In this example, $\frac{45 \text{ rounds}}{5 \text{ cuts}} = 9$ rounds per cut, so that at points on the 9th, 18th, 27th, and 36th rounds, directly above forks L, L^1, the yarn would be marked. In addition to the cutting marks it is usual to put a differently-coloured keel mark on each round of the mill, termed the guide or beamer's keel, and intended for his guidance only; this practice, however, is not rigidly adhered to. After keeling, the mill is driven until the forks K are reached, when the drawer's lease is formed, the yarn passed round the first fork, the mill turned, and the lease again formed. At this point, and before running down for bout No. 2, the heck is "tempered" or allowed to fall about half-an-inch by letting go one or two teeth of the ratchet wheel N, Fig. 19. This slight adjustment prevents the second bout from lying exactly over that of the first, and also ensures that all the bouts are as near as possible equal in length. Having run bout No. 2 and formed the lease at forks K for the fourth time, the yarn is cut and the ends tied round the first fork similar to the beginning, and a knot is also tied on the ends hanging in the heck. To preserve the beamer's and the drawer's lease, bands are passed between the threads at forks K^2, K^3, also at L, L^1, and firmly tied in these positions. The warper then lifts the yarn off the first fork and proceeds to draw it away, linking it meanwhile into a chain. When about two rounds are withdrawn the heck is raised to its original level by means of the ratchet N, Fig. 19, and the yarn attached as before to the forks K. The warper then proceeds to link off the remainder of the first part, at the same time running on a portion of part No. 2, which is in all respects similar to the first.

The above describes the machine and the method by which practically all warps, intended to be beamed dry, were made up to a recent date. At the best it is a comparatively slow process, and, except in the hands of an efficient operative, unsatisfactory chains are common. Even with skilled workers it is difficult to prevent faults, particularly variations in the length of groups of the threads in one part, hence it is not surprising to find that the linking machine is being used more and more for the preparation of dry chains for weaving, for ropemaking, and for similar purposes. The linking machine has been used for some considerable time in the cotton trade, and, with slight alterations, is capable of being employed satisfactorily in the jute and linen trades. At present there are several in general use in the Dundee district.

Three photographical reproductions of the linking and measuring machines appear in Fig. 20, and if these be referred to in conjunction with Figs. 21 to 32 which illustrate a full range of the machines and apparatus, a good idea of this ingenious and useful invention will be obtained. Figs. 21 to 24 represent graphically the complete range as used in the jute trade; they indicate respectively the spool or bobbin bank, the leasing apparatus, the measuring machine, and the linking machine. In the last machine, Fig. 24, the linked chain is seen dropping into a box, or else sliding down an inclined plane to be deposited on the floor as illustrated in the upper photograph in Fig. 20. The makers provide special apparatus for leading the linked

chain from the machine and depositing it into a frame fixed at some convenient place near the delivery side of the linking machine.

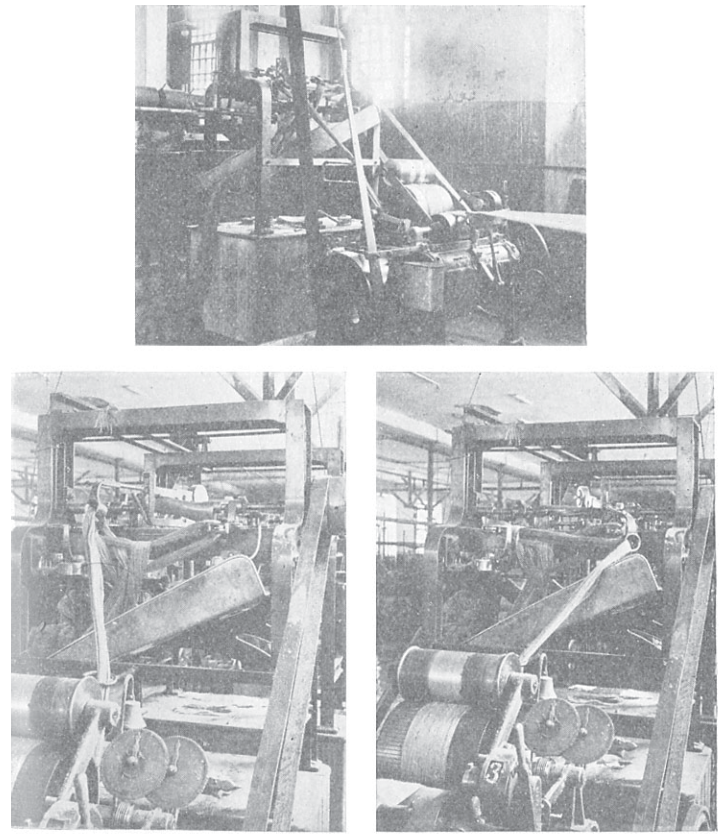


Fig. 20.

The measuring machine, Fig. 23, is driven through pulley A direct from the main shaft, and a belt at the

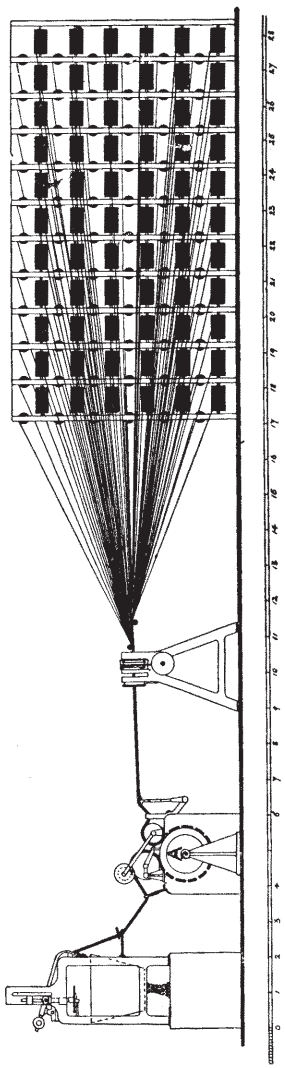


Fig. 21. Fig. 22. Fig. 23. Fig. 24.

opposite side of the measuring machine communicates the drive to the linker. The delivery of warp from the measuring machine is constant, but although the take up of the warp by the linker varies slightly from moment to moment in one complete cycle, it is evident that the average speed must be the same as that of the measuring roller in order that the warp may neither get too tight nor yet collect between the two machines.

It is unnecessary to give a description of the bank; the only thing that need be said is that one side only is shown in the figure—the other side being identical, and the whole capable of accommodating from 300 to 400 spools. The remaining machines will be described separately.

Fig. 25 illustrates an end elevation of the leasing apparatus, while Fig. 26 is a front elevation showing one side only of the frame as viewed from the bank, together with the parts for forming the lease.

The threads from the bank are collected in the ordinary way and first passed over roller A, and then under roller B. They

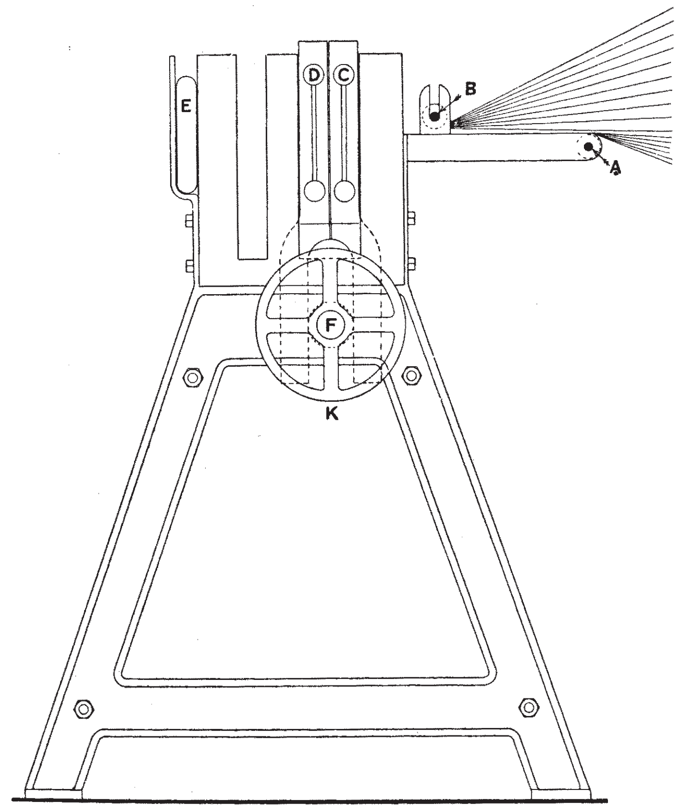


Fig. 25.

are then drawn through the two leasing reeds C and D, the odd threads passing through the centre portion of the soldered splits in one reed, say C, and through the long splits in the other reed D, while the even threads pass through

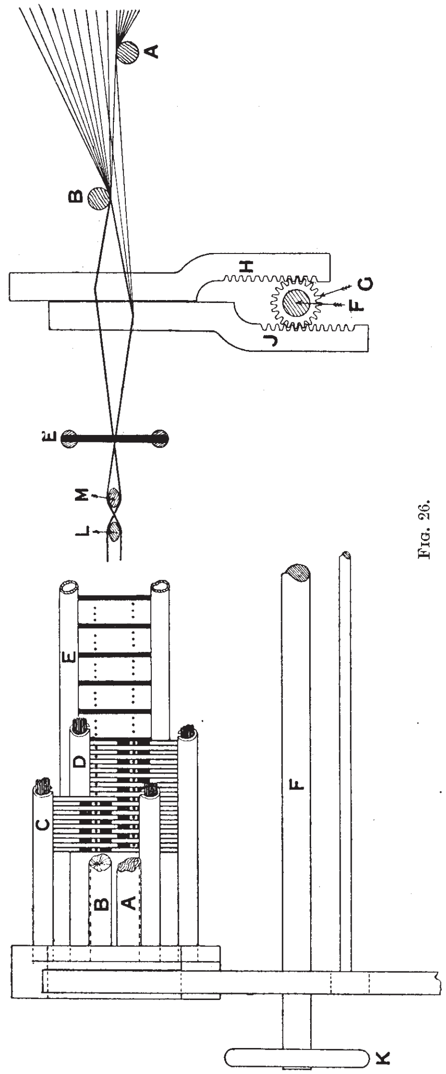


Fig. 26.

the long splits in reed C, and through the centre portion of the soldered splits in reed D. They are then grouped into definite numbers, termed pinfuls, and each group passes between two of the pins in pin frame E. The number of threads between each pair of pins should be the same, or nearly so, for any one warp, but the number per pinful may, and will vary for warps of different setts. In Fig. 26 it will be seen that there are six threads in each pinful.

The mechanism for obtaining the thread by thread or drawer's lease consists of shaft F, which carries at each end of the frame a pinion G. This

pinion G is in gear with the racks H and J of the leasing reeds C and D, and it is evident that when wheel K is rotated, one rack will rise and the other will fall, thereby raising one leasing reed and depressing the other. In Fig. 26 the racks are shown in position for inserting the first lease rod L—the reverse movement being, of course, necessary when it is intended to insert lease rod M. It is usual to pick the pin lease or beamer's lease by hand. This operation is easily done provided that the pin frame E is pushed to one side so that every pinful of threads will bear hard on the side of their respective splits, and thus separate the pinfuls effectively.

After leaving the leasing apparatus, the threads pass to the measuring and marking machine, Fig. 23, details of which appear in Figs. 27 and 28. The group of warp threads A, distinctly indicated by the heavy line, first passes over a concave support B, then through an oval opening in bracket C, over guide roller D, around drum E, over measuring roller F, and under pressure roller G; it is finally deflected and passed through another oval guide H, previous to being led to the linking machine.

The measuring machine is driven direct through pulley J, and the speed reduced by means of pinion K, wheel L, pinion M, and wheel N. Sufficient grip between the drum E and the measuring roller F is obtained partly by pressure roller G, and partly by means of a strong spiral spring (not shown) acting on rod O, and communicating its force to the shaft P, of measuring roller F, through the lever Q, fulcrumed at R.

The measuring roller F is one yard in circumference, consequently bevel wheel S, which rotates with the measuring roller, will make one complete revolution for each yard of yarn passed between the rollers. Bevel wheel S, Fig.

28, is geared with bevel wheel T of the same number of teeth, hence shaft U, and single thread worm V, Fig. 27,

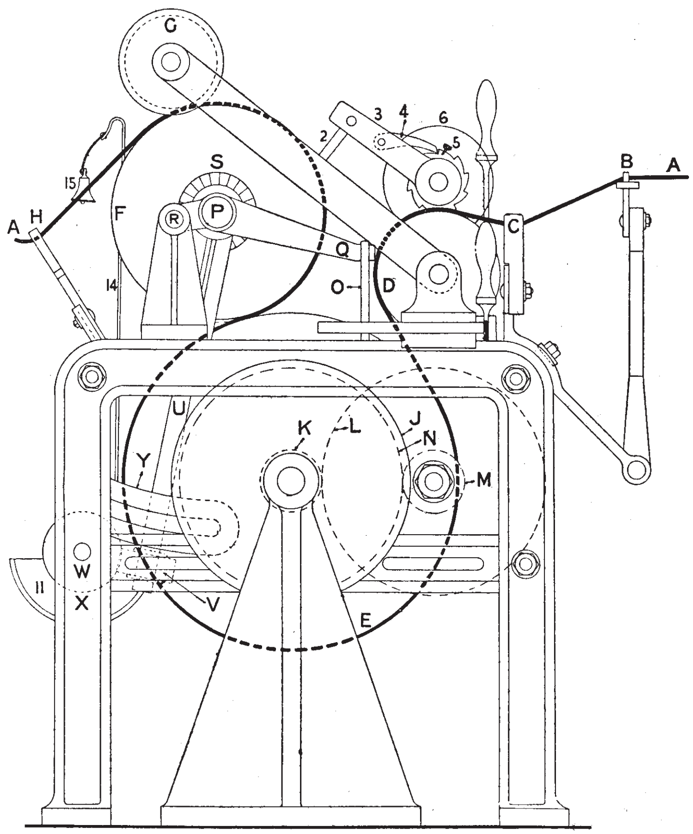


FIG. 27.

will make one revolution for each yard of yarn. Clearly, then, it is possible to make shaft W make one revolution for any reasonable length of piece by introducing a wheel

X with the same number of teeth as the laid cut should

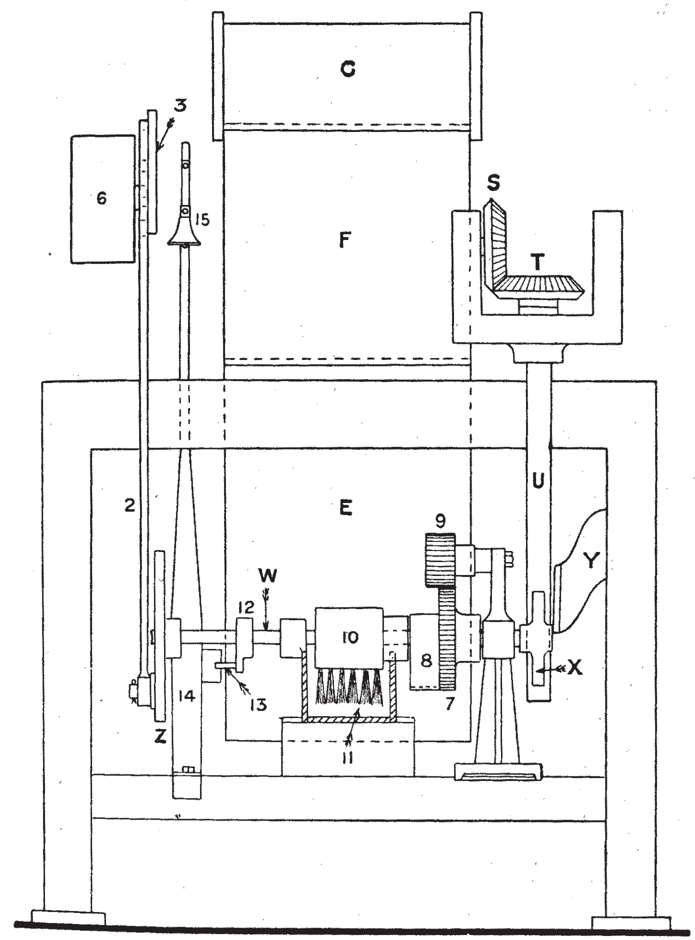


FIG. 28.

contain yards of yarn. The bracket Y, concentric with shaft P, facilitates the employment of different sized wheels X according to the lengths desired.

The parts marked S and onwards are introduced not only for measuring the warp, but also for marking it every cut length, and for registering the number of cuts which pass through the machine. These functions are performed as follows—The shaft W, Fig. 28, makes one revolution per cut, and so will the disc Z; therefore rod 2 will receive an up-and-down movement every cut. This rod 2 moves rod 3, Fig. 27, to which pawl 4 is attached. The pawl 4 moves the ratchet wheel 5 one tooth, which is equivalent to one-tenth of a revolution of wheel 5. In line with the ten ratchet teeth, but enclosed in box or clock case 6, are the numerals 1 to 10 which move in unison with wheel 5, and which are exposed to view in succession in the glass of the clock (No. 3 is seen clearly in the bottom right-hand photo in Fig. 20). The clock which is usually supplied with the machine is driven direct from shaft P, and consists of two dials; these dials are also seen in Fig. 20, but are not in use for this class of work.

The marking motion is as follows:—On the same shaft W, a wheel 7 moves continuously, and at one point a pin projects which carries round the weighted part 8. The latter has a few teeth which come in contact with the wide teeth of pinion 9, driven by wheel 7; this arrangement ensures that the weighted lever will drop every revolution at precisely the same point. It will be seen that the weighted lever 8 and brush 10 drop almost one-half a revolution when the former is free to drop; consequently wheel 7 makes this proportion of a revolution before the pin again catches the weighted lever 8. The brush is so arranged that the ends of the bristles, which carry the ink from box 11, come in contact with the warp or drum E when falling, and thus mark the cutting keel for the weaver's guidance. Between the brush 10 and disc Z is placed a collar 12, from which a pin 13 projects. Every revolution this pin comes in contact with a flat spring 14, and continues to force the spring backwards until the brush is ready for dropping. The brush is dropped and the spring released at the same moment, and when the pin has thus relieved the spring 14, the latter naturally vibrates and rings bell 15 which is attached to the end of the spring.

Figs. 29, 30, and 31 are respectively front elevation, plan, and end elevation of the linking machine—the last and most important machine in the group. For some classes of work this machine rests on the floor, but in the case under notice it is raised to a position about two feet from the floor in order to provide sufficient height for the linked chain to drop. The threads of the warp are condensed by passing them through an iron eyelet A before being taken to the trumpet-shaped carrier B of the lever C. This lever is fulcrumed at D, Fig. 31, and receives a motion of a rather complicated nature for the purpose of carrying the yarn from side to side of the machine, and for placing it in suitable positions to suit the movements of the supplementary linking mechanism. The trumpet-shaped carrier B describes the figure 8 as it would appear when on its side, thus ∞; its vertical movements being due to the peculiarly shaped cam E, while its lateral movements are obtained by the oscillation of bracket F. A belt from the measuring machine transmits the motion to fast and loose pulleys G and H, the former communicating the motion to the main shaft J, in the centre of which is the cam E. Shaft J extends beyond the opposite framework, and carries a bevel wheel K, which, through bevel wheel L and a vertical shaft, transmits the movement

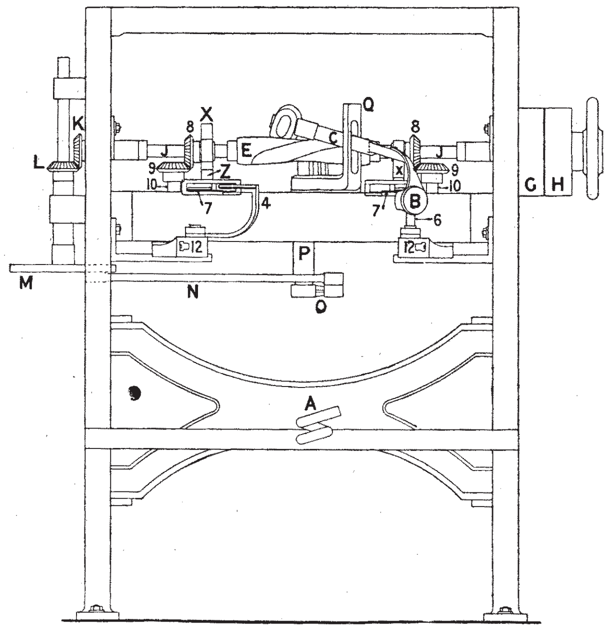


FIG. 29.

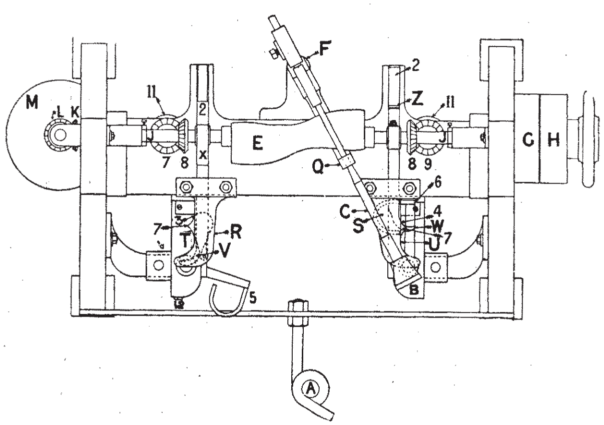


FIG. 30.

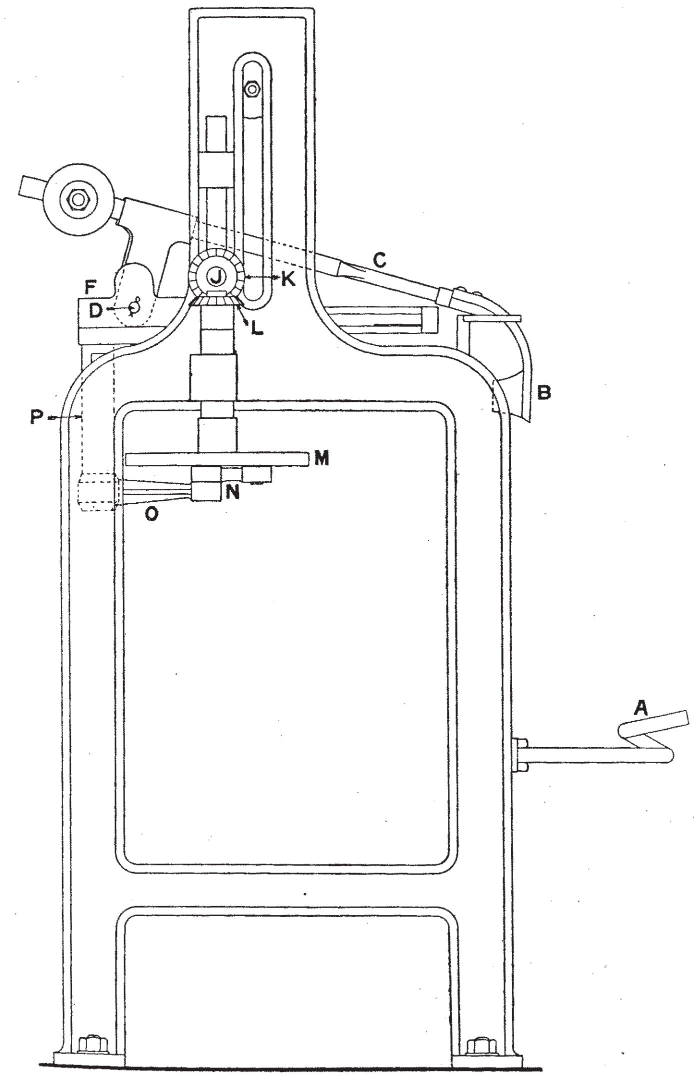


FIG. 31.

to disc M. At the proper distance from the centre of disc M is fixed a stud upon which connecting rod N is placed, and as the disc rotates, the end of rod O, and therefore vertical shaft P, are oscillated through a sufficient angle to communicate the necessary travel to rod C. The guide Q moves in unison with the lever C, and the slot in Q is long enough to permit of the vertical movement of lever C. The actual function of the trumpet-shaped carrier B is to convey the group of threads from left to right, and from right to left, and to bring the threads from the under side over the ends of brackets R and S alternately, and to place them into the recesses T and U.

Immediately under the brackets R and S are sliding hooks V and W—the hook of the former being shown near the end of the bracket, whereas the hook of W is beyond the limit of the recess U. Each hook is alternately pulled to the back position (that occupied at present by W) by means of a cam X on shaft J. The two cams X are set diametrically opposite, so that every half-revolution of shaft J either one or other cam comes in contact with a finger Z, which projects perpendicularly from the upper surface of slide 2 to which the hook V or W is attached. It will thus be seen that the movements of the hooks synchronise with the movements of lever C. When the trumpet-shaped carrier B of lever C is carrying the yarn upwards to place it in recess T, the hook V is full forward, and, similarly, when the yarn is being placed in recess U, the hook W is full forward, so that the yarn may be placed behind the point of the hook, the curved part of which at this moment coincides with the recess T or U. As the trumpet-shaped carrier B is approaching the extreme left or right-hand position the threads are in the recess T or U, and the hook V or W is carrying them backwards in order

to place them in front of rotating hook 5 or 6, the latter of which at this moment is coincident with the back groove 4 on the right hand, but hook 5 is at its outward position on the left hand.

The point between the two recesses, say 3 and T, or 4 and U, is formed by a small brass plate 7, which yields as the yarn is being drawn back by hook V or W, but which springs forward immediately to its position when the yarn has passed into recess 3 or 4. The hook 5 on the left rotates clockwise, so that the hooked part gets behind recess 3 just before hook V draws the yarn back—the corresponding hook 6 on the right is in this position. The hook V thus forces the yarn over and into the hook 5 when the latter has moved to its limit in a clockwise direction; hook V then quickly springs forward again ready to receive the next length presented by the trumpet-shaped carrier B. When this is being placed in recess T and on hook V, the hook 5 (which would then be under bracket R in a similar position to what hook 6 is at present) reverses and rotates counter-clockwise into the position shown on the drawing, and in doing so carries the loop over the end of bracket R, and consequently over the warp which is for the moment suspended on the end of the bracket R. This movement will perhaps be better understood by examining Fig. 32, in which hook 5 has just rotated counter-clockwise, and placed the loop 15 over the loop 16, which still remains over bracket R, but which will be treated similarly the next time the trumpet-shaped carrier moves from the left-hand side.

Hooks 5 and 6 are operated by means of bevel wheels 8 and 9, Figs. 29 and 30, and vertical shaft 10, on the end of which is a disc 11. From a pin near the periphery of this disc a rod connects the disc to the end of rack 12, which in moving backwards and forwards rotates pinion 13, Fig. 32. Pinion 13 and finger 5 are compounded and both rotate on stud 14; consequently, as the rack 12 moves backwards and forwards, the finger 5 is rotated clockwise and counter-clockwise through about 270 degrees. The order of the linking of the yarns is easily followed by means of the heavily-marked arrows and the progressive

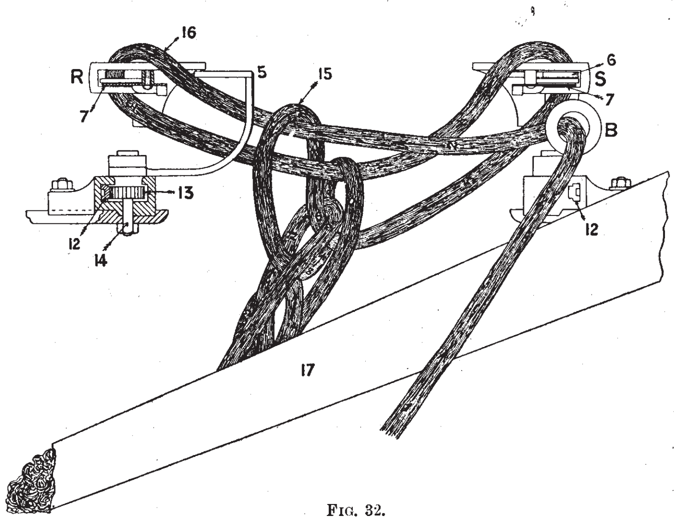


Fig. 32.

numbers which appear immediately behind the arrows. After the chain has been linked as indicated, it drops into the inclined channel which directs it on to the floor as illustrated.

The production of this linking machine varies from 24 to 30 yds. per minute when operating jute yarns, but this speed can be increased for cotton yarns. In some machines the linking apparatus is duplicated, one above the other, in which case two chains may be linked at the

same time; while in other cases, where linking is not essential, the yarns from the bank pass through an ordinary warping machine, the pressing roller of which drives a balling frame. Here the group of threads, in the form of a tape, is wound into a large roll of a similar shape, and in a similar manner to those made by roll winding machines.

Chain Beaming.—After the warp or chain has been made on the warping mill, the linking machine, or by any other similar method, it is necessary to wind the yarn on, and to distribute it equally over, a weaver's beam, or over a warper's beam if the yarn has still to be dressed. This is done on what is termed a dry-beaming machine, one of the different types of which is illustrated in Fig. 33. The ends of the chains, containing the beamer's or pin lease, are passed round the three rollers A, which are set from 12 to 20 feet behind the actual beaming apparatus. In some machines fixed tension bars are used instead of rollers. By means of the pin lease the beamer spreads the warp over the swinging and fixed "raddles," "eveners," or "wraiths" B and C to the width of the beam, from flange to flange. This should always be a few inches more than the width the warp is to occupy in the reed. After leaving the eveners the ends are passed under the guide roller D and attached to the loom beam E, which may be driven either fast or slow as the beamer finds necessary. The pressing roller I is introduced to make the beam as firm and solid as possible. In order that weaving may proceed satisfactorily it is essential that the beam should be firm, and that the different parts of the chain should be tensioned equally. The eveners B and C, which resemble coarse reeds, are about 6 ins. deep, and have movable caps. The pitch or sett in common use is $\frac{5}{8}$ in., although finer and

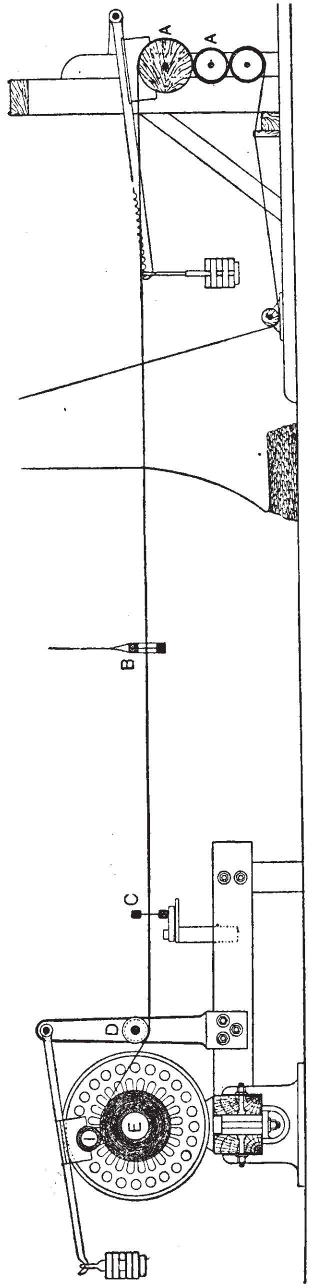


Fig. 33.

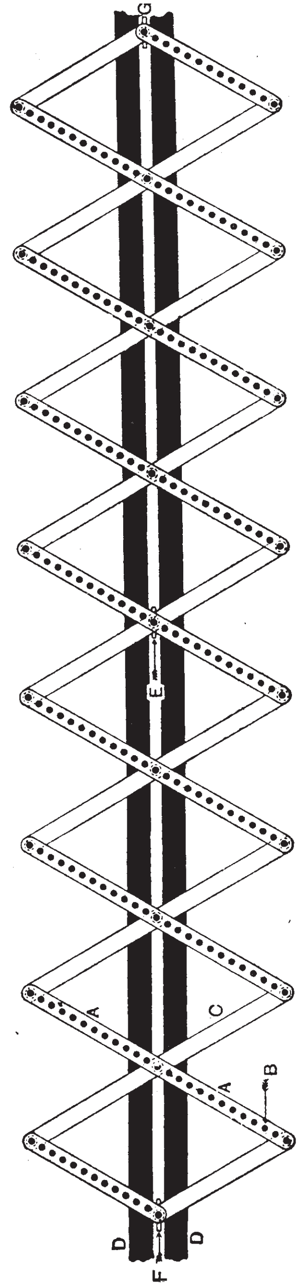


Fig. 34.

coarser setts are used where great varieties of warps are made. The evener C remains fixed throughout the process, and the threads of the warp are distributed as evenly as possible between the pins of this evener, so that the total width occupied is exactly the same as the width between the flanges of the weaver's beam. Evener B, on the other hand, is suspended by cords, and is swung backwards and forwards to unravel or open up the pinfuls of warp before they reach the fixed evener C, and thus prevent breakages. If it is desired, however, as is sometimes the case, to put a given chain on a narrower or a wider beam than that for which it was intended, it is necessary with this evener either to "cram" or to split up the pinfuls until the desired width is obtained. Either of these expedients generally results in an unsatisfactory beam. This difficulty, however, may be overcome by using a special evener similar to that shown in Fig. 34, which consists of a number of sections A in which the pins B are fixed. These sections are jointed together in the centre and at the ends to the connecting bars C, the whole resting in a slotted framework D, and capable of being expanded or contracted at will. By means of a thumb-screw E the centre of the evener may be adjusted to the centre of the beam, and the ends fixed to the required width by similar screws at F and G.

In the evener or wraith illustrated in Fig. 34 it is clear that either half may be extended or contracted at will without interfering with the other half. Although this may appear to be an advantage, it is usual to make these wraiths with a right- and a left-hand screw, in which case both halves move in or out simultaneously. Such a wraith is illustrated in Fig. 35, where the dark lines in A and B show diagrammatically the positions of the movable pins when intended to be used for a narrow and a wide width respectively. C

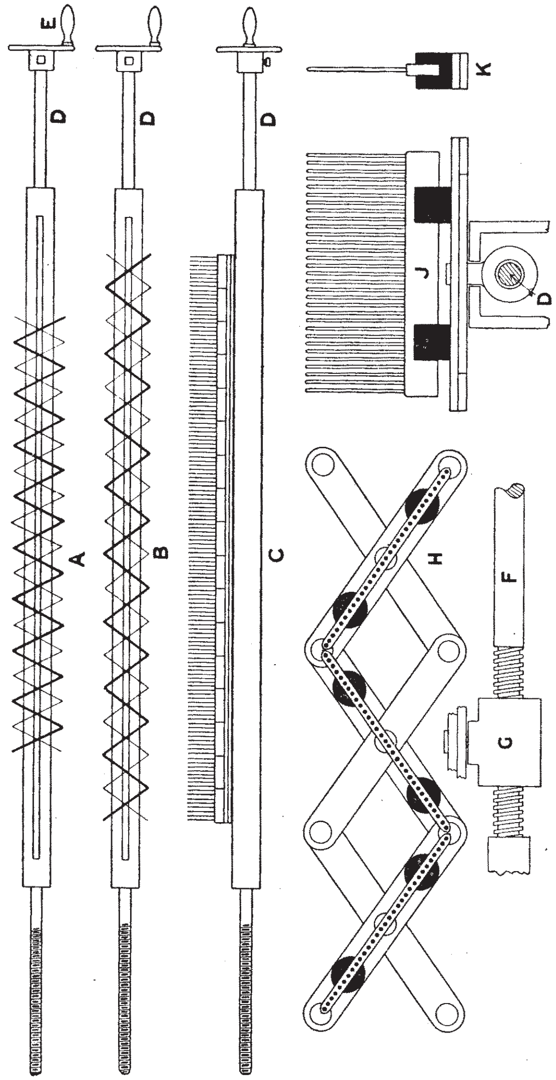


Fig. 35.

is an elevation representing the same width as B. The shaft D is supported at both ends at a convenient height for the threads and the beam, and the handle or wheel E is used for rotating the shaft, the centre part of which is made with right- and left-handed screws—one part F, together with the bearer G for the pins, being illustrated in detail. A plan of three of the rows is shown at H,

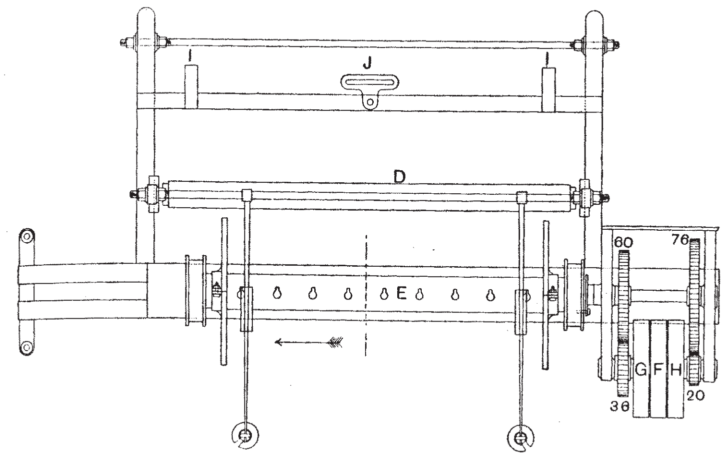


Fig. 36.

while a front view of one row with necessary parts, and an end view of one row, are supplied at J and K respectively.

As already stated, the eveners or wraiths guide the threads to their proper positions on the beam, but the beam itself is driven by the mechanism illustrated in Fig. 36, where F is a loose pulley, while pulleys G and H are compounded with driving pinions of 36 and 20 teeth respectively. The pinion of pulley G gears with a wheel of 60 teeth, and that of pulley H with a wheel of 76 teeth, thus giving a fast or slow motion to the beam as required.

Wheels and pinions of other sizes than those mentioned may, of course, be found in use. The fixed evener C, Fig. 33, is supported by the rests I and the slotted bracket J; the latter also permits of the evener's position being adjusted in relation to that of the beam.

Dressing and Beaming.—Dressing is the term generally used when speaking of the coating of the warp yarn with some adhesive substance while beaming. It is resorted to for various reasons, the chief of which is the laying of the loose fibres on the surface of the thread, thus reducing friction in the shedding, and facilitating the weaving operation generally. Other results incidental to this process are increased production in the spinning department, as yarns for dressing require less twist than those which are to be woven dry; waste is reduced to a minimum; the yarn being softer twisted, as well as starched, enables the cloth produced to take a superior finish and glaze. Most of these results may, however, be nullified by careless or inattentive drying. Over-drying weakens the yarn and makes it brittle, while under-drying has a tendency to produce mildew. A certain percentage of weight is added to the yarn: from 5 to 25 per cent in jute, while in some linens a higher percentage is often found. Where a high percentage of weight is desired special ingredients are introduced into the dressing mixture. It is, of course, understood that where the cloth has to undergo bleaching or dyeing, the warp of which it is composed must be treated with only that amount of size which is necessary to carry it successfully through the weaving process.

The materials in general use for the production of sizing mixtures may be classed as follows:—Adhesive substances, softening agents, deliquescent agents, antiseptic agents, and weighting agents. As a great variety

of each of these classes is in use, a list of each is appended, those most generally used being indicated by an asterisk:—

ADHESIVE.

* Wheaten flour . . .	Chief constituent of which is starch, $(C_6H_{10}O_5)_n$.
* Farina or potato starch .	
Rice flour . . .	
Sago flour . . .	
Maize flour . . .	
Dextrine or British gum .	

Irish moss, or Iceland moss.

SOFTENING.

* Tallow . .	A glyceride composed mostly of Tristearin, $C_3H_5(C_{17}H_{35}.CO.O)_3$. Tripalmitin, $C_3H_5(C_{15}H_{31}.CO.O)_3$. Trioleïn, $C_3H_5(C_{17}H_{33}.CO.O)_3$.
Bleached palm oil . .	Similar to above, but containing a larger proportion of trioleïn.
Castor oil . . .	
Lard	

Glycerine, $CH_2(OH).CH.(OH).CH_2(OH)$, or $C_3H_5(OH)_3$.

Soaps . . .	Hard, $C_{17}H_{35}.CO.ONa$. Soft, $C_{17}H_{35}.CO.OK$.

Paraffin wax.
Resin.
Gloy (one of the many patent softeners).

The soaps should not be used when salts of the alkaline earths (calcium, strontium, barium, or magnesium) are present, nor when zinc chloride is used. All these react with the soap, and produce insoluble compounds. In fact, it is risky to use soap when any metallic salt is present, sodium and potassium excepted, these two forming probably the only soluble stearates; while wax should not be used in cloths which are to be bleached or dyed, as it cannot be removed by ordinary methods.

DELIQUESCENT.

* Magnesium chloride, $MgCl_2.6H_2O$.
Calcium chloride, $CaCl_2.6H_2O$.
Glucose or dextrose, $CH_2(OH).(CH.(OH))_4.CHO$, or $C_6H_{12}O_6$.
Glycerine, $CH_2(OH).CH(OH).CH_2(OH)$.
Zinc chloride, $ZnCl_2.H_2O$.

Magnesium chloride should be used sparingly when the cloth is to be finished on hot cylinders. The heat has a tendency partly to decompose the salt, in which case hydrochloric acid is produced.

ANTISEPTIC.

* Zinc chloride, $ZnCl_2.H_2O$.
Salicylic acid, $C_6H_4(OH).CO.OH$.
Phenol or carbolic acid, $C_6H_5(OH)$.
Mercuric chloride, $HgCl_2$.

The two latter are highly poisonous, and on this account are seldom used.

WEIGHTING.

* China-clay (decomposed felspar), $Al_2O_3(SiO_2)_2(H_2O)_2$.
Heavy spar (barium sulphate), $BaSO_4$.
Barium chloride, $BaCl_2.2H_2O$.
Epsom salts (magnesium sulphate), $MgSO_4.7H_2O$.
Glauber's salts (sodium sulphate), $Na_2SO_4.10H_2O$.
Talc or steatite, $H_2Mg_3(SiO_3)_4$.
Gypsum (calcium sulphate), $CaSO_4.2H_2O$.
Magnesium chloride, $MgCl_2.6H_2O$.
Zinc chloride, $ZnCl_2.H_2O$.

A few of the above compounds have more than one property; they are, therefore, mentioned in more than one class.

Sizing mixtures are so varied in character and object,

and opinions are so different as to the benefits derived from any special compound with respect to its application to similar warps, that it is impossible to give more than a very general indication as to how they should be composed.

In the jute trade special loading agents are seldom employed, the dressing mixtures being generally restricted to the common adhesive substances (farina and wheaten flour), with the addition of some softening material (tallow or oil), and an antiseptic (invariably zinc chloride). This being so, the mixtures are very simple in character, and the proportions of farina or flour, or of both combined, to that of water vary between one-quarter of a pound to one pound per gallon, just as the dressing is desired light or heavy, the proportions of materials used, irrespective of water, being approximately :—

Farina or flour	90	per cent.
Softening agent	5 to 8	„
Antiseptic (when flour is used) .	2 to 5	„

It is usually considered unnecessary to use an antiseptic where farina is the only adhesive substance used, but it is a distinct advantage to add about $\frac{1}{4}$ per cent of caustic soda to pure farina size, since this not only preserves the proper consistency of the dressing for many days, but increases considerably the strength and thickness of the paste; if no caustic soda be added, farina size turns watery in a short time. Although no antiseptic is needed, zinc chloride is often introduced into such mixtures to fulfil the double purpose of a deliquescent and weighting agent.

The dressing mixtures for linen (where simple dressing is required) are similar in composition to the above, with perhaps the addition of from 5 to 10 per cent of a deliquescent agent such as chloride of magnesium. Where loading is desired, either one or other of the agents mentioned may be introduced in the necessary proportion. Where the adhesive substance is farina alone, the mixture should not be boiled, but simply raised to boiling-point. The same remarks apply where flour is used, although in some cases it is considered preferable to boil a dressing of this kind. In any case the flour should first be allowed to ferment, as fermentation reduces its tendency to produce mildew. Fermentation may occupy anything from ten days to many weeks. In flour dressings, soap may be employed with advantage as the softening agent, for the alkali it contains not only dissolves the fats present, but also neutralises the acid developed in fermentation. Farina is best alone where the yarns are bleached or coloured, as it forms a transparent film on the yarn; but it is of little use where weighting is desired, since it contains no gluten to carry the weighting agent. On page 75 we give in tabular form particulars, which have been derived from various sources, of several sizing mixtures in actual use. In each case the percentage of loading expected or obtained is stated, and, for the sake of comparison, all the ingredients used have been reduced to a basis of 100 lbs. of adhesive substance. Such a table, besides supplying the data given, also shows the great absence of uniformity and apparent want of principle which obtains in this important section of the weaving industry, and suggests a wide field of investigation for the textile chemist.

% Loading.	Wheaten Flour (lbs.).	Sago Starch (lbs.).	Farina Starch (lbs.).	China Clay (lbs.).	Tallow (lbs.).	Wax (lbs.).	Zinc Chloride 102° T.	Magnesium Chloride.	Caustic Soda 70° T.	Aniline Blue.	Water (Gallons).	Remarks.
Pure size	100	...	...	...	10	...	1 gall.	...	1 pint	...	80	Flour to be previously steeped with 1¼ galls. of Zn. $Cl._2$, 102° T. added for every 100 lbs. of flour.
,, ,,	50	50	...	...	10	...	...	...	1 ,,	...	80	
,, ,,	...	...	100	...	5 to 10	...	...	...	1 ,,	...	150 to 200	
10%	100	...	...	...	2½	1½	3½ lbs.	...	...	...	...	
10%	...	...	100	...	...	10	...	...	...	...	100	
20%	60	10	30	15	10	1	5 lbs.	...	...	...	...	
20%	100	...	...	30	2½	...	5 lbs.	...	...	¼ oz.	...	
20%	...	...	100	22	...	12½	5 lbs.	...	...	¼ oz.	...	
30 to 40%	100	...	...	80	10	...	...	2 gall. 60° T.	...	...	35	Flour previously steeped as above.
50%	100	...	...	45	12	...	3 lbs.	4 lbs.	...	...	30	ditto.
50%	100	...	...	60	20	...	7½ lbs.	6½ lbs.	...	...	...	
50%	85	15	...	80	35	...	10 lbs.	27½ lbs.	...	...	...	
80 to 100%	88	...	12	250	33	...	¼ gall.	5 gall. 60° T.	...	...	22	ditto.
100%	100	...	...	120	25	...	10 lbs.	12 lbs.	...	½ oz.	...	
100%	82	18	...	160	36	...	18 lbs.	36 lbs.	...	...	...	
100%	100	...	...	135	27	...	6½ lbs.	9 lbs.	...	½ oz.	...	

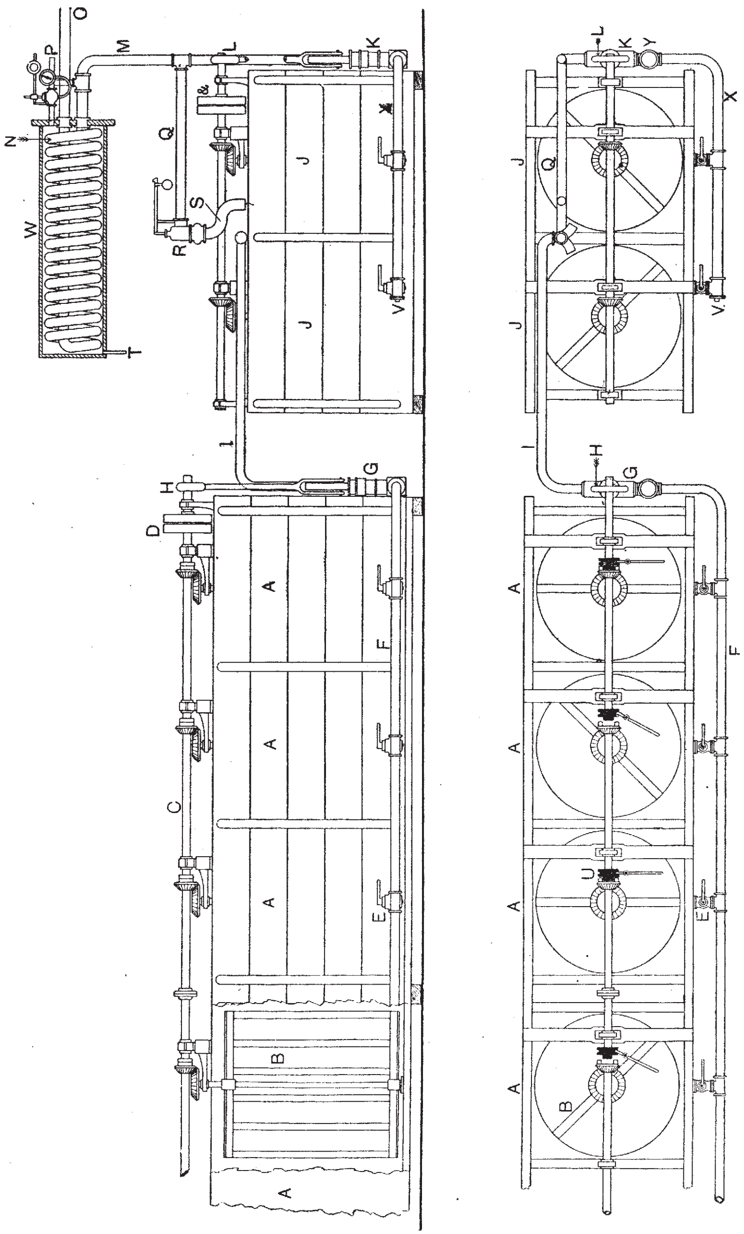


Fig. 37.

Figs. 37 to 40 are illustrative of a full starch mixing apparatus as made by Messrs. Joseph Hibbert and Co., Darwen, Lancashire. The fermenting vats A shown in plan and elevation in Fig. 37 are each provided with agitators B. The latter receive motion from a shaft C through bevel wheels and pinions as shown. Each agitator may be brought into action at will by means of the clutches U. Vats A are connected by means of brass taps E and copper piping F to a brass ram pump G, which is worked by the eccentric H on the shaft C. When in action the pump draws the fermented mixture from vats A as required, and discharges it through pipe I into either of the mixing and diluting vats J. These are provided with agitators, taps, and piping similar to vats A. The pump K forces the diluted mixture through the pipe M into the coil N, which is enclosed in steam-chest W; the mixture, after having passed through coil N, leaves the coil by means of pipe O, which is connected by copper piping to the starch boxes of the dressing machines. Steam, at from 5 to 10 lb. pressure, is admitted to W through pipe P and a reducing valve. The condensed steam is allowed to pass off at T, which is connected to a steam trap. Between K and the coil N an overflow valve is provided at R, which allows of the return through pipes Q and S of all superfluous supply.

Fig. 38 is an end elevation of the diluting vat J and steam-chest W. Between the pipe X and pump K is a brass tap Y, shown in detail in Fig. 39. It is provided with a sieve A, through which all size must pass. When in action, this sieve is opposite the inlet B, and thus arrests all foreign matter, which may be removed when the sieve is turned in the position shown. At Z, Fig. 38, an extra tap is placed to take up back pressure of the size when the

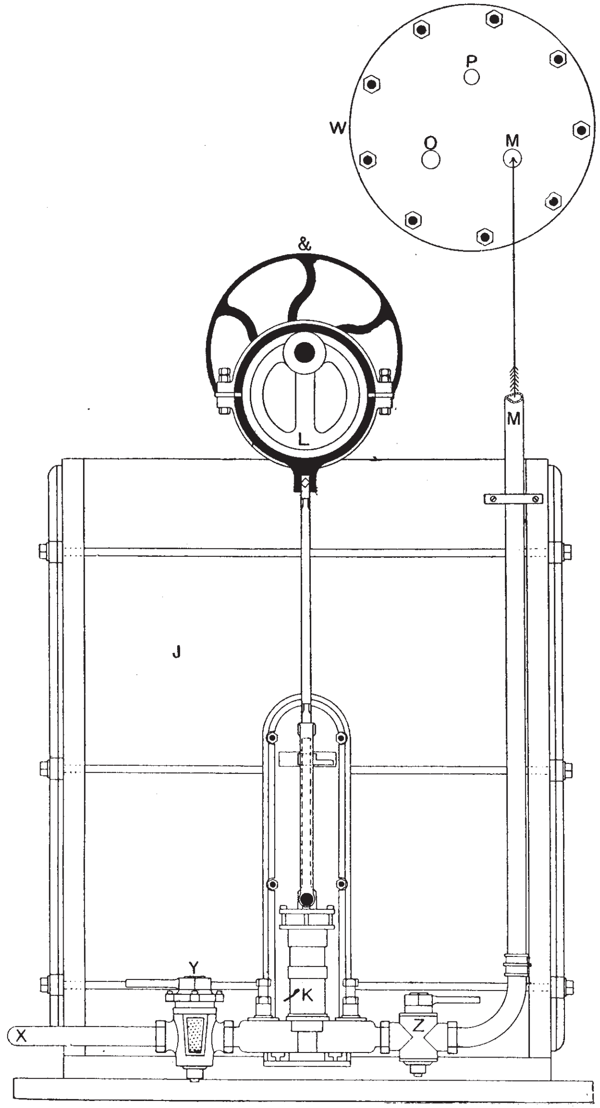


Fig. 38.

machine is not in use. For pure farina dressings all parts to the left of J, Fig. 37, are unnecessary. The full plant suitable for from ten to fourteen dressing machines consists of six fermenting vats A, of which only four are shown, one being in section.

For some classes of cheap goods, and especially where thick, soft, twisted cotton warps are used, an additional tank I, Fig. 40, is necessary if excessive weighting is

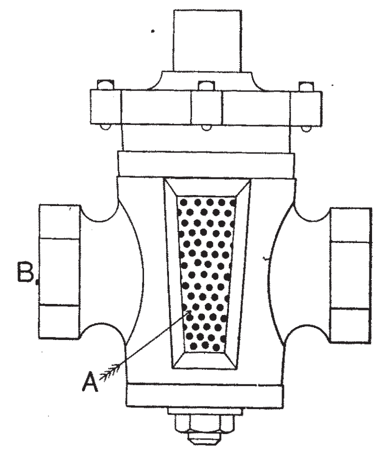


Fig. 39.

desired. When in use it occupies a position preferably immediately over vats J, Fig. 37. It is provided with an open boiling steampipe, and also with agitators attached to the shafts G and H, which are rotated by the shaft B through bevel pinions and wheels C, D, E, F. The mixture, when required, may be run into the mixing vat through J and K. To regulate the supply of mixture to the starch-box of the dressing machine an automatic feed is sometimes introduced as illustrated in Fig. 41. It consists

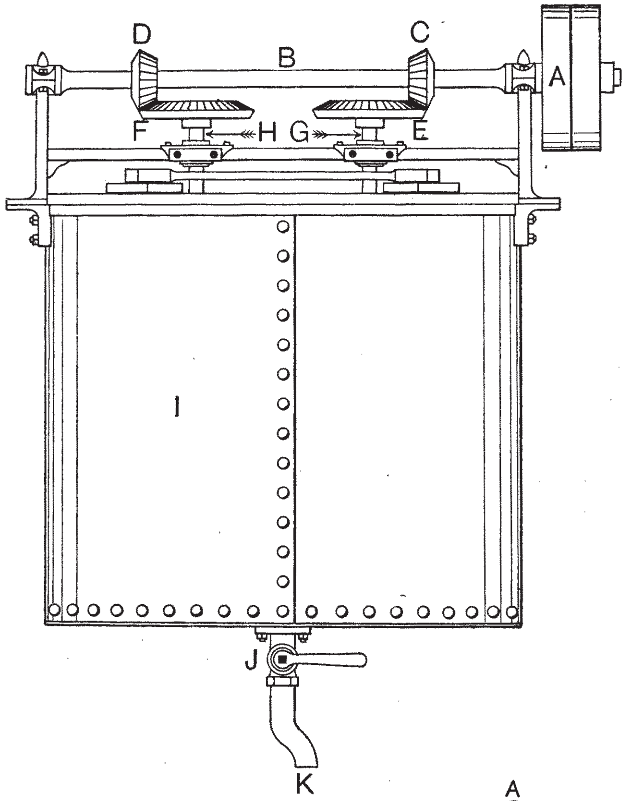


FIG. 40.

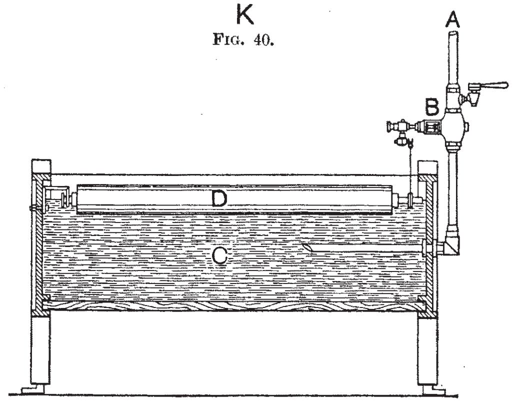


FIG. 41.

of a floating copper cylinder D, which is supported by the starch C, and opens or closes the valve B on the supply pipe A as the starch in the box falls or rises.

For jute yarns, the operations of sizing, drying, and beaming are carried on simultaneously by a dressing machine similar to that shown in Figs. 42 to 46, which are representations of different parts of the machine made by Messrs. Robertson and Orchar, Limited, Dundee. Fig. 42 shows in plan and elevation a six-cylinder machine (they may also be made with four or eight cylinders as required). A shows the line of the warp as it passes from >-shaped banks—one at each end of the machine—to the loom beam B. Spools or bobbins equal to half the number of threads required for the warp are placed in each bank, their ends passed through a reed at C (two ends in each split), then between the starch roller D and pressing roller E, the latter being weighted as shown. They are then passed through a guide reed at F, round the guide roller G, and then on to the drying cylinders H, being passed round these as indicated by the arrows. Between E and F the yarn is usually split thread by thread by a lease rod, to prevent the threads being dried together in pairs; occasionally reeds set with inclined wires instead of vertical wires, and termed angle reeds, are used for the same purpose. After leaving the cylinders, the yarn is guided by rollers I to the yarn beam, as shown, and is firmly pressed thereon by the deadweight of the pressing rollers J, and the massive framework carrying these between the framing proper of the machine. By means of an ordinary rack-and-pinion arrangement the pressing rollers and framework may be raised clear of the beam when necessary, and retained in this position by the ratchet wheel K, on the rack-wheel shaft, and the retaining catch L. This motion

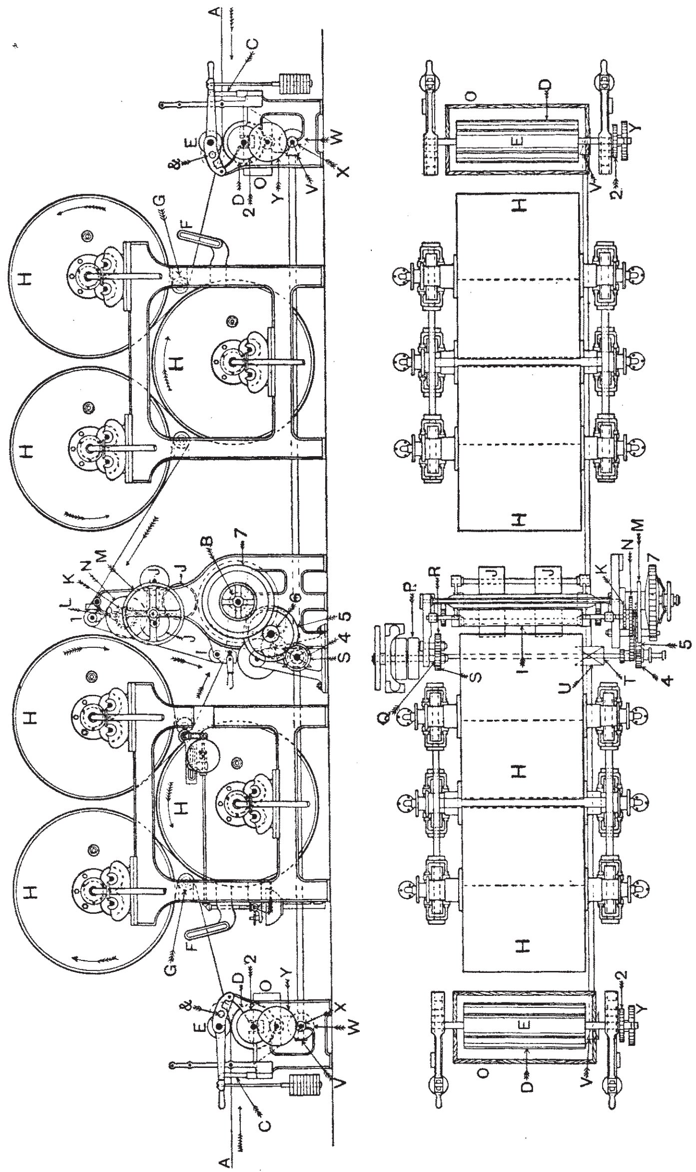


Fig. 42.

is actuated by the hand wheel M, compounded with which is a small pinion gearing with the toothed wheel N, on the end of the rack-wheel shaft.

The dressing mixture is preferably conveyed from the mixing tanks by copper pipes direct to the starch-box O, in which the starch roller D—usually copper-covered—revolves. The yarn may be kept in contact with the starch for a longer time by removing the roller E and placing it in bearings &; or a rod, adjustable if desired, may be placed near the bottom of the trough, and extending from end to end, under which the yarn may be passed before bringing it to the rollers, thus allowing the starch plenty of time to penetrate into the yarn. The pace of the yarn is determined by the surface speed of the starch roller D, which by the aid of the pressing roller E draws the yarn from the banks at a uniform speed. The drive of the starch roller D, and also that of the loom beam, is illustrated in plan and elevation in Figs. 43 and 44.

Driving pulley P = 400 revolutions per minute.
Change pinions Q = 19, 22, 26, 30, 36, and 42 teeth.
Intermediate wheel R = 34 teeth.
Wheel S on driving shaft = 42 teeth.
Bevel pinion T on driving shaft = 25 teeth.
Bevel wheels U on side shaft = 40 teeth.
Bevel pinion V on side shaft = 20 teeth.
Bevel wheel W on cross shaft = 40 teeth.
Spur pinion X on cross shaft = 22 teeth.
Intermediate wheel Y on stud = 72 teeth.
Intermediate pinion Z on stud = 29 teeth.
Spur wheel 2 on starch roller D = 40 teeth.
Starch roller (over copper) = 13 in. diameter.

The speed is therefore found as follows:—

$$P \times \frac{Q}{S} \times \frac{T}{U} \times \frac{V}{W} \times \frac{X}{Y} \times \frac{Z'}{2} \times \frac{D\pi}{36 \text{ ins.}} = \text{yards per minute,}$$

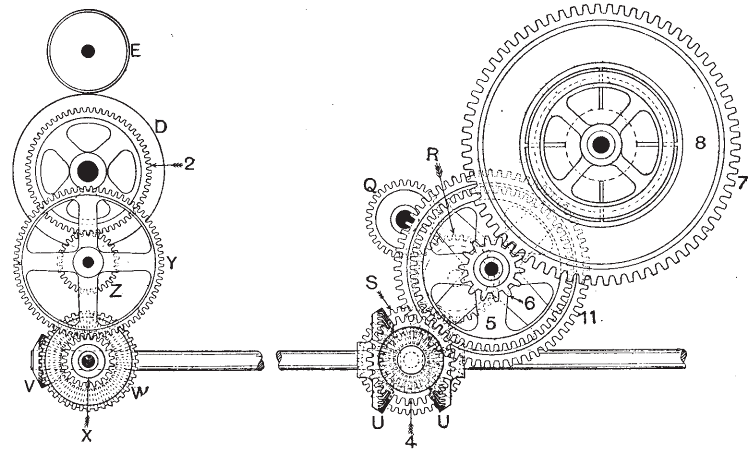


FIG. 43.

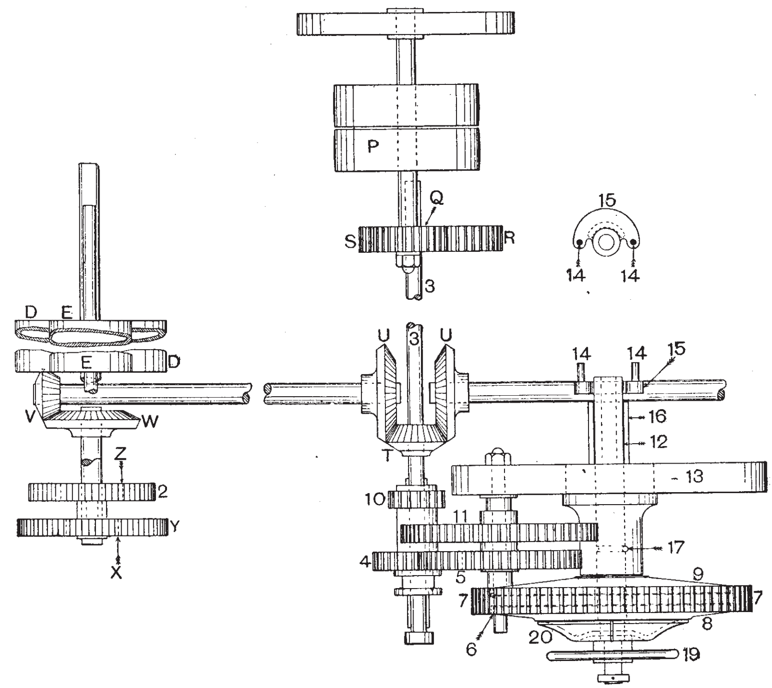


FIG. 44.

the numerical values in above being:—

$$\begin{matrix}400 \text{ revs.}\\ \text{per min.}\end{matrix} \times \frac{19}{42} \times \frac{25}{40} \times \frac{20}{40} \times \frac{22}{72} \times \frac{29}{40} \times \frac{13 \text{ ins. dia.} \times 3{\cdot}1416}{36 \text{ ins.}} = \begin{matrix}9{\cdot}46 \text{ yds.}\\ \text{per min.}\end{matrix}$$

The speed with	22	change pinion	= 11 yds. per minute.	
"	26	"	= 12·9	"
"	30	"	= 14·94	"
"	36	"	= 18	"
"	42	"	= 20·93	"

For some classes of work the latter speed is often attained and even exceeded in practice.

In cases where a large variety of work requires to be dressed on the same machine, necessitating different speeds, the advantage of obtaining these by means of a simple change pinion will be readily appreciated. Where, however, the class of work seldom varies, the pulley P may be keyed on the driving shaft 3. When this latter arrangement obtains, a variation in speed can only be got by the introduction of a stepped cone drive. The loom beam is driven as follows:—

Pinion 4 on shaft 3 = 30 teeth.
Stud wheel 5 = 56 teeth.
Stud pinion 6 = 14 teeth.
Friction wheel 7 = 70 teeth.
Diameter of beam = $5\frac{1}{2}$ ins.

$$\begin{matrix}\text{revs. per minute}\\ \text{of P}\end{matrix} \times \frac{Q}{S} \times \frac{4}{5} \times \frac{6}{7} \times \frac{D\pi}{36 \text{ ins.}} = \text{yards per minute,}$$

numerically:—

$$400 \times \frac{19}{42} \times \frac{30}{56} \times \frac{14}{70} \times \frac{5{\cdot}5 \text{ ins.} \times 3{\cdot}1416}{36 \text{ ins.}} = \begin{matrix}9{\cdot}33 \text{ yds.}\\ \text{per min.}\end{matrix}$$

It will be observed that this speed is slightly less than that of the starch roller, and it is claimed for this arrangement that the strain upon the yarn at the start of a new beam is not so great as if the speeds were equal. In many machines, however, the speeds at the start are the same. As the speed of the starch roller is uniform throughout, and as the surface speed of the beam increases as it fills, a driving arrangement (consisting of friction wheel 7 and friction plates 8 and 9) is introduced to allow the necessary slip of the beam to take place. As the beam fills, this slip increases to such an extent that special parts are introduced whereby the speed of the friction wheel 7, and therefore the slip of the friction plates 8 and 9, can be reduced when the beam has reached between 11 and 12 ins. diameter. The driving pinions 4 and 10 are compounded, and can be moved freely endwise on driving shaft 3, by means of an ordinary clutch fork, until the pinion 4 be withdrawn from gear with the wheel 5, and pinion 10 of 18 teeth placed into gear with the wheel 11 of 68 teeth. The speed of the beam is then reduced as follows:—

$$\frac{30}{56} : \frac{18}{68} = \text{one revolution} : \frac{42}{85} \text{ revolution, or practically one-half.}$$

Shaft 12, to which the friction plate 9 is keyed, is continued inside the framework 13 as shown, its inner end being hollow to receive and support the beam arbor, while the pins 14, fixed in the sector plate 15 (an inverted end elevation of which is shown in the detached figure), engage with the beam head and rotate it. The dotted lines in the detached figure indicate the end of a bracket 16 supporting the shaft 12 from underneath, which prevents the shaft 12, and therefore pins 14, from being withdrawn from the beam, except when plate 15 is in a position diametrically opposite to that shown. A groove is turned out of shaft 12 to receive a pin 17, which prevents the accidental withdrawal of pins 14 from the beam. When the latter is

filled, pin 17 is withdrawn, plate 15 is turned in the proper position, and the whole is drawn forward until the beam arbor is clear of shaft 12.

Fig. 45 is a sectional plan showing in detail the frictional driving arrangement. On shaft 12, which gives motion to the beam as already described, plate 9 is keyed, and its nave lengthened to receive the friction plate 8 and the wheel 7. The plates 8 and 9 are keyed together by the sliding key 18, but wheel 7 revolves freely between them. Provided the parts mentioned are in the position shown, the wheel 7 would revolve without imparting motion to the shaft 12. But by means of the hand wheel 19 and spring plate 20, frictional contact of any degree may be obtained between wheel 7 and plates 8 and 9, thus rotating the shaft 12. To ensure this, it is customary to place flannel washers between the wheel 7 and plates 8 and 9.

These washers are usually freely lubricated with powdered black lead because of the great amount of slip which necessarily takes place between the plates 8 and 9, and the wheel 7 at certain stages in the filling of the beam. As this slip increases in proportion to the increasing diameter of the loom beam, it is almost natural to conclude that the frictional contact between the plates and the wheel should be reduced. On the contrary it must be gradually increased, since the increase in the diameter of the beam gives the yarn an increased leverage or pull over the beam and its drive, which must be counteracted by a gradually increased frictional contact through the medium of wheel 19 and spring plate 20.

The measuring and marking motion is shown in detail in Fig. 46. A again indicates the line of the warp as it passes over the cylinders B, which are all supported on anti-friction rollers C; the supports of the latter, and also

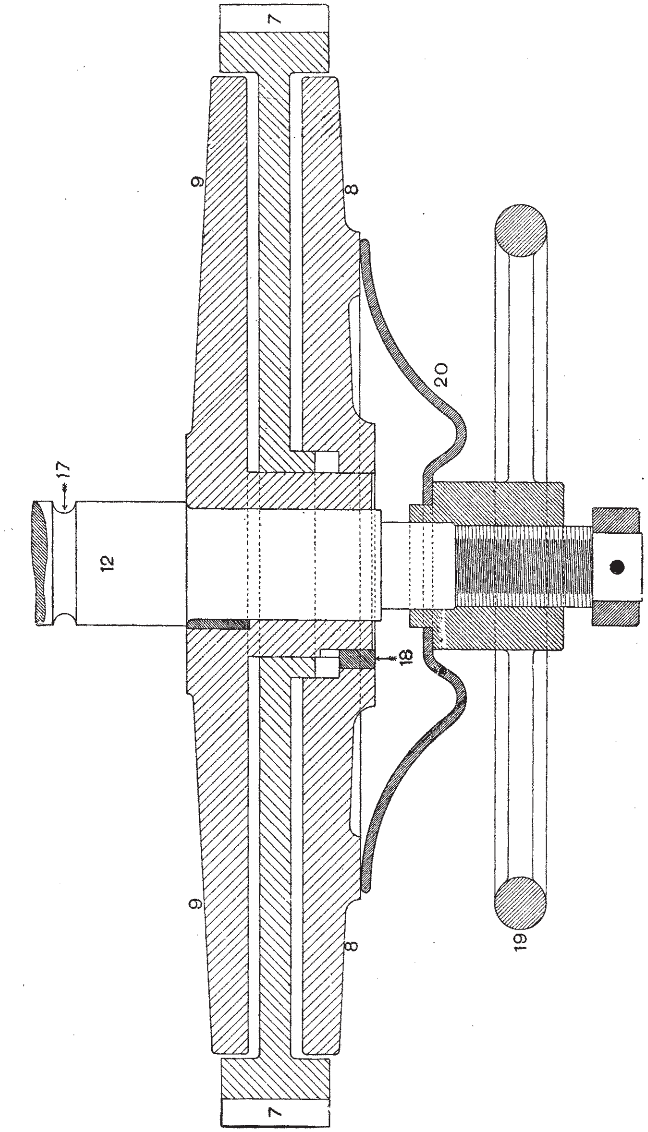


Fig. 45.

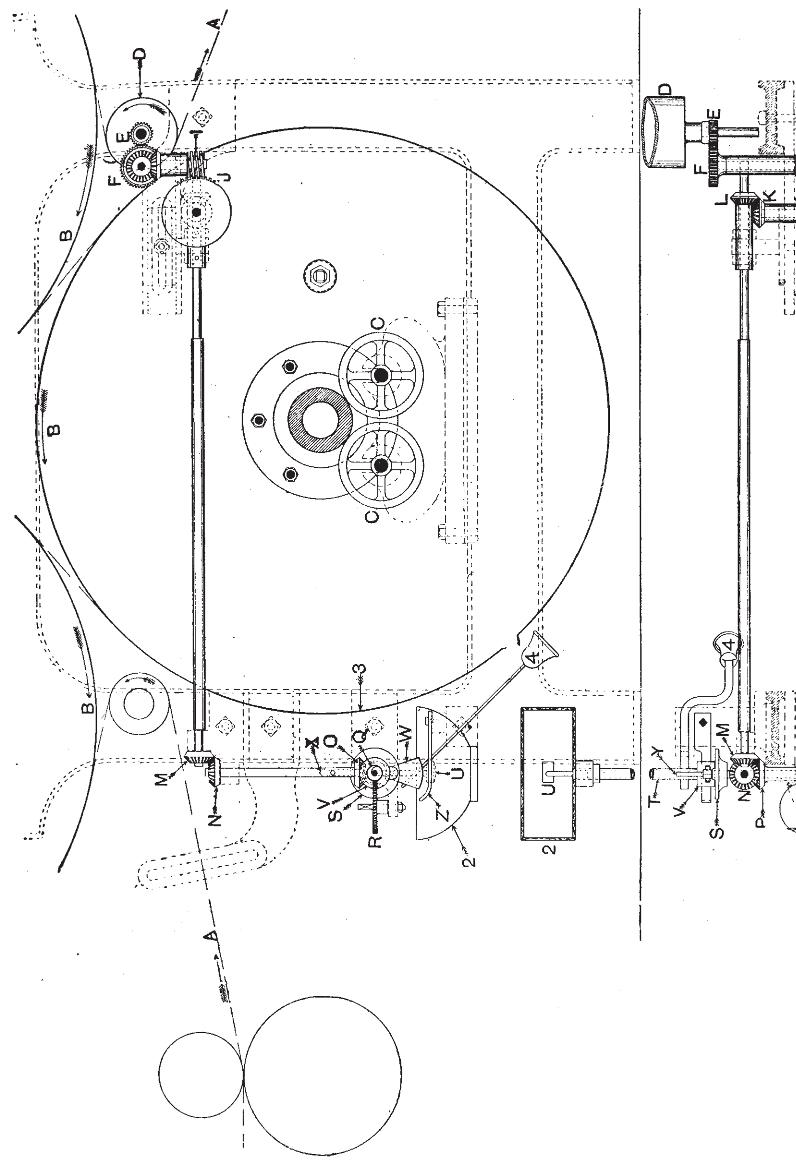


Fig. 46.

the framework proper, being indicated by dotted lines. The guide and measuring roller D, 18 ins. circumference, is rotated by the yarn, and it is obvious that in two revolutions of D 1 yd. of yarn will have passed over the machine. As the counter wheel J contains the same number of teeth as it is desired to have yards of yarn in the cut, the object of the gearing is to move the wheel J one tooth every two revolutions of the roller D. This is accomplished by the following wheels:—

> Pinion E on shaft D = 22 teeth.
> Stud wheel F = 44 teeth.
> Stud bevel wheel G = 24 teeth.
> Bevel wheel H on vertical worm shaft = 24 teeth.
> Single thread worm I gearing with counter wheel J.

Two revolutions of E will give one revolution of F, and as G and H are equal, one revolution also of the worm I, and wheel J will be advanced one tooth, while one revolution of J will equal one cut length.

By means of equal bevel wheels K, L, M, N, O, P (twenty-four teeth each), and worm wheel Q, the worm wheel R is advanced one tooth for each revolution of J, thus registering the number of cuts on the beam. It is necessary, however, that each cut length be marked at the proper point for cutting when woven. Keyed on the shaft of the worm Q is a disc S, provided with a projecting part at one point of its periphery. On the same shaft is a sleeve T carrying at one end a marking pad U, and at the other end a boss V, a weight W, and fingers X and Y, the whole moving in unison, and therefore retaining their relative positions. As disc S revolves, its projecting part, when about 25° from the bottom, comes into contact with and carries upward the weight W. When the projecting part reaches within 25° of the top, the

finger X bears on the spring Z, and continues to do so until the point of Z is reached. By this time the weight W and marking pad U have passed the vertical position, and therefore fall immediately X clears Z. In falling, pad U (carrying colour from colour-box 2) is adjusted to strike the yarn on cylinder B about point 3. The finger Y actuates the bell 4 slightly in advance of the marking motion.

Fig. 47 (part in longitudinal section) shows the construction of a steel cylinder, diameter 4 ft., and intended for a maximum working pressure of 40 lbs. per square inch. Steam from a reducing valve is admitted by the pipe A, and a steam-tight joint is obtained by means of the ordinary glands B and packing as shown. A syphon arrangement at C serves to rid the cylinder of condensed steam, while waste of effective steam is prevented by a steam trap connected to the exhaust pipe of each cylinder. Atmospheric valves are, of course, fitted in all cylinders to prevent the creation of a vacuum and possible collapse of the cylinder. In cylinders where stay rods are necessary, the condensed steam is removed by revolving scoops attached by conducting pipes to the exhaust pipe proper.

In the dressing of jute and of the heavier linen yarns it is invariably the practice to run the yarn direct from the bank to the loom beam, as already described. In these cases it is, of course, necessary to have banks or creels of a capacity in the aggregate equal to the total number of threads in the warp. Where, however, as in the finer linen fabrics, the number of threads in the warp exceeds the capacity of the largest banks in general use, it becomes necessary to run the yarn on warping beams, each of which may contain one-half, one-quarter, one-sixth, or other suitable portion of the total threads required. For

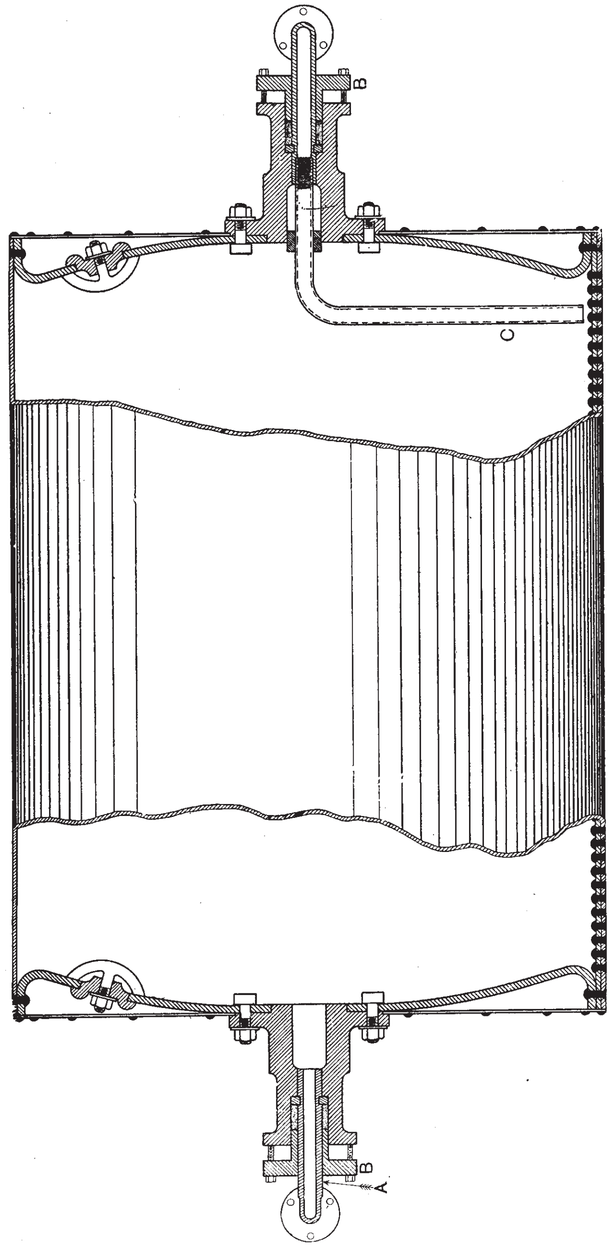


FIG. 47.

example, a warp of 3000 ends may be warped either in four sections of 750 ends, six sections of 500 ends, or even eight sections of 375 ends each; either of the two latter ways being in most cases the more probable. The particular number, however, depends greatly upon the amount of yarn to be used, and also upon the selection of the most convenient number of leas or cuts per bobbin for the required length; the latter reason must be observed for comparatively short lengths, say up to 30 or 40 pieces, as the production of the winding department and the minimising of waste depend largely upon this. The capacity of the bobbin bank or creel may reach in exceptional cases 1000 bobbins (600 to 800 being the usual limits), but the best and most economical results are obtained when the number of bobbins in use does not exceed 500. Six warping beams would therefore suit the above example, were the 3000 ends ultimately to go on one weaver's beam, since three warping beams could be placed at each end of the dressing machine. If, however, the loom beam were required in two sections owing to the width of the web (those above 60 ins. wide are usually in two sections), it would be advisable to warp half the total threads on four warping beams, each one of which would contain double the length required for one loom beam, and all four utilised for each section of the loom beam, two at each end of the dressing machine. By doing this the number of bobbins would also be well within a practical limit.

Figs. 48 and 49 show respectively the side and front elevations of the warping machine made by Messrs. Robertson and Orchar, Limited, Dundee, one-half of the bobbin bank or creel being indicated in elevation and plan at A in the former figure. The ends from the various

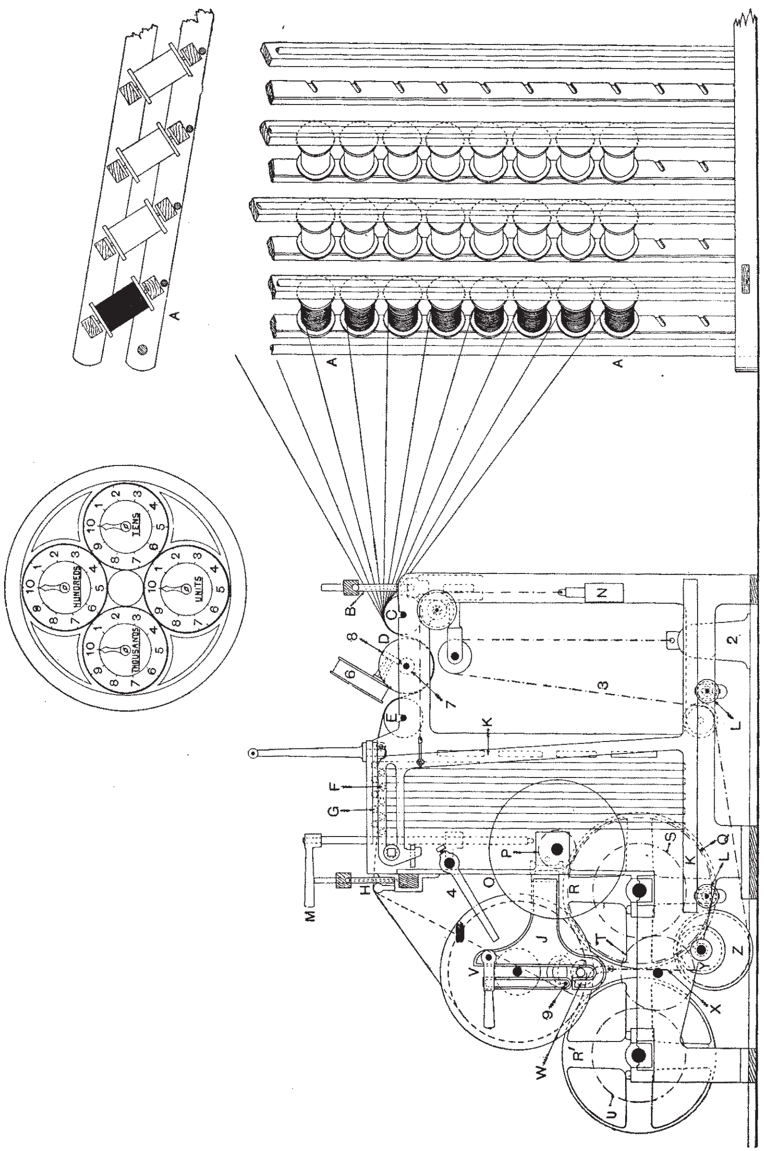


Fig. 48.

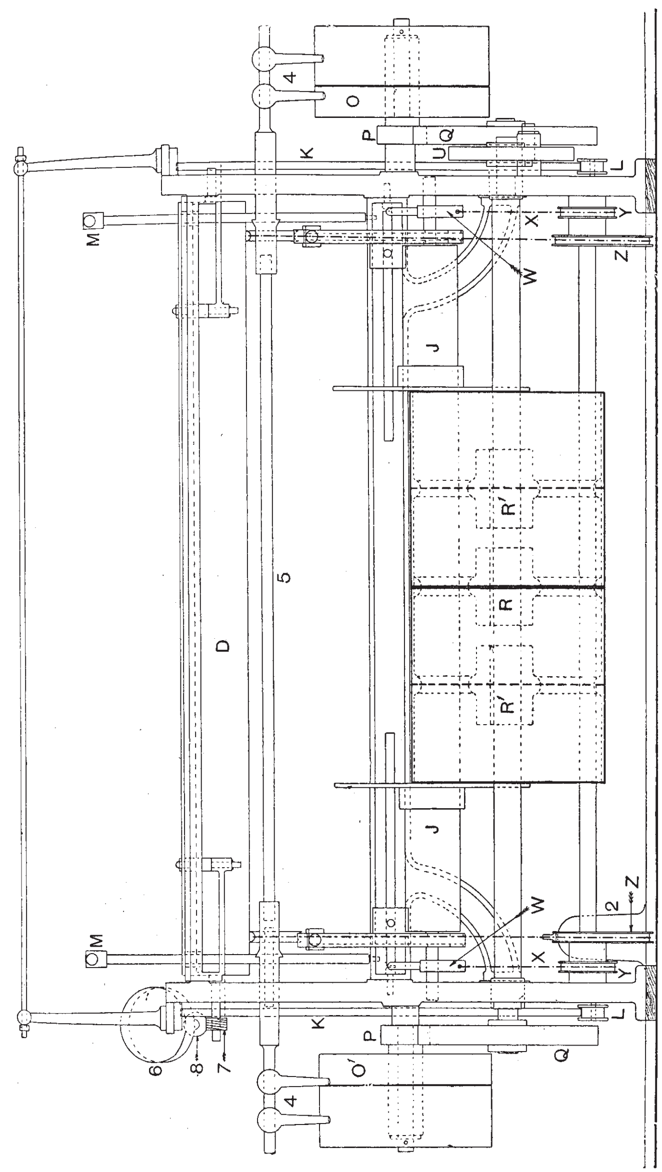


Fig. 49.

bobbins being first passed through a guide reed B, are taken over a guide roller C, then partially round the measuring roller D, and again over a second guide roller E. They are then taken alternately over and under a series of rods F and G, are passed through a second or leasing reed H, and finally attached to the beam J. In some machines the reed H is an expanding one, so that whatever number of threads are in the bank, they may be readily arranged to occupy the exact width between the flanges of the warping beam or reel. Rods F—those under the yarn—are fixtures in the framework, but rods G—above the yarn—are capable of falling one by one in their respective guide slots in the framework, in order to take up slack yarn when it becomes necessary to unwind the beam to "piece" broken or run-out ends. Under ordinary circumstances these rods are supported clear of the yarn by two frames K which rest on flanged guide pulleys L, but which are caused to move from under the rods, as the beam J begins to unwind, by means of a cam or other suitable connection actuated from the "set-on" handle M. Frames K are gradually moved forward again by means of counterpoise weight N as the yarn is rewound, and consequently the rods G are lifted.

Beam J is driven forward in the following manner. Compounded with pulley O—which, however, revolves loosely upon its central stud—is a driving pinion P of 24 teeth. This gears with and drives spur wheel Q of 90 teeth keyed on the arbor of the frictional driving drum R of 16 ins. diameter. From this arbor a similar motion is imparted to the 16-in. driving drum R^1 by wheels S and U, 70 teeth each, and intermediate wheel T of 56 teeth. The beam J rests upon and is frictionally driven by the rotary movement of drums R and R^1, the surface speed of the beam, when no allowance for slip is made, being that of drums R and R^1. As the beam fills it gradually rises in a vertical plane, the beam arbor being guided in its vertical movement by means of the slots V in the framework. The front portion of this slot is jointed at 9, and folds down to facilitate the transfer of full and empty beams. Sufficient grip or friction is generated between the beam J and drums R and R^1 for driving and pressing purposes by means of hooks W and strap X attached to pulley Y. Compounded with Y is a second and eccentric pulley Z, to which a weight 2 is attached by a chain 3. It will be observed that as the beam rises and gradually gains in weight, the eccentric pulley Z gradually presents its thin face to the chain 3, reduces its leverage, and therefore reduces the effect of weight 2 proportionately.

Unwinding or winding back is accomplished by means of a crossed belt running on driving pulley O^1 at the opposite side of the machine. Belt forks 4 are so situated on the fork rod 5 that it is impossible for both belts to be on the inside or driving pulley at the same time. Driving drums R and R^1 are arranged to overlap so that no portion of the yarn may be unsupported. The length warped or run upon the beam is registered by means of a clock 6, an enlarged view of the face of which is shown at the top of Fig. 48. Measuring roller D is 18 ins. in circumference if measuring in yards ($22\frac{1}{2}$ ins. if measuring by ells of 45 ins.), and has keyed upon its arbor a single thread worm 7 which gears with and drives a worm wheel 8 of twenty teeth fixed on the axle of the units hand or pointer. Twenty revolutions of the roller D, or 10 yds., will therefore cause this hand to make one revolution. The movement is carried to the other hands and suitably reduced by simple gearing inside the clock. Since the beam is driven from drums R and R^1 by rolling contact, it is obvious that the velocity of the yarn will be constant throughout. This velocity at 70 revolutions per minute of the driving pulley O will be $\frac{70 \text{ revs.} \times 24 \times 16 \text{ ins.} \times 3{\cdot}1416}{90 \times 36 \text{ ins.}} = 26{\cdot}0636$ yds. per minute when no allowance for stoppages or slip is made. This speed is considerably increased for certain classes of yarn, and a speed of 60 to 70 yds. per minute is not uncommon in the linen trade.

The necessary number of warping reels or beams having been warped, they are placed in the standards or frames at each end of the dressing machine proper. These, in the case of linen, may or may not be fitted with steam drying cylinders, it being unusual to apply heat to the finest linen yarns in this manner. Figs. 50 to 52—in which the letters and numerals refer to the same part—illustrate a linen dressing machine of the latter type as made by Messrs. William Smith and Brothers, Limited, Heywood. The plan and elevation are shown in Fig. 50, where A, A, A, A are the warping beams in standards, as already mentioned, a similar number — four — being of course situated at the other end of the machine. The ends of the yarn B from each of the reels A first pass through the reed C, then over the guide roller in adjustable bracket D, and then between pressing and starch rollers E and F, both of which are covered with flannel, and the latter supported on the anti-friction roller G, and revolving in the starch box H. After leaving E and F the yarn is deflected by roller I on to the top of the brush J, which revolves in the opposite direction to that in which the yarn travels. From roller I the yarn in its passage through the reeds K is split by rods L into two equal

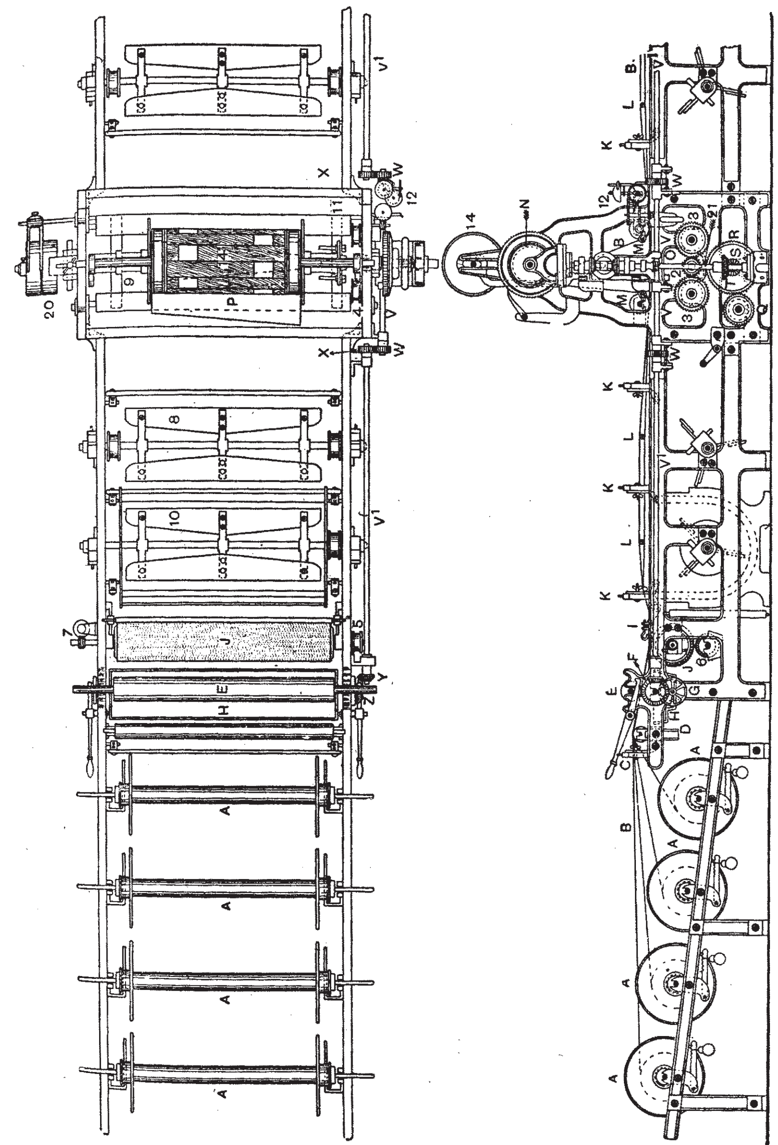


FIG. 50.

layers to facilitate drying. It then passes under the guide roller M to the loom beam N, as shown.

The starch roller F—the surface speed of which regulates the speed of the yarn—is driven as follows:—The cone pulley O on the driving shaft is connected with and drives by means of a belt, cone pulley P, on the shaft of which is the driving pinion Q which gears with spur wheel R compounded with bevel pinion S, the latter in turn imparting motion to the bevel pinion T on the vertical shaft 21. On the same shaft is a worm U which gears with and drives a worm wheel on the short side shaft V, at the end of which pinion W drives pinion X of equal teeth on the long side shaft V^1. The bevel wheel Y on the same shaft gears with and drives bevel wheel Z on starch roller F. The brush J is driven by the pinion 2 on the shaft of cone pulley O through pinion 3 and pulleys 4 and 5, while the cleaning brush 6 is driven by the brush J through the worm and worm wheel 7. A similar arrangement extends to the opposite end of the machine. The drying fan 8 is driven by a belt from the pulley 9 on the main driving shaft, while the fan 10 is driven from fan 8 by a similar arrangement. Pulley 11 drives in a similar manner the fans at the other end of the machine. Where steam is introduced to facilitate drying, these fans may be made to revolve inside a steam-heated chest, hot air being thus blown on the yarn. The measuring and marking motion 12 is an essential part, but being similar in principle and application to that already described in jute dressing, further description is unnecessary. The speed of linen yarn, as it passes through the dressing machine, usually varies from about $3\frac{1}{2}$ yds. to 8 yds. per minute, according to the class of yarn; naturally the slower speeds are used for the finer and more expensive yarns, as well as for weak yarns of a less expensive kind.

Fig. 51 is an elevation of the driving side of the centre of the machine. Between M and N the yarn passes through an ordinary "leasing heald" supported in frame 13. While the beam fills, the expanding presser 14 rests

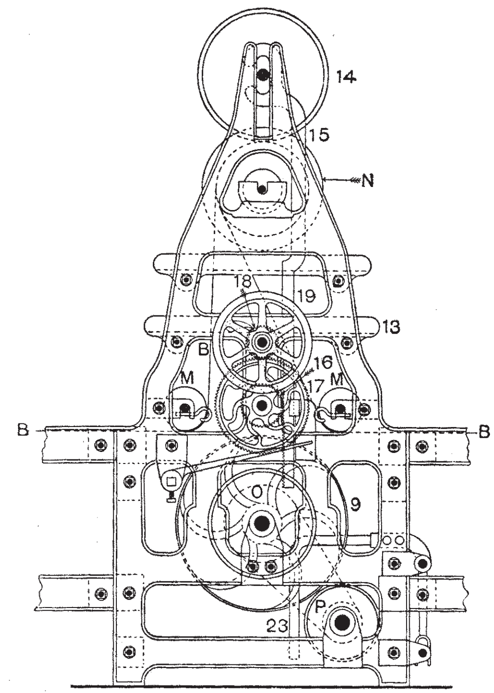


Fig. 51.

upon the yarn, and by means of its deadweight ensures a firm beam. The presser may be raised clear of the beam by means of the rack 15, rack wheel 16, wheel 17, pinion 18, and hand wheel 19, and retained in this position by a pawl and ratchet wheel behind pinion 18. Fig. 52 shows the centre of the machine in cross elevation. The drive is conveyed from pulley 20 to vertical shaft 21 through the

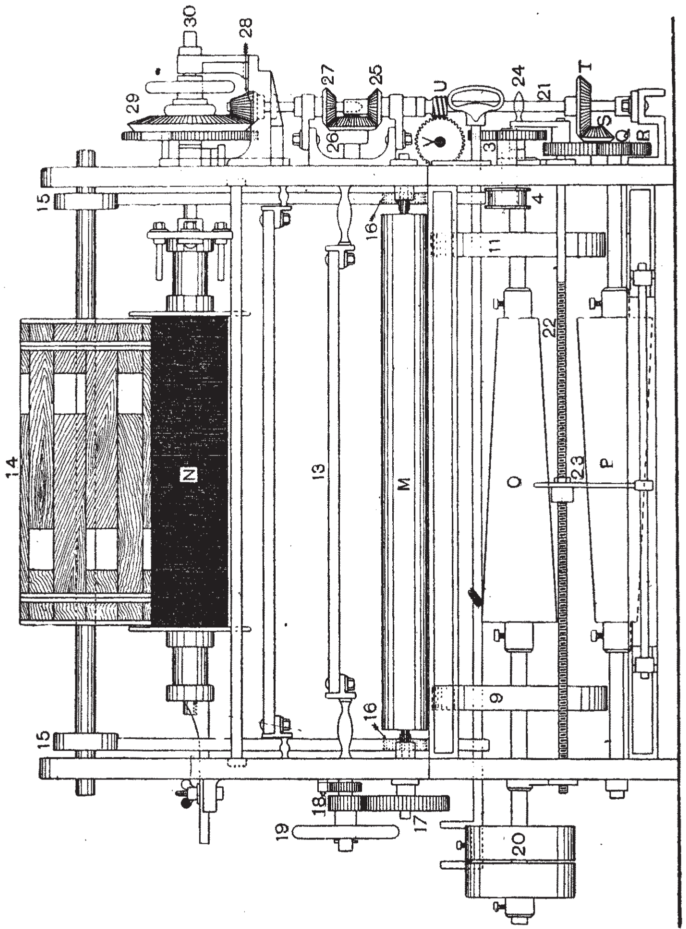


Fig. 52.

cone pulleys O and P, as already indicated, and the speed of the whole machine, except that of the brushes and the

driving fans, is regulated, according as necessity arises, by the above cone pulleys. The belt on the pulleys may be made to take any position between the ends of the cones by means of the screw 22 and the belt fork 23, actuated by handle 24. The loom beam N is driven from the upright shaft 21 by bevel pinions 25, 26, 27, and 28, the latter of which gears with the bevel wheel 29, loose on shaft 30. From this point the drive is by friction, and is similar in principle to that already fully described in the dressing machine for jute yarns. It will be observed that pinions 25 and 27 revolve in opposite directions, this being permitted by allowing the shaft of the latter to revolve loosely in a step, as shown. When the loom beam is in two halves it is necessary to drive one half beam in the opposite direction to the other when in the dressing machine, in order that the yarn may unwind in the proper direction when weaving. This is due to the fact that each sectional beam has only one draghead end by which it may be driven, and which must therefore come to the friction side of the dressing machine. To reverse the direction of the beam drive, pinion 26 is withdrawn, and pinions 25 and 27, Fig. 52, are clutched together in a simple manner, not shown, but by which they rotate together in the same direction.

Sometimes in the case of heavy linens it is necessary to use a steam-heated cylinder to aid in the drying of the dressed yarn, but in other respects this machine is similar to those already described, and Fig. 53 has been prepared to give a general view of this type of machine. It will be observed that instead of a leasing heald in the centre of the machine, two leasing reeds (one at each end) are used for the purpose of taking a drawer's lease. Fig. 54 shows four views of the lease or hook reed which is generally employed for this purpose. It is built on the same general lines as an ordinary loom reed, and is about 5 ins. deep between

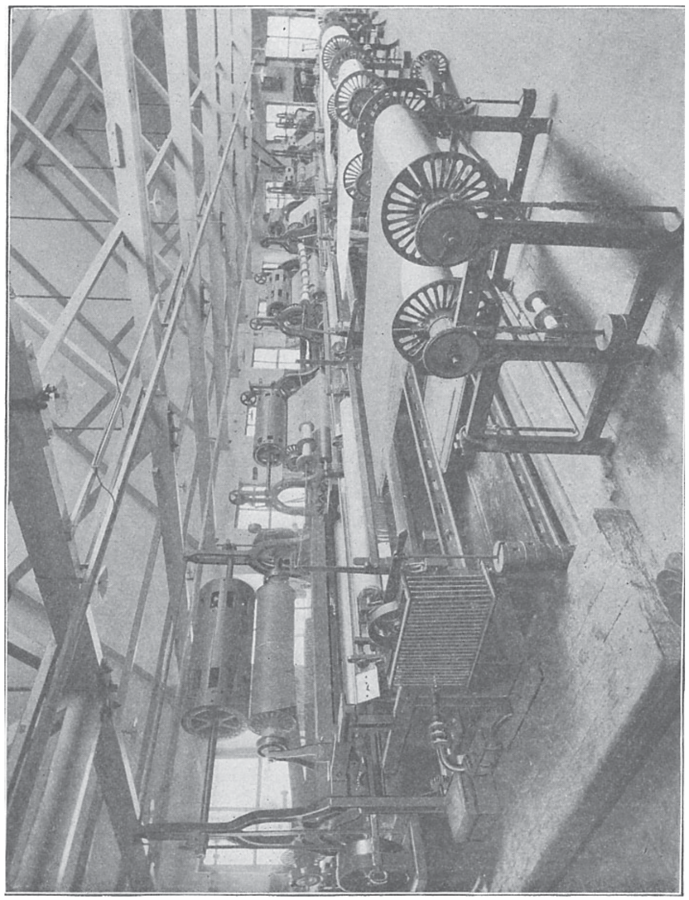


FIG. 53.

the ribs. It differs from an ordinary weaving reed in that the wires are brass instead of iron, and that alternate wires

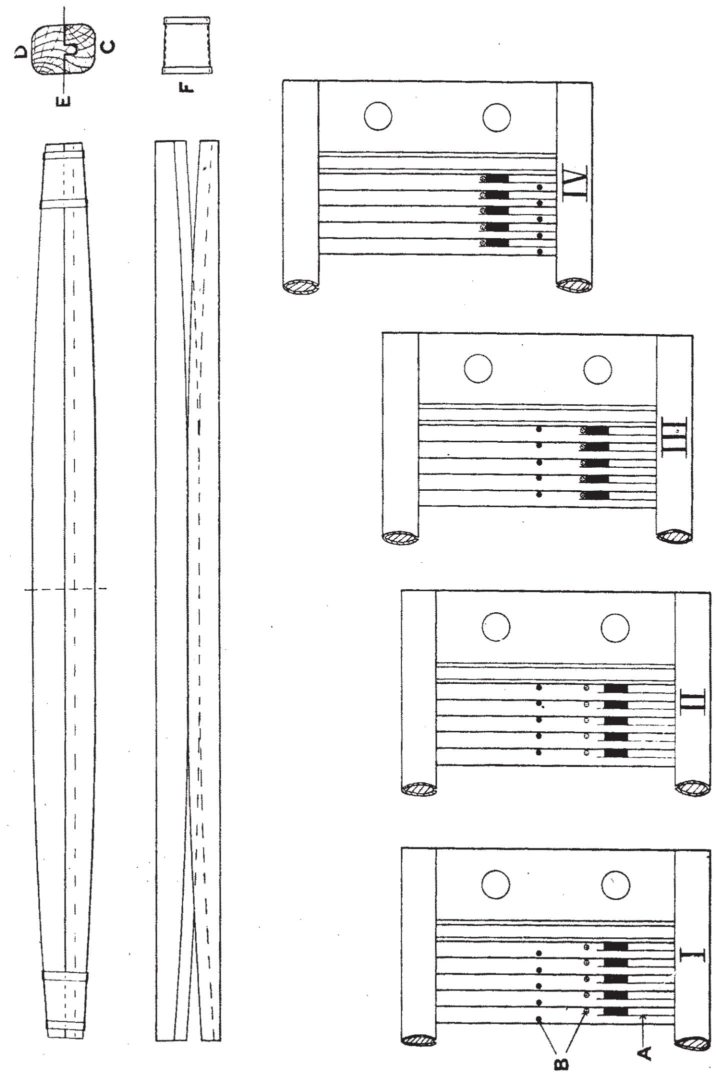


FIG. 54.

are short ones, and project only about $1\frac{5}{8}$ ins. above the lower rib. Each thin wire A is placed midway, as shown, between two ordinary wires, and is soldered to its neighbouring long wire in such a way that about one-eighth of an inch projects above the solder, the top of the wire thus forming, with the long wire and solder, a kind of hook into which a warp thread may be caught.

Two threads B (shown in distinctive marks for easy reference) are drawn through each split formed by the long wires, and the warp is divided permanently during dressing into two layers of odd threads and even threads by means of a rod which is situated between the dressing roller and the lease reed. This division, as is evident in diagram I., forms one part of the thread-and-thread lease required, which part may clearly be retained by passing a cord, or else a thin rod, usually termed a "wand," between the two layers, but in front of the reed. This wand is then allowed to move forward with the warp for a short distance, so that it will not interfere with the formation of the second part of the lease, which is obtained as follows:—A fellow-workman helps the dresser to take the hook reed from its supports, and to move it slightly endwise (to the left in the figure) until all the threads are in close contact with the hook side of the split, as demonstrated in diagram II.; the reed is then raised until each thread in the bottom layer is caught in its respective hook (diagram III.); the reed is then pulled endwise, or to the right, until each thread in the top layer of yarn bears against the left-hand wire; the reed is now raised until all the threads of the bottom layer are lifted by the hooks above the threads in the other layer, these latter threads being capable of moving downwards until they reach the bottom rib of the reed (diagram IV.). A second wand or else a cord is now inserted in front of the reed, and brought close up to the first wand or cord, after which the reed is returned to its original position.

It is obvious that if this procedure be carried out at both ends of the dressing machine, without modification, it will result in two separate thread-and-thread leases, each lease containing one-half of the total threads in the warp, and that tying-on or drawing-in must proceed from two sets of lease rods. This method is very simple, and is widely adopted, notwithstanding the apparent complication of the two sets of rods. It is possible, however, to obtain a perfect thread-and-thread lease on one set of lease rods by a modification of the above system and the use of another reed, sometimes termed a "crown" reed; this reed is situated immediately under the loom beam, and the yarn from both ends of the dressing machine passes through it, as indicated, just before it is wound on to the weaver's beam. In drawing the warp through this reed—which must, of course, be done in the dressing machine—a portion of the reed, say about two inches, is filled with yarn which comes exclusively from one end of the machine; then another two inches is filled with yarn which proceeds from the other end of the machine; and so on alternately until all the warp from both ends has been entered, in what are sometimes termed "basses," through the crown reed.

To obtain the lease required it is first of all necessary to obtain the thread-and-thread leases at each end by the method described above. These leases are retained on the thin wands which are run up with the yarn until they are close to the crown reed. The dresser then proceeds to pass these leases through the crown reed, bass by bass, in the well-known manner, when they naturally form a single thread-and-thread lease on the other side of the reed.

While this method may be troublesome and require a little time to perform, it nevertheless prevents crossed threads absolutely, and is widely adopted for very fine setts.

In many cases, and particularly for coarse yarns in low setts, no lease at all is taken, the threads of the warp being simply but firmly held in their approximate positions by a pair of specially constructed rods, termed "clasp-rods." Two views of these are also shown in Fig. 54. In the upper view the rods are closed; in the lower view, they are open. The sectional views at C and D show that their inner surfaces are formed with a mortise and tenon, slightly convex, between which parts the yarn E passes, and by which it is gripped firmly while it is in tension in the dressing machine. A soldered tin collar F is pushed firmly on each of the rods; these collars draw the two surfaces together, and thus practically all the threads are in touch with the two surfaces of the mortise and tenon. No matter how well and closely fitting the rods are made, nor how carefully they may be handled, it is impossible at times to avoid awkward crossings of the warp, and the practice cannot be recommended generally as a good substitute for the lease rods.

Some few firms prefer to dress each warping beam separately, and then to place all in the standards and to beam them dry. This is not the usual way, but there is an advantage in that a much smaller number of threads have to be watched during the dressing process, and when all are beamed dry there is obviously no danger of burnt threads caused by undue length of stoppages.

The warping machine illustrated in Figs. 48 and 49 (or at least very similar machines) is also used for sectional beaming, that is, by which the warp is made up of sections, but in which each section contains a certain number of threads in the exact order in which they are intended to appear in the cloth; the exact number of threads is a definite proportion of the total number of threads required. The sectional beams are from 6 ins. to 18 ins. wide between the flanges, and have a square hole through which an arbor may be passed during the beaming process. When the desired number of beams have been made, they are placed on a square arbor so that they will rotate with the arbor, the ends of which are naturally turned to fit into the sockets on each side of the loom. Sometimes these sectional beams are placed behind the beaming frame, and re-beamed on to an ordinary weaver's beam.

CHAPTER VII

DRAWING-IN, REEDING, AND WEAVING

Drawing-in consists simply of drawing the warp yarn through the heddles of each leaf of the camb or mails of the harness in the proper order; reeding, in placing one or more of these threads through each split of the reed. For the relation between the draft, cloth, and weaving plans, Fig. 55, see *Textile Design: Pure and Applied*, pp. 9 to 18. The order of drawing and the number of threads respectively depend chiefly upon the design or weave of the fabric, but are also influenced by other considerations, such as the sett of the warp, etc. Referring to Fig. 55, in which the warp threads are shown passing from the yarn beam A and through the four leaves of the camb—represented by the lines 1, 2, 3, 4,—the order of drafting or drawing-in, and the leaf on which each thread is drawn, are plainly seen by the numerals placed at points where

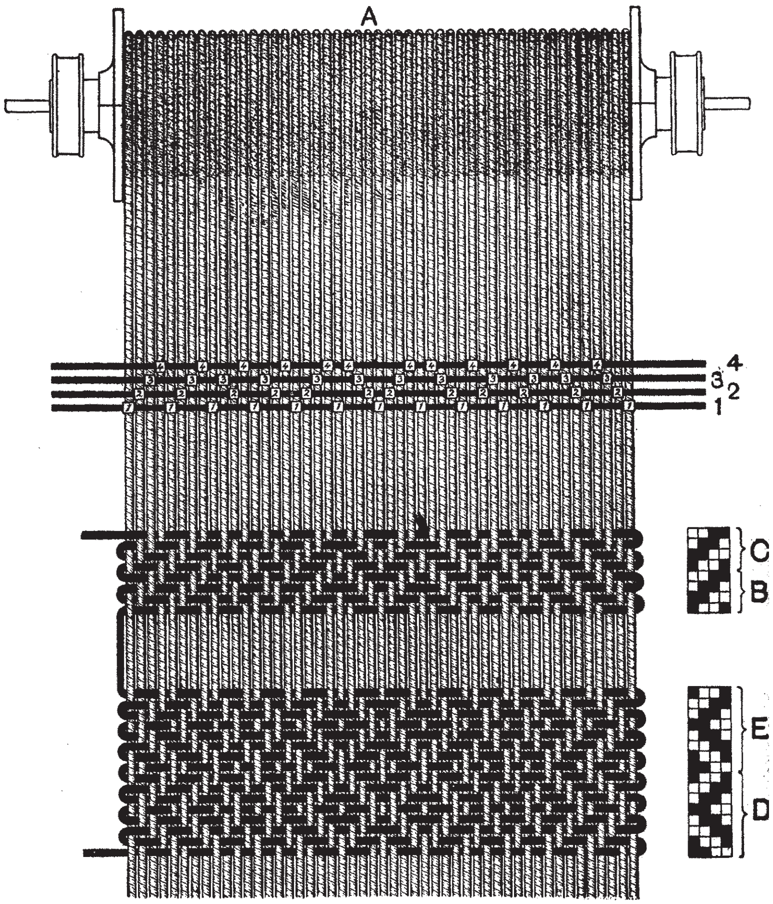


FIG. 55.

the threads cross the horizontal lines or leaves. This, however, is not the usual method of showing the order of

drafting, the figure having been introduced to show approximately the relative positions of the yarn, the leaves, and the cloth. In the following simple examples of drafting, A to F, Fig. 56, the method in general use—that of indicating the shaft on which a thread has been drawn by a dot or other suitable mark—has been adopted. The order of reeding is shown by a short horizontal line,

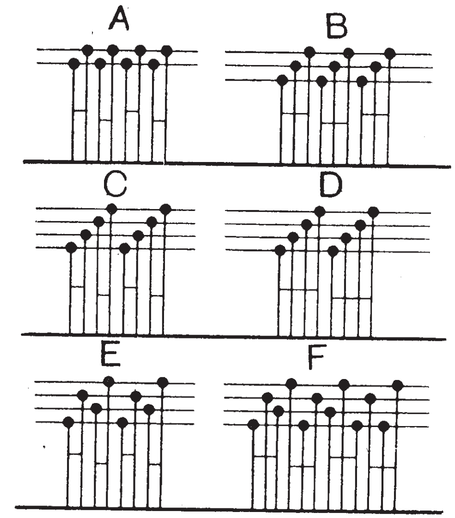


FIG. 56.

below the draft, connecting two or more threads which pass through the same split of the reed. In this figure, A is the draft for a plain cloth on 2 leaves, 2 in a split; B is a straight draft on 3 leaves, 3 in each split; C is a straight draft on 4 leaves, 2 in each split; D is a straight draft on 4 leaves, 4 in each split; E is a broken draft (commonly called skip shaft) on 4 leaves, 2 in each split; and F is a broken draft on 4 leaves, 3 in each split.

If possible, the camb and the reed should be the same sett, as the best results will be obtained when this is the case. Often, however, a camb is used of a finer sett than that of the reed, and when this is resorted to it is necessary that the surplus mails or heddles shall be "cast out" or "fileyed" at regular intervals. The order of casting out may be found as follows:—

$$\frac{\text{The sett of the camb}}{\text{Sett of camb} - \text{sett of reed}} = \text{the fileying interval or point}$$

at which a heddle on each leaf must be left empty.

Example 1: Suppose a 10-porter cloth were required to be woven in a 12-porter camb. Then $\frac{12}{12-10} = \frac{12}{2} = 6.$ Thus every sixth gait,[1] or a heddle on each leaf, must be cast out; that is, if the camb consists of two leaves only, then 10 threads, equal to 5 gaits, must be drawn, and the sixth gait or one heddle on each leaf of the camb missed.

Example 2: An 1100's linen in a 1400's camb.

$$\frac{14}{14-11} = \frac{14}{3} = 4\tfrac{2}{3}.$$

In this case we have a fraction in the result. When this happens, the denominator represents the number of gaits to be missed or fileyed in each round or repeat. Had there been no fraction, every fourth gait would have been missed. It is evident that since $4\frac{2}{3}$ is nearer 5 than 4, a fifth will have to be missed more often than a fourth. The numerator of the fraction determines the number of times per round the fifth gait must be missed, and the difference between the numerator and denominator the number of times per round the fourth gait must be missed. Thus:—

[1] *Draft* = the order for one complete pattern.
Gait = one heddle on each leaf.

4 gaits drawn		1 gait missed.			
4	,,	1	,,		
3	,,	1	,,		
11	+	3			= 14.

Example 3: An 11-porter cloth into an 18-porter camb

$$\frac{18}{18-11} = \frac{18}{7} = 2\tfrac{4}{7}.$$

2 gaits drawn, 1 gait missed for 4 times;
1 gait ,, 1 ,, ,, 3 ,, ;

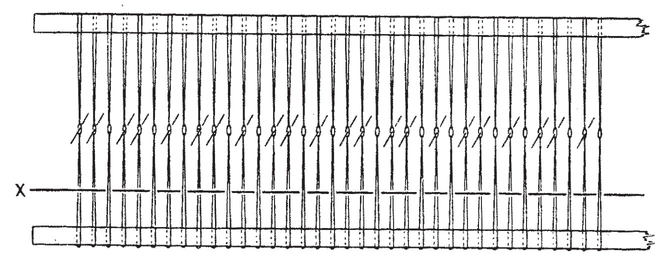


Fig. 57.

arranged as in Fig. 57 for better distribution; a band X is passed behind those heddles which represent gaits to be missed. For diced patterns and complicated drafts it is advisable to have the cambs built specially and the heddles spaced according to the pattern. In these cases it is usual to accompany the order for the camb by the draft and the sett of the pattern to be woven. Cambs are sometimes built with the heddles loose upon the leaves so that they may adjust themselves to almost any position necessary for the draft. These loose heddles may be made either of ordinary heddle twine or of wire; for some classes of work the wire heddles are extensively employed.

Weaving.—Before proceeding to consider more particularly in detail the three principal motions in weaving—viz. shedding, picking, and beating up—it will be advisable to consider them collectively in their usual relation to each other in an ordinary tappet loom. With few exceptions, each of these motions occurs once in every revolution of the crankshaft. As in the great majority of power looms, this is the driving shaft, and controls either directly or indirectly all the motions, Figs. 58 and 59 (which are diagrams showing a revolution of this shaft) have been prepared to illustrate more clearly the relationship of these motions and the times at which they occur. The positions of the rocking shaft A, connecting pin B, and crank C have been carefully taken from a representative type of loom, largely used both in jute and linen weaving, the only difference in the diagrams being the direction of rotation of the crank as indicated by the arrows. The

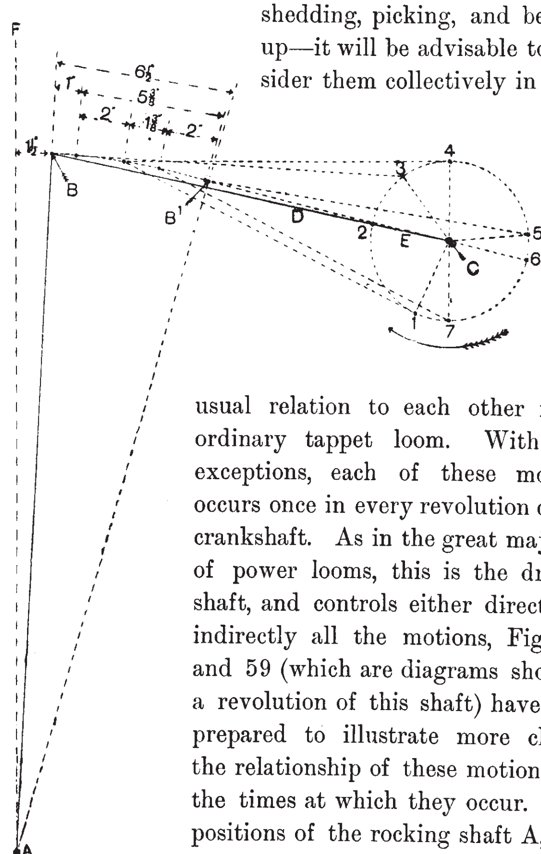


Fig. 58.

various dimensions are as follows:—Length of sword from A to B, $28\frac{1}{2}$ ins.; distance of B, when full forward, from the vertical line F, $1\frac{1}{2}$ ins.; length of connecting rod D, $13\frac{1}{2}$ ins.; radius of crank E, $3\frac{1}{4}$ ins.; and diameter of crank circle, $6\frac{1}{2}$ ins.; the chord of the arc B B′ described by the connecting pin (or its effective travel) being also $6\frac{1}{2}$ ins. approximately.

In considering the path of the crank — the crank circle — it is customary, in order to facilitate reference, to term the four cardinal points the top, bottom, back, and front centres. Taking Fig. 58, which shows the direction of movement invariably adopted in looms for jute weaving, the numbers 1 to 7 on the crank circle indicate the position of the crank at the following times:—

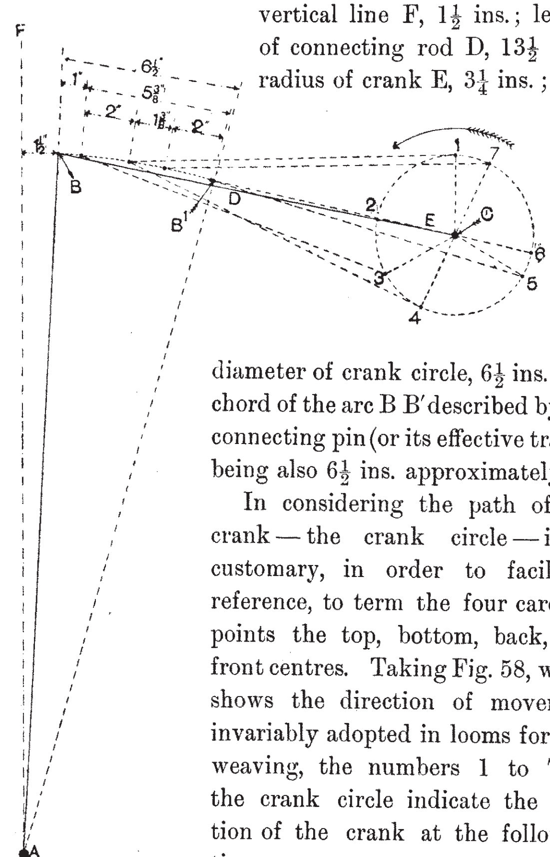


Fig. 59.

1. When the leaves of the camb are level—that is, midway in their action of changing the shed.

2. When beating up occurs, the reed being in contact with the cloth.

3. When the wypers enter on the dwell or pause, assuming one-third of a pick or 120° of the crank circle for dwell.

4. When the shuttle begins to move, generally termed the picking position.

5. When the wypers leave the dwell.

6. When the reed is full back, or farthest removed from the cloth.

7. When the shuttle should be at rest in the opposite box.

In general, point 1 (which in this case has been taken at 25° forward of the bottom centre) is found by withdrawing the shuttle from the shuttle box and turning the crank until the tongue and knee or frog of the warp protector are hard in contact. Point 2 must occur when the crank and the connecting arm are in one straight line. In this case point 2 is approximately 10° above the front centre. Points 3 and 5 must each be 120° removed from point 1. Point 4 shows the earliest time at which picking may occur, being made later according to circumstances. It will be observed that at this point the tongue of the warp protector in its backward movement will just have cleared the knee. Assuming the shuttle to begin its movement at point 4, it will have partly entered the shed about 40° later in the crank's revolution, at which time the pick is usually fully developed. At point 6, which is slightly farther removed from the back centre than point 2 is from the front centre, the crank and connecting arm must again be in one straight line.

The positions of the connecting pin in Fig. 59, which shows the direction of rotation more generally adopted in linen weaving, are identical with those shown in Fig. 58, and the relative positions of the crank at these points are

indicated by similar numbers. Due, however, to the fact that the plane of the crankshaft is so much lower than the plane of the connecting pin, points 1 and 7 (which have changed from the lower to the upper half of the crank circle) are 25° farther from the front centre; and points 3 and 4 (which have changed to the lower half) are 25° nearer the front centre than those in Fig. 58. Now, if picking may occur when the crank is at point 4 in Fig. 58, it is obvious that it may occur at point 4 in Fig. 59, as the connecting pin, and therefore the reed, occupy similar positions in each case. Where, however, shorter cranks are used, the plane of the crank circle invariably occupies a higher position than that shown in the two figures. It therefore follows that the time for picking, when the crank revolves as shown in Fig. 59, will be thrown nearer the bottom centre. With a 2-in. crank, and other dimensions unchanged, this position has been found to be approximately 15° in front of the bottom centre.

CHAPTER VIII

SHEDDING

THE first of the three principal motions in weaving is that of separating the warp threads according to pattern, for the insertion of the weft. Previous to shedding, the warp yarn may occupy one of the three following positions:—

1. At the bottom of the shed, in which case those threads forming the top part of the shed must be returned to the bottom every pick before a fresh selection can be made. An illustration of this type, termed "bottom

closed shedding," is shown in Fig. 60, where the solid lines passing through the heddles represent the position of the warp yarn when at rest, and the dotted lines show the

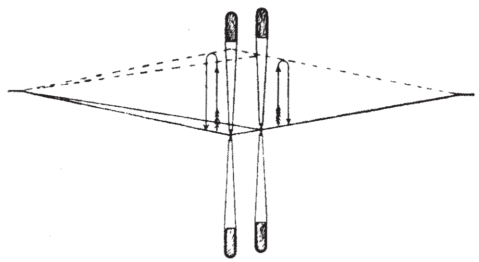


FIG. 60.

position of that part forming the top when the shed is open; the arrows indicate the distance through which each thread travels in one shedding operation—*i.e.* twice the depth of the full shed.

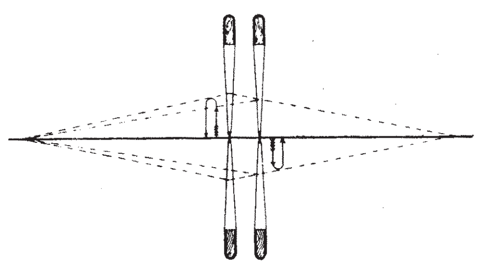


FIG. 61.

2. At the centre of the shed, in which case those threads that are to form the top and bottom parts are taken up and down respectively, and returned to the centre each pick. This type is termed "centre closed shedding." In Fig. 61 the solid line again shows the position of the yarn

when at rest, the dotted lines its position when the shed is open, while the arrows show the distance travelled in forming the shed. It will be seen that this distance is only half that of the first system, and on this account the shed ought, theoretically, to be formed in one-half the time. To obtain the full advantage of this, however, it would be necessary to drive the loom at twice its former speed; but from consideration of other parts this is impossible, and only a slight increase in speed is actually gained. One disadvantage in this style of shedding is that all threads are set in motion for every pick. This is particularly objectionable in jacquard weaving, as an excessive amount of movement is imparted to all lingoes. A further disadvantage of this method is that it produces reed-marked cloth; and, since the shed closes as the reed approaches the fell of the cloth, the warp threads are slack when beating up takes place, unless a vibrating back rest is provided to take up the slack. Without such a back rest, beating up comes on the warp in the nature of a shock, since the fell of the cloth is pulled backwards as the shed opens, and consequently must be driven forwards by the reed as the shed closes.

3. In this case the threads forming the top and bottom parts of the shed are retained in these positions until a change is necessary, when the threads are moved continuously and simultaneously from these points to form the new shed. This is termed "open shedding," and is represented by Fig. 62, where the solid lines indicate the shed at rest, and the arrows the distance travelled by any thread when a change in the shed is made. For most classes of work this is undoubtedly the best type of shedding, as the time occupied and the strain on the yarn

are reduced to a minimum, besides being the ideal shed for giving "cover" to the cloth.

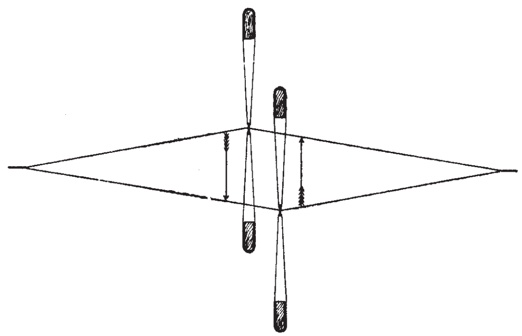


FIG. 62.

Fig. 63 represents a shed of a semi-open type, the only difference between it and the pure open shed being

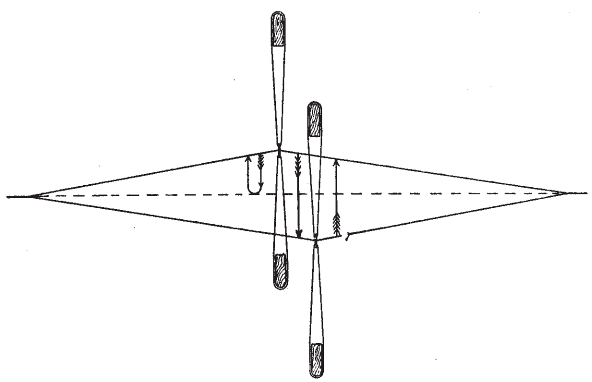


FIG. 63.

that all threads forming the top part travel to the centre position each pick in forming the new shed. Any thread, however that is to change from top to bottom, or *vice versa*,

does so in one direct movement as in the open shed. Threads that are to occupy the top position for two or more successive picks are caught in the centre of the downward movement and returned again to the top as indicated by the doubled arrow. This type of shed gives better cover to the cloth, is easier upon the warp from the point of view of shedding, but is harder upon it when beating up than that type indicated in No. 1.

The bottom-closed shed is formed principally by single-lift jacquards, by certain types of hand-loom dobbies, and by a few power-loom dobbies.

The centre-closed type of shed is found in all kinds of hand and power looms, but not extensively in any.

The open shed is utilised in all modern wyper and tappet looms, and in many power-loom dobbies, but very few jacquards are found working on this principle.

The semi-open type of shed is common to all double-lift jacquards and to a few double-lift dobbies.

In power looms there are three distinct methods of accomplishing this operation of shedding—by wyper or tappet, by dobby machine, or by jacquard. The first, that of wyper or tappet shedding, may be either negative or positive. If the former, the tappet is usually constructed simply to depress a treadle to which is attached one of the leaves of the camb, the raising of the leaf being accomplished by counterweights, by springs, by camb rollers, or by some other similar compensating motion situated either over or under the leaves of the camb depending upon the position of the wyper itself. When any type of roller motion is used, the connections are such that the movement of any leaf of the camb in one direction causes another leaf to move in the opposite direction. Positive tappets and their connections are constructed and arranged both to raise and to depress the camb leaves to which they are attached.

Before proceeding to construct a wyper or tappet it will be necessary to discuss some of those considerations which go to affect its shape or form. Chief amongst these are the pause or dwell which is to be given to the leaves —first, to permit of the passage of the shuttle; and second, to enable the warp threads to spread equally or give "cover" to the cloth,—and the nature of the movement to be given to the leaves of the camb while changing from one fixed line to another. Wypers will be found having dwells from one-third to one-half of a pick, or, in other words, equal to from 120° to 180° *of the crank circle.* It will be readily understood that any increase in the time given to the dwell will reduce by that extent the time allowed for closing and opening the shed, thus increasing the strain on the yarn and on all the shedding parts of the loom which happen to be in motion. In the face of this it is not surprising that in most cases the theory of long dwells is fast dying out, and that it is now exceptional to find a loom of 36-in. reed space with a wyper having a dwell exceeding 120° of the crank circle, or one-third of a pick. Provided the wypers are properly set, this pause of 120° is found, even in some 60-in. reed-space looms, to be quite sufficient to enable the shuttle to pass through the shed, and at the same time to have the latter sufficiently well opened to prevent reed marking when the weft is beaten up.

In wide looms the dwell may be, and often is, increased with advantage to the general working of the loom, as the increased dwell permits of the wyper being set so as to enable the shuttle to pass freely from the shed, and yet have sufficient "shed on" to prevent reed marking. In fact, in wide looms, satisfactory work will not be easily produced unless the dwell of the wyper be increased to some extent. This increase of dwell, however, does not necessarily mean a decrease in the time allowed for shedding. As a matter of fact, due to the reduced speed of the loom, the dwell may be increased, and the time allowed for shedding be still greater than that allowed in narrow looms.

Hitherto the amount of dwell to be given for looms of different widths has been pretty much neglected; in fact, no rule for such purpose, so far as our knowledge goes, has ever been observed.

In determining the increase to be given to the dwell beyond 120° of the crank's revolution, which we shall consider as the minimum dwell suitable for looms of 36-in. reed space, it is of course necessary to take into account the reduced speeds of the wider looms. Consideration should also be given to the fact that in the wider looms the initial velocity of the shuttle is usually greater than that in the narrow loom; but, since in practice the proportionate increase in velocity of the shuttle is very slight as compared with the proportionate increase in the reed space, even when due allowance is made for the reduced speed of the loom, we shall, in order to simplify calculation and to ensure erring on the safe side, assume that the shuttle travels at the same velocity in all widths, and that the time taken by the shuttle in passing through the shed is in exact proportion to the reed space. Further, the speeds of the different widths will be approximately the same as those found in present-day practice for looms of a moderately heavy type, viz. :—

36-in.	reed space.	160	picks per minute.
46-in.	„	145	„ „
60-in.	„	130	„ „
81-in.	„	115	„ „
120-in.	„	95	„ „
156-in.	„	85	„ „

Now in a 36-in. reed-space loom 120° of the crank's revolution are allowed for dwell, but, as the shuttle enters the shed when the crank is 40° behind the top centre, or 75° past point 3, Fig. 58, at which point the wyper enters on the dwell, only 45° of the dwell remain to pass the shuttle through the shed before the leaves begin to close. Hence the actual time allowed for the shuttle to cross in the narrow loom before the leaves commence to close is :—

$$\frac{60 \text{ seconds}}{160 \text{ picks per minute}} \times \frac{45^\circ}{360^\circ} = 0{\cdot}0468 \text{ second.}$$

While an eighth of the crank's revolution, 45°, may seem a small portion of the time to allow for the passage of the shuttle in any loom, it will be shown later that the form of the wyper immediately beyond the dwell is such as to increase considerably the extent of the dwell, and the time during which the leaves of the camb remain practically in full shed.

It will be evident from the foregoing that, in order to find the extent of the dwell necessary for the passage of the shuttle in any width of loom greater than 36-in. reed space, 45° must be increased in direct proportion to the reed space, and reduced in proportion to the reduction in the speed of the crankshaft. Thus for a 46-in. reed-space loom, at 145 picks per minute, we should have :—

$$45^\circ \times \frac{46''}{36''} \times \frac{145 \text{ picks}}{160 \text{ picks}} = 52 \text{ degrees dwell ;}$$

and similarly for the others, the values of which are :—

Reed space	36″	46″	60″	81″	120″	156″ ;
Degrees dwell	45°	52°	61°	73°	89°	103° ;

while the total dwell, etc., will be :—

Reed Space.	Speed.	Degrees of Dwell before Shed is entered.		Degrees of Dwell for Passage of Shuttle.	Total Dwell.
36-in.	160	75°	+	45°	120°
46-in.	145	75°	+	52°	127°
60-in.	130	75°	+	61°	136°
81-in.	115	75°	+	73°	148°
120-in.	95	75°	+	89°	164°
156-in.	85	75°	+	103°	178°

But it is obvious that as that part of the crank's revolution devoted to opening the shed is reduced, the amount of "shed on" when beating up occurs will not be sufficient to give "cover," unless the wyper enters on the dwell earlier than 35° before the top centre is reached, in proportion (approximately) as the time for opening is reduced. For example, the time for opening in a 36-in. reed-space loom is 120°, but in the 156-in. reed space it is only 91° ; therefore the wyper would require to enter on the dwell :—

$$91 : 120 = 35^\circ : 46^\circ \text{ in front of the top centre.}$$

As these extra 11° fall to be added to the dwell already found, the total dwell for the 156-in. reed-space loom would be $178 + 11 = 189^\circ$, say 190° of the crank's revolution. Similarly with the other widths.

Fig. 64 represents the path of the crank divided into three equal parts of 120° each, the arrow indicating the direction of motion. When at point A the shed should be closed, and the wypers, of course, level. From point A to point B is occupied in opening the shed ; from B to C in dwell ; and from C to A in closing the shed. It will thus be seen that two-thirds of a full revolution, from C to B, are utilised in changing the shed. The positions of these points, which have been found satisfactory for comparatively light and open fabrics which have a tendency to show reed marks, may vary slightly according to the class of work and the extent of the dwell, as before mentioned.

In regard to the nature of the movement of the camb leaves, this should be such that as the strain on the warp increases, the speed of the leaves will decrease. Each leaf should begin to move slowly from the full open point, gradually increase in speed until the centre of the stroke is reached (at which point the speed is greatest), when the speed should as gradually decrease until the opposite extreme is reached. Given a loom going at the rate of 160 picks per minute, it will be found that the changing of the shed has to be accomplished in one-quarter of a second, while one-eighth of a second is occupied by the dwell. Thus :—

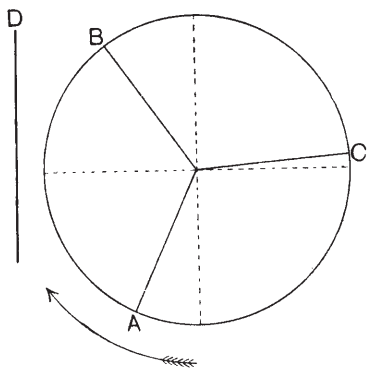


FIG. 64.

$$\frac{60 \text{ secs.}}{160 \text{ picks}} \times \frac{240^\circ}{360^\circ} = \tfrac{1}{4} \text{ sec. for change.}$$

$$\frac{60 \text{ secs.}}{160 \text{ picks}} \times \frac{120^\circ}{360^\circ} = \tfrac{1}{8} \text{ sec. for dwell.}$$

Fig. 65 shows how the irregular motion to the leaves is generally obtained. A to B is the full depth of the shed. The semicircle DCE (with diameter DE equal to AB)

is divided into six equal parts, and from points obtained by this division perpendiculars to the shed line are dropped. This divides each half of the shed into three graduated parts, and as to each of these unequal parts is allotted an equal portion of time—one-sixth of the full time occupied in shedding,—it follows that the movement will be as already indicated. The same length of time—$\frac{1}{24}$ sec.—is occupied by the camb leaf in travelling through each of

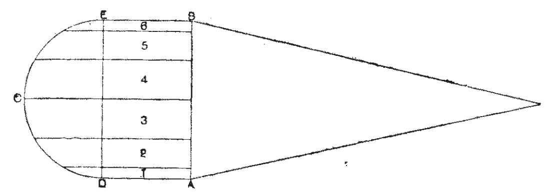


FIG. 65.

the spaces 1, 2, 3, 4, 5, 6. The actual distances of these spaces can be obtained as follows :—

For a radius of 1 in.—

The versed sine of 30° = 0·133975.
" " 60° = 0·5.
" " 90° = 1·0.

Then for a shed of, say, 5 ins.—that is, a radius of $2\frac{1}{2}$ ins.—

0·133975	× 2·5 = 0·3349375 in.,	depth of spaces	1 and 6
(0·5 − 0·133975)	× 2·5 = 0·9150625 in.,	" "	2 " 5
(1 − 0·5)	× 2·5 = 1·25 ins.,	" "	3 " 4
	2·5 ins.		

and

2·5 ins. × 2 = 5 ins. total depth of shed.

Fig. 66 shows the construction of a negative tappet or wyper. Data necessary :—

1. Distance from the centre of wyper shaft to the centre of treadle bowl, when the treadle is level (say 6 ins.).

2. Throw or stroke of wyper (say $3\frac{1}{2}$ ins.).

3. Dwell of wyper (one-third of a pick, or 120° of the crank circle).

4. Diameter of treadle bowl or anti-friction roller (say 3 ins.).

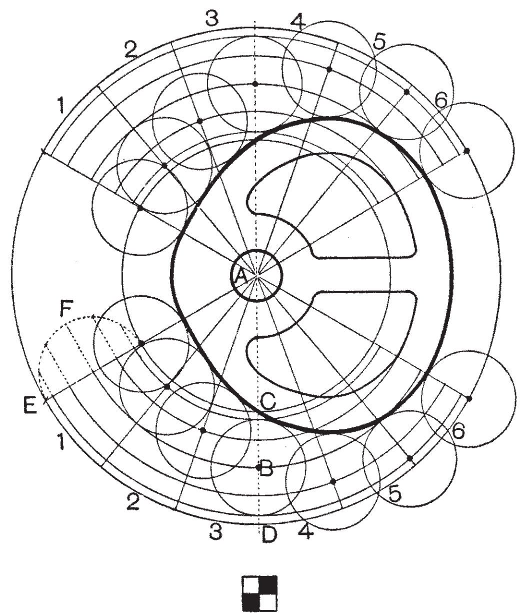


FIG. 66.

From a point A on a vertical line set off B (the distance from the centre of the wyper shaft to the centre of the treadle bowl when the treadle is level — viz. 6 ins.). Above and below B set off at C and D half the throw of the wyper—viz. $\frac{3\frac{1}{2}}{2} = 1\frac{3}{4}$ ins. With A as centre, and AC, AD as radii, describe circles, and, since these circles represent

one complete revolution of the tappet, divide them into the same number of equal parts as there are picks in one repeat of the weave. The amount to be allowed for dwell per pick should then be marked off on each division of the circle. The extent of this will always be determined by the extent of the dwell as part of a revolution of the crank, and by the number of picks in a repeat of the weave, and can always be found as follows :—

$$\frac{\text{dwell in degrees of crank circle}}{\text{number of picks in one repeat of weave}} = \text{degrees dwell on wyper circle.}$$

When the number of degrees on the crank circle is 120, and the weave $\frac{1}{1}$ plain, the number of degrees on the wyper circle is 60, or $\frac{1}{6}$ of the circle; consequently, the simplest plan is to divide the wyper circle into six equal parts: similarly, for any other weave with the same amount of dwell on the crankshaft, *e.g.* a 3-pick weave has 40° dwell, a 4-pick weave has 30° dwell, and these values are respectively equal to $\frac{1}{9}$ and $\frac{1}{12}$ of the respective wyper circles; in all such cases the number of divisions of the wyper circle is found by multiplying the picks per repeat by 3. In the present case 2 picks $\times 3 = 6$ divisions. Each of these divisions in Fig. 66 represents one-third of a revolution of the crank, or one-third of a pick, the time occupied by the dwell. To each pick one part is allotted for dwell, and two parts for closing and opening the shed. Divide these two parts into any number of equal spaces (say six). On one of the lines dividing the circle, say EA, describe a semicircle F, equal in diameter to the distance CD, and subdivide it also into six equal spaces (similar to Fig. 65). From points obtained on the semicircle by this division, drop perpendiculars to meet the line on which it is constructed. With A as centre, and points where these perpendiculars cut the line as radii, describe arcs in the parts allotted to the closing and opening of the shed. The points where these arcs cut the radial lines may be taken as the centre of the treadle bowl at different points of its travel, and with the radius of the treadle bowl describe circles showing its position at these points. A curved line drawn tangent to these circles will be the outline of the tappet. Those parts at the dwells may be drawn in with the compasses, as the outline of the tappet there must be part of a circle. The above is the construction of only one blade of the wyper, two blades being necessary, but set diametrically opposite, for plain cloth, one for each leaf or treadle.

Any negative tappet may be constructed on the same principle. Say one is required for a four-leaf twill, 1 down, 3 up, in regular order. Four blades will be required, set in their proper order according to the weave shown in Fig. 67, in which figure is also the construction of one blade of the tappet. Four picks $\times$ 3 = 12 parts into which the circle must be divided, one part being allowed for dwell, and two parts for closing and opening the shed in regular succession, as shown. Further construction is in all respects similar to that already gone through, and will be readily understood.

Fig. 68 shows the construction of one blade of a wyper for the first leaf of the weaving plan on 4 leaves. (This weaving plan is the same as that illustrated at D and E, Fig. 55, page 110.) Since there are 8 picks in a repeat, the wyper circle is divided into 8 equal parts. It is a convenient plan to mark each pick, A......H, as indicated, immediately opposite the part intended for the dwell. When this is done it will be observed that at one part there are three successive marks, while at each of two other

parts there are two successive blanks. A change from one position to another is required obviously only between dissimilar blocks or squares; hence it is only necessary to divide the spaces for change between A and B, C and D, D and E, and F and G. When the blade is constructed it

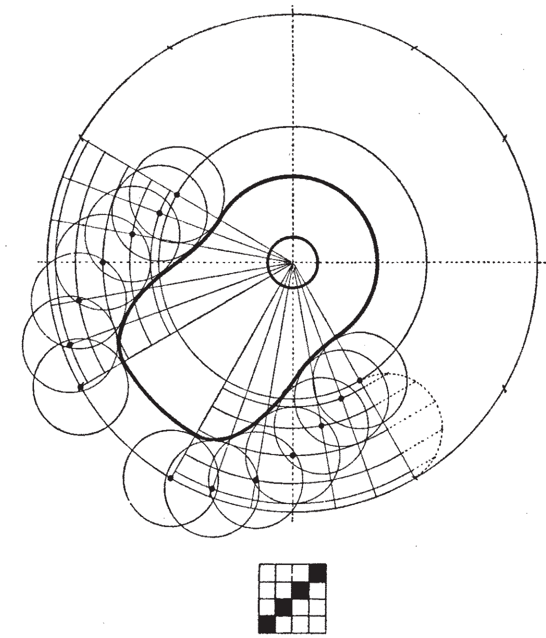


Fig. 67.

is clear that the dwell extends over picks G, H, and A, as well as between the two intervening parts during which some leaves will be changing; this is necessary if the shedding is to be on the open-shed principle, *i.e.* if the leaf in question is to remain motionless for three successive picks. Similarly for picks B and C, and for E and F, the dwell extends over the two parts marked with blank

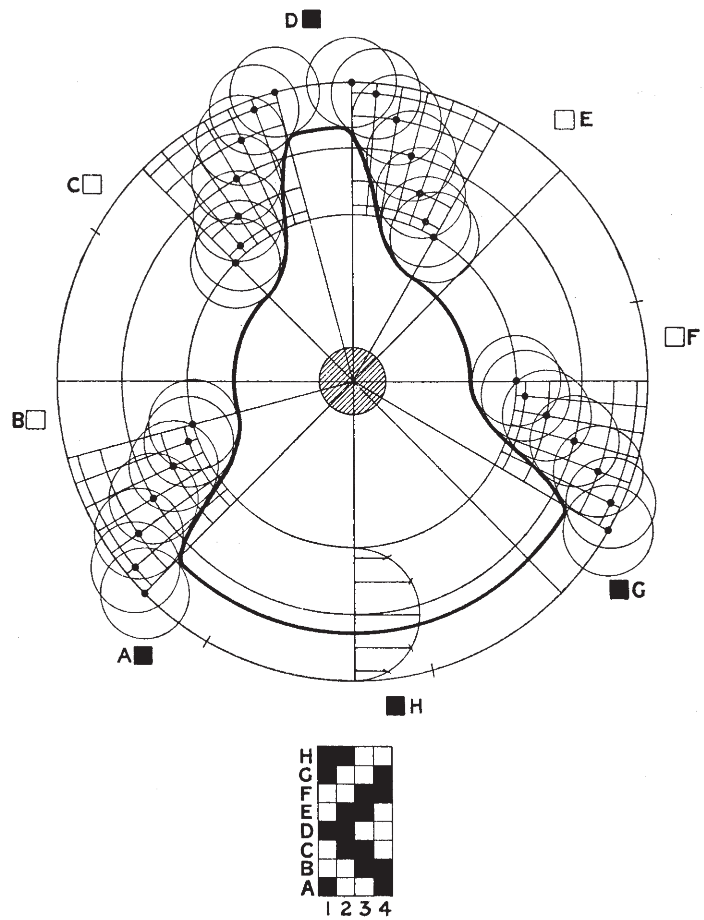


FIG. 68.

squares (the dwells) and the space between the dwells.

Fig. 69 shows the construction of a plain wyper for a 4-yd. loom, with 190° of the crank circle as dwell. On a vertical line A draw circles B, C, and D, as in Fig. 66. The line A thus divides these circles into two equal portions, each of which represents one revolution of the crank. As the wyper shaft revolves at half the speed of

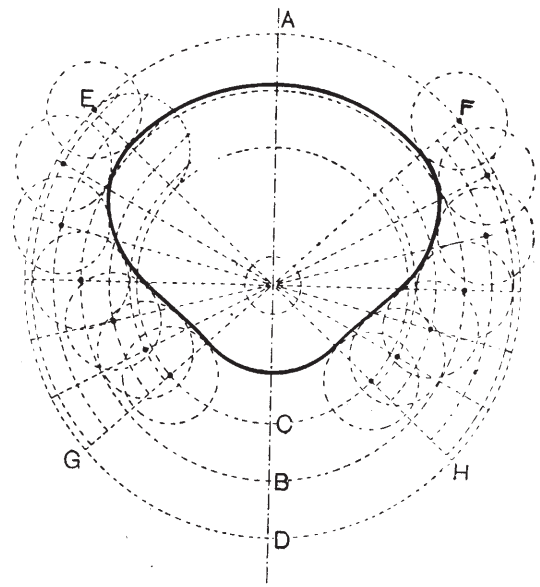


FIG. 69.

the crankshaft it follows that $\frac{190}{2} = 95°$ of the wyper circle will be the requisite amount for dwell. Therefore on both sides of A and D set off $\frac{95}{2} = 47\frac{1}{2}°$ at points E, F, G, H. The times for changing the shed will therefore be from E to G and from H to F. Divide these spaces into six equal parts, and proceed as explained with reference to Fig. 66.

As already stated, the method adopted in the construction of the foregoing tappets for obtaining the irregular movement of the camb leaves is that generally used; but under certain conditions—*e.g.* where the yarns are very weak, etc.—it may be desirable to reduce still further the speed of the leaves when they are near their extreme

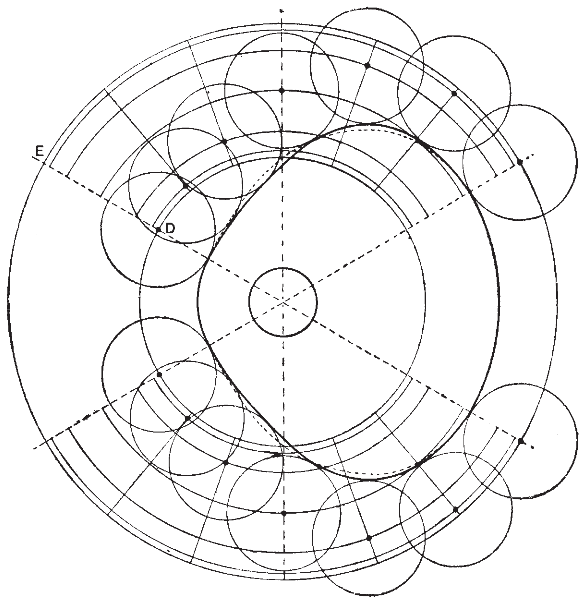


Fig. 70.

positions. Fig. 70 shows one method by which this may be obtained. Line DE—representing the stroke of the wyper—has been divided arbitrarily in the ratio of 1 . 3 . 6 . 6 . 3 . 1. The outline of the wyper resulting from this ratio of acceleration is shown by the heavy black line; while the dotted line shows the outline of that constructed from the ratio obtained by the semicircle, as in

Fig. 66. A decrease of speed at any point must necessarily mean a corresponding increase at some other part of the stroke. The speeds of these two methods will be seen by the following comparative table:—

	Parts 1 and 6.	Parts 2 and 5.	Parts 3 and 4.
Harmonic ratio obtained by semicircle .	0·3349375 in.	0·9150625 in.	1·25 ins.
Obtained by arbitrary ratio . .	0·25 in.	0·75 in.	1·5 ins.
Difference in $\frac{1}{24}$ of a second .	0·0849375 in.	0·1650625 in.	0·25 in.
	Decrease.		Increase.

It must be understood that these figures assume a perfectly made wyper to the above conditions. It is, however, impossible to work to anything approaching such exactness; indeed, in practice it is unnecessary to consider any figure beyond the second place of decimals.

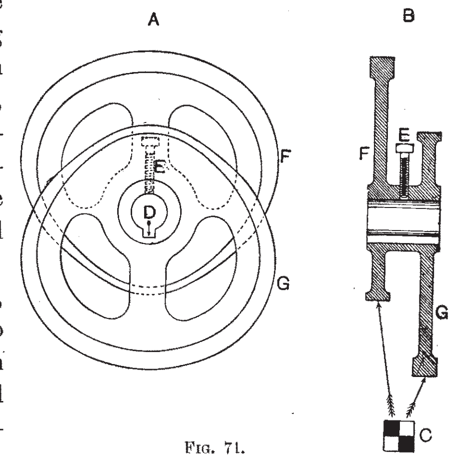


Fig. 71.

Part A, Fig. 71, shows the two blades of a plain wyper as arranged to be driven on a supplementary shaft, part B showing a section through the centre, and C a plan of the plain weave. In this shaft a long key is fixed to take into the key-seat D in the wyper, lateral movement being prevented by the set screw E. Since all wypers on a supplementary shaft are driven by means of toothed gearing from the wyper shaft proper, it is only necessary, when they require to be changed as regards their time of shedding, to lift out the shaft and replace it into gear later or earlier, as required. When the wyper is intended for the wyper shaft proper, it is sometimes made in halves and bolted together on the shaft; in other cases it is made solid, as above. The former is probably the better method, as it permits of adjustment or replacement more readily than the other. As the leaves of the camb recede from the fell of the cloth it is necessary that they shed proportionately deeper in order to present an equal opening to the shuttle. In the wyper shown, blade F, which is intended to actuate the back leaf of the camb, is arranged to give a greater travel to that leaf than blade G will convey to the front leaf. This is necessary, owing to the fact that the fulcra of the treadles are at the back of the loom, and the farther the leaf is removed from the fell of the cloth, the nearer will its point of connection be to the fulcrum of the treadle. When the fulcra of the treadles are at the front of the loom, the increased depth of shed is obtained by the increased leverage, and the throw of all the blades, no matter how many are employed, is the same.

Positive Tappets.—These may be either cast solid or built of sections. The former is of course preferable, as it gives more satisfactory work, but the latter allows of an almost endless variety of weaves being employed, as the tappet may be arranged to suit any design within its compass. Weaves up to 8 leaves and 24 picks to the round are, however, about the limit, although tappets are sometimes built for 32 picks to the round. Any weave may be

arranged for, provided the number of picks in a repeat is a measure of the number of picks in a round of the tappet. For example, a weave repeating on 2, 3, 4, 6, 8, or 12 picks can be arranged on a tappet constructed for 24 sections to the circle. The construction of a solid positive tappet is in all respects similar to that of a negative one, with the addition of an outside bead running parallel to the outline of the tappet, to prevent the treadle bowl from leaving

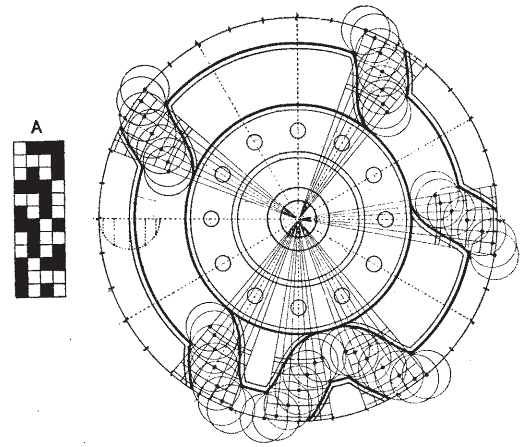


FIG. 72.

its position. The groove in which the treadle bowl runs must be greater than the diameter of the bowl by about $\frac{1}{8}$ in. Fig. 72 shows the construction of one blade of a positive tappet for weave A, 12 picks to the round $_{3}{}^{2}{}_{2}{}^{1}{}_{1}{}^{3}$. Woodcroft positive tappets are built of sections, and may be arranged either for centre or for open shedding. For centre shedding only two types of sections are used—Nos. 1 and 2, Fig. 73; while for open shedding the eight different types shown in the same figure are required.

Fig. 74 shows one or more sections of each kind built to

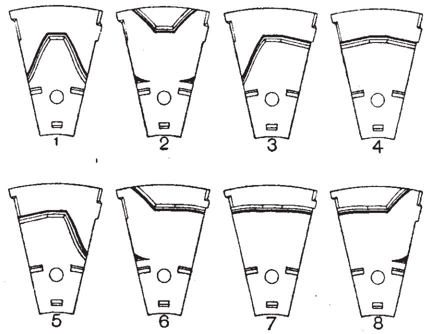


Fig. 73.

actuate the first leaf of weave B—shown in the same figure, —14 picks to the round $\frac{4}{4}\frac{2}{2}\frac{1}{1}$. Seven plates would be

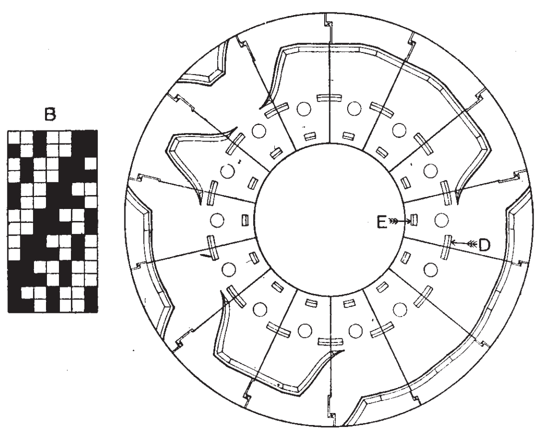


Fig. 74.

required to produce the above weaves (one plate for each leaf), each plate to contain 14 sections (one section for each

pick). These sections are held together by binding plates or rings (Fig. 75). A and B are plans of different rings, while C is a sectional elevation. The latter shows two beads, Nos. 1 and 2, which grip respectively outside and inside the projecting pieces D and E on each section of the plate (Fig. 74). All plates and rings are bolted together through bolt holes shown in each plan A and B and in each section of the plate. The bolt holes in A are spaced irregularly so that they may suit plates composed of various numbers of sections, whereas B is intended for plates consisting of 14 sections only. These tappets are invariably placed outside the loom frame, and are driven by suitable gearing from the crankshaft.

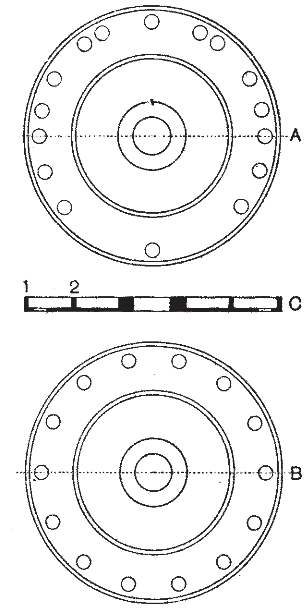


Fig. 75.

The front and end elevations in Figs. 76 and 77 show the method of actuating the camb leaves by means of the above positive tappets. A is a pinion on the crankshaft, B a wheel on the supplementary shaft, C a treadle fulcrumed at D, and E a treadle bowl carried by the stud projecting from the treadles C at a suitable point above the tappet. As the tappet revolves, the bowl E, and therefore the treadle C, is alternately raised and depressed, according to the build of the tappet; and the treadles C being connected to the camb leaves F by means of the top and bottom levers or jacks G, fulcrumed at H, and the cords J, it follows that the desired motion results. Variation in the lift is obtained by the strap from the treadle C being attached nearer to or farther

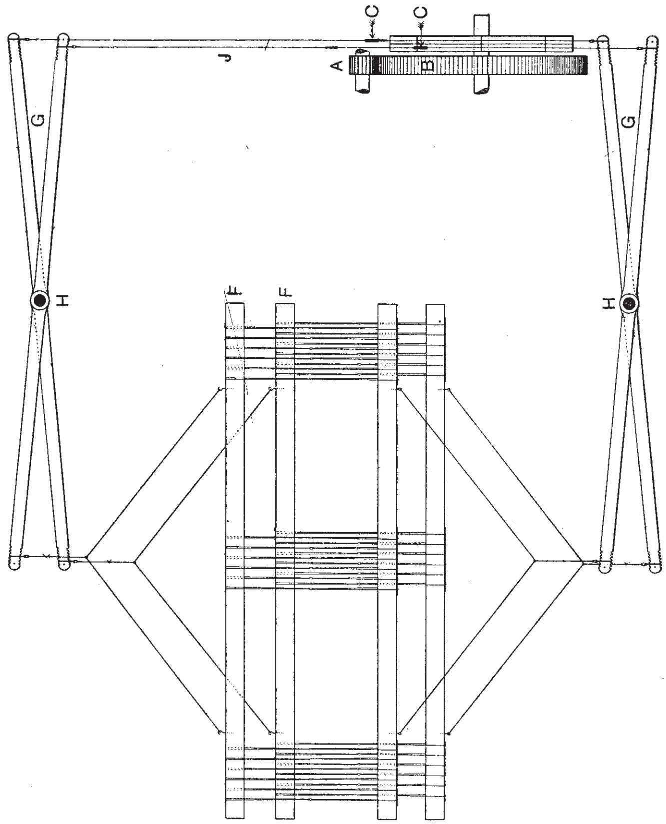


Fig. 76.

from fulcra H and D. Other types of shedding tappets are in more or less restricted use, but since they act on much the same principle as one or other of those already described, it is unnecessary to introduce them.

To calculate the throw necessary for a shedding wyper under any conditions, the following data are necessary :—

1. The breadth and depth of the shuttle.
2. The distance of the reed from the fell of the cloth when the full depth of the shuttle has entered the shed.
3. The distance from the fell of the cloth to the leaf of the camb.
4. The length of the treadle from the fulcrum to the point of connection with the leaf.
5. The length of the treadle from the fulcrum to the centre of the treadle bowl.

The following dimensions may be taken as typical of a loom for coarse fabrics :—

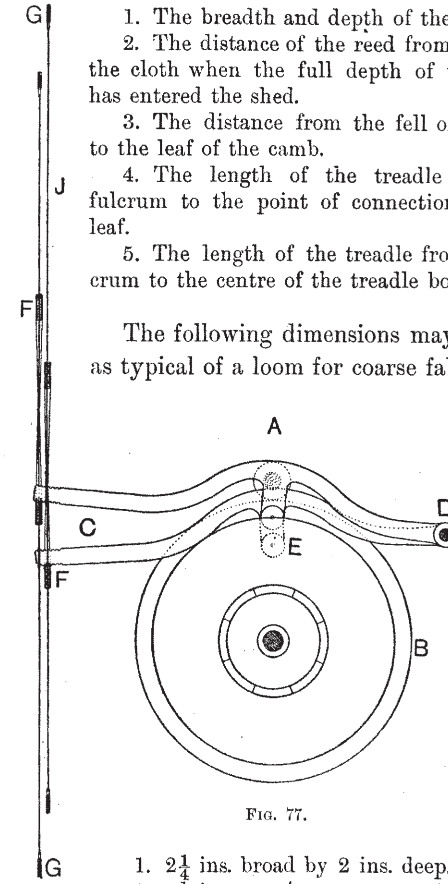


Fig. 77.

1. $2\frac{1}{4}$ ins. broad by 2 ins. deep.
2. $6\frac{1}{4}$ ins.
3. $9\frac{1}{2}$ ins.
4. 33 ins.
5. $16\frac{1}{2}$ ins.

Fell of cloth to reed ($6\frac{1}{4}$ ins.) − breadth of shuttle ($2\frac{1}{4}$ ins.) = fell of cloth to face of shuttle (4 ins.).

Therefore the shed at 4 ins. from the fell of the cloth must be 2 ins. deep. Required, its depth at $9\frac{1}{2}$ ins., the distance of the leaf from the fell of the cloth :—

4 ins. : $9\frac{1}{2}$ ins. = 2 ins. : $4\frac{3}{4}$ ins., depth of shed required.

$4\frac{3}{4}$ ins. is also the travel of the treadle at its point of connection (33 ins.) with camb leaf. Required, its travel at treadle bowl :—

33 ins. : $16\frac{1}{2}$ ins. = $4\frac{3}{4}$ ins. : $2\frac{3}{8}$ ins.

Therefore the throw of the wyper = $2\frac{3}{8}$ ins.

CHAPTER IX

TAPPET DRIVING AND SETTING

WHERE changes are seldom made, plain tappets—*i.e.* those with two picks to the round—are almost invariably keyed to the bottom or wyper shaft, this shaft being so called because of the fact that in an ordinary plain loom it carries both the shedding and the picking wypers. In ordinary cases this shaft revolves at half the speed of the crankshaft, and so gives the requisite speed. Where changes are frequent, it is advisable to have the plain wyper or tappet on a supplementary shaft, and driven from the wyper shaft by wheels having an equal number of teeth. With this arrangement changes from two to three or four-leaved work can be done rapidly. Each different wyper having its own shaft with pinion keyed on, it is only necessary, as previously mentioned, to lift out the one shaft, lift in the other, and put the wheels into gear.

Fig. 78 shows the gearing for driving a tappet having eight picks to the round. The pinion A of 30 teeth on the wyper shaft gears with the intermediate wheel B of 60 teeth, with which is compounded the pinion C of 30 teeth. The latter gears with the wheel D of 60 teeth on the supplementary shaft. Take an ordinary case where the spur wheel on the crankshaft has 26 teeth, and the wheel which it drives on the wyper shaft 52 teeth, the value of the motion will then be as follows :—One revolution of

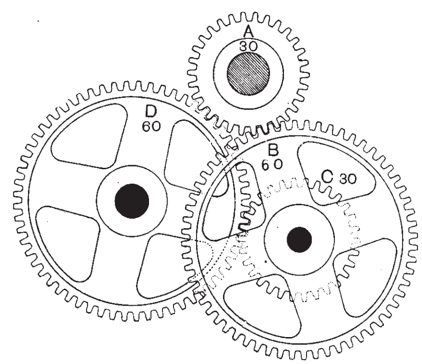


FIG. 78.

the crank $\times \frac{26}{52} \times \frac{30}{60} \times \frac{30}{60} = \frac{1}{8}$, or the speed of the supplementary shaft one-eighth that of the crankshaft. The foregoing wheels are in general use in looms for jute fabrics, but other wheels of the same value are employed in looms of a lighter character. To change the above motion to four picks to the round it is only necessary to withdraw the intermediate wheel B and pinion C from their stud, and to gear pinion A direct with the wheel D on the supplementary shaft. The value of this motion will then be :—One revolution of crank $\times \frac{26}{52} \times \frac{30}{60} = \frac{1}{4}$, or the speed of the supplementary shaft one-fourth that of the crankshaft. If a motion for three picks to the round be required, the speed of the supplementary shaft will require to be one-third that of the crankshaft; but as the speed of the wyper or bottom shaft is to the speed of the crankshaft as 1 is to 2, the speed of the supplementary shaft to that of the wyper shaft must be as 2 is to 3. The pinion on the supplementary shaft will therefore require to be to that on the wyper shaft as 3 is to 2. Suitable wheels bearing this relation would be :—Supplementary shaft wheel, 54 teeth; wyper shaft wheel, 36 teeth. That this would give the required motion is shown thus :—One revolution of crank $\times \frac{26}{52} \times \frac{36}{54} = \frac{1}{3}$, or the speed of the supplementary shaft one-third that of the crankshaft. The motion necessary for driving a tappet having any given number of picks to the round may be determined in a similar manner, whether it be an inside negative tappet driven through the medium of the wyper shaft, or an outside positive tappet driven by the crankshaft direct or through the medium of intermediate pinions. In all cases suitable pinions and wheels may be found by the formula :—

$$\frac{\text{Product of driven wheels}}{\text{Product of driving wheels}} = \text{picks per revolution of the tappet.}$$

Fig. 79 illustrates in plan and elevation the method adopted by Messrs. Robertson and Orchar, Limited, of Dundee, in arranging for the three- and four-leaf wypers on a supplementary shaft, with provision for actuating the plain wyper from the wyper shaft without necessitating a change of treadles. In the elevation the spur wheels A of 26 teeth and B of 52 teeth, or their equivalents, are common to most looms for jute weaving. For the four-leaf gearing shown, the pinion C of 20 teeth on the wyper shaft D gears with the wheel E of 40 teeth on the supplementary

wyper shaft F; the latter will therefore revolve at one-

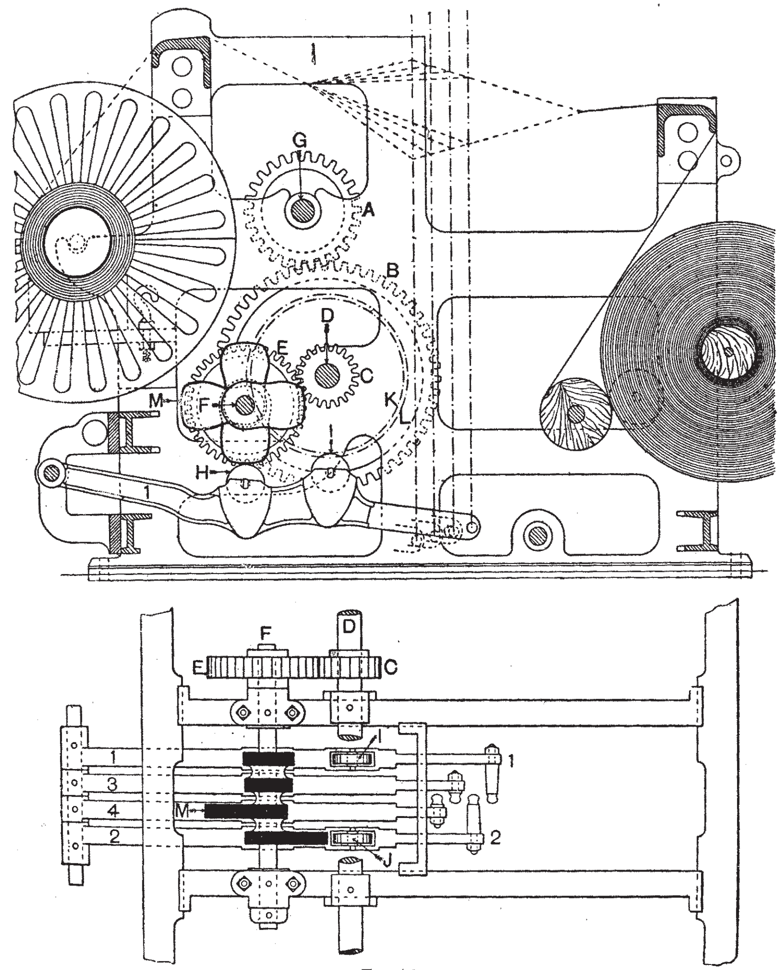


FIG. 79.

fourth the speed of the crankshaft G. The wyper in this case is cast solid and is keyed rigidly to the shaft F, as is also the wheel E. The four blades of the wyper (shown solid black in plan, and in heavy outline in elevation) actuate the treadles 1, 2, 3, 4 through the medium of the treadle bowls H. For three-leaf work the wyper, again solid (the boss being continued from blade 2 to 3), is keyed to a separate supplementary shaft, with its proper wheel of 36 teeth, which gears with a pinion of 24 teeth on the wyper shaft. Both of the above wheels are at the opposite side of the framework to C and E. The blades of this wyper will, of course, actuate the treadle bowls H, treadle 4 remaining idle. For plain work the wyper is cast in halves. These are bolted together on the shaft D, and are held in position by means of a friction key and a set screw. They give motion to the treadles 1 and 2 through treadle bowls I and J, treadles 3 and 4 remaining idle. The dot-and-dash circles K and L represent the paths of the two blades of the plain wyper. It will be observed that, for reasons already discussed, the blade whose path is shown at L will impart a larger shed to the second leaf than K will to the first leaf; similarly in regard to the four-leaf wyper shown, the blade M imparts the largest shed.

In some cases the three- and four-leaf wypers are fixed to sleeves which rotate freely on the ordinary wyper shaft; each sleeve with its corresponding wyper is then driven at the required speed by means of suitable wheels on the wyper shaft and the tappet sleeve, and an intermediate pair of wheels on a supplementary shaft or stud. In this case it is unnecessary to lift out the wypers and shafts, and, since the wypers are near the leaves, any irregularities in their action are not multiplied to so great an extent as when they are acting nearer to the fulcrum

of the treadles, but there is sometimes a danger of the revolving wyper coming into contact with the rod which connects the back leaf of the camb to the treadle.

Fig. 80 shows the usual method of driving outside

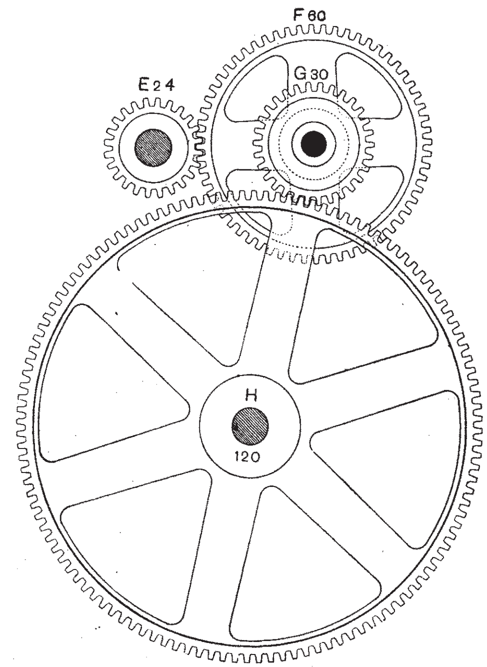


Fig. 80.

positive tappets, the train of wheels being arranged for a tappet having ten picks to the round. The pinion E of 24 teeth on the crankshaft gears with the intermediate wheel F of 60 teeth, with which is compounded the pinion G of 30 teeth, the latter in turn gearing with the wheel H of 120 teeth on the tappet shaft or stud. The value of the motion is therefore one revolution of crank $\times \frac{24}{60} \times \frac{30}{120} = \frac{1}{10}$, or the speed of the tappet shaft one-tenth that of the crankshaft. Changes in speed may be made at any point, and, when suitable, the pinion on the crankshaft is geared direct with the wheel on the tappet shaft. For example, the pinion E and the wheel H would be a suitable gearing for a tappet of five picks to the round, no intermediate wheels being necessary.

Tappet Setting.—As has already been stated, the position of the crankshaft may vary in relation to that of the shedding wyper as regards the time of shedding. For instance, with tender yarns it may be advisable to have the crank farther forward than the point shown in Fig. 58, page 114, when the shed is closed, so that the strain upon the yarn will be reduced when the reed is beating up the weft. Also, if the cloth be heavy and the reed fine, the strain on the loom will be slightly reduced by setting the crank farther forward, as stated above, while sufficient cover or spreading of the yarn will still be obtained because of the fineness of the reed. Again, if a narrow cloth be woven in a wide loom, a similar position of the crank, when the shed is closed, will aid greatly in the production of a good selvage.

In some few cloths, for special effects, it is desired that the marks of the reed be shown distinctly, but in by far the greater majority this is considered a fault to be guarded against; and, generally speaking, to have the cloth well covered, or, in other words, the threads of the warp yarn equidistant from each other, is one of the main desires of merchant and manufacturer alike. The position of the warp line when the shed is closed, the time of shedding, and also the position of the lease rods, all aid or retard this desired result. To illustrate in what manner

the position of the warp line affects this result, Figs. 81 and 82 are introduced. In Fig. 81, when the shed is closed, the warp yarn forms a straight line from back to front, as indicated by dotted line CE, but when the shed is opened, shafts A and B are raised and depressed through equal distances, and the upper and lower portions of the shed are formed respectively by the lines CDE and CFE. The

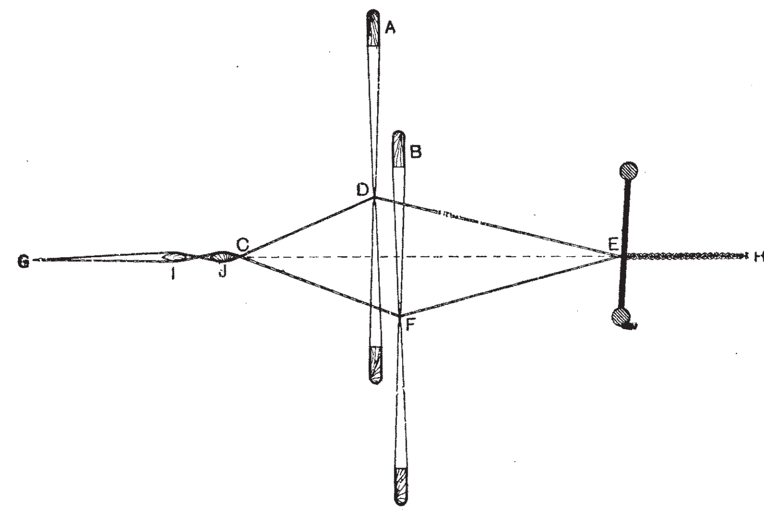


Fig. 81.

dotted line CE thus divides the shed into two equal triangles, and it therefore follows that an equal strain will be thrown upon each half of the shed. Each pair of threads, therefore, passing through their respective splits in the reed, will be retained in the position into which the reed places them when beating up, as the high tension on the yarn will permit of no lateral movement on the part of any individual thread. G and H denote respectively the points where the yarn leaves the back rail and where the woven cloth reaches the front rail or breast beam. I and J are the lease rods.

In Fig. 82 similar letters refer to similar parts. The shafts A and B have again been raised and depressed through equal distances from the centre of the shed, the line of the warp being shown when in this position by the

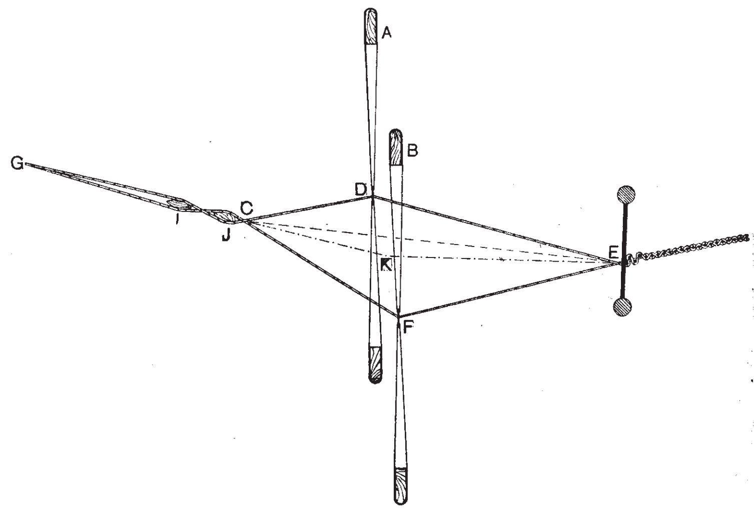


FIG. 82.

dotted line CKE, and the upper and lower portions, when open, by the lines CDE and CFE. The shed is again divided into two triangles by the line CE, which is common to both, and therefore the shortest distance between these two points. This being so, it follows that the strain upon the yarn will be least when the yarn occupies this position. But as the altitude of triangle CFE is about twice that of the triangle CDE, the lower

portion of the shed will be in great tension, while the upper portion will hang slack. This is the condition of things aimed at, and it is brought about by the raising of the back and front rails as far as may be necessary above the level of point K at the centre of the shed. In the diagram, point H has been raised about $\frac{3}{4}$ in., while point G has been raised about 4 ins. above this level. Since any alteration in the height of the point H would interfere with the position of the warp line in its relation to the race of the lay, it is advisable, when this point is once properly adjusted, that all changes be made on the back rail at G. It is seldom necessary to raise G to a greater height than is shown in the diagram.

In regard to the time of shedding, when weaving light fabrics—that is, fabrics woven in a reed of coarse set—requiring cover, it is absolutely essential that the new shed be almost completely formed when the reed is at the fell of the cloth, and thus beating up the last shot on a crossed shed. To obtain this it may be necessary to adjust the shedding wypers level when the crank has just passed the bottom centre. The position of the crank when this condition obtains should be as already shown in Fig. 58, point 1, page 114. The result of this will be that as the reed carries the last shot of weft to the fell of the cloth, it will carry with it a certain portion of the slack from the top half of the shed, which permits of each alternate slack thread adjusting itself midway between the adjacent threads which are under extreme strain. Cloth woven under these conditions always presents a raw, irregular appearance in front of the reed (as indicated near E, Fig. 82), but this irregularity gradually disappears, and eventually the cloth assumes a practically perfect state. If shedding be too late, the inequality of the strain upon the two parts of the shed is reduced to such an extent that the tendency of the threads of the upper part to adjust themselves is considerably diminished.

CHAPTER X

SUPPLEMENTARY SHEDDING MOTIONS

ALL negative shedding motions require some supplementary mechanism to return the camb leaves to their original position when released by the shedding motion proper. This in its simplest form is an arrangement of spiral springs, and these (where the system of compensating rollers is not applicable), because of their simplicity and ease of adjustment, are undoubtedly the best. The system of overhead compensating rollers should, however, be applied in all possible cases, as it converts an otherwise negative action into a perfectly positive, and at the same time ideal, shedding motion. To obtain the full advantage of such a motion, however, it is essential that the rollers should be designed to take up exactly the same amount of shed as that given off by the wypers with which they are intended to work in conjunction. Fig. 83, besides illustrating most of the loom parts in relation to each other, shows how the compensating rollers or top rollers are arranged for two shafts. X and Y are parallel rollers, the difference in their diameters being due to the fact that the camb leaf W attached to the roller X receives, for reasons already stated, a greater travel than leaf V attached to roller Y. Attention is, however, drawn to the fact that this consideration, as well as the effect of the thickness of the

connecting strap, will be neglected in the following further explanation of these motions. X and Y being set-screwed on the roller shaft T, it follows that any downward movement of the leaf W will produce a corresponding upward

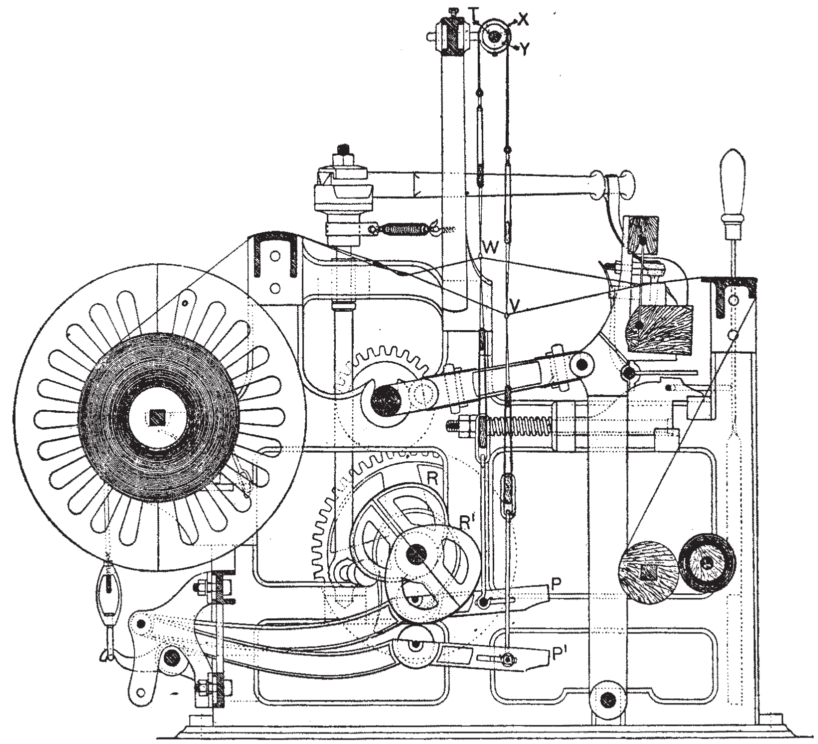


FIG. 83.

movement of the leaf V; and, *vice versa*, any downward movement of V will give a similar upward movement to W, as shown. The shedding wypers R and R^1 are constructed to actuate the treadles P and P^1 in perfect harmony, so as to produce the desired movement in the camb leaves W and V.

Figs. 84 to 87 are introduced to aid in the explanation of the action that takes place in the camb rollers for a three-leaf twill, $\frac{2}{\ \ 1}$. In Fig. 84 the leaves 1 and 2 are up, and the leaf 3 is down. K and L are the shed lines, 5 ins. apart; M is a line $2\frac{1}{2}$ ins. above L; and N $2\frac{1}{2}$ ins. above M. The rollers O and P are fixtures as regards vertical movement, their diameters being in the proportion of 1 to 2 respectively. The rollers R and S are equal in diameter, and are suspended from the roller O. In Fig. 86, the next actual step in the weaving process, leaves 1 and 3 are up,

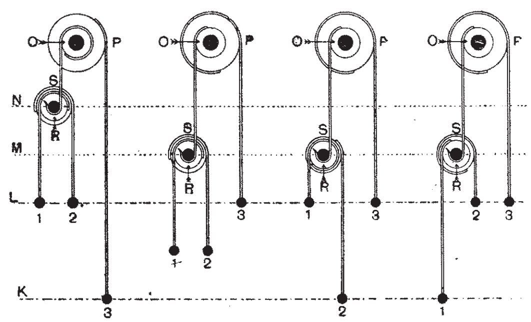


FIG. 84. FIG. 85. FIG. 86. FIG. 87.

while leaf 2 is down. How this is accomplished will be better understood by reference to Fig. 85, where the leaf 3 is represented as having moved upwards 5 ins., the roller P revolving through the same distance. The roller O being compounded with, but only half the diameter of, the roller P, allows rollers R and S, and therefore leaves 1 and 2, to fall only $2\frac{1}{2}$ ins. as shown. Leaf 2 is, however, pulled down to the bottom shed line K, which movement raises leaf 1 to its proper position by means of the rollers R and S, as shown in Fig. 86. It must not be understood that leaves 1 and 2 ever assume the position represented in

Fig. 85, this figure being introduced for explanatory purposes only; the change of position from Fig. 84 to Fig. 86 is made in one continuous movement. In Fig. 87 the leaves 2 and 3 are up, and the leaf 1 is down. In this change the downward movement of leaf 1 has simply produced an equal but upward movement in leaf 2.

Figs. 88 to 90 are explanatory of the four-leaf twill motion, $\frac{3}{\ \ 1}$. K, L, M, and N represent the same positions as in the preceding figure. The roller O simply rotates, while the rollers Q R and S T, of equal diameters, may be

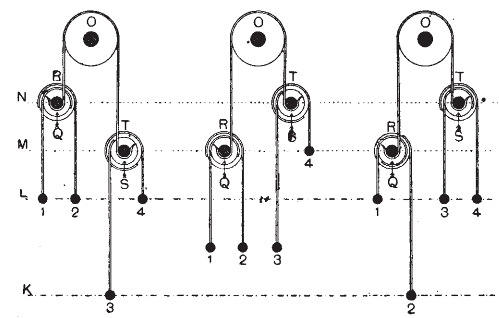


FIG. 88. FIG. 89. FIG. 90.

raised or lowered at will. The change from 1, 2, and 3 up and 4 down to the position shown in Fig. 88 is a simple movement already explained. The change from Fig. 88 to Fig. 90 is again, in actual work, one continuous movement, Fig. 89 being introduced for explanatory purposes. Here the roller O has revolved through $2\frac{1}{2}$ ins. (from its position in Fig. 88), raising the rollers S and T, and lowering rollers Q and R, through equivalent distances ($2\frac{1}{2}$ ins.). This would bring leaves 1 and 2 to the centre of the shed, and leaves 3 and 4 to the position shown; leaf 4 is, however, retained at the line L, which causes the leaf 3 to be raised to the same level, while leaf 2 is taken to the bottom line, at the same time returning leaf 1 to its position on line L.

In Figs. 91 to 93 (explaining the action in a five-leaf twill, $\frac{4}{1}$) K and L are again the shed lines, 5 ins. apart, the two lines A and B dividing the shed into three equal parts of $1\frac{2}{3}$ ins. each, while lines C to H represent positions also $1\frac{2}{3}$ ins. apart. In Fig. 91, where leaves 1, 2, 3, and 5 are up and 4 down, the first two are suspended from rollers

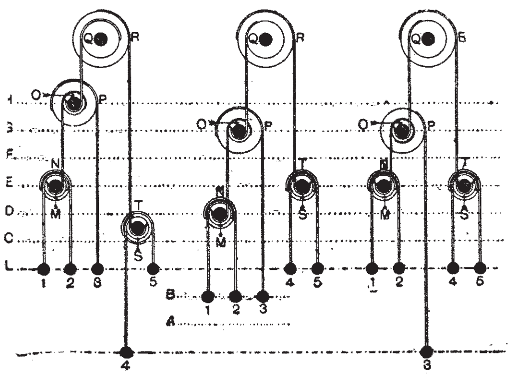


FIG. 91. FIG. 92. FIG. 93.

M and N of equal diameters, these in turn being suspended from the roller O compounded with the roller P, to which is attached the leaf 3. The diameters of O and P are in the ratio of 1 to 2. These three leaves (1, 2, 3) are attached to the roller Q, with which is compounded the roller R, these two latter having diameters in the ratio of 2 to 3. Leaves 4 and 5 are suspended by rollers S and T (of equal diameters) from the roller R. Q and R simply rotate, while the others may be raised or lowered at will. In this figure it will be observed that the rollers S and T

occupy a position midway between lines C and D. The leaf 4 rises to the line L (5 ins.) and allows the rollers S and T to rise to the line E, a distance of $2\frac{1}{2}$ ins. (*i.e.* $\frac{5}{6}$ in. + $1\frac{2}{3}$ ins.); roller R will therefore rotate $2\frac{1}{2}$ ins., but roller Q—being only two-thirds the diameter of roller R —will give off only $1\frac{2}{3}$ ins. ($2\frac{1}{2}$ ins. $\times \frac{2}{3} = 1\frac{2}{3}$ ins.) of strap, allowing rollers O and P, and therefore leaves 1, 2, and 3, to fall through this distance, as shown in Fig. 92. Leaf 3 is, however, taken down to the line K, a further distance of $3\frac{1}{3}$ ins. ($1\frac{2}{3}$ ins. + $1\frac{2}{3}$ ins.), and in doing this returns leaves 1 and 2 to the line L ($1\frac{2}{3}$ ins.), through the medium of rollers P and O, whose diameters are as 2 to 1 as stated. This action places the leaves in the positions shown in Fig. 93. The further motions in the five-leaf twill are, as already explained, under the three-leaf twill, and need not be recapitulated. Any practicable number of leaves may be similarly connected, and the diameters of the rollers compounded with each other will always be in inverse proportion to the number of leaves suspended from these rollers. Arrangements of this type necessitate the same number of leaves being raised each pick, but the numbers lifted are not restricted to those illustrated. The mounting illustrated in Figs. 84 to 87 is suitable also for $\frac{1}{2}$ twill; the $\frac{2}{2}$ twill requires simply two rollers, or it may be woven with the mounting illustrated in Figs. 88 to 90, and so may the $\frac{1}{3}$ twill. Similarly, any five-leaf weave, with a constant number of leaves lifted on each pick, can be woven with the mounting illustrated in Figs. 91 to 93. Should this uniformity of lifting not obtain, it is still possible in nearly every case to employ similar mountings, provided a special tappet be used to actuate an extra treadle for the purpose of raising and lowering all leaves from one imaginary "level" position to another.

The above motions, although excellent in principle, are seldom used where the number of leaves employed exceeds five, as they then become cumbersome and difficult to adjust; even for five leaves springs are in many cases considered preferable. In all cases where this number of leaves is exceeded, and in most cases where the number of leaves lifted varies throughout the weave, springs are invariably adopted as the supplementary shedding motion for negative tappets or dobbies. When used in conjunction with inside negative tappets the springs are supported in a simple framework bolted to the top rail of the loom, and they usually exert a direct pull on the leaves, two springs being allotted to each leaf. An improved spring-top motion, termed the "Climax," and made by Messrs. Lupton and Place, Burnley, is illustrated in Fig. 94. Each camb leaf is connected to two levers AB, A′B′, etc., all of which are fulcrumed at C and D. Each lever has a curved projection E and F which replaces the usual toothed segments. Opposite levers of each succeeding pair are connected by means of a strong spring—thus, A′ is connected to B—and the continuations E and F are reversed in position in each succeeding pair of levers in order that the one spring G may act upon all four levers and upon two contiguous leaves of the camb. The levers are arranged one straight and one hooked on, say, the left hand, and one hooked and one straight on the right, and, if necessary, double springs may be attached. Adjusting plates H are provided with pins at J and K which fit into the corresponding guide slots in the levers; the plates themselves keep the levers parallel and facilitate smooth working. The whole is bolted to the loom frame at L and M. Handle N is used to extend all springs, and so bring all the leaves of the camb to the same level for the purpose of repairing broken

threads. Where, however, the shedding motion is an outside negative tappet, or a negative dobby, an under-motion similar in some form or other to that shown in Fig. 95 is usually adopted. Connections from the camb

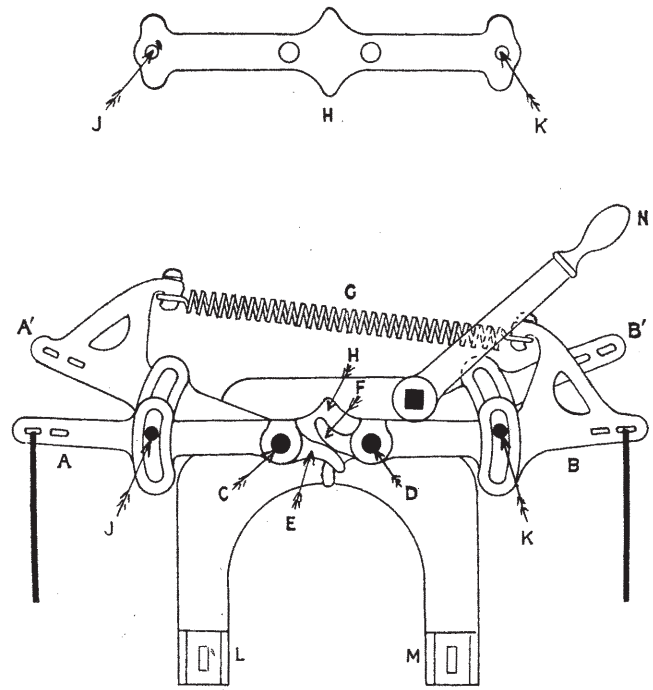


FIG. 94.

leaf above are attached to the outer ends of the spring levers A. These are fulcrumed at B, and geared together by toothed arms C, which secure equal lifts at A. In the majority of similar under-motions, springs D are connected to the framework vertically under their points of connection E. Here, however, the springs occupy a diagonal position, being hooked to the adjustable bar F in the centre of the framework. This bar provides to some extent a means of increasing or decreasing the tension of the springs in action. The main feature of the arrangement, however, is the diagonal position of the springs. It is obvious that, as the lever A rises, the line of springs D will move towards the fulcrum B, and will thus minimise the stretch of the spring. Moreover, due to this position and to

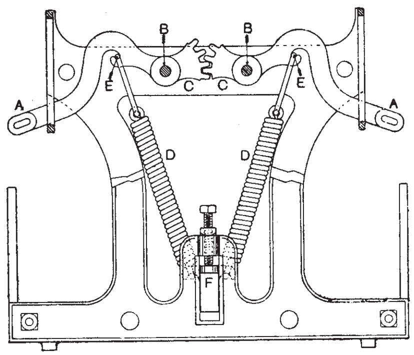


FIG. 95.

the peculiar shape of the levers A, a decided mechanical advantage is obtained, as with the upward movement of the leaf, leverage is increased at A and decreased at E. Provided it were possible in actual work to lift A until the centre line of the spring D passed through the centre of B, the pull of the spring D on the lever A, and therefore on the corresponding leaf, would be zero. In the figure, each arm A is provided with a spring D; but where desirable or necessary, each pair of arms may be controlled by a single spring, these being attached alternately right and left to each succeeding pair of levers.

A modification of Kenyon's well-known spring under-motion is shown in Fig. 96, adapted for looms of 45-in. reed space and over. It consists of a series of segment levers G, G, arranged in pairs, and connected together by links and the spiral spring H. From the outer end of each lever, connections to the leaf I above are taken, and as the latter rises, the spring H is slightly distended, but at the same time advances towards the line of the fulcra J, J, round which the levers G move. From this it is obvious that the leverage of the spring H on the lever

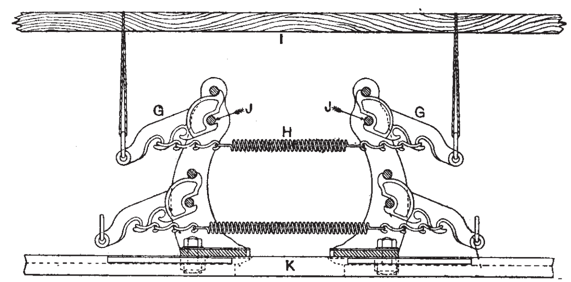


FIG. 96.

G, and therefore the pull on the leaf I, is greatly reduced. The levers G are so constructed that any one may be readily removed and replaced without disturbing any other. They are arranged in tiers in suitable frames, which may be adjusted on the rail K according to the width of the loom.

Fig. 97 shows an under-motion (also arranged for wide looms), the principal feature of which is an eccentric E round which a strap G is passed, connecting the outer end of the levers B with the tension spring F; F in turn being attached to the inner end of B by a link and thumb-screw I. This arrangement affords a means of increasing or decreasing the tension on F. The levers B are fulcrumed

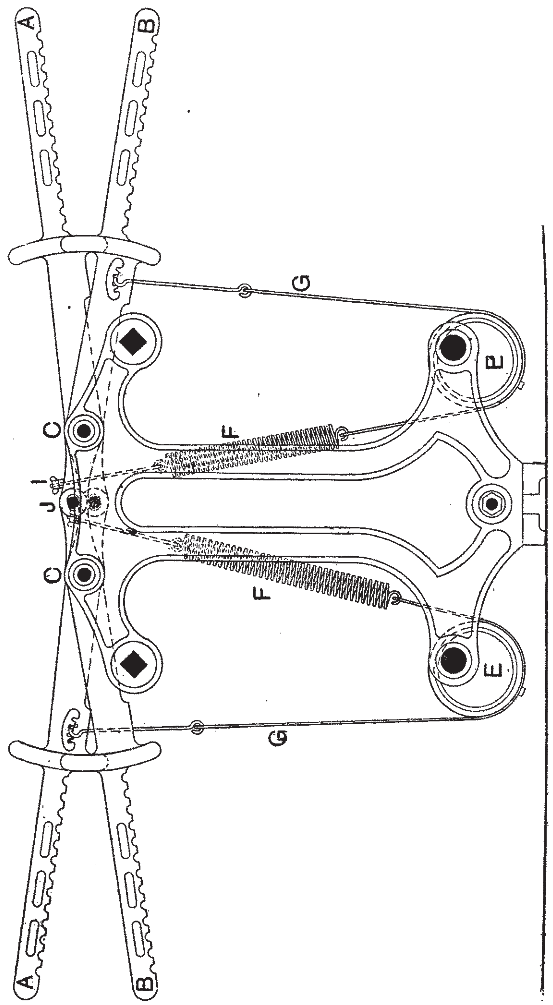


Fig. 97.

at C, and their inner ends are connected at J by a pin or

knuckle joint. The arrangement of parts is such that for a lift of 5 ins. of the leaf the spring F is distended only about $\frac{3}{4}$ in. This advantage is due to the fall at I and to the action of the eccentric E in winding the strap on its

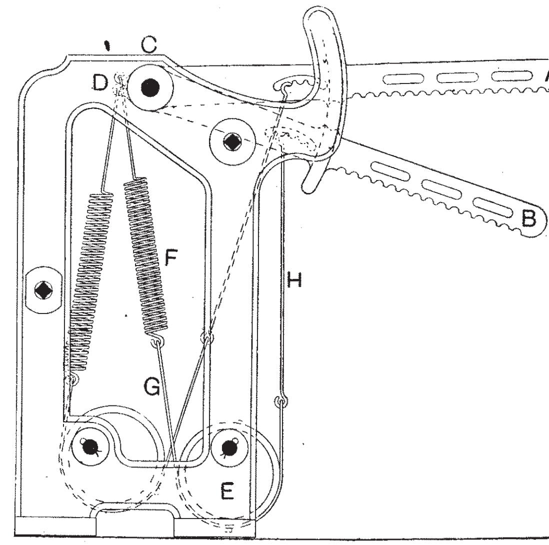


Fig 98.

thin part while unwinding from its thick part. Fig. 98 shows a similar arrangement for narrow looms.

CHAPTER XI

DOBBY SHEDDING

Dobby machines are utilised as shedding mechanisms for patterns of a character (generally symmetrical) which are beyond the scope of an ordinary tappet, and which may be more economically produced by the dobby than by a jacquard machine. Although positive tappets may be built to weave cloth the design of which occupies as many as 32 picks to the round, it is generally advisable to utilise the dobby when the picks in one repeat of the pattern exceed the limit of an ordinary negative tappet (which is about twelve), although the number of leaves required may be as few as four, the principal benefit of the dobby being that there is practically no limit to the number of picks in a repeat. Dobbies are built variously to actuate from 8 to 48 leaves, and also according to the weight or class of work required. This maximum number of leaves is rarely used even in the woollen, worsted, and cotton industries, scarcely ever for linen fabrics, and never for jute goods. Dobbies capable of operating 12 leaves for jute and 20 leaves for linen are quite large enough for satisfactory work, and provide means for developing a fairly extensive range of designs.

Figs. 99, 100, and 101 show respectively side, front, and sectional elevation of a bottom shedding dobby as usually applied to hand looms for pattern work. The griffe or block A is actuated by means of a foot treadle through the cord B, lever C, and pendant arm D, the vertical movement being ensured by the spindles E, which pass through the lugs F cast on each end of A. The lifting knife G is rigidly fixed in, and therefore moves with the block A, taking with it the selected hooks H. The catch I, in the upward movement of the block A, to which it is attached, takes hold of the projecting pins J fixed in the star wheel K on the head of the lag barrel L, and causes it to rotate one-eighth of a revolution each time. The lags M, which pass round and take into the grooves of the barrel L, are

thus brought successively into position. As shown in Fig. 101, the normal position of the hook H is off the knife—*i.e.* not in the same vertical plane,—and therefore, if

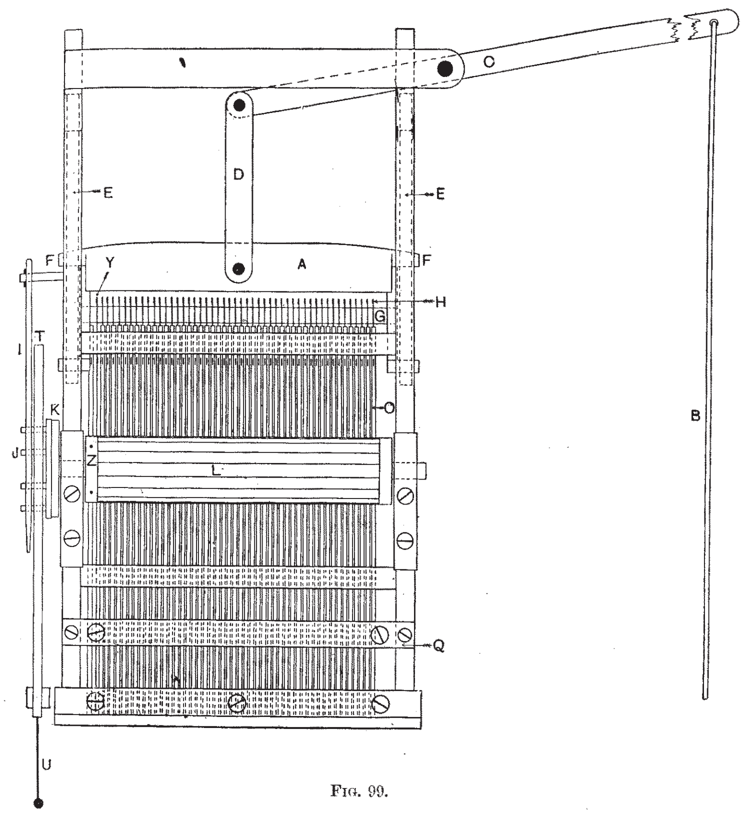


FIG. 99.

allowed to remain in this position, will not be affected by the upward movement of G. By means of a cross-wire or needle N the hook H is attached to a vertical flat spring O, against which the pegs in the lags M press. One lag is necessary for each pick of the design, and each lag is

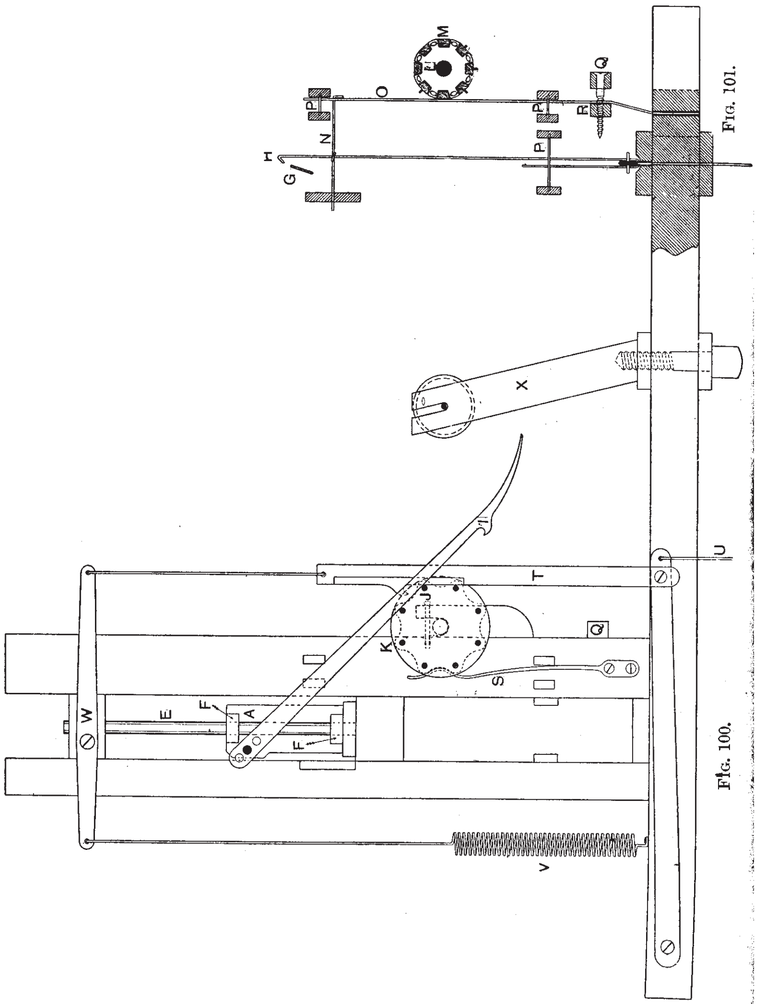


Fig. 101.

Fig. 100.

pegged according to the order of lifting necessary for that

pick. It is obvious that a peg pressing against the spring O will, through needle N, cause the hook H to occupy a position over the knife G, which in its upward movement will lift the hook H and the camb leaf attached below. When the knife G descends, the hook H is released, and the spring O returns it to its normal position, unless it is required to rise again for the following pick. P, P, P are horizontal grates for the guidance of the hooks H and springs O, and the tension or spring of the latter may be adjusted by screws in the bars Q and R. Any vibration or rocking of the barrel L, when not turning, is prevented by the spring S, the end of which is shaped to coincide with the star wheel K. Lagging back or reversing is accomplished by the catch T and cord U, while the spiral spring V and the lever W, with their connections, keep the catch T clear of the pins J when working in the forward direction. When the lags M form a chain of any considerable length they are passed round and kept taut by means of a roller in the adjustable carrier X.

The first hook Y in the machine is arranged to work a "catch-band" or selvage thread at each side of the cloth by means of pegs Z fixed in the end of the barrel L. Under certain circumstances, such as picking twice in succession from the same end, this arrangement of selvaging ceases to be effective; but the objection can be overcome by making the pegs movable instead of fixed, so that different arrangements of lifting this thread may be obtained. A further improvement, now introduced, is the addition of a second hook for this purpose, so that a proper plain or other selvage can be woven without its being necessary to peg and arrange for the same on the lags.

Fig. 102 shows one method by which the lag cylinder or barrel L of the machine illustrated in Fig. 100 may

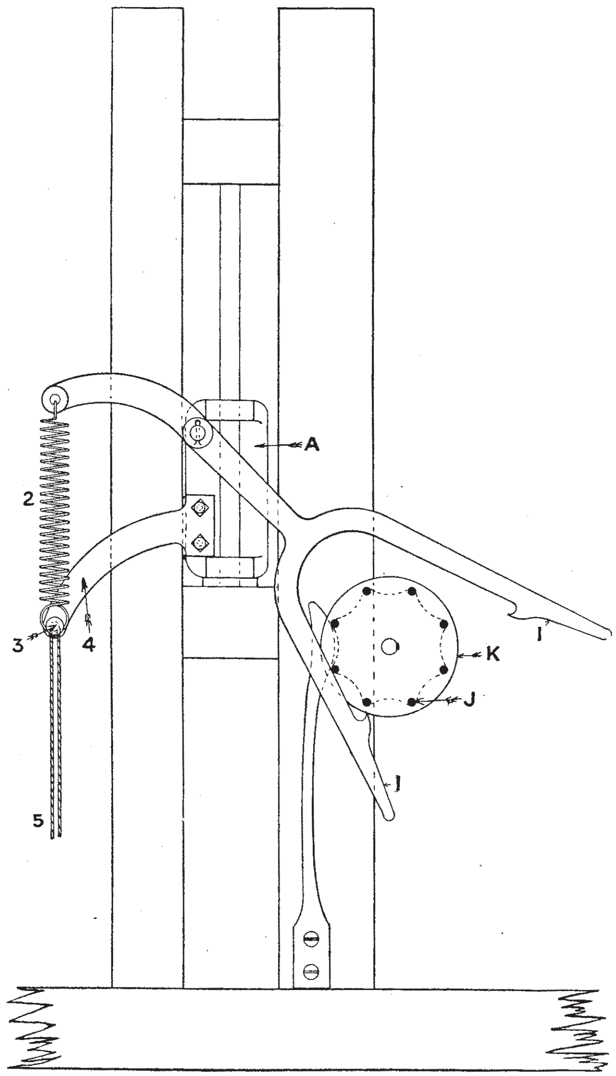


FIG. 102.

be rotated in either direction at will, and a considerable saving therefore effected in the pegging of lags for patterns which are perfectly symmetrical in the way of the weft, *e.g.* those illustrated in *Textile Design: Pure and Applied*, pages 109 to 130. In Fig. 100 the catch I is shown as resting by gravitation on the upper side of the pins J which project from the cylinder head K; consequently, as the block A rises, the cylinder is rotated always in a counter-clockwise direction. In Fig. 102, however, the catch I is forked, and, as desired, either its upper or its lower hook may be caused to operate on the pins of the cylinder head. The catch is fulcrumed loosely on a stud which is fixed in the lifting block A; it is, in this case, however, continued to the left beyond the stud, and a light spiral spring 2 attached which may be readily hooked over the stud 3 in the bracket 4—also bolted to block A—in order that the lower side of the catch I may be caused to operate, and thus rotate the cylinder in a clockwise direction. The cord 5 is attached to the spring 2, and falls to the weaver's hand so that he may readily hook or unhook the spring, and thus place the catch I in the desired position.

Positive Centre Shedding Dobby.—For the heavier fabrics it is advisable that the shedding should be positive. A dobby of a positive centre shed type for heavy fabrics, and constructed by Messrs. Charles Parker, Sons and Co., is illustrated herewith. Figs. 103 and 104 show in front and side elevations general views of the knives, hooks, and connections to the camb leaves. The lifting knife A and reciprocating grate B (fulcrumed at C and D respectively) are so connected that they continually move in opposite directions—*i.e.* as A rises, B falls, and *vice versa.* Each camb leaf E is connected to two hooks F and G—to F from the underside by cords passing round the guide pulleys H and attached to a flat bar I, which in turn is

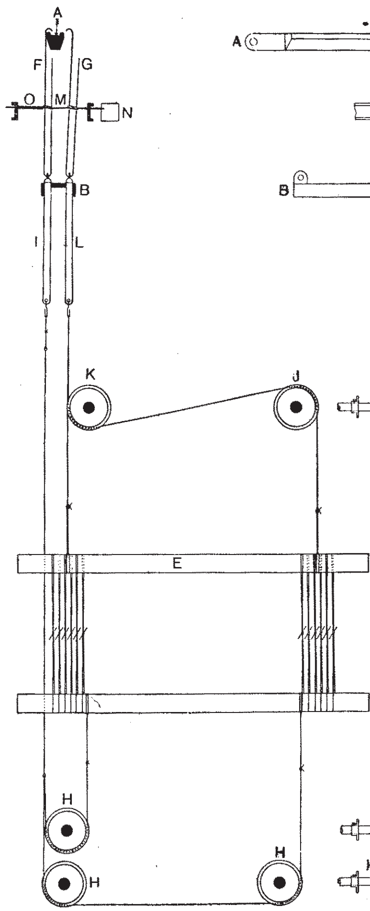


FIG. 103.

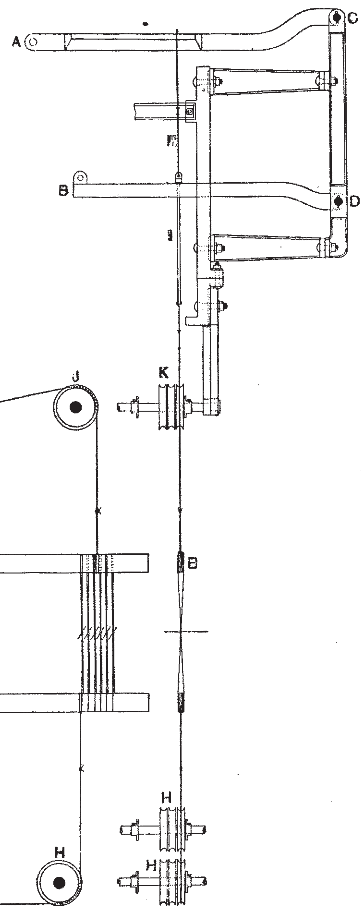


FIG. 104.

hooked on the lower end of F; and to the hook G from the upper side by cords passing over J and under K to a

similar bar L hooked to G. The bars I and L slide freely in corresponding slots in the grate B, and are provided with a shoulder at their upper end which keeps in touch with B when falling, and by which B lifts them when rising. The hooks F and G are controlled by one needle M in such a manner that both cannot be over the lifting knife A at one time; they are thus free to move in opposite directions. If, therefore, as in the figure, F be over the knife and be taken up with it, the leaf E and hook G are pulled down in a corresponding degree, the latter being permitted to fall by the downward movement of the grate B. It is apparent that as hooks F and G are level, the knife A and grate B are in their lowest and highest positions respectively. The respective positions of the hooks F and G are determined by means of cards passing round the cylinder N. A hole in the card opposite the point of the needle M permits the needle to enter the cylinder as the latter advances, and the hook F will be lifted. If, on the other hand, a blank card be presented, the needle M will be pressed back by the advancing cylinder, thus placing hook G over the knife, and forcing F clear. The spring O always tends to place the hook F over the knife, unless prevented by the card on the cylinder, as stated. It will thus be seen that a hole in the card means a falling leaf. Being a centre shedding dobby, all hooks, and therefore all leaves, are brought level after each pick. Guide pulleys J and K revolve freely on studs carried by brackets bolted to the top girder rail of the loom; while pulleys H revolve on similar studs carried in special frames usually fixed to the floor.

The method adopted for driving the dobby is shown in Fig. 105. The connecting rod P (provided with a union screw for adjusting the level of the lifting knives) imparts motion from a crank or eccentric on the crankshaft to the outer arm of the lever Q, fulcrumed at R, the extremity of its inner arm being connected to the lifting knife A by the vertical connecting rod S. A method of driving is sometimes adopted which imparts a partial dwell to the leaves when the shed is open. The reciprocating grate B receives its motion from the same lever Q, through the

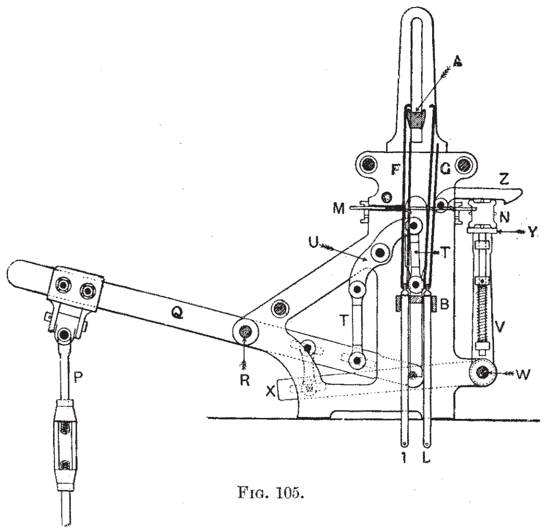


Fig. 105.

rods T and lever U. This will be better understood by referring to Fig. 106, where the solid lines represent the machine when the lifting knives are level, and the dotted lines similar parts when the shed is open. In consequence of the necessary clearance between the knife A, when horizontal, and the hooks, the knife A will commence to rise before the hooks which are to be lifted, although those hooks which are required to be down will commence to fall simultaneously with both the upward movement of A and

the downward movement of B. Apart from this, however, the connections clearly show that any upward movement imparted to A will produce an approximately equal but downward movement in B. A and B in the figure have been moved through an angle of 90° from their true position.

Referring again to Fig. 105, the card cylinder N is

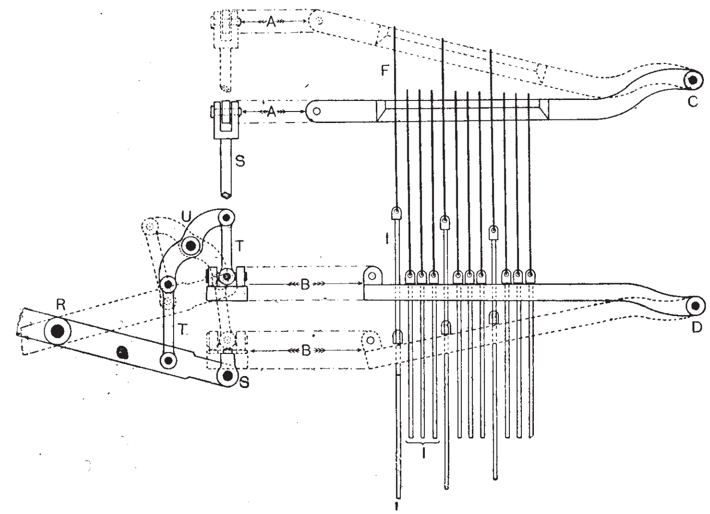


Fig. 106.

supported at each end by similar arms V set-screwed to the rocking shaft at W, motion to which is imparted by the lever X connected to the lever Q, as shown. An ordinary spring hammer Y is introduced to aid in levelling the cylinder and in preventing vibration when selecting the hooks. The downward movement of the rod P raises the lever X, throws out the arms V and the cylinder N, the corner of the latter, in its outward movement, being caught by the catch Z and forced to rotate towards the needles. The cylinder N is double-decked—*i.e.* provided with two

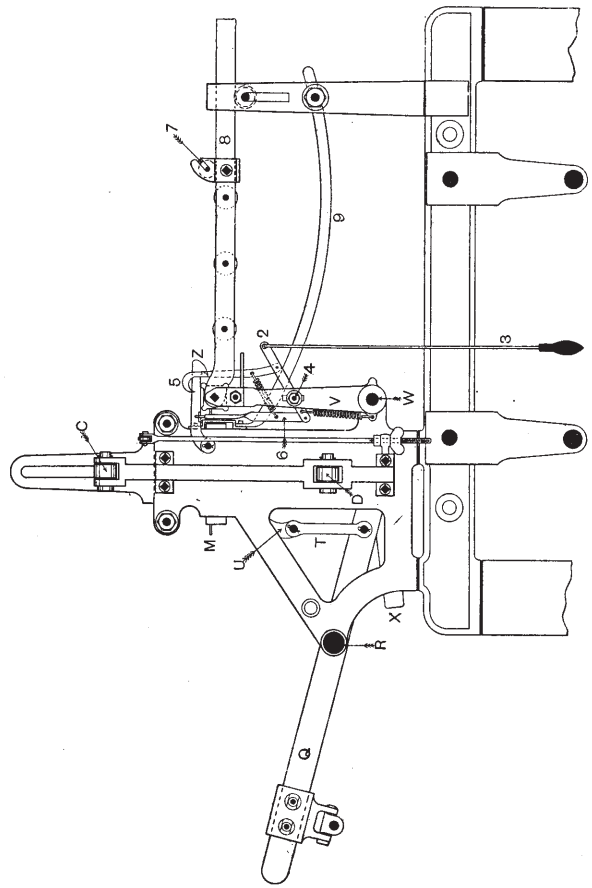


Fig. 107.

rows of holes on each face,—and may thus be adapted for cross-border or similar work, such as seamless bags. When intended for this kind of work, either the needle-plate must

be depressed or the cylinder N raised, so that the bottom row of holes may face the needles. To effect this change slight additions to the machine are necessary.

The arrangement for reversing the cylinder is shown in the front view of the dobby in Fig. 107. The lever 2, actuated by the cord 3 and fulcrumed at 4, carries the pulling catch 5 and lifting bar 6. The cylinder N, being thrown out clear of the needles, is reversed by pulling down the cord 3, and therefore the catch 5, the lifting bar 6 meanwhile raising the catch Z clear of the cylinder. Short chains of cards are kept taut by means of a roller 7 carried by adjustable brackets on sliding rods 8, which move in and out with the cylinder N. Long chains of cards are wired and pass over the roller 7 from the card race 9.

Keighley Dobby.—Since its introduction by Messrs. George Hattersley and Sons about the middle of last century, the Keighley dobby in its various forms has been exceptionally successful in obtaining wide recognition and extensive adoption. Especially is this the case for light and medium goods, as for these classes of fabrics there are probably more dobbies in use of this type than of any other. Although machines on this principle are made by several different firms, their general characteristics are in all respects the same, and will be readily understood from the following illustrations and description of those made by Messrs. Ward Brothers, of Blackburn. Fig. 108 is a sectional elevation of a right-hand, double-lift, negative open-shed dobby, viewed from the front of the machine. Being a double-lift machine, motion is imparted from a crank on the bottom or wyper shaft, through the connecting rod A, to the ⊣ lever B, the rod A being connected to the lever by a universal swivel joint. The lever C corresponds with the arms of the ⊣ lever B at the other side of the machine, both being outside the framing, keyed to shaft D, and therefore moving in unison. Each arm of the lever C, and the corresponding arms of the lever B, carry near their extremities an eye-bolt E, through the eye of which the end of the corresponding horizontal drawing knife is passed; each eye-bolt being also attached to an arm of the driving lever by a knuckle joint F. The camb leaves are attached by straps or cords to the long arms of the bell-crank lever G, fulcrumed at H, and con-

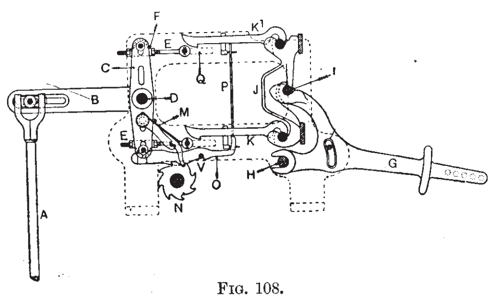


Fig. 108.

nected at I to the beam levers J, the drawhooks K and K^1 being connected to the levers J as shown. The octagonal lag or pattern barrel L is driven negatively from the lower arm of the lever C by the pushing pawl M, which, through the ratchet wheel N at the head of L, turns the latter one-eighth of a round every revolution of the wyper shaft. It will thus be seen that one lag determines the position of the levers G for two picks, and therefore effects an economy in the number of lags. The drawhooks K, K^1 are supported by the inner arms of the levers O and O^1, the top hook by means of a steel needle P, and the bottom hook direct by a suitable bend on the arm of the corresponding lever. The fulcrum V of the levers O, O^1 is so situated, and the

outer arms of the levers so weighted, that the tendency of these levers is always in favour of keeping the draw-hooks K, K^1 clear of the horizontal drawing knives. In their normal positions the outer arms of O, O^1 will rest on the lag barrel, and so long as the corresponding hole in the lag remains unpegged, no change in the position of the drawhooks will take place, the knives simply moving to and fro in the guide slots Q in the framework. If, however, a lag be pegged, the outer arm of the corresponding lever O or O^1 will be lifted, the inner arm will fall, and at the same time the supported drawhook will fall over

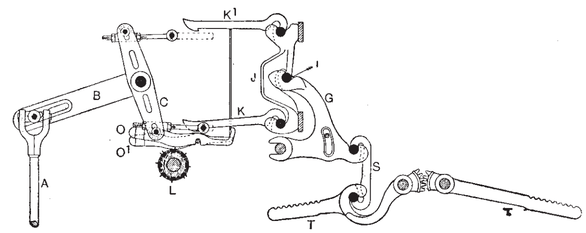


Fig. 109.

the drawing knife as shown in Fig. 109. When this occurs, the driving crank on the wyper shaft will be at, or near, its bottom centre, and will have caused the arms of the evers C and B to place the drawing knives in the positions indicated. From the figure it will be seen that it is the lower drawhook K that has come into contact with the drawing knife, the top hook K^1 being still clear, due to the fact that no peg has been inserted in the lag at the position immediately underneath the lever O^1. The crank, in moving from the bottom to the top centre, reverses the positions of the arms of the levers C and B, and therefore of the drawing knives, as shown in Fig. 110. In performing this change the lower end of beam lever J is withdrawn from R^1, at the same time raising the bell-crank lever G and the leaf attached. R and R^1 are parts of the framework which are utilised as fulcra for the ends of the beam lever J; when K^1 is in action R^1 is the fulcrum, and when K is in action R is the fulcrum. When the crank again reaches the bottom centre, the lag barrel will have been rotated one-eighth of a revolution clockwise, and a peg will be under each lever O and O^1, and both drawhooks will fall, and be acted upon in turn by their respective drawing knives. When this occurs—*i.e.* when a leaf has

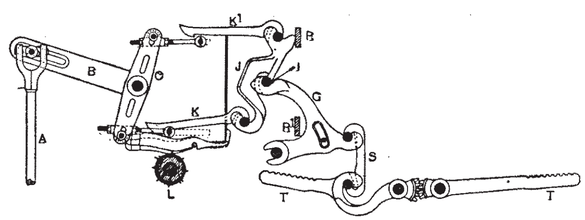


Fig. 110.

to be up for two or more picks in succession—the beam lever J simply moves about its connection with the bell-crank lever G at I, imparting little or no movement to the latter lever. With the bell-crank lever G prolonged, as in Fig. 108, the connection to the leaves must be by means of bow bands; but with connections S and T, as in Figs. 109 and 110, a more direct and steady lift is obtained. By making the connections to the leaves nearer to, or farther from, the extremities of the levers T, a varied lift may be acquired. Variation of lift may also be obtained by adjusting the knuckle joint F in the slots of the driving levers C and B.

A further decided improvement in the double levers by

Messrs. Lupton and Place, Limited, Burnley, is illustrated in Fig. 111. Here it will be seen that the movement of the levers is obtained without the usual toothed gearing shown in Fig. 110. The drawhooks, beam lever, etc., are practically unaltered except at the fulcra, but the outer jack or bell-crank lever G, while being fulcrumed as before at H, is prolonged so as to connect directly with one end of the leaf, while the link S conveys the movement to

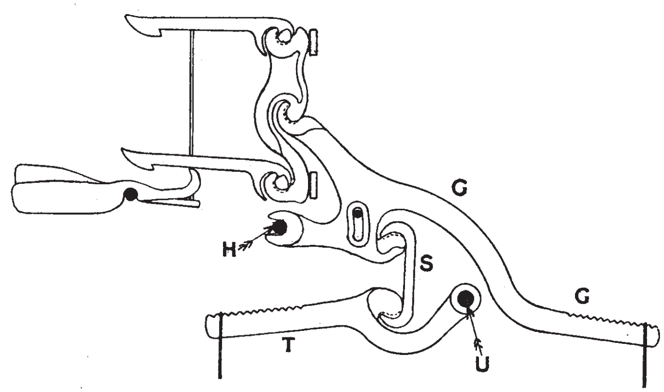


Fig. 111.

an inner lever or jack T, fulcrumed at U, which connects with the other end of the leaf.

Fig. 112 shows a weave pegged for 16 leaves, 8 picks to the round, complete on 4 lags; but since the barrel is octagonal, 8 lags would be necessary to complete a chain. The second 4 lags would be similar in every respect to those shown. The pegs on the barrel L (beginning with that peg under lever O) represent the first thread of the weave—picks A to H twice over. The arrangement of pegging as shown in Fig. 112 is, however, suitable for a left-hand loom only. When pegging for a right-hand loom