

THE MECHANISM
OF
WEAVING

THE MECHANISM OF WEAVING

BY

THOMAS W. FOX, M.Sc.TECH.

FORMERLY PROFESSOR OF TEXTILE MANUFACTURES AT THE MUNICIPAL
COLLEGE OF TECHNOLOGY, MANCHESTER

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PREFACE TO THE FIFTH EDITION

IN view of the wide circulation and general popularity which this work has enjoyed, I readily acceded to the request of Mrs. Fox to undertake its revision for a new edition.

In carrying out the task I have endeavoured to make as few alterations as possible to the previous edition, in order that its distinctive character might be preserved.

W. M.

January 1922.

PREFACE TO THE FIRST EDITION

THE hand-loom was a comparatively simple machine, and the beauty of its productions depended chiefly upon the handicraft skill of the weaver; but with the introduction of the power-loom, weaving became a new industry. With new machinery, and new processes, a want of definite information respecting their functions and actions was keenly felt, and books were published which dealt with the more pressing problems. Nevertheless, when an impetus was given to technical education by the establishment of technical schools, the paucity of this class of literature was revealed.

During recent years several admirable books have been written on weaving, but it has been too much the custom to consider designing, fabric structure, and the calculations relating thereto, as the most important parts of the subject. Hence, only one treatise has appeared within the last twenty years in which the mechanical side of weaving has not been subordinated to the structural side.

The present treatise is designed to supply this deficiency, and to place within the student's reach exact and practical information bearing upon the principles of weaving as exemplified in the various processes of the trade. If this book assists in some small degree to give students a better

knowledge of the textile industry, the author will feel that his labour has not been in vain.

Within the compass of this volume it is manifestly impossible to deal fully with all kinds of weaving mechanism. Some branches of weaving have been unavoidably passed over, but an effort has been made to include the leading types of machinery.

The illustrations have been mainly prepared from machines and appliances in the Municipal School of Technology, Manchester.

MANCHESTER, *September* 1894.

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PART I

INTRODUCTION

THE POWER-LOOM

THE construction of an automatic weaving machine has engaged the attention of loom-makers and others for more than a century, during which time much has been accomplished, but much still remains to be done. Many problems have been solved, many are still awaiting solution.

Various causes have retarded the rapid development of the loom, such as the nature and varying weaving capabilities of the material to be manipulated, and defective work in the spinning and preparatory departments, all of which render the application of delicate and sensitive movements essential.

The want of higher training in mechanics has led to the addition of unsuitable parts which, after a trial, had to be discarded. The comparative isolation of loom-maker from loom-user has also placed both at a disadvantage; the one from lack of practical experience in the use of the loom, and the other from lack of mechanical skill to carry out ideas that daily contact with the work suggested. Nevertheless, part after part has been

permanently added as the needs presented themselves, and the credit for such additions must be equally shared by weavers, overlookers, mill managers, manufacturers, and machinists.

The loom is a machine in which a series of intermittent movements are required to control its various parts; and all must be accurately timed and fixed to ensure a regular sequence. The aim should, therefore, be so to unite the parts that one cannot get out of harmony with another; but, after a century spent in developing the loom, its parts are often so imperfectly connected that, on reversing the motion of a slay, some continue to move in their normal direction, while others are reversed. This is a cause of much annoyance and loss of time to the weaver.

Taking-up motions, dobbies, and Jacquard cylinders are the most familiar instances of this; for many looms, provided with specially designed pieces of mechanism, still require the Jacquard cards, the picking-chain, the box-chain, and the taking-up motion to be separately adjusted after unweaving, and before restarting the machine. There are, however, other looms in which all the principal movements are positively controlled.

The mechanisms of a loom are, A, primary,—namely, shedding, picking, and beating-up; B, parts which assist or modify the primary motions, as over and under reversing gear, fast and loose reeds, check straps, buffers, breaks, and shuttle guards; C, secondary motions, as letting off, taking up, shuttle-box, weft stop, warp stop, temples, selvage, and others. In the following pages each part is separately treated with regard to construction, the principles governing it, and the means adopted for uniting all in one machine. Finally, the loom is considered as a whole, and the timing and adjusting of its parts are dealt with.

PART II

HEALDS

WEAVING consists in interlacing two sets of threads, one set placed longitudinally and the other transversely in a fabric. The longitudinal or warp threads having been carefully arranged and evenly wound upon a beam, must be separated into two lines, and a transverse or weft thread passed through the division. It is by the proper selection of warp threads for successive upper and lower lines that patterns are formed in fabrics.

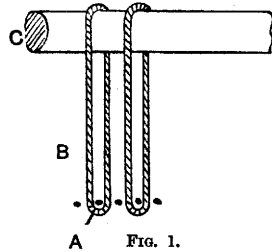
Healds have been employed for many centuries to divide the warp, because under certain conditions they supply the most perfect means of accomplishing the work technically known as shedding. But before healds can be used with advantage, the different kinds available must be described, and the purposes they are intended to serve must be defined.

From the time a heald was first introduced the principle of forming a shed was established, and it only remained for later inventors to improve upon the model and introduce new appliances for actuating it.

The most primitive heald of which there is any record consists of a series of twine loops, each passing round a warp thread and fastened to a wooden rod. The number of loops on a rod, and the number of rods employed, depend upon the breadth and closeness of the warp threads and the order of interlacing them; but for all but plain weaving the loops collectively equal the number of warp threads. A shed is formed by drawing forward the proper

rod, and thus carrying part of the threads across the rest. The rods being moved by the weaver's hands, renders the operation a slow one; still it is vastly more expeditious than the previous method of threading a needle through the warp in a manner analogous to darning.

Fig. 1 shows such a heald; the dots A are cross-sections of warp threads, B is the twine formed into loops, and C is the wooden rod to which the loops are attached. When the rod C is drawn forward, all warp threads controlled by it will be carried in advance of those operated by other rods.

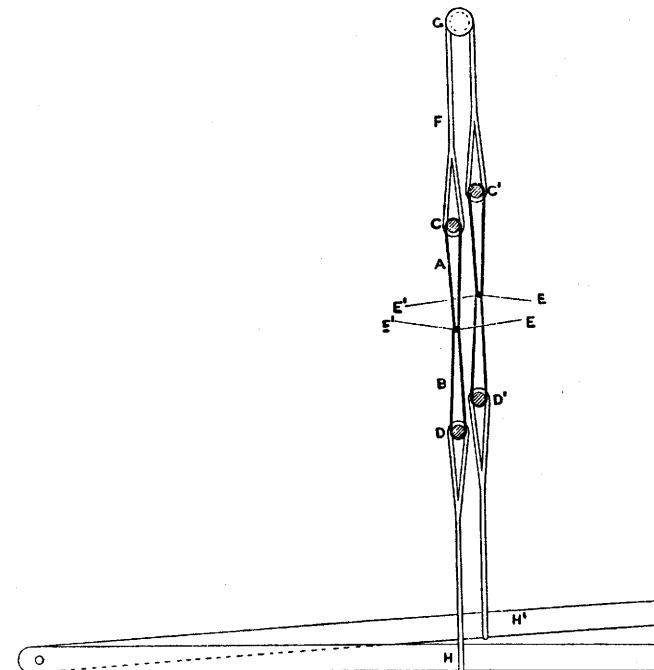


The next alteration is said to be of Indian origin, and more than two thousand years old. It is almost as great an improvement upon the primitive heald as the latter was upon older appliances. It is made by linking, or clasping.

a second and similar series of loops into those previously described, passing each round a second rod, and securing them to a "ridge band," whose office is to keep each loop in its proper place upon the rods. By the introduction of this simple contrivance the productiveness of a loom was largely increased, for the healds were actuated by the weaver's feet, and his hands were free to control other parts of the machine simultaneously instead of consecutively. Similar healds are still used in different parts of the world, but they have been superseded in Great Britain.

Fig. 2 shows the construction and the method of controlling clasped healds; A, B are two of a series of loops attached to the rods C, D. From rod C a cord F passes over a grooved pulley G to a rod C', which contains a

similar number of loops. The bottom rods D, D' are connected by cords to treadles H, H', and the warp threads E are drawn between the linked loops. When at work the weaver depresses the treadles H, H' alternately with



his feet. Assuming H to be pressed down, shaft C, D, together with the warp threads passed through its loops, will receive a similar motion; but shaft C', D', the warp controlled by it, and the treadle H', will all move through an equal space in the opposite direction. When the treadle H' is forced down the position of every part is reversed,

consequently the warp threads can be raised and lowered in a very expeditious manner; but great strain is put upon the warp when a shed is open, owing to the heald loops preventing the threads from making a sliding movement.

In Fig. 2 the healds are placed at right angles to the warp, with one rod above and the other below it, and each shaft is arranged to rise or fall vertically. When the healds are inoperative all warp threads are horizontal, but any movement of the former will bend the latter, and so increase their length between E, E'. It is desirable to leave the threads free to slide in the healds when an upward or downward movement is given to them, but with clasped healds this cannot be done, for the force exerted to move a shaft causes each pair of loops to bear tightly upon the thread between them (see 1, Fig. 3). Where weak or inelastic warps are used excessive breakage results from forming sheds in this manner.

That so many generations of skilled workmen failed to adopt the simple plan now in use, and that it should have required two stages to develop, is remarkable. The first change consisted in doubling the number of loops on each pair of rods, and in causing those loops to lie in two ranges; a warp thread was then passed over one loop and under another, so that as the rods rose or fell the warp was positively moved without undue strain (see 2, Fig. 3). The second change introduced the modern heald, which has been rendered almost perfect by tying a knot at a short distance above the point where the upper loop links with the lower half, thus forming an eye large enough for a thread of warp to move in without being unnecessarily strained. Thin laths have also displaced round rods, as they allow a larger number to be placed side by side in a given space.

No. 3, Fig. 3, shows an eyed heald; B, B' are loops which, for cotton manufacturing, vary between 10" and 14" from top to bottom; C is an eye whose depth is from $\frac{1}{4}$ " for cotton goods to $\frac{5}{8}$ " for silk goods, and D, D are the laths or shafts.

Eyed healds are used in many forms and are of varied materials, as, for example, those where twine loops support a steel, brass, glass, or other metal eye, as at 4, Fig. 3. Such healds are usually employed when rough, knotty warps have to be woven, but glass is principally used for silk and occasionally for cotton gauzes. They all offer less resistance to the passage of warp than twine eyes, and wear better; but they usually take up more room.

The following amongst other materials have been used to make healds:—Worsted, linen, silk, cotton, iron, and steel; but cotton, steel, and worsted are now chiefly employed. Down to a comparatively recent period worsted was the principal heald twine used in the cotton and silk industries, but cotton healds have entirely superseded worsted in the former, and to a large extent in the latter, because they are cheaper, will work as well as and last longer than worsted for all but exceptional purposes.

Heald-making is now a special business and is usually conducted in separate establishments. During the latter half of the nineteenth century healds were greatly improved by the introduction of automatic knitting machinery, and by the skill and care bestowed upon sizing, varnishing, and drying them; but as this branch is outside the scope of the present work, the machinery and processes requisite for its successful accomplishment will not be dealt with. Too much importance cannot, however, be attached to sizing and varnishing, for defective work at this stage produces detrimental effects in the loom, such as swollen and

twisted twine, eyes closed or sideways to the warp instead of open and facing it, roughness, lumps of size and varnish in the eyes, rigidity, stickiness, and lack of lasting properties. Healds should be flexible, smooth, capable of resisting friction and strain, and readily adjustable to any reed or pattern.

The twine of which healds are made should vary in thickness and strength to suit the warp it has to actuate. If a given twine is suitable for a fabric containing few threads per inch, it would be crowded upon the shafts if the number of loops were largely increased, and additional friction would be put upon the warp; also, twine strong enough to control fine warp would be unable to resist the strain put upon a coarse warp.

A rule that would enable a manufacturer to select heald twine with an approximation to mathematical accuracy is much to be desired, but unfortunately no such rule is available, chiefly owing to a lack of definite information respecting the effect spinning and doubling twist has in reducing the diameter of a thread, and that of sizing and varnishing has in increasing it. Several attempts have been made to proportion heald twine, but from various causes they have been rejected, and the matter is still left to the experience of the mill manager or the knitter.

The following table of yarns will serve as a guide in the selection of counts suitable for different reeds; but, although the higher foldings for any reed will make the strongest healds, they are the most costly:—

[TABLE

Reed, viz. number of dents on 2".		Suitable Counts from which a Selection can be made.				
30	36	20/40	24/50	28/60	...	...
38	44	18/40	20/50	24/60	...	...
46	52	15/40	18/50	21/60	...	...
54	60	12/40	15/50	18/60	...	...
62	66	12/40	12/50	15/60	...	...
68	72	...	9/50	12/60	16/70	...
74	80	...	...	9/60	12/70	...
82	100	...	...	...	9/70	12/80

With ordinary knitting each heald occupies a fixed position upon a shaft, and a change of pattern often necessitates a change of healds. This is both inconvenient and expensive, and adjustable twine healds have been introduced in order to render such changes unnecessary. The Miller loose heald is made from two pieces of twine and is similar to the usual eyed heald, except that above the upper and beneath the lower shaft each twine is double knotted; the first knot completes the loop, the second forms an eye through which a band is passed to prevent the healds on one shaft from becoming crossed. But the band permits each heald to slide freely into its proper place. Loose plaited healds are also used. They are made in one continuous length by plaiting, say, six strands of yarn together for a fixed distance above and below the eyes, and then twisting two sets of three strands to form the eyes and the lengths between the eyes and the ridge bands; similar plaitings, together with short lengths of twisted twine, occur above and below the shafts. The healds are folded and bands are inserted in the top and bottom loops to define the relative position of each heald. These healds are superior to others because at the eye they are no thicker than elsewhere, whereas knotted eyes are

apt to rub and break adjacent warp threads as they rise and fall. A few years ago metallic clips were employed to form eyes on twine healds, but they were not successful; experience proved them to be more costly without being more durable than ordinary healds. Other healds are made

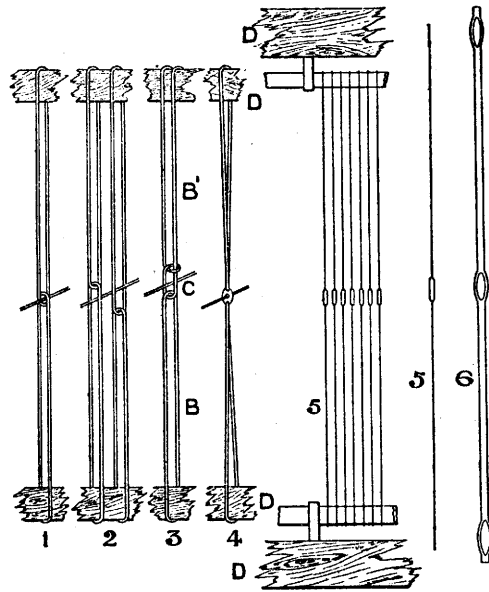


FIG. 3.

of twisted wire, a small loop being left in the centre for the warp to pass through, and longer ones at each end for the reception of shafts, upon which they are loosely placed (see 5, Fig. 3). Instead of the top and bottom loops, some are bent over and under thin metal shafts to form hooks, as then they are more readily attached and removed. Others again are made of reed wire, each strip of which has an eye punched at the centre for a thread, and slots formed near

the top and bottom to receive thin shafts (see 6, Fig. 3). When used for silk the eyes of these healds are sideways to the reed, but when used for cotton, the wire, at the eye, is slightly bent to the right and left in order that the eye may face the reed. It is claimed that wire healds last longer than twine healds, that they are perfectly smooth and equally suitable for close and open textures. Being loose upon the shafts they are self-adjusting, for each heald will readily move into its appointed position by the pull of the warp. By sliding a few healds on or off a shaft the required number can be obtained for any draft.

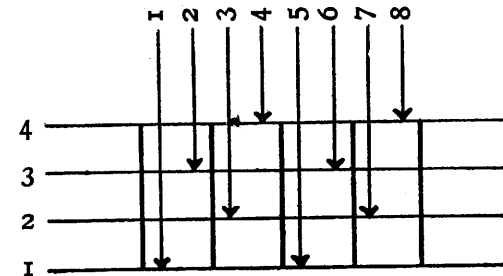


FIG. 4.

The disadvantages of wire healds are, that if one breaks, there is a tendency to cut contiguous warp threads, and being less flexible than twine, more difficulty is experienced in repairing broken warp. Many wire healds also occupy more space in the loom than those made from twine. In some manufacturing centres wire healds are largely used, but in others they are rarely met with.

The positions of healds upon the shafts must correspond with the order in which warp is to be drawn through them, and with the reed to be used. See Part XVII. For example, if a reed contains 100 warp threads per inch, the shafts in a set must contain 100 healds in one lineal inch,

but they may be equally or unequally spaced upon the shafts, therefore it will also be necessary to consider their distribution.

A reference to Fig. 4, which is a draft or plan of draw-

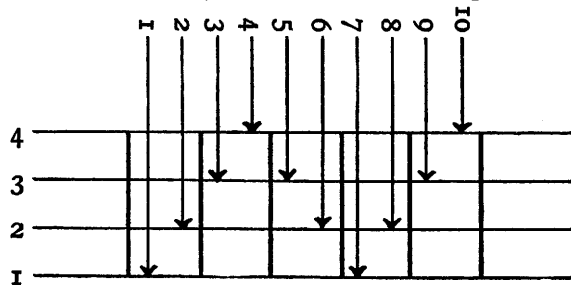


FIG. 5.

ing the warp through the healds, will make this clear. Each horizontal line represents a heald shaft; each thick vertical line a reed wire; each thin vertical line a warp thread; an arrow-head marks the position of a heald eye;

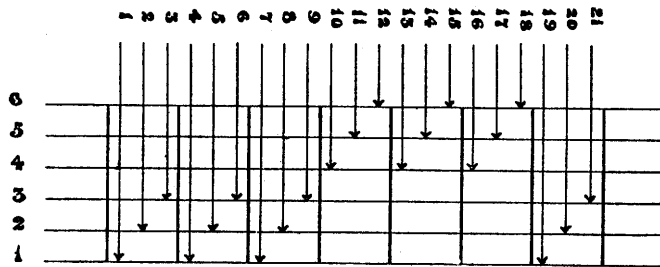


FIG. 6.

and the spaces between the thick lines show the scheme of drawing the warp into the reed.

In order to find how many threads a draft repeats upon, the position of every thread must be observed, and a place

found where the scheme recurs. Thus wherever consecutive threads from two places occupy similar positions, the repeat is obtained by counting from one point to the other.

In Fig. 4, four threads complete the pattern, because 1 and 5, 2 and 6, 3 and 7, 4 and 8 respectively occupy similar positions. In Figs. 5, 6, 7, and 8 the drafts are complete on 6, 18, 16, and 40 threads respectively.

The number of healds required for any shaft can be found by the following rule:—

$$\frac{\text{Dents per inch in the reed} \times \text{the inches of reed filled}}{\text{The number of dents filled by one pattern}} =$$

the number of patterns required:—The number of threads per pattern, on any shaft, multiplied by the number of patterns required, gives the healds for that shaft.

In the following examples a reed is assumed to contain 30 dents per inch, and to be filled for 24 inches, irrespective of selvage threads. In Fig. 4 four threads give one repeat, and they fill two dents; each shaft will therefore require $\frac{30 \times 24}{2} = 360$ repeats of the pattern on 24 inches; also,

since there is only one thread on each shaft to a pattern, 360 healds per shaft.

In Fig. 5 six threads equal one repeat, and they occupy 3 dents in the reed, $\therefore \frac{30 \times 24}{3} = 240$ repeats. Here shafts

1 and 4 have each one thread to a pattern, but shafts 2 and 3 have each two threads to a pattern. . . .

$$240 \times 1 = 240 \text{ healds on shafts 1 and 4.}$$

$$240 \times 2 = 480 \text{ healds on shafts 2 and 3.}$$

In Fig. 6 the warp threads are arranged in groups upon two sets of shafts, and in the case of all healds that occupy

fixed positions upon the shafts, it is desirable to obtain the rate and order of knitting as well as the number on a shaft.

The draft indicates three threads to each dent, and six dents to one repeat, $\therefore \frac{30 \times 24}{6} = 120$ repeats, and as there are three threads on each shaft to one repeat, $120 \times 3 = 360$ healds per shaft, but they are irregularly distributed.

The *rate* of knitting can be obtained in the following manner:—Since one dent of this reed equals $\frac{1}{30}$ of an inch, and 6 dents are used for each pattern, one pattern = $\frac{6}{30}$ of an inch; but as each shaft requires 3 healds knitting, and a space leaving equal to 3 more, it follows that 3 healds must only occupy $\frac{3}{30}$ of an inch, \therefore 1 heald = $\frac{1}{30}$ of an inch, and 30 is the rate of knitting. Or the rate of knitting may be found in this way:—

$$\frac{\text{The threads per inch in the reed}}{\text{The number of shafts in a group}} = \text{the rate.}$$

$$\text{Thus, } \frac{30 \times 3}{3} = 30, \text{ the rate.}$$

The distribution or *order* of knitting is determined by the draft and the denting, thus:—3 knitted, 3 missed, for shafts 1, 2, and 3; and for shafts 4, 5, and 6, 3 are missed, 3 knitted. In practice the healds for all these shafts would be knitted alike, but then those on the three back shafts must be placed opposite the gaps in the first three.

Some drafts are irregular in both healds and reed and necessitate the making of several distinct calculations; as in the following examples:—

In Fig. 7 the threads from shafts 1, 2, 3, and 4 are reeded two in a dent, and those from shafts 5 to 12 are four

in a dent; in all there are six dents to a repeat, $\therefore \frac{30 \times 24}{6} = 120$ repeats. Shafts 5 to 12 have each one thread to a pattern, $\therefore 120 \times 1 = 120$ healds per shaft.

Shafts 1 to 4 have each two threads in a pattern, $\therefore 120 \times 2 = 240$ per shaft.

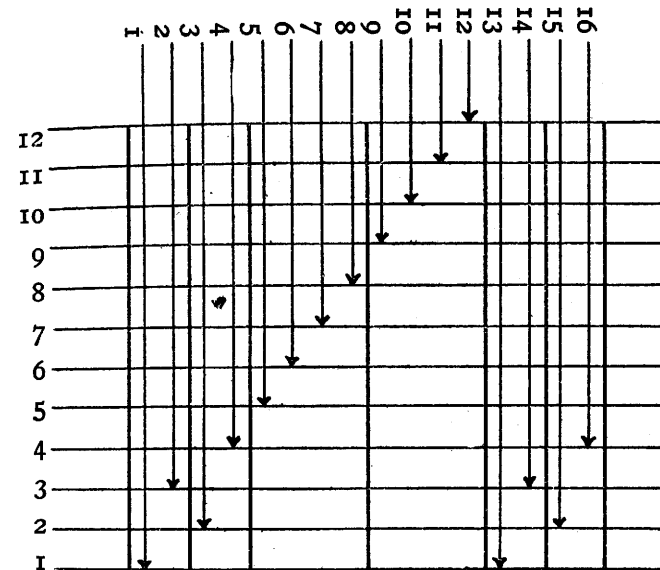


FIG. 7.

Calculations should be checked by finding the number of warp threads required to fill the reed, and comparing that number with the healds in a set; unless both correspond, an error has been made, for every thread has a separate eye:—Thus 16 warp threads per pattern \times 120 patterns = 1920 warp threads.

Shafts 5 to 12 each with 120 healds	=	120 × 8	=	960
" 1 to 4 " 240 "	=	240 × 4	=	960
		Total		1920

thus proving the preceding calculation to be correct.

The rate of knitting is as follows :—

Shafts 1 to 4 control threads which are two in a dent in the reed, or $30 \times 2 = 60$ per inch, and $60 \div 4$ shafts = 15, the rate of knitting. Also shafts 5 to 12 control threads which are four in a dent in the reed, or $30 \times 4 = 120$ per inch, and $120 \div 8$ shafts = 15, the rate of knitting.

The order is as follows :—Since the pattern occupies six dents, and there is only one thread in two dents on any shaft, it follows that provision need only be made for three healds on six dents,

∴ Shafts 1 to 4, knit 1, miss 1, knit 1.
Shafts 5 to 12, miss 1, knit 1, miss 1.

In Fig. 8 the drafts in the healds and reed are both irregular; the threads from shaft 4 are reeded two in a dent, those from the remaining shafts three in a dent, and one repeat occupies 14 dents.

$$\therefore \frac{30 \times 24}{14} = 51\frac{3}{7} \text{ patterns,}$$

$\frac{3}{7}$ of 14 dents = 6 dents; these may be filled with selvage threads, and 51 patterns used.

Shafts.	SUMMARY.	Healds.
1, 2, 3 each has 1 thread to a pattern	= 51 × 1 =	51 × 3 = 153
4 has 4 threads	" = 51 × 4 = 204	= 204
5 " 3 "	" = 51 × 3 = 153	= 153
6, 9 each has 6 "	" = 51 × 6 = 306 × 2 = 612	
7, 8 " 8 "	" = 51 × 8 = 408 × 2 = 816	
10 has 2 "	" = 51 × 2 = 102	= 102
	Total	2040

Proof.—Forty threads per pattern × 51³/₇ patterns = 2040 warp threads. In all cases provision must be made for selvage threads, either by knitting extra healds upon the shafts used for the body, or, if the selvage weave differs from the body weave, by adding separate shafts.

It has been shown that the number of dents per inch in a reed will give the rate of knitting; but it is often more expeditious, and equally accurate, to use a lower rate. It is advisable, however, that the lower rate shall be a measure of the number of dents per pattern, as $\frac{1}{2}$ or $\frac{1}{4}$. In the following example shafts 1, 2, 3 are knitted at half the reed rate, namely, 15 per inch, and the order for those shafts is, knit 1, miss 6. The order for shaft 4 is, knit 2, miss 10, at the rate of 30 per inch. This rate will place threads 1, 2, 39, 40, facing dents

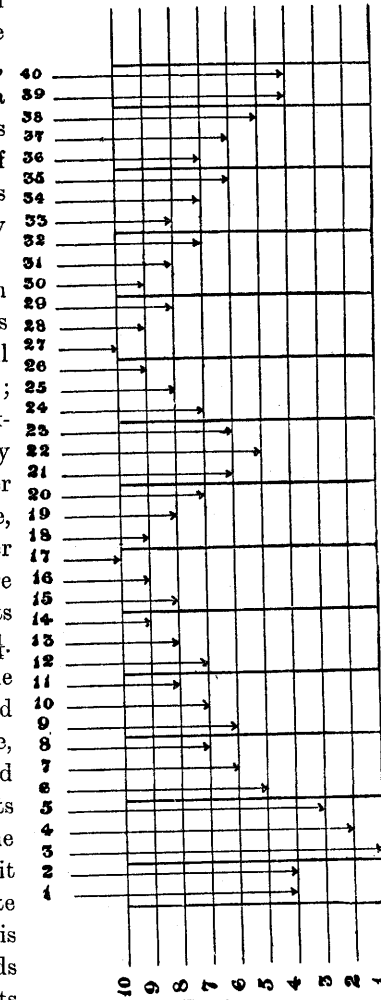


FIG. 8.

1, 2, 13, 14, respectively, instead of threads 1, 2, facing dent 1, and threads 39, 40, facing dent 14. But a rate of 60 per inch would overcrowd the twine on the shafts.

The warp is drawn one thread in an eye.

For shaft 5, miss 1, knit 1, miss 1, knit 1, miss 2, knit 1, at the rate of 15 per inch.
 „ 6, miss 2, knit 2, miss 3, knit 2, miss 2, knit 2, miss 1, at the rate of 30 per inch.
 „ 7, miss 2, knit 3, miss 1, knit 1, miss 1, knit 1, miss 1, knit 3, miss 1, at the rate of 30 per inch.
 „ 8, miss 3, knit 4, miss 1, knit 4, miss 2, at the rate of 30 per inch.
 „ 9, miss 4, knit 3, miss 1, knit 3, miss 3, at the rate of 30 per inch.
 „ 10, miss 2, knit 1, miss 1, knit 1, miss 2, at the rate of 15 per inch.

Heald-setting is resorted to when a set of healds, knitted for a given reed, is used with a coarser reed. In such an event some healds must be left empty; but they should be equally distributed on the shafts.

The order of setting can be obtained by the aid of the following formula:—

The reed to be used

—————
 The reed for which the healds are knitted — the reed to be used.

Example.—Let it be assumed that healds suitable for a reed with 39 dents per inch are to be used with a reed containing only 26 dents per inch, then there will be two full courses of the healds to one empty course from end to end.

$$\therefore \frac{26}{39 - 26} = \frac{2}{1}$$

Or, set above the reed to be used, and in the form of a fraction, the difference between the count of the healds and the reed. Reduce it to its lowest term, and the denomi-

nator will show the number of courses to be drawn, the numerator those to be missed.

Example.—The healds are 78 count, the reed to be used is 52 count; therefore, $78 - 52 = \frac{26}{52} = \frac{1}{2}$

If healds suitable for a reed with 38 dents per inch are used with a reed containing 32 dents per inch, 16 courses will be filled to 3 missed.

$$\therefore \frac{32}{38 - 32} = \frac{16}{3}$$

Or the healds are 76 count, and the reed to be used is 64 count; therefore, $76 - 64 = \frac{12}{64} = \frac{3}{16}$

In this case probably the best result will be obtained if the warp is drawn as follows:—

	5 courses filled and 1 missed.			
	5	"	"	1
	6	"	"	1
Total	16 filled			3 missed.

PART III

SHEDDING OR DIVIDING THE WARP

Two kinds of sheds are formed which are respectively known as "closed" and "open." In the former, the mechanism employed places all the warp threads level after the insertion of each pick of weft. In the latter the warp is only moved when the pattern necessitates a change of position.

There are two methods of producing closed shedding; first, by giving motion only to threads that are to form the upper line. Under this condition the warp is level on the bottom line; hence, in order to form a top shed, it is necessary to move some threads through a space equal to twice the depth of a shed, once up and once down, before a

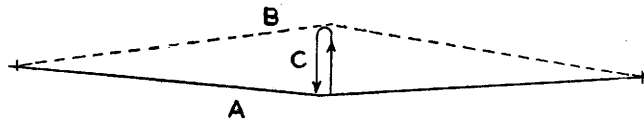


FIG. 9.

fresh selection can be made. A shed of this kind is known as a stationary bottom with a rising and falling top. See Fig. 9, where A represents the bottom line of warp, B the rising and falling line, and C an arrow showing the space passed through. The foregoing method is defective in the following respects:—1st, it takes a long time to make a change, and is unsuitable for high speeds; and 2nd,

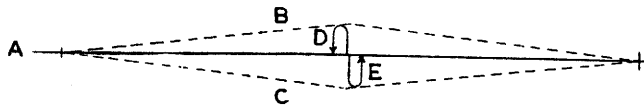


FIG. 10.

great and unequal strain is put upon the warp by moving it through an excessive space. Certain tappets, all single-lift dobbies and Jacquard machines act in the above manner.

The second method of forming a closed shed consists in imparting an upward movement to those threads which are to form the top line, and a downward movement to those threads which are to form the bottom line; then, after

inserting a weft thread, both lines are restored to the closed position, which is often half-way between the highest and lowest points of an open shed. Fig. 10 represents a centre shed; A is the closed warp line, B and C are respectively the upper and lower lines of an open shed, D and E are arrows which show the movement of each thread to equal the depth of shed—namely, half the distance in an upward and half in a downward direction.

If compared with a stationary bottom shed, it will be found superior in the following respects:—1st, although every thread is moved to form every shed, yet the strain is less; 2nd, the time occupied in opening a shed is approximately reduced by half, for the distance travelled by a thread is as 1 : 2; 3rd, a rising thread is partially balanced by a falling one; but an unsteady movement is caused by the warp being in constant motion. In this respect it is inferior to a stationary bottom shed.

Many Woodcroft tappets, the Jamieson, the oscillating, and certain others, together with all centre shed dobbies and Jacquards, act in this manner, but although closed shedding is best adapted for the manufacture of certain types of fabrics, open shedding has the widest range of application.

In open shedding the bulk of the warp forms two stationary lines, and changes are made by carrying threads from one fixed line to the other. The ascending and descending threads move simultaneously, and form a shed in the minimum of time, with comparatively little strain upon the warp, because there is no unnecessary movement given to it, and the falling threads help to lift the rising ones.

In Fig. 11 A and B are the stationary lines of warp, C and D are arrows which show the movement of falling

and rising warp to equal the distance between A and B.

This method, however, is troublesome to a weaver in proportion to the number of shafts in use; because the two fixed shed lines make it more difficult to repair broken threads than where all the warp forms a single line. Some simple and effective apparatus should be added to all open shedding motions to place the healds in one plane whenever repairs become necessary, and replace them in their original positions before restarting the loom. By one plan the top shaft A, Fig. 51, is mounted in slotted brackets but

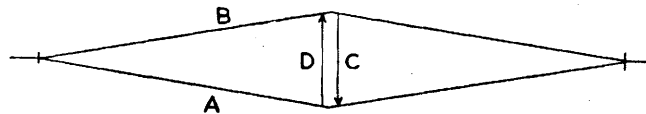


FIG. 11.

rests upon two cams. By operating a lever the cams lower the shaft sufficiently to slacken the straps 1, 2, 3, 4, 5, and bring the healds level; then, before recommencing to weave, the shaft A is restored to its normal position. Other plans are illustrated in Figs. 73, 74. Where the number of heald shafts is great, the warp in the back shafts is strained and broken more than that in the front shafts; and means have been devised for reducing such strain during beating-up. Open shedding is obtained by the use of ordinary tappets, the Hattersley, and the Knowles dobbies, and a few Jacquards.

Many of the best-known shedding motions form a shed which is compounded for the closed and open principles, and may be defined as semi-open. In it the stationary bottom line is retained, but threads from the top line either

pass to the bottom at one movement, or are arrested midway and again carried to the top.

Such a shed can be formed as expeditiously as an open one, for the upward movement begins and ends with the downward through movement, and the arrested downward movement is converted into an upward one immediately the falling threads are in the same plane as the rising ones; they all reach the top together, but the strain upon them is not so equally distributed as in an open shed. Double-lift Jacquards and certain dobbies form semi-open sheds.

In Fig. 12, A is the stationary bottom, B the top line,

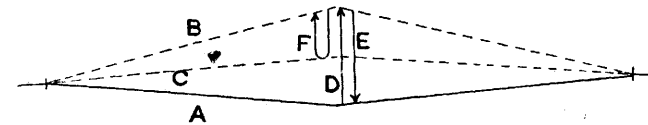


FIG. 12.

C the point where downward movement ceases in threads that are to form part of the top line for the succeeding pick, D and E are arrows showing the movements of through threads, and F that of threads which are to lift for the following pick.

On p. 3 it is stated that healds, under certain conditions, are capable of giving the most perfect form of shedding. It remains to consider what those conditions are, and in what respects healds fail to meet all requirements. Healds can only be employed when a large number of warp threads move up and down in the same sequence. A reference to any of the heald calculations, pp. 13 to 18, will show how many threads must move with each shaft. If that number is reduced and the same warp retained, the number of shafts must be increased in proportion, but a point is soon reached

beyond which it is impossible to go, owing to the great space that separates the front and back shafts when in a loom.

In the cotton trade this limit is reached at from 20 to 24 shafts, but in the worsted trade a larger number is employed. In any event, only a few warp threads can be moved independently. This is the weakest feature of healds for general work; they are only suitable for patterns which are of a more or less set character, and in which curved lines are absent or only present to a limited extent. Where flowing lines and elaborate geometrical or floral effects are required a Jacquard machine must be employed.

Healds are placed at right angles to the warp threads, and must be so connected to the shedding motion that a vertical pull will be exerted upon them, for a lateral movement, however slight, is detrimental to good weaving. They must also be moved at a varying velocity to correspond, as far as possible, with the tension upon the warp. Although this strain is not equal in all systems of shedding, still it rapidly increases as the warp approaches the upper and lower lines, hence to minimise strain the healds should move slower as the work to be done increases.

The parts generally used for heald-shedding are known as tappets, barrel motions, and dobbies. The two former are, as a rule, best adapted for the production of patterns with not more than 16 weft threads to a repeat.

In respect to length of pattern dobbies are only limited by the space provided for cards or lags; they are frequently used for more than 8 shafts, and generally so for more than 12. Still, if a tappet or a barrel motion can be conveniently employed, the best results will follow, for they are the simplest of all shedding motions; they are certain in action, and capable of lifting a heavy weft with less wear and tear than other appliances. They

can be made to move healds at any speed, and leave them stationary for any length of time. No shedding motion will put less strain upon the warp, consume less power, give a greater output, or cause fewer defects in a finished fabric. These are points that tell greatly in favour of tappets.

TAPPETS

“Tappet, cam, and wiper are names given indiscriminately to those irregular pieces of mechanism to which a rotary motion is given for the purpose of producing, by sliding contact, reciprocating motions in rods and levers. When the rod is to receive a series of lifts, with intervals of rest, the piece is generally called a tappet; but if motion is continuous, the terms cam and wiper are used.”

Tappets are made in great variety, and are fixed on different parts of a loom—namely, under and over the heald-shaft centres; under and over one end of the heald shafts, and outside the end framing. Position is, however, often a question of convenience; but the leading ideas which govern it are economy of floor space, handiness of parts, and the best manner of performing the work to be done. For 2, 3, 4, and 5 shafts tappets are often placed under the warp, but for more than 5 shafts they are generally placed at one end of a loom. They act in different ways; the simplest in construction have merely a rotary motion, but some have a compound movement, partly rotary, partly oscillating. Tappets differ also in principle—some are negative or conditional, others are positive. A negative tappet can only either pull the healds down, or lift them; in all such motions additional mechanism must be added to impart the opposite movement, but a positive tappet controls the healds in both directions without the aid of secondary appliances.

Figs. 13, 14, 18, 26, 27, and 33 show tappets with their requisite connections in each of the positions above named.

In Fig. 13, A, A' are two plates of a negative tappet, both fixed on the tappet shaft beneath the centre of the healds C, C'. Two treadles, D, D', move on a fulcrum pin E, and each carries an antifriction roller F, F', upon which the plates act as they rotate; G, G' are straps and cords which connect the treadles D, D' to the bottom heald shafts. Cords and straps, H, H', connected to the upper heald shafts are secured respectively to the peripheries of two rollers K, K', which may be either fast or loose upon a shaft B; if fast the shaft works freely in bearings. When these tappets are in motion the treadles are alternately depressed, and the under connections impart a similar downward movement to the healds; but as the tappets are incapable of lifting either the treadles or the healds, the upward motion is entirely due to the top connections and pulleys. Thus, as one heald shaft is depressed by a treadle, the strap H is unwound from the roller K, and H' is wound upon K' or *vice versa*; therefore a sinking heald is made to lift its fellow, and the negative action of a tappet is converted into a positive one by the rollers and straps. When these tappets are placed above the healds their positive action is to lift the shafts, and rollers, springs, or weights are fixed below to reverse the direction of motion (see Fig. 27).

Various defects are common in tappet-shedding, such as over, under, and unequal shedding, and that in which the healds move as the shuttle passes through the warp, and in which they move unsteadily. Of these the most frequent is over-shedding, or making the division in the warp unnecessarily wide; this strains and breaks the threads. In under-shedding the warp is not sufficiently divided to allow the shuttle to pass through, therefore it

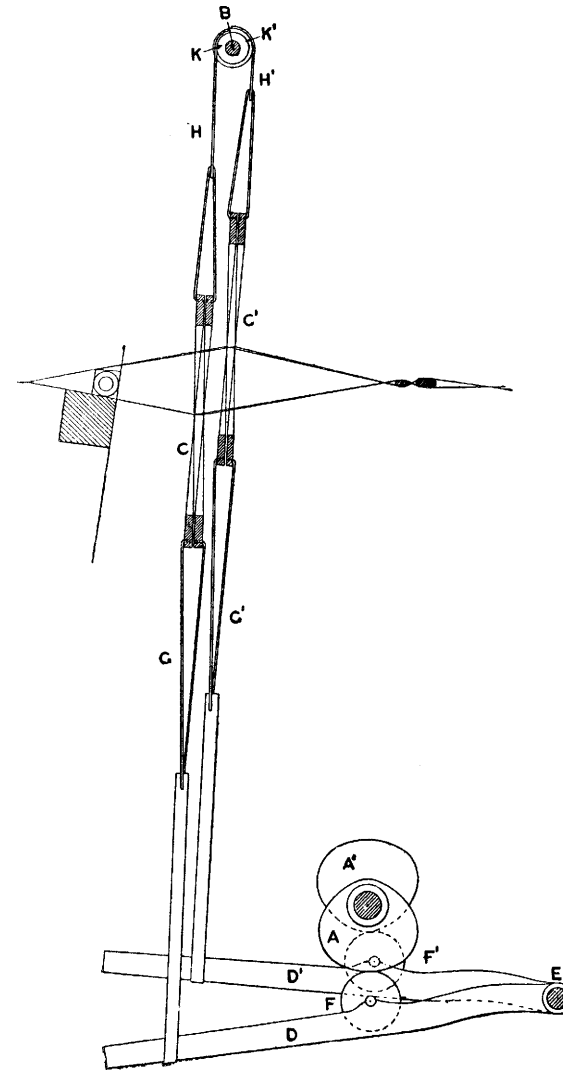


FIG. 13.

moves over threads it should move under, or breaks them, and a stronger pick is required. Unequal shedding is caused by lifting one end of a shaft more than the other, also by cording the shafts so that they do not lift or sink the warp to one level where the shuttle passes through it. When shedding is mistimed, the warp is opened or closed without due regard to the slay's motion; the cloth is then faulty by reason of the shuttle passing between the wrong threads and breaking them. If the dwell or pause of a tappet is unsuited to the fabric, the last-named defects will also be caused, and when a tappet is faulty in form, it imparts a harsh movement to the healds. In the majority of cotton looms, contact between the tappet and the treadle bowl is only maintained for about half a revolution of the tappet, hence as the tappet turns into its treading position a blow of considerable severity is inflicted upon the bowl, from whence vibration is transmitted to the healds and the warp. All these defects put unnecessary strain upon the warp, but most of them can be avoided by care on the overlooker's part.

As the quality and quantity of work produced by a loom are influenced by the form of the tappet employed, care should be taken to construct it in such a way that the greatest length and the best quality of cloth will be obtained in a given time.

Before commencing to design a tappet, the following items must be carefully considered :—

1. The pattern to be produced in the fabric—A, the number of picks of weft to one repeat; B, the order of lifting and depressing the healds.
2. The size of a tappet—A, the space through which the healds must move to give room for a shuttle

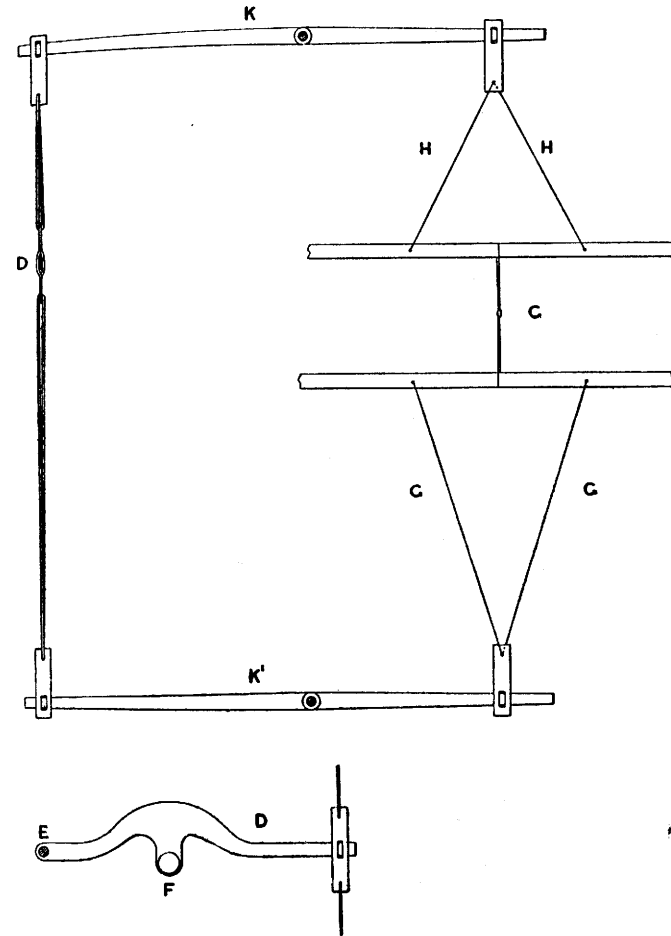


FIG. 14.

to pass through a shed; B, the difference in size between the small and large surfaces of a tappet to impart the necessary movement to the healds; C, the distance from the centre to the smallest part of the tappet surface.

3. The nature of the movement to be imparted to the healds.
4. The time during which the healds are to remain stationary.
5. The diameter of the treadle bowl.

A plan showing how the healds must rise and fall for one repeat of a pattern is given to a tappet-maker.

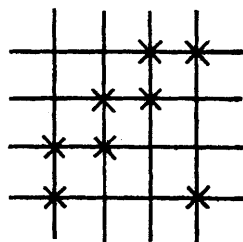


FIG. 15.

This is known as the tie-up or lifting plan; the marks upon it may represent either rising or sinking healds, but it is usual to state which is intended.

Figs. 15 and 16 show different ways of making a tie-up; in the first, each vertical line represents a tappet treadle, and each

horizontal line a heald shaft.

By reading up a vertical line, the crosses at the points of intersection show which healds are to be moved for one pick; and by reading across a horizontal line, the order of lifting one shaft for a repeat of the pattern is obtained. As one tappet plate acts only on one shaft, horizontal readings must be taken when designing a tappet, and the number of vertical lines gives the number of picks to a repeat.

The only difference between the first and second figures is that, in the latter, the spaces between the vertical and horizontal lines respectively represent treadles and shafts instead of the lines themselves.

The first of the five points named is thus seen to be a simple matter—namely, that of obtaining the number of picks to a repeat, and the order of lifting the healds.

The next point requires more attention. It is necessary to ascertain the depth of the shuttle to be used when measured along its front edge; the distance of its front edge, at the time it enters a shed, from the last pick of weft in the fabric, and the distance from the last pick to the heald shaft. The arrangement of levers, and the position of the bowl upon the tappet treadle must also be defined. In Fig. 17 all the above-

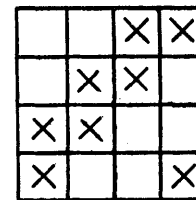


FIG. 16.

named parts are shown in working positions. Assume A, the shuttle, to be 1·125" deep; B, the last pick, or the cloth fell, to front of shuttle, 3·375"; C, the cloth fell to front heald shaft, 10"; and that from the cloth fell to the back heald shaft 12"; D, the treadle fulcrum to the bowl centre, 11·25"; D, E, the point of connection with the front heald to treadle fulcrum, 19·25", and to the back heald 17·25". Then 3·375 : 10 : : 1·125 : 3·33", the lift of the front heald; and 19·25 : 11·25 : : 3·33 : 1·94", which equals the lift of the tappet for that heald. Also, 3·375 : 12 : : 1·125 : 4", the lift of the back heald; and 17·25 : 11·25 : : 4 : 2·609", which equals the lift of the tappet for the back heald.

When a tappet is placed at the end of a loom, additional levers are required, as seen in Figs. 14, 18, and 19.

In Fig. 18 A is a shuttle 1·125" deep at its front edge; B, the cloth fell to front of shuttle, 2·75"; C, the cloth fell to heald shaft, 8·5"; D, the top lever fulcrum to heald strap, 5·75"; E, the top lever fulcrum to treadle connection, 6·5"; F, the treadle fulcrum to centre of bowl, 22·5"; G, the

treadle fulcrum to connection with top lever, 30", $\therefore 2.75 : 3.5 :: 1.125 : 3.477$ = the lift of heald; and $5.75 : 6.5 :: 3.477 : 3.93$ = the fall of top lever at the treadle connection; also $30 : 22.5 :: 3.93 : 2.947$ = the required lift of the tappet.

Fig. 19 is an arrangement for positive shedding, but the method of obtaining the lift of a tappet is precisely similar to that in the last example: A is the shuttle which is 1.25" deep at the front; B, the cloth fell to front of shuttle, 4"; C, the fell to heald shaft, 8"; D, the top lever fulcrum to heald strap, 19"; E, the top lever fulcrum to treadle connection, 20.5"; F, the treadle fulcrum to centre of bowl, 11"; G, the treadle fulcrum to connection with top lever, 26"; H, the bottom levers, which correspond with top ones. See Fig. 14, which shows the up and down movement of a heald shaft to be equal.

To find the tappet lift—

$4 : 8 :: 1.25 : 2.5$ = the lift of the heald.

$19 : 20.5 :: 2.5 : 2.7$ = the fall of the top lever at the point where it is connected with the tappet treadle.

$26 : 11 :: 2.7 : 1.1$ = the lift of the tappet.

In order to prevent unnecessary breakage of the warp, it is desirable that a shed shall be as small as the nature of the work to be done will allow. This matter is of great importance, because the strain upon a warp increases approximately as the square of the space passed through. If, for example, from a closed shed the warp is lifted 2", the strain is represented by 4, but if lifted 3" or 4", the relative strains are as 9 and 16 respectively, hence doubling the size of a shed increases the strain fourfold.

The following simple practical test may be of use in demonstrating the above. Assume the distance from the

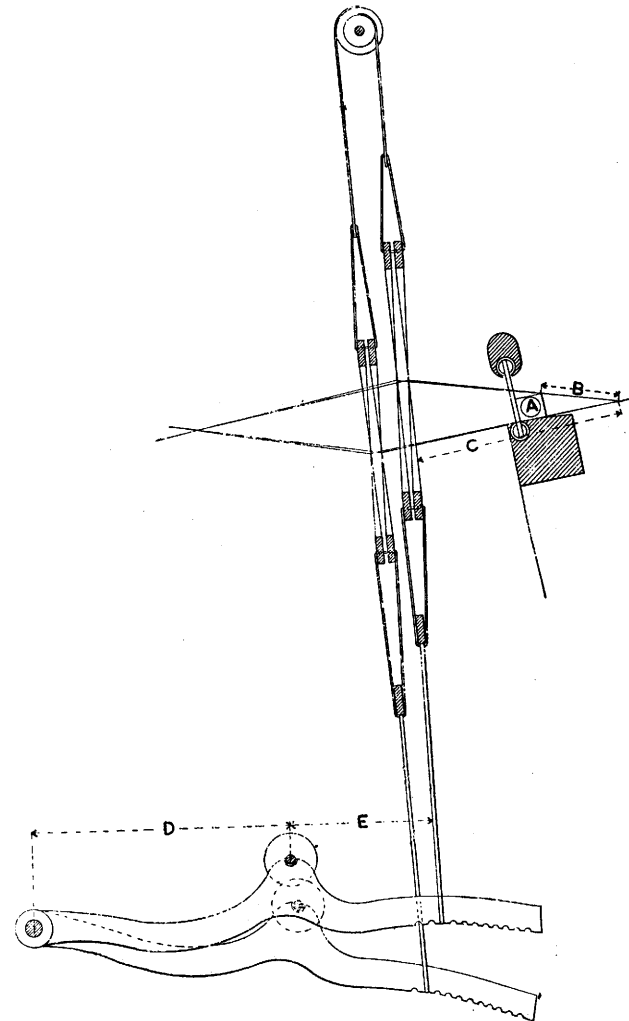


FIG. 17.

strain upon the warp. This requires a quick movement when the healds are midway between the extremities of their journey, and a gradual reduction in speed as the upper and lower shed lines are approached. Third, that movement in a heald shall only take place when absolutely

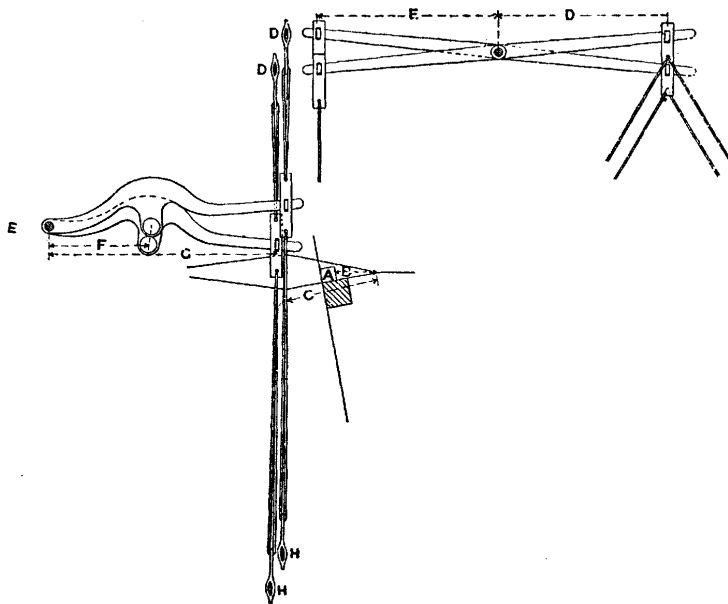


FIG. 19.

necessary. By adopting these courses jerks are avoided, and an approximately equal strain is maintained throughout the movement.

Tappets should be so made that healds will be stationary while a shuttle is in the warp; this stationary period is known as pause or dwell, but its duration must vary to suit the fabric to be made.

In certain textures the warp threads may run, more or less, in pairs without the pieces being considered defective; they are then said to be reed marked, or without cover, and the tappets employed may be made with just sufficient pause to allow a shuttle to move through the warp, and that varies from $\frac{1}{4}$ to $\frac{2}{3}$ of a pick. But in *covered* cloths all the threads are equidistant; for such, and also for heavy fabrics, a pause of $\frac{1}{2}$, $\frac{2}{3}$, or $\frac{1}{3}$ of a pick should be given.

The correct dwell for a tappet has been defined as follows:— Divide the circle described by the cranks into 12 equal parts, as in Fig. 21. If number 1 represents the reed in contact with the cloth, the shuttle will begin to move at 4; at 5 it will enter the warp; at 9 it will leave it; at 10 it will be stationary in the opposite shuttle-box. From

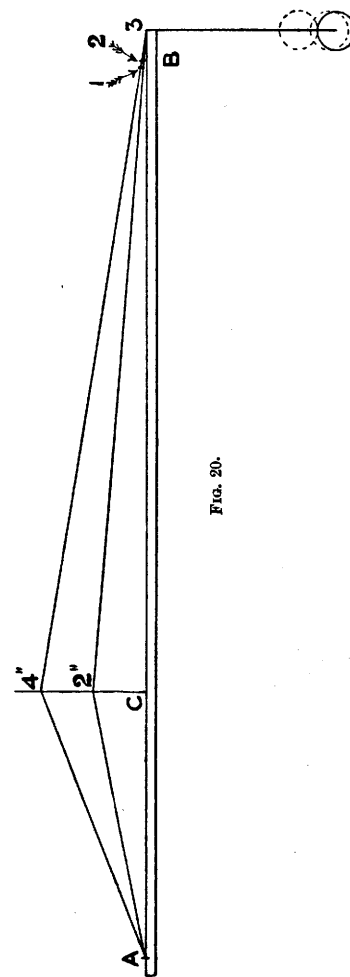


FIG. 20.

9 to 5 equals $\frac{2}{3}$ of a revolution, this is therefore the maximum time to allow for changing the positions of the healds; and from 5 to 9, which is $\frac{1}{3}$ of a revolution, all the healds must be stationary.

A dwell of $\frac{2}{3}$ of a pick has been advocated for heavy and well-covered fabrics, but this appears unnecessarily long, as any reduction in the time for moving the healds increases the strain upon the warp proportionately. Only a small

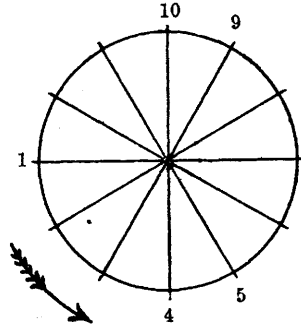


FIG. 21.

number of the tappets in use have a dwell exceeding $\frac{1}{2}$ a pick. The majority of those fitted upon Lancashire looms for weaving well-covered fabrics have only $\frac{1}{3}$ of a pick for dwell; cover can be obtained by other means. See Part XXIII.

The last point refers to the treadle bowl, which is employed to reduce friction at the point of contact with

the tappet. Generally speaking, a large roller gives a steadier motion than a small one, but the incline on the tappet surface may thereby be rendered too steep for good running. The diameters in common use vary from $1\frac{3}{4}$ " to $3\frac{1}{2}$ ", the smaller ones being used with tappets having the greatest number of picks to a repeat. A tappet must be shaped to overcome the effect an antifriction roller has upon the motion of healds, or they will rise and fall at other times and speeds than those intended.

A tappet has an irregular surface, but a *point* could be made to follow its most minute variations. A point is, however, impossible, and an antifriction roller is used,

whose surface, under certain conditions, is capable of touching two parts of the tappet surface at one time (see Fig. 26).

Whatever space there may be between the points so touched is lost to the pause of the healds, and one will begin to rise or fall before another. The only plan by which this defect can be overcome is to make the *roller*

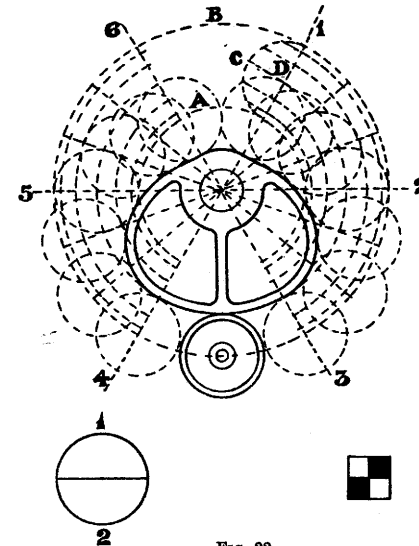


FIG. 22.

centre move as the healds are required to move, and to do this either the roller diameter must be reduced or the distance from the centre of the tappet to its surface must be increased. A tappet constructed for one size of roller will never work as satisfactorily with a roller of other dimensions.

Figs. 22, 23, 24, 25, and 28 show the methods to be

adopted when constructing tappets for different weaves; of these 22, 23, 24, and 25 are negative, or conditional, tappets.

Fig. 22 is for plain cloth. Fig. 23 is for a three-thread twill, one down, two up. Figs. 24 and 25 are for four-thread twills, one down and three up, and two up and two down respectively for each pick.

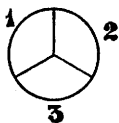
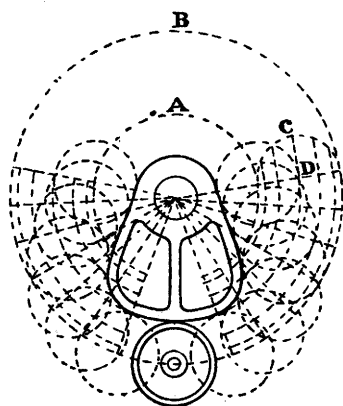


FIG. 23.

Fig. 28 is a positive tappet for weaving the 6-picked pattern which accompanies it.

Assume the plain cloth tappet to be $1\frac{1}{4}$ " from its centre to the smallest surface, to have a lift of 3", a dwell of $\frac{1}{3}$ of a pick, and a treadle bowl 3" in diameter. To draw such a tappet, describe circle A, Fig. 22, equal in radius to the distance between the tappet centre and the centre of the treadle bowl when that bowl is touching the smallest part of the tappet. This = $1\frac{1}{4}$ " + the radius of bowl $1\frac{1}{2}$ " = $2\frac{3}{4}$ "; add to that the lift of the tappet 3 " = $2\frac{3}{4}$ " + 3 " = $5\frac{3}{4}$ ", and describe a second circle B. When in action the treadle bowl constantly works on or between these lines. Since the pattern has 2 picks to a repeat, divide the circles, by a line 1, 4, into two equal parts. Subdivide each space into three equal parts, and draw the radial lines, 2, 5, 3, 6. The space 1, 3 equals $\frac{2}{3}$ of a pick, and is to be used for moving a shaft for the first pick. The space 3, 4 equals $\frac{1}{3}$ of a

pick, which is allowed for dwell. The space 4, 6 is to be used for moving the same shaft for the second pick, and 6, 1 is for dwell. Divide the spaces 1, 3 for the first, and 4, 6 for the second picks, into any number of equal parts by radial lines, say 6 each. Upon one of the radial lines describe a semicircle C, whose diameter shall equal the space separating the circles A, B, and touch both; divide the periphery of C into a number of equal parts corresponding to those in divisions 1, 3 and 4, 6 — namely 6. From each point of intersection on the periphery of C drop a line D perpendicular to its chord; the latter will then be unequally divided for the purpose of imparting a variable velocity to a heald shaft. Through each intersection on the chord describe a circle concentric with A, B. Let each point, where a radial line is cut by a curved one, represent the centre of the treadle bowl at one part of the lift; from those points, beginning on the inner circle A, and taking the others in rotation, describe circles equal in diameter to the treadle bowl, and the construction lines will be completed.

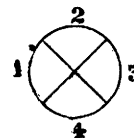
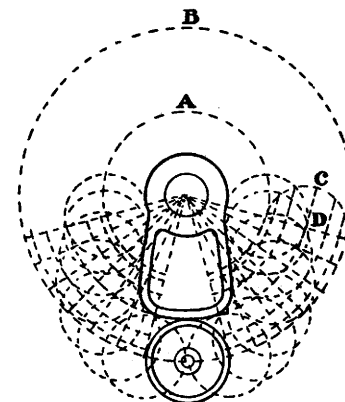


FIG. 24.

To find the shape of the tappet, trace a line touching the periphery of each bowl circle, and where the heald is

to be stationary, describe an arc from the tappet centre. What remains to be done is to show the thickness of the metal in a finished tappet, as in Figs. 22, 23, 24, and 25, and to suitably arrange the plates. For plain cloth two plates are needed, but taking the same point on the surface of each, the second plate must be turned through an angle of 180 degrees, and made fast by the side of number

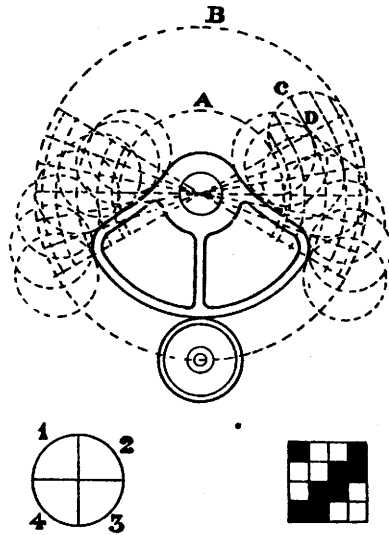


FIG. 25.

one. In Fig. 23 similar points on three plates must be placed at angles of 120 degrees to each other. In Figs. 24, 25 similar parts of four plates must be secured at angles of 90 degrees, and in Fig. 28 similar parts of six plates must be secured at angles of 60 degrees.

In order to reduce the strain upon delicate yarns during beating-up, the tappet shown in Fig. 25 would have a

slight inward curve on its surface, where the bowl is shown in solid lines, and a slight elevation exactly opposite the depression, for these reduce the size of a shed at the moment of beating-up.

Some tappets are split in the centre and provided with flanged bosses to facilitate attachment to, or removal from, a loom, and in places where changes are of frequent occurrence there is much to recommend the practice.

A tappet treadle, by swinging on its fulcrum pin, causes the friction bowl continually to change its place of contact relatively to the tappet centre; but the movement required is a rise and fall in a straight line. Hence, to approximate to the best motion, the centres of the treadle fulcrum and bowl should be in the same horizontal plane at half the lift; and the bowl and tappet centres in the same vertical plane, or the treadle will partially counteract the curved surfaces of the plates. Many looms are so constructed that the above-named adjustments cannot be made; in such cases the parts should be fixed to give a treadle, at its point of connection with the heald shaft, an equal swing in both directions from half the tappet lift. Contact between the treadle bowl and the tappet must be maintained, or the heald will have a jerky movement.

In order to place the warp level where a shuttle enters it, a back shaft must rise higher and sink lower than a front one; but if the treadle fulcrum pin is at the back of the loom as in Figs. 13 and 17, this cannot be accomplished with uniform tappet plates, for the connecting point with the back shaft is nearer the treadle fulcrum than that of the front shaft, hence the movement of a back shaft would be less instead of greater; it is usual to give an increased lift to a back plate of from $\frac{1}{8}$ " to $\frac{1}{4}$ ", but the exact amount can be determined by calculation, as shown on p. 31.

If a treadle fulcrum is at the front of a loom, the back shaft connection is farther from the fulcrum pin than that of the front shaft, for which reason all plates may be of one size, and the difference in leverage will give a difference in lift.

If the stepped rollers called cones, see *K, K'*, Fig. 13, do not wind on or off exactly as much strap as the tappet treadle gives out or takes up, the straps will not be kept at a uniform tension. Suitable dimensions for the rollers may be found as follows:—

The correct lift of the back shaft : the correct lift of the front shaft :: the diameter of the largest roller : that of the smallest one. Thus, assuming the lift of the back shaft to be 4", that of the front shaft 3.33", and the large roller to have a diameter of 2":—4 : 3.33 :: 2 : 1.665", the diameter of the small roller.

JAMIESON'S TAPPET

A negative tappet, known as Jamieson's, is placed under the healds with its axis *B'*, Fig. 26, at right angles to and in the same horizontal plane as the bottom shaft *A*. A short shaft *B* carries a large bevel *C*, which engages with one of two small bevel pinions *E, E'*, that are fast upon the shaft *A*; their teeth face each other, but only one engages with *C* at any time. When desired, however, one can be put out of, the other in, gear with *C*, to drive the latter in either direction.

A spur wheel *D* is keyed upon the tappet shaft *B'*, and gears with a pinion *C'*; it contains a bolt-hole for each pick in the round of the tappet; these holes are concentric with *B'*, and equidistant from each other. Bolts are passed through the holes, and a plate *F*, similarly drilled, is dropped

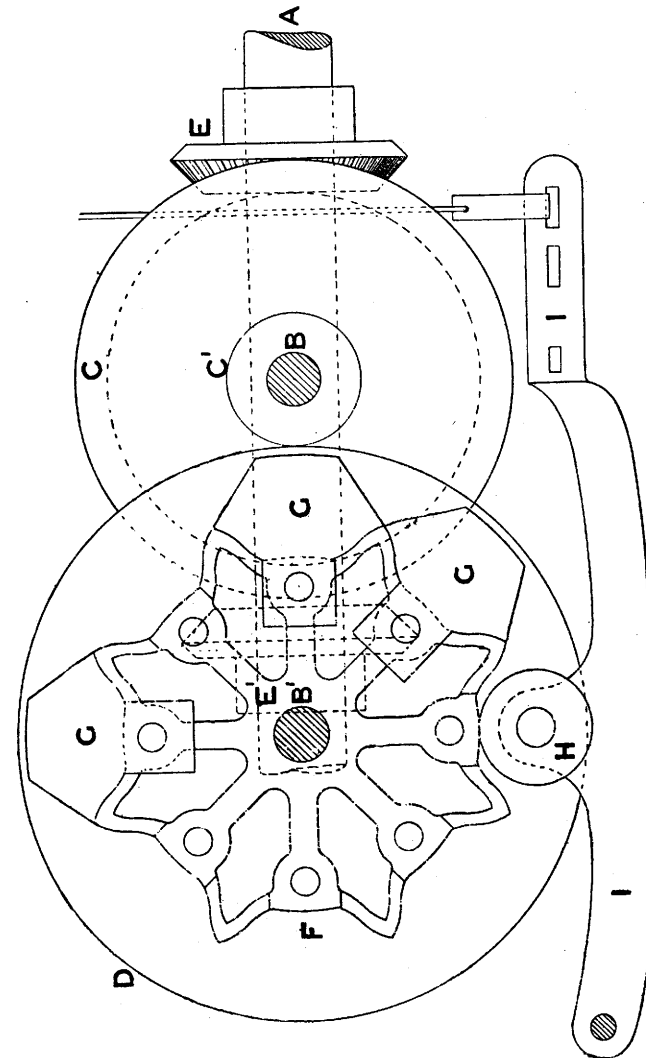


FIG. 26.

over them. The periphery of F has a slight curve over each bolt-hole, and tooth-shaped projections between them. Every bolt-hole in F passes through the centre of a slotted recess prepared for the ear of an interchangeable plate G, which fills the space between two teeth and projects above them. A plate G sinks a shaft, and a depression in F permits one to rise. When reading from a tie-up, sinkers are placed where required upon as many plates F as there are shafts to be used, and all are then bolted firmly together. The treadles I are mounted below the tappet plates, and as the antifriction bowls H bear upon F the shafts are pulled down, but springs attached to a frame above the loom lift them.

For open shedding four differently shaped sinkers are used—one to lower a shaft for a single pick, two others serve as right- and left-hand sinkers respectively when a shaft is to remain down for two or more picks, and a fourth holds a treadle bowl in one plane as it rolls against the tappet. In all segment tappets the plates are liable to work loose, and the bowls H then slip between two plates; with this exception they are valuable shedding motions.

THE BARREL TAPPET

Another negative tappet known as the barrel motion is fixed above the heald shafts with its axis at right angles to them. It is driven either from the bottom, or the crank shaft by an upright shaft A, and bevel wheels B, Fig. 27. The shaft A sometimes passes through the warp, direct to the large tappet bevel, but it is preferable to fix it to the end framing, and drive the tappet D by a short horizontal shaft C. This arrangement necessitates the use of two additional bevels and a shaft, yet the warp space of a loom is left unobstructed.

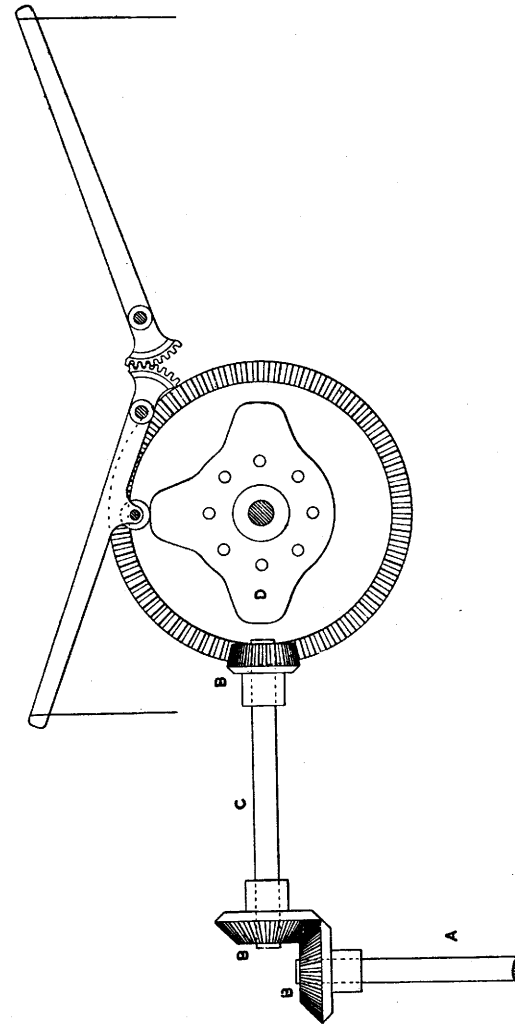


FIG. 27.

The tappet may consist of a series of solid plates bolted, or cast together, or of interchangeable sections bolted upon plates; if made in separate plates, a hole is left in each exactly in the centre of every pick, so that by turning similar plates into different positions with relation to each other, many patterns may be woven from them. If the

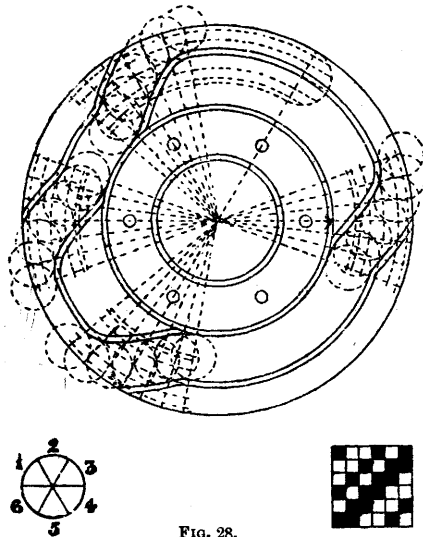


FIG. 28.

tappet is cast in one piece, fewer changes are possible; but, on the other hand, it is solid, and there is no risk of bolts working loose. Two treadles are connected to each other by toothed segments, one of which rests upon a tappet, and cords from the treadles provide connections for the heald shafts. The upward movement is positive, but springs or other appliances pull the shafts down.

When arranged for cross stripes or bordered fabrics requiring two patterns in the same piece, a barrel is

furnished with two plates for each shaft to be moved, and the treadles act on alternate plates at one time. By operating one lever all the treadles are taken out of contact with the tappet plates, and by operating another, the remaining series of plates are brought under the bowls to weave the second pattern, after which the bowls are again lowered into contact with the tappet.

POSITIVE TAPPETS

A positive tappet, of the type shown in Fig. 28, consists of a metal disc, upon one face of which two flanges are cast for a treadle bowl to work between them. In constructing such a tappet the method employed is similar to that for a negative one, except in the lift, and there at least $\frac{1}{8}$ " must be added, because the space between the outer and inner flanges must exceed the diameter of the treadle bowl by that amount, to give freedom of movement.

In setting out such a tappet it is usual to add $\frac{1}{8}$ " to the lift, and after finding the points of intersection between the radial and concentric lines, as explained on p. 41, to describe circles round each, of a diameter exceeding that of the treadle bowl by $\frac{1}{8}$ ". Lines are then traced, touching the periphery of each circle at two points; which lines are the inner and outer flanges. To these sufficient thickness must be added for strength and sufficient depth for the bowl to roll against. In Figs. 28, 29, and 32, the outer flange is broken, but there are tappets in which that flange is continuous except at one place, and there a portion is removed to allow an antifriction bowl to be dropped into, and lifted out of, position. If a treadle is above the tappet centre, as in Figs. 14 and 19, an inward curve on the outside flange causes a shaft to lift, and an outward curve on the

inner flange causes a shaft to sink. But if a treadle is beneath the tappet centre these conditions are reversed.

WOODCROFT'S TAPPET

In 1838 Bennet Woodcroft patented a positive tappet

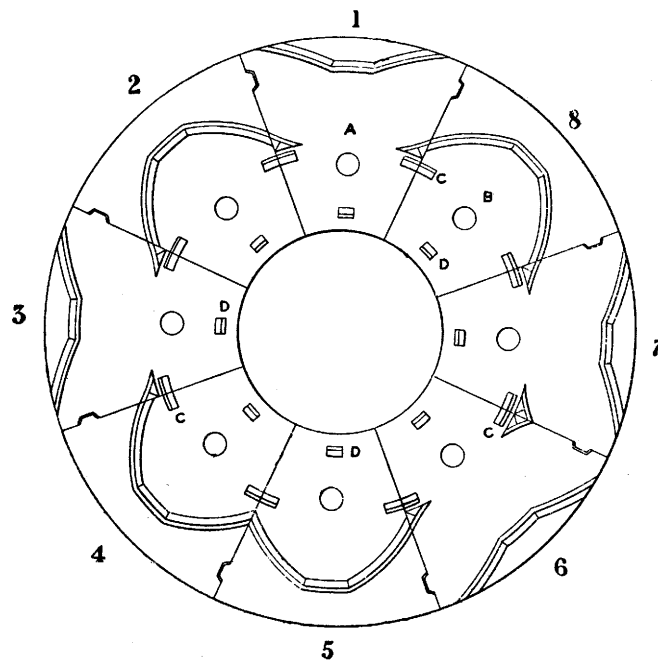


FIG. 29.

that is still used for heavy work, and for eight or more picks to the pattern. The makers advertise it for 56 picks to the round, but in practice the useful limit is reached at 20 or 24 picks.

It consists of corresponding sections cast with an

elevator or depressor on each, and, when placed together, they form one plate. By changing the relative positions and thus forming new combinations of sections, patterns may be varied at small cost, provided the picks in the new pattern equal the number of sections in a plate, or that two or more repeats are contained on a plate. For example, in a tappet for 16 picks, a section equals $\frac{1}{8}$ of a plate, therefore any pattern of 2, 4, 8, or 16 picks can be made by suitably arranging the same sections; but if a pattern has any other number of picks, new sections must be used. In Fig. 29 A shows the form of an



FIG. 30.

elevator, and B a depressor. Dark squares on the slip of design paper, Fig. 30, indicate a rising shaft, and blank squares a sinking shaft. As eight squares are shown, eight to the round sections are employed, and they must be placed to correspond with the position of the tappet in a loom and the direction of its motion. If fixed at the right-hand end of a loom, to revolve in an opposite direction to the crank shaft, pass a number of bolts through the holes provided in the tappet wheel, and place the latter horizontally on a stand. Lay an elevator in position for number 1 on the design paper, and follow with a depressor for number 2 on the left side of number 1. Continue reading from the design and laying the sections until all are in position; then lock the sections by placing the outer flange of a ring, Fig. 31, above the projections C, and the inner flange below those of D, Fig. 29. Proceed to form other circles of sections from similar slips of design paper, one for each heald shaft employed, always beginning immediately above number 1 of the first plate. When complete, bolt all together and the tappet is ready for use. If a tappet revolves in the same

direction as the crank shaft, lay the second section on the right of number one.

A tappet fixed at the left-hand end of a loom, to revolve in an opposite direction to the crank shaft, requires a ring to be first placed upon a blank plate on the tappet wheel, and the second section to be laid to the right of the first. All sections are laid face down, to permit the treadle bowls to run in the groove between

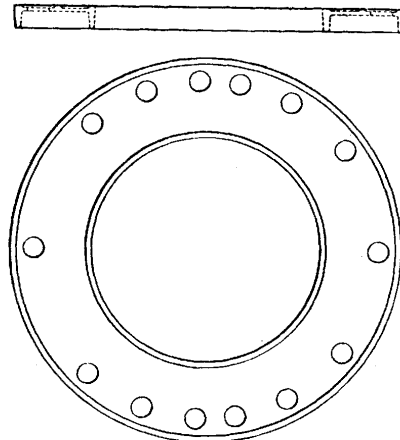


FIG. 31.

two plates. Because, with treadles on the right hand, the bowls face the loom, but if on the left hand they face away from the loom. By attaching the bowls to the opposite sides of the treadles, the sections could be laid face up. If the tappet is to turn in the same direction as the crank shaft, lay the second section on the left of number one.

Woodcroft's tappet is now made for open shedding, but the parts are somewhat complicated, for, in place of using

duplicates of two sections throughout, eight distinct sections are necessary—namely, ordinary risers and sinkers, right- and left-hand risers, right- and left-hand sinkers, riser

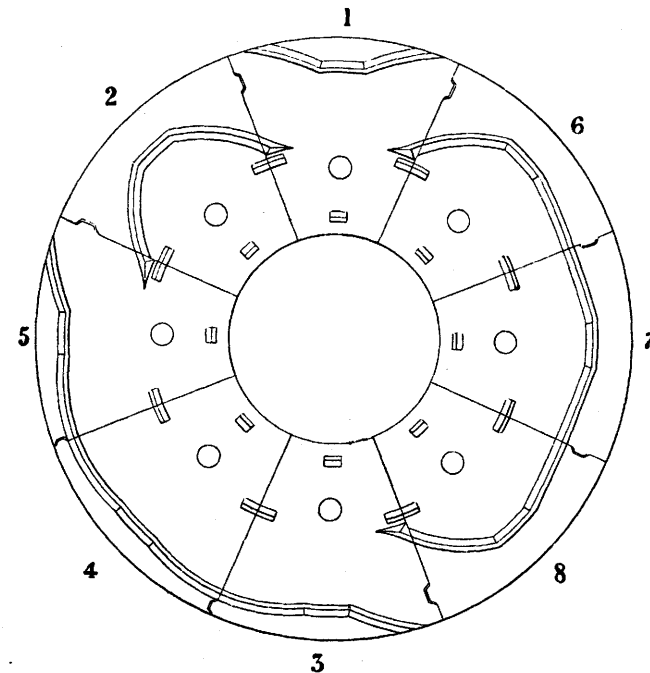


FIG. 32.

dwells and sinker dwells; the two last-named refer to sections that hold the treadles stationary.

Each section is clearly shown in Fig. 32: number 1 is a riser; 2, a sinker; 3, a left-hand riser; 4, a riser dwell; 5, a right-hand riser; 6, a left-hand sinker; 7, a sinker dwell; and 8, a right-hand sinker. With the above

exceptions, these sections are laid in the manner described on the preceding pages.

In Fig. 33 an antifriction roller *F* is carried by a treadle *G*, and *G* is centred at *E*. The treadle is pushed up and down by the rotating sections, and imparts an oscillating motion to the outer end of *G*. Straps and cords pass from

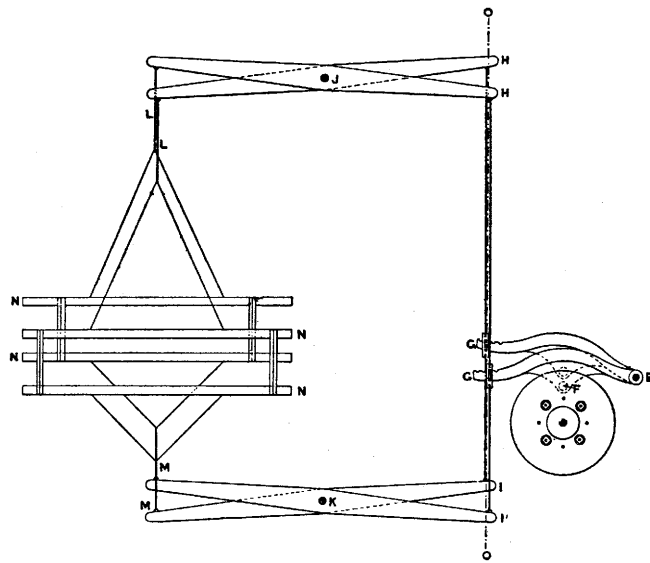


FIG. 33.

a treadle to the top and bottom jacks *H*, *I*, which are fixed in the loom at right angles to *G*; but in the sketch are turned 90 degrees from their true positions in order to show the parts more distinctly. The dotted line *O* indicates the hinge on which the parts are assumed to be turned. The fulcrum pins of *H*, *I* are shown at *J*, *K*; and cords, *L*, *M* are attached to the top and bottom heald shafts;

therefore if a treadle *G* is raised, a shaft *N* is depressed; also if *G* is depressed, *N* is raised.

A Woodcroft tappet is less firm than one made from solid plates, and where there is no outer flange the treadles tend to leave the tappet unless the warp threads put considerable strain upon the shafts. This may be minimised by attaching springs or weights near the fulcrum of the treadles to hold them down, and thus keep the bowls in contact with the tappet.

THE OSCILLATING TAPPET

Since 1840 chains of various kinds have been used as shedding motions. The first was invented by George Clark, the second by John Knowles in 1859, and there are several others. One of the best of them was patented by William and Thomas Nuttall in 1872. Their chain is composed of rollers *A* and collars *B*, Fig. 34, which are threaded upon long spindles *C*, to form a separate row for each heald shaft employed, the spindles being connected at both ends by flat links *D*. A roller causes a shaft to lift, a collar causes one to sink, and the bowls and collars hold each other in place upon a spindle. The chain is divided in two parts—one providing for all the odd picks, and the other for all the even picks. Both are passed round octagonal barrels *E*, that turn in bearings attached to the tappet. Flat pieces of metal *F* are weighted at their outer ends, and form parts of elbow levers *F*, *G*; these rest upon the chains, and are lifted by a roller, but fall by gravity if a collar is beneath them. The arms *F* impart a corresponding motion to the arms *G*, and from each arm *G* a projecting stud *H* enters a slot in a tappet plate *I*, *I*. The plates *I*, *I* are fulcrumed at *J*, *J*, and lifted by a roller

into the position shown at I, on the right of the drawing, but a collar leaves them, as at I on the left. The tappet makes one complete oscillation for two revolutions of the crank shaft, in the following manner:—A pinion 1, Fig. 35, on the crank shaft drives a carrier wheel 2 round a stud M, and 2 gears with a slide wheel 3; the teeth in 3 are in the proportion of two to one in the pinion. A boss compounds

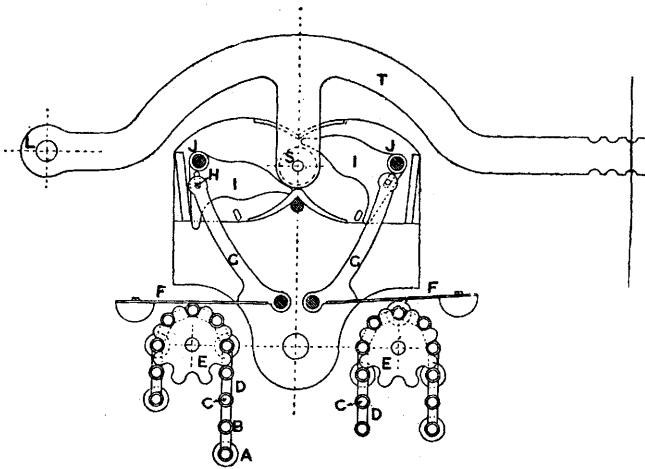


FIG. 34.

the wheel 3 with an eccentric 4, so that both revolve upon a stud K. By means of a strap, and an arm N, a connection is made with a lever O, which is centred at P. A second arm Q is fastened to O, and to the tappet by a pin R. As the eccentric 4 revolves the tappet rocks; if to the left, the treadle bowl s, Fig. 34, will run along the under side of I, depress a treadle T, and cause a heald shaft to lift. But if the tappet rocks to the right, s will roll along the upper

side of I, lift T, and depress a shaft, for the heald connections are similar to those of a Woodcroft tappet, see

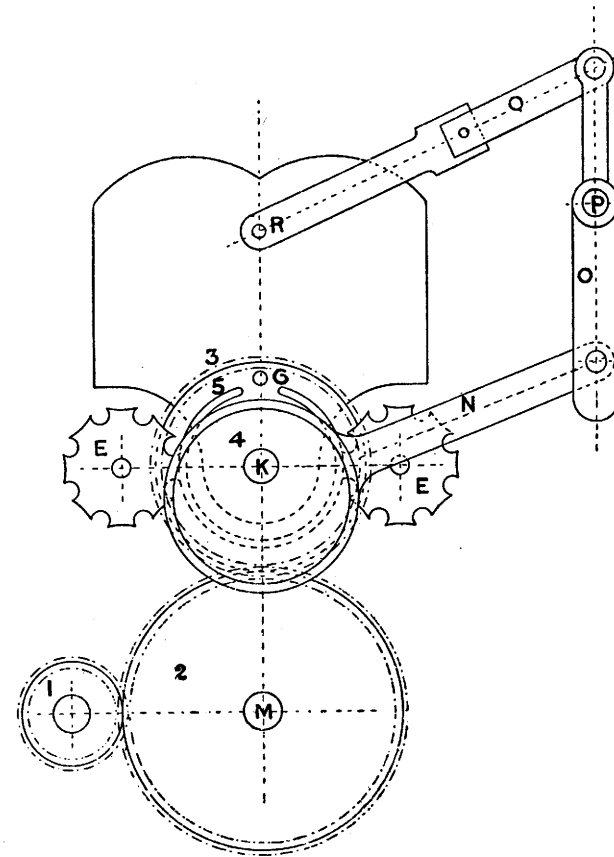


FIG. 35.

Figs. 14 and 33. A bowl s can run above or below the plates I, I any number of times in succession; its course

depends upon the construction of the chains, which are rotated, by slide and star wheels, to place the picks progressively in the fabric. Thus, the slide wheel 3, Fig. 35, has a circular flange 5, shown broken at the top where a stud 6 is inserted. The star wheels \mathbb{E} , \mathbb{E} are respectively keyed upon each chain barrel, and as the slide 3 revolves it carries the stud 6 alternately into a notch of the star wheels \mathbb{E} , \mathbb{E} ; and a barrel is turned $\frac{1}{2}$ of a revolution.

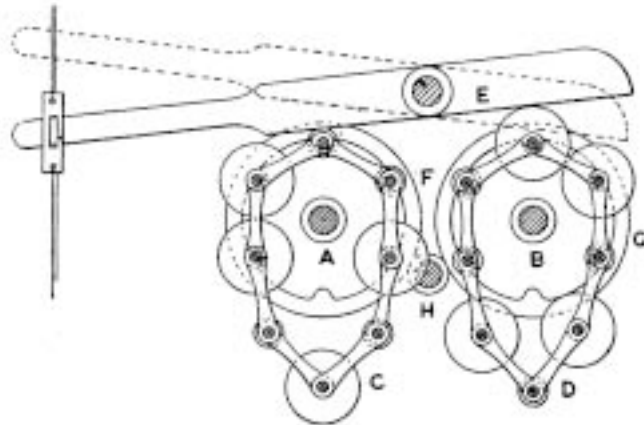


FIG. 36.

Hence one link of the pattern chain acts upon one set of levers \mathbb{F} , \mathbb{G} , Fig. 34, to prepare for the next shed, while corresponding parts on the other side are forming a shed for a shuttle to pass through. When the reed and cloth are in contact all the treadles \mathbb{T} are level, the bowls \mathbb{S} are over the centre of the tappet, and the tappet midway between the extremes of its oscillation. Immediately a shed is fully formed the peg 6, in the slide wheel 3, will have turned that barrel \mathbb{E} which occupies the lowest position.

Flat steel cards have been added to this tappet in order to effect economies in the pattern chains, but they are better adapted to the production of diaper fabrics in which the weave is reversed at intervals than to the general run of goods.

This motion is positive, and if the tappet centre is placed above the crank shaft, patterns of from 80 to 100 picks can be woven, by reason of the chain being divided in two parts. The same bowls, collars, and spindles when rearranged can be used for all patterns, but the tappet is suitable for heavy rather than light fabrics.

A tappet introduced by Grube and Hall, in 1887, has a pendulum lever suspended from each treadle, and an anti-friction bowl is fitted at the base of each lever to run above or beneath curved plates, similar to those in the oscillating tappet. The chief difference between this tappet and Nuttall's consists in vibrating the pendulum levers every pick and leaving the tappet stationary, also in the use of lags instead of bowls and collars.

NUTTALL'S CHAIN

Another positive chain tappet, patented by William and Thomas Nuttall, in 1872, is also used where heavy goods are made. It is placed in a stand that can be fixed to the floor at the end of any loom, and driven by a pinion from the crank shaft. It consists of two parallel chain barrels, A, B, Fig. 36, which are mounted in suitable bearings, and rotate the chains, C, D, at the required speed by two spur wheels, \mathbb{E} , \mathbb{G} , keyed upon the barrel shafts. These wheels are in gear with a small carrier, \mathbb{H} , that turns both in the same direction. The chains are composed of similar rollers and collars to those for an oscillating tappet,

but here a collar on one barrel must be opposite a roller on the other, as both chains move at the same time, and act upon the same straight levers *E*, one of which is shown resting upon them. Each lever is fulcrumed midway between the centres of *A*, *B*; with its rear end projecting slightly beyond *B*, and its forward end long enough to permit of connections, similar to those in Figs. 14 and 33, being made to the upper and lower jacks.

This tappet is not so suitable for long patterns as the oscillator, for a link of each chain is required for a single pick; the first to lift the rear ends of *E* and the shafts; the second to lift their forward ends and depress the shafts; but it is positive in action and simple in construction.

A Continental machine of more recent date only differs from the above in having antifriction bowls fitted to the under side of *E*, and a chain made of links, resembling those of Diggle's shuttle-box motion, see Figs. 209 and 210.

SCROLL TAPPETS

Scroll tappets are chiefly used to weave narrow stripes and chain effects; they govern threads that rise for three, four, or more picks in succession, and then remain depressed for an equal number of picks, while the remaining warp is actuated by tappets of the usual form, and to which the scroll plates are bolted. As a shedding motion the scroll is not a recent invention; it is similar in construction to a picking scroll (see Part X. Fig. 196), but the half-moon is attached to a tappet treadle. A scroll plate makes two revolutions for one repeat of the pattern, hence, if used in conjunction with a four to the round tappet, the scroll will hold its heald up for four picks, during which time the

half-moon traverses the inner groove; it then changes to the outer groove and holds the heald down for four following picks.

Other tappets are to be met with, which do good work, but want of space precludes a detailed description.

TAPPET DRIVING

Tappets are driven, directly or indirectly, from the

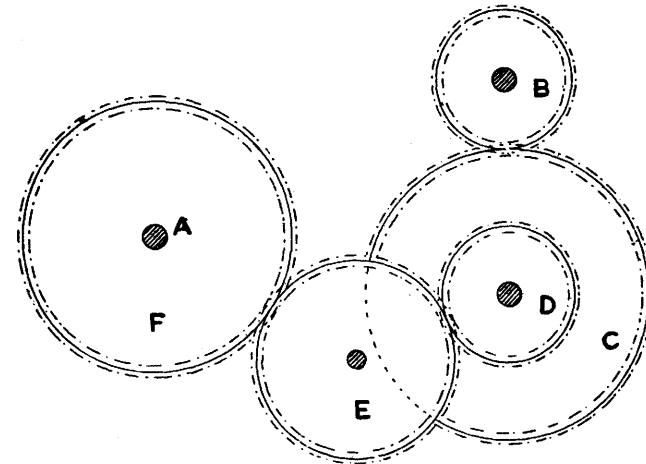


FIG. 37.

crank shaft by spur wheels. When convenient, a large wheel is fitted on the tappet and a small one on the crank shaft, and their relative dimensions determine the speed of the tappet; thus a 4-picked tappet requires a wheel with four times as many teeth as that on the crank shaft, also, if a 2-picked tappet has a wheel containing 120 teeth, the number of teeth in the driving wheel = $120 \div 2 = 60$.

If with 5 picks to the round, $120 \div 5 = 24$ teeth. But it frequently happens that two wheels will not answer, because both shafts occupy fixed positions, and unless the wheels are the proper size they will not gear; in such cases carrier wheels are employed. A single carrier will cause a tappet to revolve in the opposite direction to

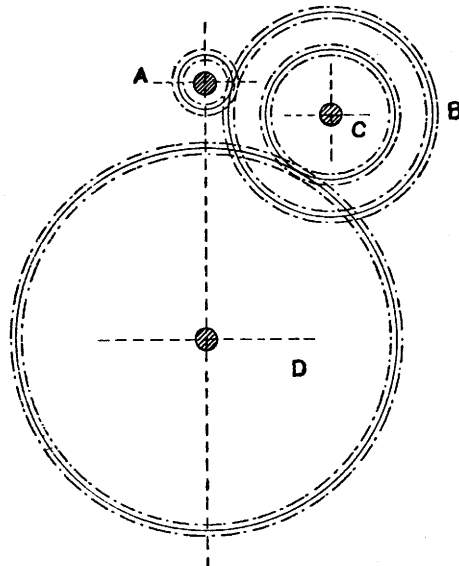


FIG. 38.

one directly driven, or to one with two carriers. Fig. 37 shows the driving for tappets which are placed under the healds, and fixed upon a short shaft A. Motion is given to A by the crank wheel B, the bottom shaft wheel C, a wheel D, which is compounded with C, a carrier E, and a tappet wheel F. If $B=40$, $C=80$, $D=20$, and $F=40$

teeth respectively, the revolutions of A will be to those of the crank shaft as 1 : 4, for,

$$\frac{40 \times 20}{80 \times 40} = \frac{1}{4} = 1 : 4.$$

The carrier wheel E is omitted from the calculation as it merely conveys motion from D to F, without influencing the values of B, C, D, F. Plain cloth tappets with 2 picks to the round are generally keyed to the bottom shaft, because the revolutions of that shaft = $\frac{1}{2}$ those of the crank shaft, and other gearing is unnecessary.

Compounded intermediate wheels are used to drive tappets having a large number of picks to the round; the intermediate wheels then work loosely on a stud, the larger one gears into the crank shaft wheel, and the smaller one into the tappet wheel,—as in Fig. 38, where A is the crank shaft wheel, B the large, and C the small stud wheels, and D the tappet wheel. A, C are thus driving, and B, D are driven wheels. A tappet wheel can rarely be changed, but the sizes of the three remaining wheels can be found by dividing the tappet wheel by any number that will not leave a fraction. The divisor will give the teeth for one pinion, the quotient will give those for the other; the picks to the round give the first driven wheel; the tappet wheel being the second. Thus, in a 16-picked tappet, having a wheel of 180 teeth—

$$180 \div 15 = 12 \therefore 12 \text{ drives } 16 \text{ (the picks) and } 15 \text{ drives } 180.$$

For proof:—

$$\frac{15 \times 12}{16 \times 180} = \frac{1}{16} \text{ or } 1 \text{ revolution of the tappet to } 16 \text{ of the crank shaft.}$$

If it is assumed that a wheel with fewer than 20 teeth cannot be used, any multiple of the numbers obtained will answer, as 15×2 , 12×2 ; but since the tappet wheel is

fixed, 16 must be multiplied by 4, because the teeth in the driving wheels have been increased fourfold, and the same ratio in the teeth of the driven wheels must be maintained.

$$\therefore 16 \times 4 = 64. \quad \text{For proof } \frac{30 \times 24}{64 \times 180} = \frac{1}{16}.$$

By the following rule both intermediate wheels can be found if the crank pinion and the tappet wheels are given.

$$\text{Thus: } \frac{\text{Picks required} \times \text{pinion}}{\text{Teeth in tappet wheel}} = \frac{B}{C}. \quad \text{Fig. 38.}$$

Example.—If a pinion of 20 teeth and a tappet wheel of 120 teeth are used to drive a tappet having 12 picks to the round, what intermediate wheels are required?

$$\frac{20 \times 12}{120} = \frac{2}{1} \therefore \text{any wheels in the ratio of 2 to 1 are available.}$$

A change made in one wheel of the train is often sufficient; it may be either a driver or a driven, but the rules are—

$$\frac{\text{Driving wheels} \times \text{picks to the round}}{\text{Driven wheel}} = \left\{ \begin{array}{l} \text{teeth required for a} \\ \text{driven wheel;} \end{array} \right.$$

and

$$\frac{\text{Driven wheels}}{\text{Driver} \times \text{picks to the round}} = \text{teeth required for a driving wheel.}$$

PART IV

OVER AND UNDER MOTIONS

ALL negative shedding requires the addition of parts known as over or under motions to reverse the direction

of movement in healds. The terms over and under refer to the positions of these devices when in use. If a tappet is placed under the healds, an over motion is used, but if placed over the healds, or at one end of a loom, an under motion becomes necessary. Reversing motions may, however, be grouped as A, single-acting; B, compounded. In the former, each part is only capable of controlling one shaft; but in the latter, each part can be made to act simultaneously on all the shafts in a set except one. Before proceeding to describe these motions, it will be necessary to consider the nature of the work to be done by them.

Since a negative tappet moves a shaft in one direction, a reversing motion should act immediately a tappet ceases, and continue in action to the termination of the shaft's journey, where its maximum force should be exerted until the tappet is again brought into use. During the active period of a tappet little force is needed to keep a moving shaft steady, more than this is wasted energy. These remarks apply specially to centre and open shedding, for in both the tense warp exerts its greatest force to pull the shafts to the closed shed line when the reversing gear is alone available to resist such strain.

SINGLE-ACTING REVERSING MOTIONS

Single-acting reversing motions generally consist in attaching to the heald shafts dead weights, spiral springs, or elastic cords, but none of them are mechanically correct. A weight exerts a constant force, whether the tappet is acting or has ceased to act. This is undesirable, and although weights are invariably employed for Jacquard shedding, they have not met with much favour when

applied to shaft work; for one reason, if weights are free at one end, a rapid vertical reciprocating motion sets up a lateral swinging action, and considerable friction results. Another objection to their use is that the shorter

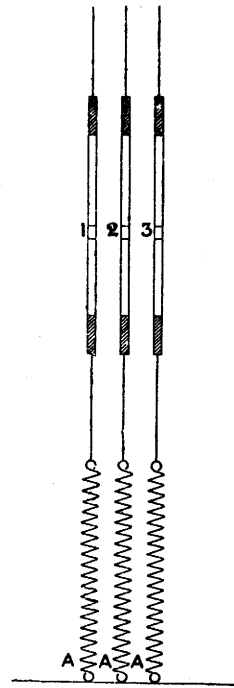


FIG. 39.

the time during which weights fall, the slower they move; this may result in changes being completed in one part of a harness before they are completed in another part.

As usually applied, a spiral spring is stretched until it exerts sufficient force to hold a heald shaft on the top or bottom line when the tappet is inoperative; hence the farther a heald moves from that position, the more a spring is stretched, and the greater the force it exerts to oppose that of the tappet. On the latter ceasing to act, a spring exerts its maximum force to pull the heald shaft in the opposite direction, but as the spring contracts, its force decreases in proportion to that of its increase when stretched; so that where its effectiveness is most needed, it exerts a minimum force.

A spring is, therefore, one of the most defective pieces of mechanism that could be devised to reverse movement in healds; it is strongest where it should be weakest, and weakest where strength is most required.

A comparison of the power consumed by springs and dead weights will make this point clear. Let it be assumed

that a force equal to a weight of 10 lbs. is needed to hold a heald shaft stationary, then a spiral spring must be stretched until it is capable of resisting that force. Let it be further assumed that such stretch = 1", and the movement of the heald = 4". Since the force of a spring increases uniformly $10 \times 4 + 10 = 50$ lbs., the force exerted when it is not wanted, and 10 lbs. its effective force. Or put into units of inch pounds, $10 + 50 \div 2 = 30$ lbs., the mean force, and $30 \times 4 = 120$ inch pounds.

A dead weight of 10 lbs. exerts a constant force in all positions, \therefore inch pounds = $10 \times 4 = 40$. Hence, under the above conditions, the work done during one movement of a shaft is, with weights, 40 inch pounds, and with springs 120 inch pounds.

Fig. 39 shows the usual application of springs; A, A, A are three springs attached by their basal ends to a bracket placed near the floor line; from the upper end of each spring a cord passes to the lower heald shafts 1, 2, or 3. It is customary to use two springs for each shaft and to connect them at equal distances from either end. Springs operated in this manner are first stretched sufficiently to hold a heald in position, and then to correspond with the lift of a heald.

Notwithstanding the faults inherent in spiral springs, they are more extensively used, for light and medium fabrics which require six or more shafts, than any other appliance, probably because they are readily fixed, easily understood, and can be employed to weave any pattern. Inventors have so applied springs that their stretch shall be less than the movement of the healds. Figs. 40, 41, and 42 illustrate three plans by which this may be attained. In Fig. 40 a heald is connected to segment levers, A, A, at C, C, and, at $\frac{1}{2}$ the distance from the fulcrum, springs D, D are

attached to the same levers. The stretch of D, D will therefore equal $\frac{1}{5}$ the movement of a heald shaft, but a

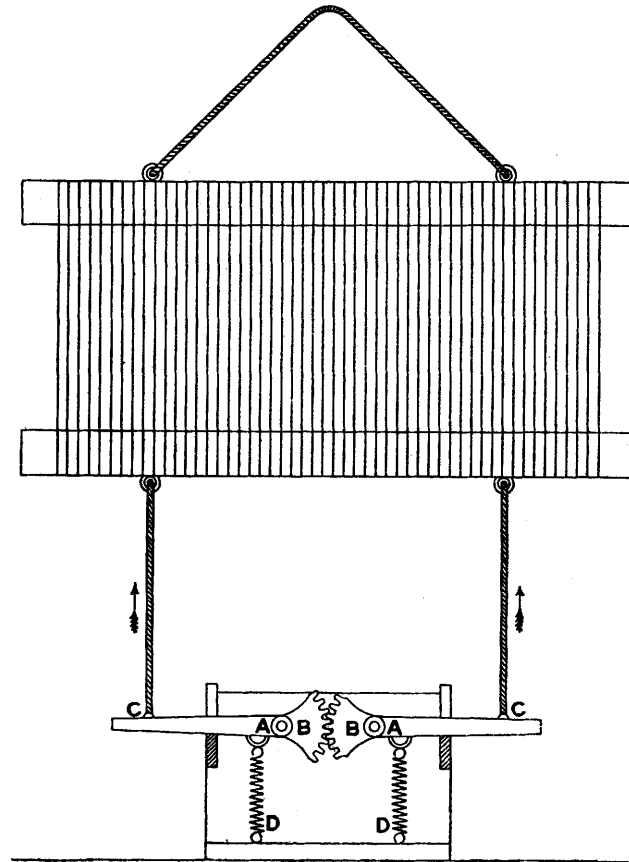


FIG. 40.

spring of a given strength will be $\frac{1}{5}$ less efficient at D than at C. Hence a spring five times as strong must be employed,

and the force required to stretch it will approximate to that needed for a spring as ordinarily used. Other inventors have so arranged springs that as a shaft moves their full force will not be exerted upon it, as in Figs. 41 and 42.

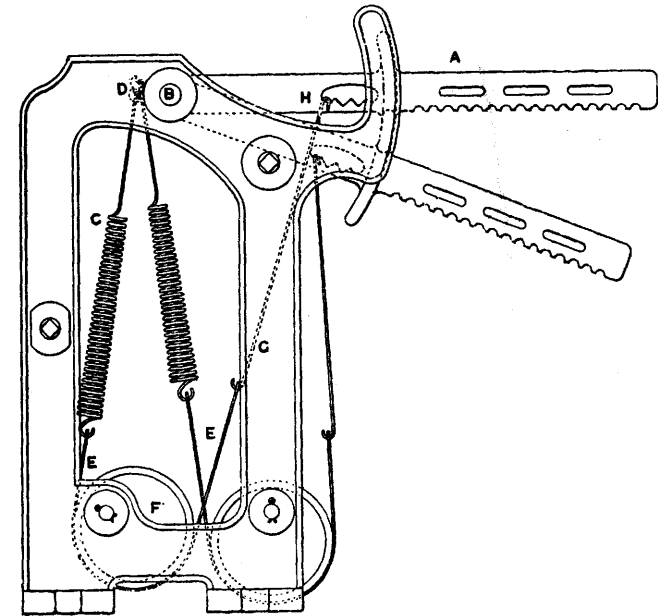


FIG. 41.

SPRING-EASING REVERSING MOTIONS

Messrs. Hahlo, Liebreich, and Hanson's patent reversing motion is simple in construction, and not liable to get out of order. It consists of levers A, Fig. 41, which are fulcrumed at B, and to the rear end of each a spiral spring c is either connected by a wing-nut and screw, for the

purpose of regulating the tension, or it is hooked upon A, as shown at D. The lower end of C is fastened to a strap E, which is set-screwed upon an eccentric F, and E is united by a hook G, with the lever A, at H.

Since a heald shaft is connected to the outer end of A, and A and G ascend together, G will draw a part of the strap E from the large side of the eccentric F and wind another part of it upon the small side; but A moves down at D simultaneously, and prevents the spring C from stretching in proportion to the length of strap wound upon the eccentric F. The surface of F and the positions of D and H are such that, for a movement of 5" in a shaft, the spring C will be stretched $\frac{3}{4}$ "; this results in a considerable reduction of power as compared with springs used in the ordinary way. Thus, on the former assumption of 10 lbs. equalling the weight required, and also a stretch of 1", an ordinary spring will exert a force upon a lifted heald of $5 \times 10 + 10 = 60$ lbs., but used as above it equals a force of $10 \times \frac{3}{4} + 10 = 17\frac{1}{2}$ lbs.

KENYON'S REVERSING MOTION

Kenyon's motion is equally simple, but it acts in a different manner upon the shafts. In Fig. 42 two chairs, A, B, are placed back to back and bolted upon a rail C to support the moving parts. In case the spring D is too strong or too weak, the chairs may be moved nearer to or farther from each other. Two chains E, F are hooked into opposite ends of D, and are respectively connected to the curved levers G, H; the latter are fulcrumed at I, J, and carry at N, O eyed links, from which straps K, L pass to a shaft M.

The levers G, H cause the spring D to rise and fall

with the shaft, and as D rises its rate of stretch decreases. Further, its leverage decreases as it approaches the line of the fulcra I, J, with the result that the actual stretch of a spring does not represent the force applied to a heald.

For example, a trial showed that a lift of 5" stretched a spring $2\frac{3}{4}$ ", and this, under the previously assumed conditions, would equal $2\frac{3}{4} \times 10 + 10$, or $37\frac{1}{2}$ lbs. when at the highest point, and 10 lbs. when at the lowest. But a spring balance gave the following stresses for each inch of movement:—Closed shed, $12\frac{1}{2}$ lbs; first inch of lift, $11\frac{1}{4}$

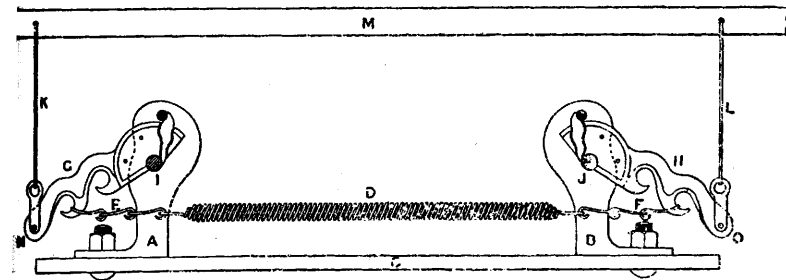


FIG. 42.

lbs.; second inch, $8\frac{3}{4}$ lbs.; third inch, $6\frac{3}{4}$ lbs.; fourth inch, $5\frac{1}{2}$ lbs.; and fifth inch, $6\frac{1}{4}$ lbs. These figures show that springs may be more economically employed to reverse the actions of tappets than is generally the case.

COMPOUNDED MOTIONS

The second class of reversing motions, known as stocks and bowls, are all based on the compensating principle; which consists in making a rising or falling shaft help to move another in the opposite direction. When one of these devices can be successfully applied, the consumption of

power will be smaller than with weights, or spiral springs as usually employed.

Stocks and bowls consist of levers either circular or

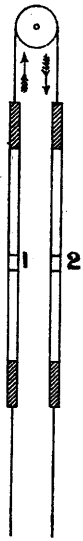


FIG. 43.

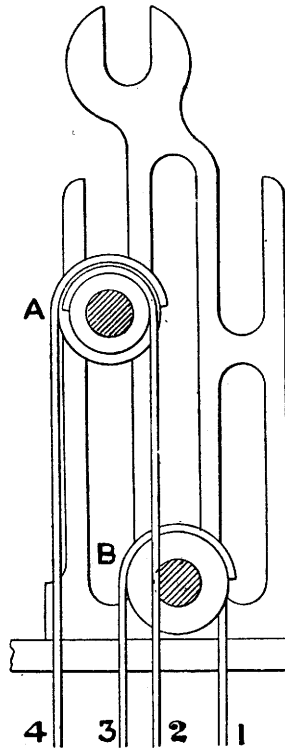


FIG. 44.

oblong in form, to which the shafts are connected, but they can only be employed when the same number of shafts are to be lifted for every pick. In cases where, say, two shafts are lifted for one pick, and three for another, a single motion must be used.

Shafts are sometimes connected in pairs to single levers, as seen in the over motions, Figs. 13, 17, 43, and 44; the three former arrangements being for plain, and the latter

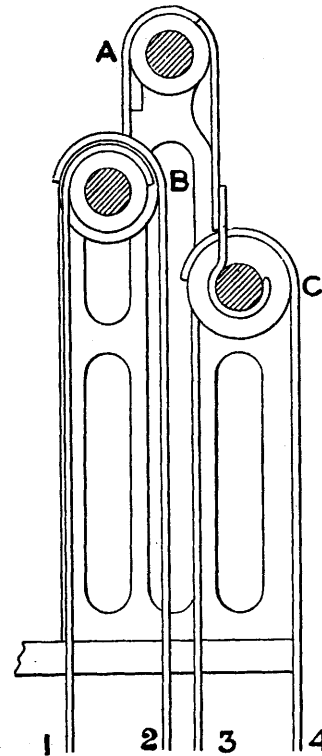


FIG. 45.

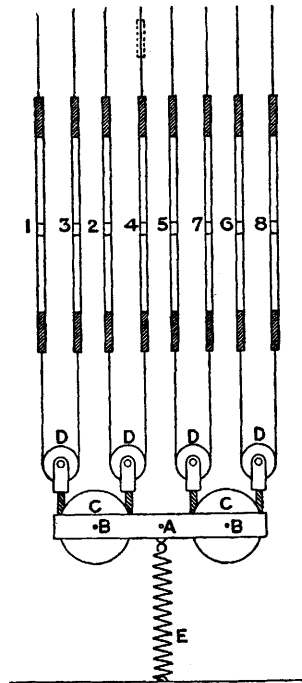


FIG. 46.

for twill weaving. This principle can be extended to work any even number of shafts, but half the number employed must be up and the other half down at each pick. In this form stocks and bowls are unsuitable for a large number of

patterns. When levers are compounded, as in Figs. 45 to 55, any constant number of shafts can be carried up or down for each pick.

Fig. 45 is an over motion showing an arrangement of bowls for moving four shafts. Two straps are set-screwed upon bowls A, to support bowls B, C, by means of hooks and rollers. Four straps, 1, 2, are secured upon separate bowls B, and attached to the heald shafts 1, 2; the straps 3, 4 are made fast upon four bowls C, and the heald shafts 3, 4. In over motions two separate bowls are used for each heald shaft connection, and those governing the most forward shaft are the smallest (see p. 44).

The under motion, Fig. 46, consists of a larger number of compounded bowls which operate eight shafts in a similar manner to the above. As the lever A, B, Fig. 46, and the roller A, Fig. 45, are essentially the same, a further description will be unnecessary.

For an odd number of shafts more bowls are placed at one end of the first lever than at the other; and the fulcrum of the first lever must ensure equilibrium; it is placed inversely to the number of shafts attached to each end. Thus in the 3-shaft under motion, Fig. 47, the bottom lever is divided into three equal parts, and the fulcrum placed at the first division from the heavy end. A is a spiral spring that serves as a fulcrum for the lever B; and C is a pulley secured upon B, but free to rotate. D, E, F are three heald shafts. Of these, D is connected to the lever B, at a point two divisions from the fulcrum, while the centre of C is only one division from the fulcrum. A band passes beneath the roller C to couple the shafts E, F.

When an under motion consists entirely of bowls, the two lower ones are compounded and a strap is screwed upon the periphery of each. The diameter of one bowl

must be to that of the other in inverse proportion to the number of shafts each controls. Thus in Fig. 48, which is for 3 shafts, the diameter of A is twice that of B, because a strap E, screwed to bowl A, is attached to shaft 3 only; while the bowl B has a strap D screwed to it and to the block of C; another strap, E, E, unites the shafts 1, 2.

Fig. 49 is a 3-shaft over motion, but is otherwise essentially the same as Fig. 48.

There are many modifications in the details of stocks and bowls, but by suitably combining a 2, 4, 6, or an 8 shaft motion with one for 3 shafts, any odd number up to 11 shafts can be worked. The following combinations for 5 and 7 shafts will sufficiently explain the methods:—In Fig. 50 a 3-shaft under motion, similar to Fig. 48, is attached to one end of a straight lever A, and a 2-shaft motion, similar to Fig. 43, is attached to the opposite end. A is divided into five equal parts, and equilibrium is established by placing the fulcrum pin two divisions from the 3-shaft motion, and three divisions from the 2-shaft motion. Fig. 51 is similar to Fig. 50, but is composed entirely of rollers and intended to be placed over the healds.

The Lacey over motion is of novel design and was patented by a Canadian inventor. It consists of an arm A, Fig. 52, which is bolted upon one end of the loom framing. A stud B is fixed in A, to support a loosely mounted lever C, whose arms are in the proportions of two to one. In the long arm of C a stud D carries

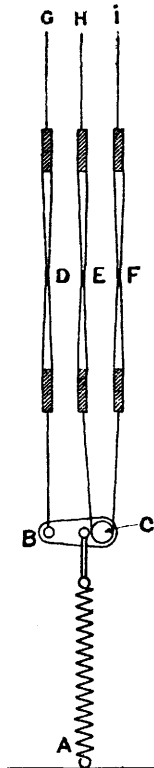


FIG. 47.

a stepped roller E, upon which two straps F, F are screwed, so that wire, strapping, and wooden guide rollers may provide connections for two heald shafts. The lower

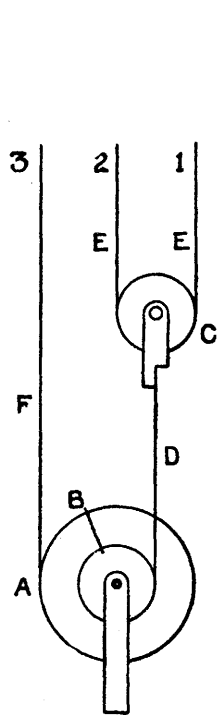


FIG. 48.

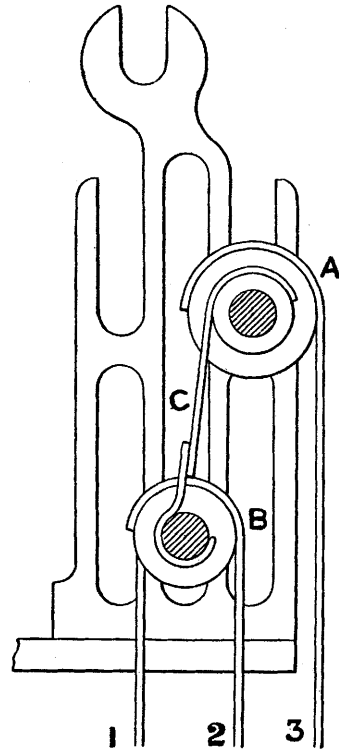


FIG. 49.

arm of C also carries a stud G, and upon it is a freely mounted lever H, whose arms are in the proportions of two to one. The long arm of H terminates in a curved face for a strap I to be screwed upon, and wire and

strapping unite I with a heald shaft. In the lower arm of H a stud J supports a second stepped roller K, and from K belts and wire make the connections with two remaining shafts. At the rear of levers C, H portions of each boss are

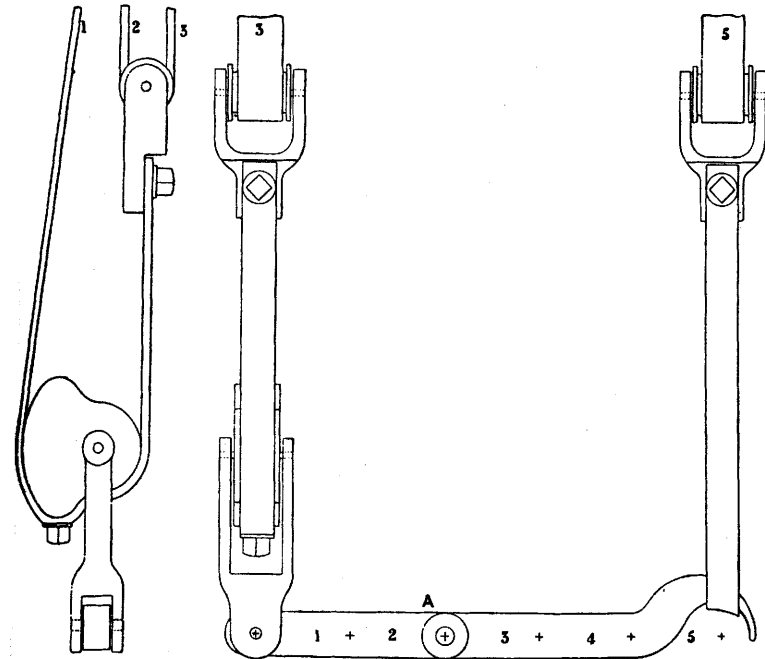


FIG. 50.

cut away to fit, when necessary, between flanges on the arm A and the lower part of C. When A, C are thus united C is prevented from rocking; and when C, H are united H is prevented from rocking independently of C.

If both levers C, H are locked in this manner, either E or

K may be used to actuate two shafts. Or both E and K may be used to actuate four shafts for a two-up and two-down pattern. By locking H only, any regular 4-shaft pattern

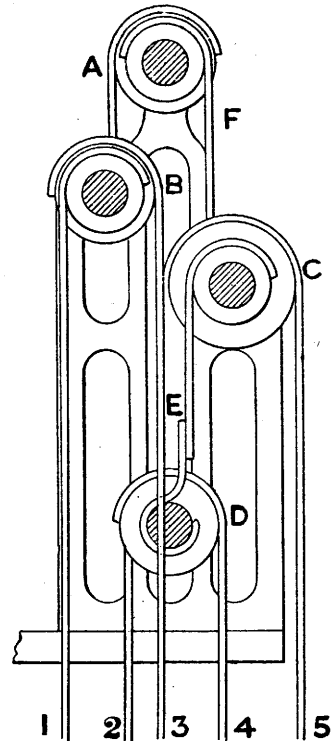


FIG. 51.

may be woven, for C will swing upon the stud B, and the rollers E, K are equi-distant from B. If only C is locked, the lever H and the roller K will serve as a 3-shaft reversing motion. With both levers C and H free, any 5-shaft pattern may be woven. Hence the device can be instantly

adapted to reverse the movements in 2, 3, 4, or 5 shafts.

Fig. 53 is also an under motion for actuating 5 shafts, but the diameters of the compounded rollers A, B are in the ratio of 4 to 1. A strap is screwed upon the surface of the small roller B, and is connected to a roller C. Round C a second strap is passed to govern the rollers D, E. A third strap from the roller D is connected to shafts 2, 3,

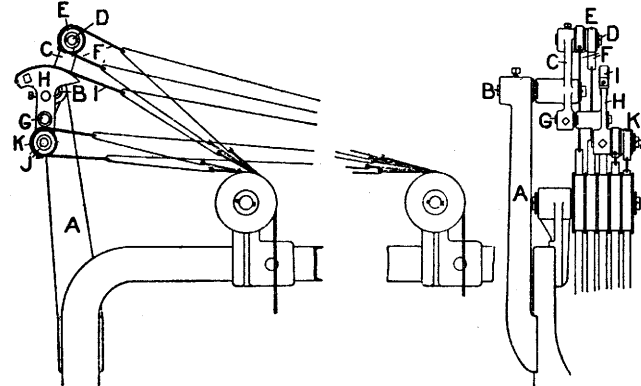


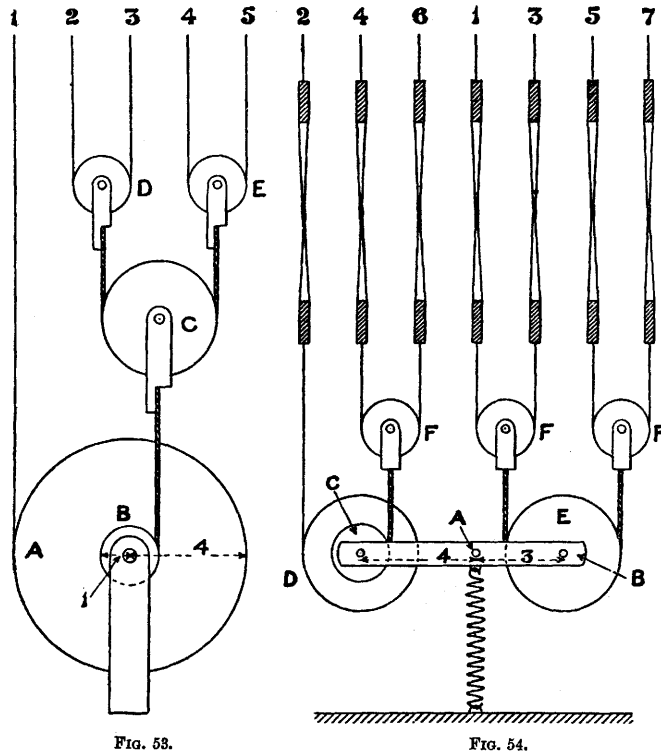
FIG. 52.

and a fourth from E is connected to shafts 4, 5. A fifth strap is secured upon the periphery of the large roller A, and connected directly to No. 1 shaft.

In Fig. 54 the 3-shaft motion shown in Fig. 48 is retained, and a 4-shaft motion, similar to Fig. 45, is added to the opposite end. The lever B is now divided into seven parts, and the pin placed at the third line from the heavy end.

Springs either flat or spiral are used, as in Figs. 46, 47, and 54, to neutralise imperfections in tappets and rollers

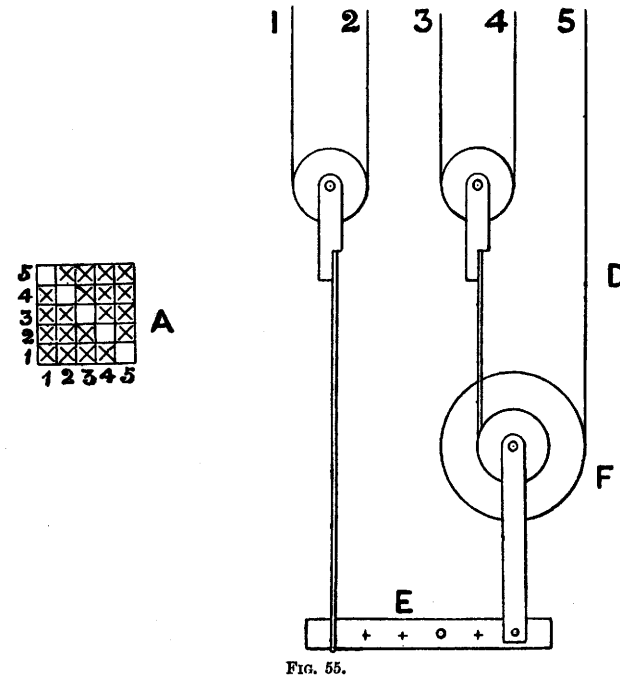
by permitting the entire set of stocks and bowls to make a slight vertical movement whenever excessive strain is put upon any of the straps. Also in Figs. 43, 46, 47, 48, 50,



53, 54, and 55, plain rollers are used, but they should be replaced by stepped ones, and the stepping should be in proportion to the lift of each heald, as described on p. 44. Even then, as looms are now made, correctly shaped tappets and correctly stepped rollers may be nullified by attaching

the heald connections to the treadles in the wrong places.

In order to prevent stocks and bowls from giving a side pull to the healds it is usual to employ two sets, each set placed at the same distance from the extremities of the



shafts; and to avoid twisting the straps, between the rollers and shafts, the axes of certain upper rollers are frequently at right angles to those below. In Fig. 50 such a set is shown in working position with the requisite connections to the shafts. The upper rollers place each strap immediately under the shaft to which it is attached.

Owing to the multiplicity of levers in large sets of stocks and bowls it is not always an easy matter to trace the movement of each roller when a shed is forming.

Something depends upon the character of the shedding motion. If, for instance, a Jamieson tappet, a single-lift, or a centre shed dobbie is used, all the warp is placed in a line after each passage of a shuttle, but an open shedding motion acts differently, for all the shafts can never be at one height at the same instant. In tying them up, some are corded level with the top, others with the bottom sheds, and in these positions they remain stationary until the pattern renders a change necessary. The same number of shafts rise and fall every time a shed is formed, and those remaining stationary are fixed either at the top or bottom by the shedding motion.

In Fig. 55, assuming a 3" shed is required, shafts 1, 2, 3, 4 must be up, and 5 down for the first pick; for the second, 5 goes up and 4 down 3". The under motion at D shows that 3" of strap will be unwound from the large pulley F, and 1½" wound upon the small one compounded with it. Shaft 3 being fixed, and the centre roller pulled down 1½", it follows that shaft 4 will be depressed 3"—namely, 1½" by the fall of the roller and 1½" by increasing the length of strap 3. A similar movement can be traced amongst the rollers and straps when any pair of shafts change places.

PART V

DOBBY SHEDDING

WHEN a pattern is beyond the range of a tappet either in the number of shafts to be manipulated or in the picks

to a repeat of the pattern, and is at the same time too small to be economically produced by a Jacquard, a machine is employed which is known as a Dobby, a Witch, a Wizard, or an Index in different manufacturing centres. The number of shafts it may be called upon to actuate varies between 6 and 40.

In the cotton industry 24-shaft dobbies are in use; but the majority of them have from 12 to 16 shafts. Where dhooties are made 40-jack dobbies are common, but they work a mail mounting, and for such a purpose may be considered as small Jacquards. In the worsted industry dobbies with 36 jacks and upwards are in use; many of them are positive in action, and on that account are specially suited for heavy shedding.

In places where patterns are often changed, a dobbie is used for fabrics well within the range of a tappet, as the former offers greater facilities for producing a variety of effects than the latter. Still, healds never work better, or last longer, than when actuated by properly constructed tappets.

The dobbie probably preceded the Jacquard in the order of time; certainly it cannot be said to owe its existence to the larger machine, for machines were applied to the hand-loom, to weave patterns beyond the range of treadles, before Jacquard's invention reached this country.

As now made, dobbies are single-acting, double-acting, negative, and positive; they form closed, centre, semi-open, and open sheds. See pp. 19 to 23. Their variety proves that no single machine is suitable for all classes of work. In practice one is slow in action, another is only adapted for light fabrics; some are complicated in construction, and in others wear and tear is excessive.

A single-lift negative dobbie, Fig. 56, is placed over the

centre of the shafts, and contains a number of vertical hooks B, each having a bend at both extremities—that at the head to form a hook, that at the foot to permit a connection to be made with a heald shaft. The hooks

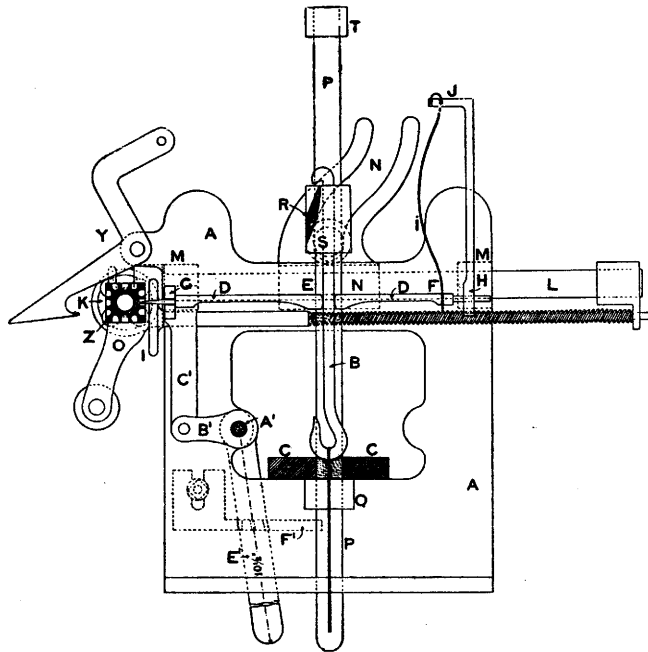


FIG. 56.

rest upon a perforated bottom board C, and each is kept vertical by a needle D, which is furnished with two eyes E, F; the eye E is formed by slotting and F by drilling the needle. A hook enters the slot, but a steel wire spring I is passed through the eye F, and its upper end is secured to a flat bar J. Two plates G, H are perforated to receive

the forward and rear ends of D and hold them horizontal. It is the office of the spring I to thrust the end of D through the needle plate G.

A square prism K, known as a cylinder, has holes drilled in each face to coincide with the pitch of the needles, and near the ends of each face two conical pegs are fitted to hold a chain of cards in position. This cylinder is supported by its gudgeons in open steps formed in brackets O, and the brackets are secured upon two bars L that slide freely in bearings, M, upon the end framing.

A cylinder requires a to-and-fro and a rotary motion. The to-and-fro motion is derived from two vertical rods P that hold a griffe bar R, either at right angles to the hooks B, or at a slight inclination to them. On the rods P are two bowls S, which work between the prongs of two forks N, and N are fast to the bars L. The rods P terminate in a cross-head T, and a link and pins attach T to a lever fulcrumed above the dobby framing. From this lever a connecting rod descends to a crank on the main driving shaft of the loom; hence, as the crank rotates, the rods P receive a vertical movement, and, by reason of the bowls S rising and falling in the curved slots N, a lateral reciprocating motion is imported to the forked brackets N, and also to the cylinder K.

Rotary motion is given to K by allowing a catch Y to rest upon the top face of a lantern Z. The lantern is secured to one end of K and consists of four rounded metal projections which are in line with the four corners of the cylinder. When K moves out, the catch Y engages a projection on Z and pulls it through an angle of 90°. K is prevented from turning too far, and assisted to turn its proper distance, by two T-shaped hammers I, each having a shank long enough to pass through the dobby. Both

shanks are partly round, partly square in section; each has an open-coiled spiral spring loosely threaded upon the cylindrical portion to impinge against a bracket on the slide bars L, and also against the square part of its shank; hence the springs continually press the heads of l upon the inner face of the cylinder K.

A chain of perforated paper cards is passed round the cylinder and held in position by the conical pegs passing through special holes in the cards. The cards are punched to correspond with the pattern to be woven; each hole equals a rising shaft, and each blank a stationary shaft. The rotary motion of K brings the cards forward successively, and the horizontal motion allows the cylinder to turn, and to press a card against the needle points.

The action is as follows:—When the driving crank is on its top centre, the griffe R is about $\frac{1}{4}$ " below the heads of the hooks B, and the top edge of R touches those that are vertical; the bowls S are at the bottom of the forks N; the cylinder K is pressing a card against the plate G, and blank places in the cards push back the points of the needles D, for the springs I yield. The receding needles press their hooks out of the perpendicular, but a perforation in the card allows a needle point to enter without producing any effect on either needle or hook.

The rotation of the crank causes the griffe R to ascend with all vertical hooks, but all inclined hooks are left. While the griffe is ascending, the cylinder K moves out to permit the catch Y to turn K without injuring the needles, and place a fresh card in position for presentation. Each rising hook lifts a heald shaft until its warp is on the top line. But all unlifted hooks permit their healds to hold the warp they control on the bottom line; the process is repeated indefinitely.

This dobbie is essentially a small Jacquard, with one row of hooks and needles. It forms a rising and falling shed with a stationary bottom line (see Fig. 9), and is only adapted for slow-running looms. It also has two other defects, namely, first, a griffe with a uniform rise and fall cannot readily place all the lifted warp threads level; and since the rear shafts must be lifted high enough to allow a shuttle to pass below the warp, the forward shafts rise too high, and unnecessary strain results. As shown on p. 31, each shaft should have a different lift, the front one the least, and the back one the greatest.

A simple alteration in the griffe, shown in Fig. 57, has rendered the machine perfect in this respect: A is the griffe bar which swings freely upon a fulcrum pin B carried by a bracket on the dobbie front. A horizontal shaft C has two arms D, E fitted upon it, the former connected to A by a link F, and the latter to the driving crank by a rod G. As A vibrates the hook nearest the fulcrum pin will move through less space than that nearest to the link F; also the lift of each from front to back will gradually increase.

The second defect relates to the in-and-out traverse of the cylinder, which must cause the needles and hooks to be held back until the griffe is above the hooks to be left down. This is done by making the space between the prongs of N, Fig. 56, almost vertical for a short distance from the bottom, then as the griffe R reaches the same point in its descent, the cylinder K again presses back some of the needles, and if any of them actuate hooks already on the griffe, those hooks will be pushed off and gravitate to the bottom board. The tendency of this is to puncture the cards, bend both needles and hooks, and increase the wear and tear.

Of the attempts to remedy the last-named defect, the most effective is to drive the cylinder by a tappet, and

independently of the griffe. For a tappet can be shaped to give any desired movement; but the initial cost and the

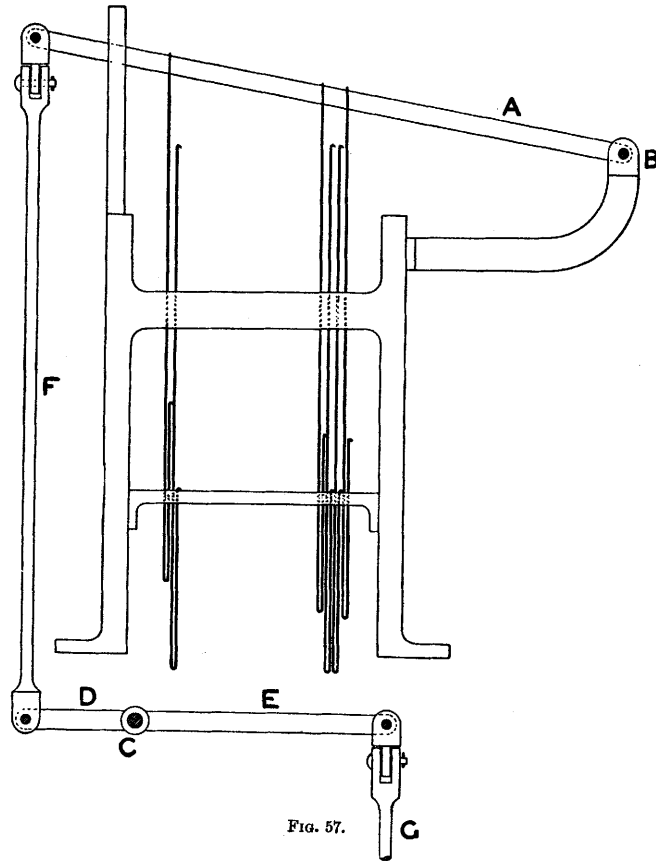


FIG. 57.

increased number of parts have prevented this plan from being generally used.

In 1884 J. E. Wadsworth attempted to attain the same

result by other means. He turned the hooks A, Fig. 58, round, and when vertical placed them out of reach of the griffe B; they were pushed upon B by blanks in the cards acting on short needles C, each needle being furnished with a disc instead of an eye. With lags in place of cards the pegs acted directly against the hooks.

Another contrivance is shown at Fig. 59, in which a needle A has three eyes; the first is large enough to receive a spring B, the second eye considerably exceeds the diameter of a hook C and takes its long leg, while the third is only large enough to take its short leg. Assuming a hook C to be on the griffe and a change to be necessary, a card will press back the point of a needle A some distance, without pushing C off the griffe, but the space between the long and short legs of C is decreased, and the natural spring of the wire carries the long leg off the griffe immediately the latter reaches its lowest point. In France a similar arrangement has for many years been attached to Jacquard machines, except that a needle has one eye which is large enough to embrace both branches of a hook.

Cards containing two or three rows of holes are often

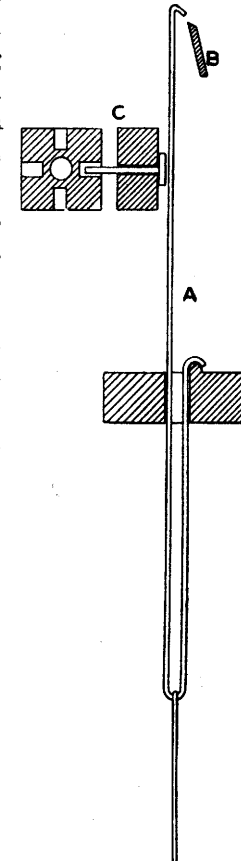


FIG. 58.

met with on dobbies which have only one row of needles; they enable a manufacturer to produce striped or bordered fabrics from a few cards, as each row of holes is cut to weave a different pattern. The cylinder is drilled to

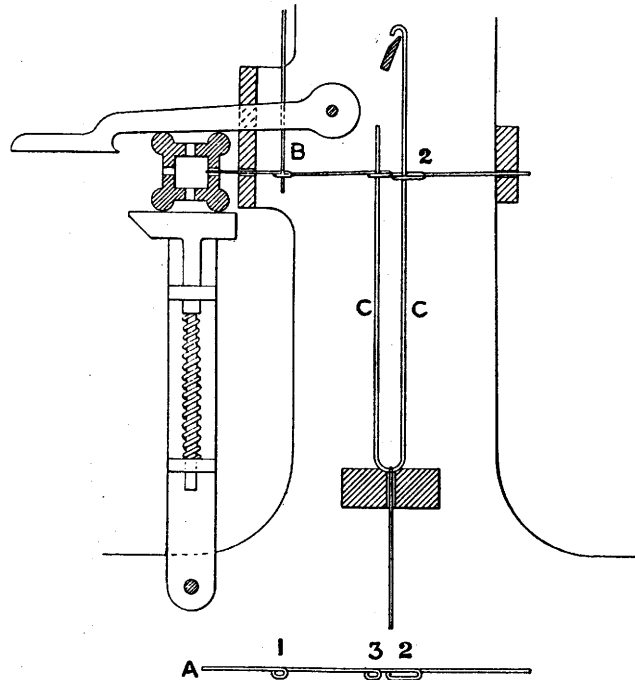


FIG. 59.

correspond with the number of rows in the card, and the dobby is said to be double-decked for two, and three-decked for three rows.

There are two methods of bringing the different rows of holes into action—one consists in lifting the needle plate,

and the other in lifting the cylinder. The latter is preferable, for needles work best when at right angles to the hooks. By lifting or depressing the forward end of a needle while leaving its rear end stationary one set of wires will be inclined to the other.

In Fig. 56 a plan for lifting a needle plate is shown: A' is a shaft and upon it two arms B' are fastened to support two bars C' and the needle plate G. A handle E' and a notched plate F' are employed to move G and the needles up or down. If a card has three rows of holes, the needles are opposite the middle row when the handle E' is in the centre notch of F'. If E' be moved to the notch on the right the top row will be used, and if moved to the notch on the left the bottom row will act upon the needles.

A needle plate G may be moved automatically by connecting the arms C' to two horizontal levers, each furnished with an antifriction bowl. Beneath these bowls two chains are passed round two chain wheels, which are set-screwed upon a shaft. A ratchet wheel on the same shaft is driven by a pawl mounted in an arm attached to a second shaft, and another arm upon the second shaft is connected to a spare hook in the dobby. At each revolution of the pattern cards this hook is lifted, and the pawl drives the ratchet one tooth, and moves the chains one link, forward. A deep link puts one pattern in action, a shallow link the other.

For cross-bordered fabrics the chief objection to this plan is that both patterns must repeat upon the same number of picks, or one must be a measure of the other.

In Fig. 60 adjusting parts are shown attached to the cylinder instead of the needle plate: A is the shaft, B an arm, C the cylinder batten, D the cylinder, E the setting handle, and F the retaining plate.

The cylinder motion of a dobbie has been referred to as horizontal, but some cylinders swing about a centre while others only rotate. The parts of a swinging

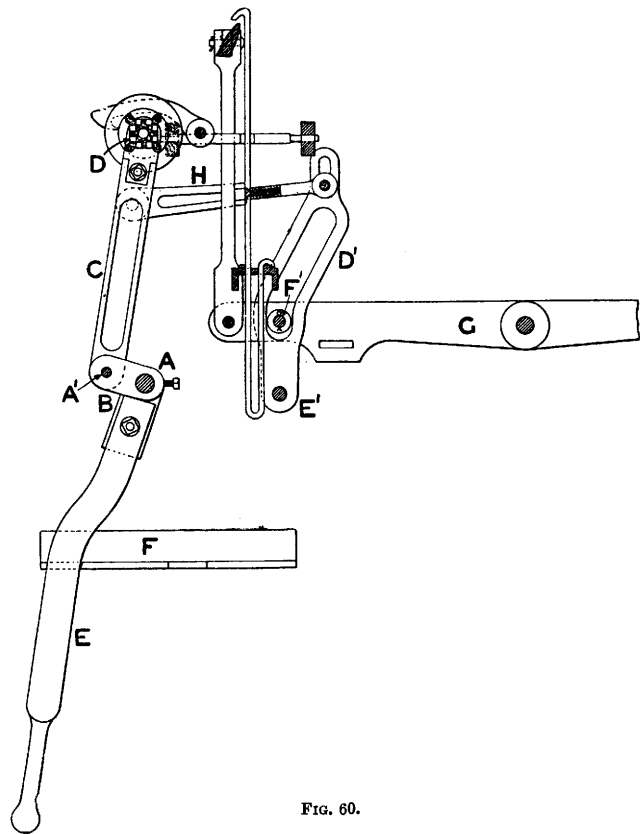


FIG. 60.

cylinder are given in Fig. 60. A shaft A is placed near the foot of the machine and carries two uprights C, in the upper ends of which the cylinder D and its bearings are

secured. An arm D' swings freely upon a pin E' as a bowl F', upon the lifting lever G, moves up and down the curved slot in D'. A connecting rod H couples D' and C, and conveys the motion of the former to the latter.

Other things being equal, a swinging motion is inferior to a horizontal one, because it moves in the arc of a circle and the needle points do not face the centres of the holes in the cards except when the cylinder arms are vertical, whereas a horizontal motion constantly holds the hole centres opposite the needle points.

A cylinder to which only a rotary motion is given requires a series of flat springs to cover the needle points, and lags are used instead of cards. In Fig. 61 the springs A are $\frac{1}{4}$ " wide; they form an almost continuous line across the machine, and so give a comparatively large surface for each peg to act on; it would otherwise be impossible to ensure perfect working, as a peg would slip off its needle. The springs are screwed upon a rail B, and slightly bent outward by a rod C. Each needle D is riveted to a separate spring, and, when the barrel E is turned, a cylindrical peg in a lag presses back A and D, and forces a hook F over the griffe G. The barrel E is rotated intermittently by centring a catch upon the griffe block. Each time the griffe rises the barrel makes $\frac{1}{3}$ th of a revolution.

In dobbies of the types illustrated by Figs. 56 to 60 fresh cards are required for each pattern, and they form the most expensive item in connection with these machines. Inventors have endeavoured in many ways to reduce the cost of using card dobbies; for example, continuous sheets of perforated paper have been tried; also sheets of wire gauze, and canvas cloth, in which some of the perforations were stopped with varnish, or other material capable of resisting the tendency of needles to break or puncture it;

but they found little favour. Lags are often preferred to cards, because pegs can be readjusted for a new pattern.

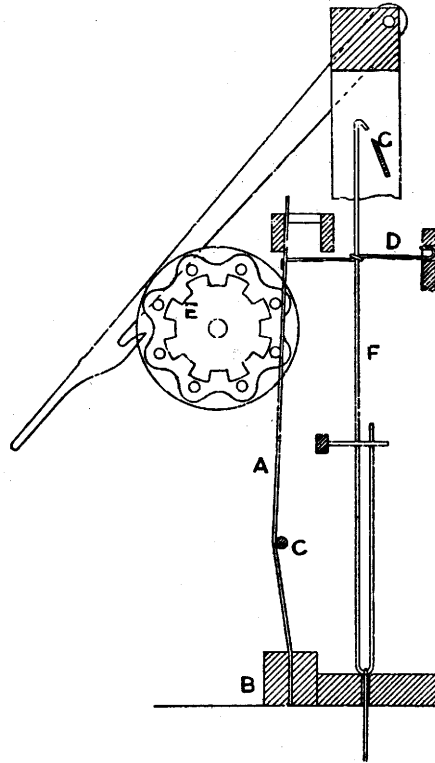


Fig. 61.

A lag is a piece of wood drilled with holes that coincide with the needles. Two staples are driven into each edge of a lag and all are linked together with rings to form a chain. Wooden pegs are then pressed into pre-determined holes to serve as risers or sinkers.

Lags are altered in form to suit the make of dobby they are intended to be used with. Some are drilled with a single line of holes, while others have two lines of holes. In the latter the holes forming the second row are midway between those of the first row. Each lag governs two sheds, thereby reducing the length of lattice required for a given pattern. Pegs for all double and many single rowed lags are cylindrical in form, and are usually about $\frac{3}{4}$ " long by $\frac{1}{8}$ " in diameter (see Fig. 62, No. 1); but as such thin wood is liable to break when working, metal in various

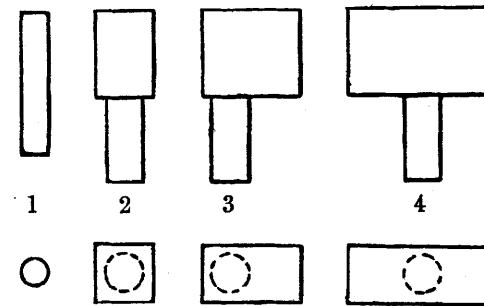


Fig. 62.

shapes, also split metal tubes pressed over wooden pegs, have been tried as substitutes, with, however, only partial success. Other pegs for single pick lags have a round shank and an oblong head; needles may then be dispensed with if the pegs are pressed against the hooks to push them on or off the griffe. A peg similar to No. 1 selects a shaft to lift, while pegs 2, 3, 4 allow shafts to remain stationary. No. 2 shows a peg for a single hook, No. 3 operates two, and No. 4 operates three hooks. A single peg is approximately $\frac{1}{8}$ " across the head and a three-hook peg 1"; all are about $\frac{5}{16}$ " thick. Large pegs such as 3 and

4 when employed reduce the time taken to prepare a set of lags.

Dobbies are known as right and left handed ; the distinction arises from the position of the starting handle of a

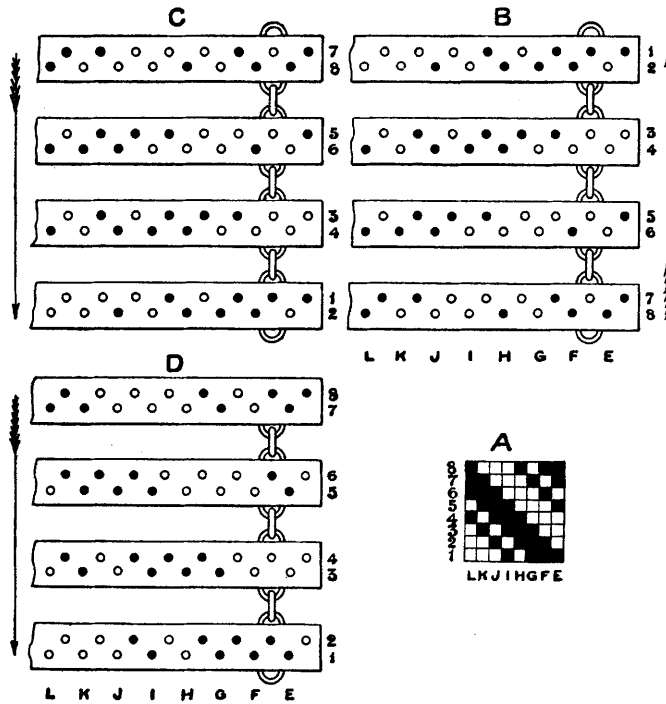


FIG. 63.

loom. If, when a weaver faces the fabric, this handle is to the right, the machine is said to be right-handed, but is fitted over the left-hand end of the framework. When the handle is on the left, the machine is left-handed and is over the right-hand end of the framework. The position

of a dobbie makes a difference in pegging a pattern, as will be seen by referring to Fig. 63, in which A is a design, B, C, D are lags, with the solid circles representing pegs inserted for pattern A. Of these, B is for a right-handed machine ; C for a left-handed machine of the old style, and D for a left-handed machine of the new style. The letters on A refer to shafts and the numbers to picks. With lags placed as above, the front heald shaft is always governed by the first peg in each row of holes, on the right of a lag. At one time all dobbies using this type of lag were constructed for the bottom griffe to move out for the first pick ; the effect of which was to reverse the direction of rotation in the lag barrel of a left-, as compared with that of a right-handed machine, and hence the necessity for varying the pegging. For a right-handed dobbie, the top row of holes in the uppermost lag of B is the first pick. In the old style of left-handed machine, the first pick is pegged in the top row of holes in the bottom lag of C. In the new style of left-handed machine the first pick is pegged in the bottom row of holes in the lowest lag of D. Each arrow indicates the direction in which the lags will rotate. A few left-handed machines of the old style are also fitted with a pulling, instead of a pushing catch, and then the lags, whether for right- or left-handed dobbies, are pegged alike.

THE CENTRE SHED DOBBY

The centre shed dobbie was introduced to expedite shedding. It is now chiefly used when the nature of the fabric to be made precludes high speeds, and when closed shedding is preferable to open shedding, as in gauzes. For such work, and for speeds of from 150 to 160 picks per

minute, it is well adapted, but at higher speeds it ceases to be reliable. Speed is limited by the striking capacity of the cylinder, for a high speed tends to throw the cards off the cylinder; the needles puncture the cards, and the short time available for selecting rising and falling hooks tends to defective shedding.

The essential parts of a centre shed dobbie are illustrated in Fig. 64, where a griffe A swings upon a pin at A', and a grid B, upon which the hooks rest, swings upon a pin B'.

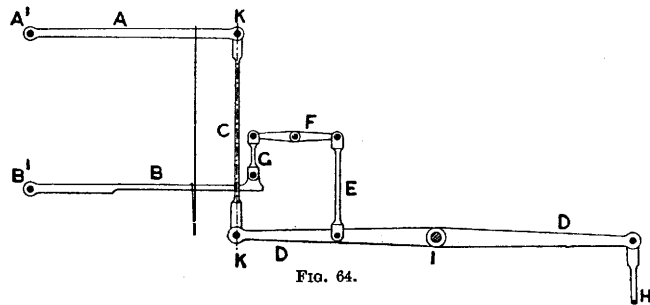


FIG. 64.

Both A and B are operated simultaneously in opposite directions by a crank, by links, and levers, in the following manner:—A crank on the top shaft of the loom vibrates a rod H, the latter is attached to a lever D, and D is fulcrumed at I, then a link C couples D to A. A second link E unites D with a lever F, which swings on a stud bolted in the framing. At the opposite end of F a link G connects F with the grid B. Since the motion of D is reversed by E, F, G, the grid B descends as the griffe A ascends. As a sequence all hooks taken up by A lift shafts to form the top shed, while those missed by A sink with B to the bottom shed. Simultaneous up and down movements of the heald shafts reduce the time occupied

in making changes to approximately half that required for a single-lift machine. In a loom the lever D is at right angles to A, B, but in the drawing, parts D, E, F, G, H have been turned on the dotted line K, to show the working clearly. With the parts arranged as here shown, the rise of A will exceed the fall of B, but slight alterations in the levers and links would produce equality of movement.

The card cylinder is frequently “decked” and swings, as in Fig. 60. Ordinary needles are employed, but each has a collar soldered upon it for one end of a loosely threaded spiral spring to impinge against; the opposite end of the spring bears upon the back plate.

DOUBLE-LIFT DOBBIES

In respect to steady working at high speeds, double-lift dobbies possess advantages over those that form a centre shed, because a card, or lag barrel, only actuates a set of hooks once for two revolutions of the crank shaft. The time for selecting a fresh series of hooks is thus doubled; the cards are not perforated by the needles, nor are the pegs broken to the same extent, and certainty of action increases with the time available for making changes. Instead of rising to the centre and sinking again for the next pick, a shaft can remain stationary at the bottom for an indefinite period. By this means the warp is kept steadier and less strain is put upon it. For gauze textures, however, the only advantage a double-lift machine possesses is a higher speed, as an open or semi-open shed must be partially converted into a closed one by the application of parts known as “shakers.” See pp. 258 to 261.

THE BLACKBURN DOBBY

The Blackburn double-lift dobbie has been developed from the single-lift type, and it possesses fewer distinctive features than most machines of this class. In many essentials it resembles a double-lift double-cylinder Jacquard, but it has been modified to meet the special requirements of a dobbie. Some of these machines contain 100 hooks, in which event they are capable of actuating 50 double jacks; but the parts are then too lightly constructed for moving heald shafts.

The machine is placed above one end of a loom so that tappets fixed at the centre of the bottom shaft may govern ordinary healds. Its central feature consists of hooks placed in two lines and operated by pegs without the aid of needles or other intermediary parts. In 1875 Yates and Brierley secured an extra pair of tappets upon the bottom shaft and allowed two treadles to rest upon them; to these they attached long connecting rods by studs. After passing through the warp, the rods were respectively made fast to griffe bars which were fulcrumed to give a varying lift. For a straight lift the griffe treadles are below the tappets, and the connecting rods are attached to the treadles and to adjusting pieces pendent for the griffes. Both griffes are then united by bolting one strap to an end of each, and a similar strap to the opposite ends; the straps are in turn bolted upon the surfaces of two pulleys, which are mounted upon a horizontal shaft placed parallel with, but above, the hooks. Hence, if one rod is depressed, the griffe shaft and pulleys oscillate and give equal but opposite movements to the griffes. The lag barrels are driven from one end of the tappet shaft by a crank and connecting rod; these rock

a lever and thus give a sliding motion to the barrels. Rotation is derived from a pulling pawl that rests upon a ratchet, keyed upon one of the barrel shafts. At each oscillation of the lever the pawl pulls one barrel through $\frac{1}{2}$ of a revolution, and the other is moved an equal distance by spur wheels fitted upon the barrel shafts.

Two tappets, one crank, and three connecting rods are thus employed to convey motion to all parts of this dobbie, and since two of the rods go through the warp, it is by no

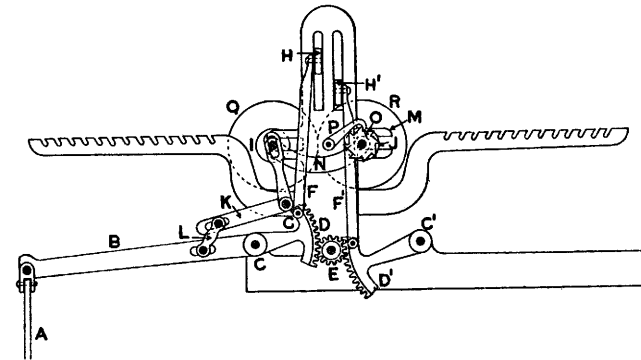


FIG. 65.

means an ideal arrangement. If the parts are connected, as in Figs. 65 and 66, a single crank and rod will suffice: the driving parts will be outside the loom framing, and either a straight or an unequal lift can be given at pleasure.

This method of positive driving was invented by Ainsworth and Ainsworth in 1879. In Fig. 65 a rod A connects a crank on the bottom loom-shaft with a lever B, which swings on a centre C, and carries a toothed segment D into contact with the teeth of a wheel E. One end of a rod F is pinned upon D, at G; the other end is

secured to the griffe H. A similar segment D' vibrates on a pin C', and gears with the opposite side of E. This segment is likewise connected to the griffe H' by a rod F'; therefore, as B ascends and H descends, the segment D' receives a simultaneous but diametrically opposite movement to D, which causes H' to rise when H falls and *vice versa*; both griffes meet in the middle and give a similar semi-open shed to that of a double-acting Jacquard.

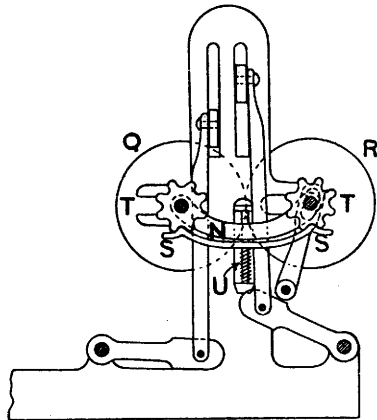


FIG. 66.

The lag barrels I, J are coupled by two curved links that form a carriage N, and move in slide bearings M. Motion derived from B is conveyed by a lever K through a link L to both barrels. The link fits upon two studs—one in B, the other in K, both permit of alterations in the throw of the barrels. A ratchet wheel O, with eight teeth, is keyed upon the rear end of the shaft of barrel J, and a pawl P, centred upon a stud in the framing, rests upon O. Two equal wheels Q, R are screwed upon the forward ends of I, J, to connect and turn both barrels inwards at the

same instant. The barrels are kept steady by a hammer consisting of a bar of metal S, Fig. 66, which is bent at two places to engage with the lower notches of two octagonal star wheels T, that adjoin the wheels Q, R. The bar S is retained in contact with T, T by threading a spiral spring U upon its shank; so that the lower end of U shall impinge against a holding bracket, and its upper end against the bar S.

The legs of a series of wire hooks, v, Fig. 67, are

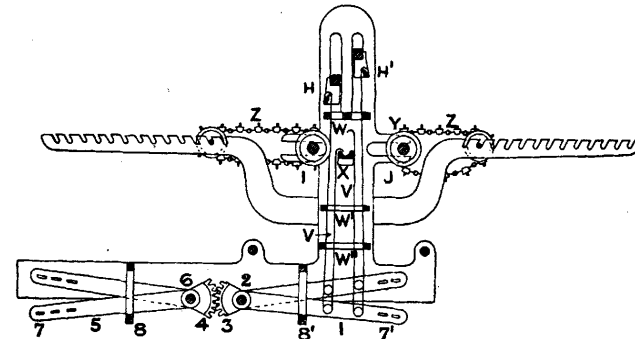


FIG. 67.

respectively 21" and 15" long; they are placed, back to back, in two parallel rows. All are retained in a vertical position by three grids w, w', w'', and by a rest x, which supports the short legs of v. When unmoved by pegs the vertical hooks are caught by the rising and falling griffes H, H'.

The lattice z is equally divided—one half is pegged for odd picks, the other for even ones; they are passed round and revolve with the barrels I, J. The pegs y force the hooks v from the griffes H, H'; hence a peg equals a hook left down, and an empty hole in a lag z permits a hook to lift.

Two hooks, one in each line, are attached to jack 1, either by nipples on the jacks or by sliding a jack through the loops of both hooks. These jacks are only $\frac{3}{4}$ " to 1" deep by $\frac{1}{16}$ " thick, and 40 of them occupy a space of 13"; each is fulcrumed at 2, and provided with a toothed segment 3, that gears with a similar segment 4, on a second set of jacks 5. The latter all move on a fulcrum pin 6, and connection is made with the harness at points 7, 7'. When a hook is lifted, the jacks 1, 5 move through a similar upward space; and the grids 8, 8' prevent side movement.

If this dobbie is used to weave striped and bordered goods, alternate lags are pegged to suit each pattern, and the lattices advance two lags at a time, until a change of pattern is needed; the barrels are then moved, either mechanically or manually, one lag, so that those previously idle may become operative. By another plan two barrels are fitted on each side of the machine, one above the other. Each pair carry lags for weaving a different pattern; when a change is needed one pair of barrels are put out of, and the other in, action.

This dobbie is chiefly employed to ornament fabrics known as dhooties—which are plain weaves figured near one or both selvages with loosely floating coloured threads. Tappets and heald shafts are then used to weave the plain fabric, and the dobbie contributes the figure by means of two Jacquard harnesses that seldom exceed 4" in width. Each harness is secured near one edge of the piece and is kept in tension by elastic cords, or dead weights.

THE KEIGHLEY DOBBY

In 1867 Messrs. Hattersley and Smith patented a dobbie that is still unsurpassed for most shaft work; but extended

use revealed defective details in the original model; these caused excessive wear and tear, slipping of needle collars, difficulty in making repairs, and a lack of stability. Many of these defects were removed before the patent rights expired, others have been rectified since the machine became public property.

During the last few years this dobbie has been modified in many ways to meet both special and general requirements. A sectional drawing of Ward Brothers' model is given in Fig. 68, where the hooks A, B are placed horizontally, and jointed at one end to a rocking bar C, and C is in turn supported at D' by the upper part of a front crank-lever D. The lever D is fulcrumed at E, and connected to a heald shaft at F. A slot G is concentric with E, and receives a pin that assists to hold D in position.

Each hook A is normally held horizontal by a needle H, which is circular or square in section, and rests upon the straight and lighter end of a lever I, whose fulcrum is at J. But each hook B is supported by a similar lever I, except that I is prolonged and bent until its upper end touches the under side of B. The needles H are kept vertical by passing them through holes in the flanges of grids T, U, and the hooks A, B are held parallel by these grids. The levers I, I' are confined by similar means. In a right-handed dobbie a lever I is placed next to the front framing, but in a left-handed machine of the new type the lever I' is the first.

Immediately below the heavy ends of I, I' an octagonal lag barrel S is free to rotate; the pitch of the lags being equal to that of the levers I, I', it follows that a peg will lift, and an empty hole will leave I or I' stationary.

By lifting a lever I, or I', where the lags act upon it, the inner end falls and removes the support from a hook,

hence the outer end of A or B will sink into contact with a draw knife K or L. Both K and L slide in horizontal slots in the framing, and are connected by adjusting rods to a three-armed lever M, which is centred at V. A crank on the bottom shaft of the loom and a lifting rod N cause M to oscillate and drive K, L. When a quicker movement and a longer pause at each extremity are required, elliptical gearing is employed.

As the crank revolves, the knives K, L slide in opposite directions, and the fall of a hook A or B is timed to occur when K, L are at the extremities of their oscillations. The hooked parts of A or B will then be slightly in advance of one drawing knife. Assuming K to move out, it will take a hook A with it, pull the top of a bar C from the stop O, press its lower end against the stop P and draw D' forward, thus lifting F, and the heald shaft, to which it is attached.

The lags being double-rowed, as shown in Fig. 63, one line of pegs acts on the levers I, the other on levers I' simultaneously, and they, and the barrel s, remain stationary for two picks; after which s is turned $\frac{1}{2}$ of a revolution to place the next lag beneath the levers I, I'. This is accomplished by hinging a jointed pawl R upon a pin Q in the lower arm of the lever M. As that arm moves in, R engages the teeth of a ratchet wheel upon the barrel-shaft and pushes it forward. A flat spring is secured to the upper part of R, it extends beyond the joint, and exerts sufficient force to turn s under normal conditions, but in case anything goes wrong with the lattice, the pawl R bends at the joint without moving the barrel. The lags and barrel are kept steady by bolting a flat spring to the framing and causing it to press upon the top of an eight-sided star wheel, which is fast upon the barrel shaft.

E

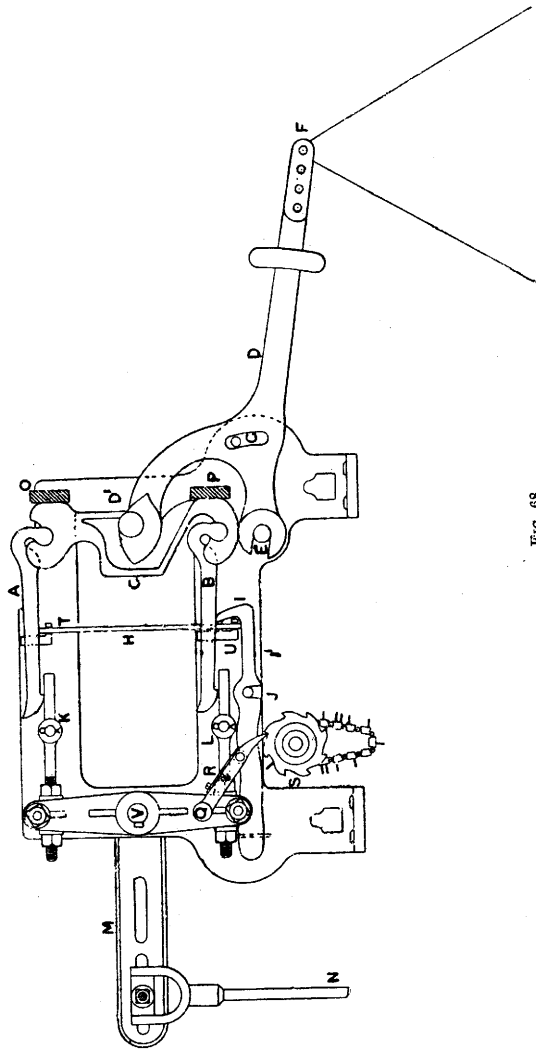


Fig. 68.