POWER-LOOM WEAVING OF WOOLLEN AND WORSTED FABRICS

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THE history of spinning and weaving was discussed in an article published in the Autumn 1951 issue of WOOL KNOWLEDGE, and the concluding sentence of that article read: "Despite the invention of greatly elaborated machinery, housed in vast mills, the basic principles of the machinery for spinning and weaving remain the same now as when Neolithic man first drew out the raw wool and twisted it into yarn between his fingers, and with it wove the first primitive woollen fabric." Some qualification of that statement ought perhaps to be made, for in present day machinery the principles involved are the same only to the extent that the fundamentals of weaving are unalterable. A woven structure requires the interlacing of one series of threads called "weft", with another series of threads called "warp", the latter being set at right angles to the weft threads. Several hundred warp threads must be delivered together so that the weft threads can pass across one at a time to interlace with the warp threads and then be closed against the cloth already woven.

The means used on modern power-looms for delivering the warp threads to the point where weft picks[1] may be interlaced with them, for separating the warp threads to produce the space or "shed"[2] for the insertion of weft in a variety of interlacings, for projecting shuttles or otherwise inserting weft picks possibly in several colours and in various orders of colouring, for closing weft picks against cloth already woven, and for moving the cloth forward on to a roller or beam as it is made, are vastly different in detail and sometimes even in principle from one make of power-loom to another. In addition, the modern power-loom has many extra mechanisms which are designed to save the operative time and effort, to improve the quality of the cloth produced, and to prevent damage to the threads and to the various mechanisms if anything out of the normal occurs during weaving.

The object of this article is to discuss briefly the different mechanisms of the power-looms used at the present time for woollen and worsted weaving, and

1. See end of article for glossary of numbered terms.

the possibilities regarding the variety of structure, colour and design of the cloths which can be woven with these mechanisms.

PRIMARY AND SECONDARY MOTIONS OF POWER-LOOMS

Three motions of power-looms or weaving machines can be classed as primary. They are shedding, picking of shuttles or other means of weft insertion and beating-up,[3] the first two providing the means of interlacing weft with warp, and the last closing the interlaced pick of weft against the cloth already woven. They are primary in the sense that they perform the fundamental operations in the making of a woven cloth.

The secondary motions of a power-loom are the warp let-off, which is the means of delivering the warp to the point of weaving, and cloth take-up[4] which is the winding of the woven cloth away from the point of weaving. These are secondary in the sense that they are not required on a simple weaving frame. In the latter case, the operations of interlacing a pick of weft with the warp and closing it against the cloth already woven can move along the length of warp as the cloth is built, whereas in the power-loom the points at which these take place are fixed and the warp and cloth must, therefore, move forward pick by pick.

An example of an ordinary plain loom of about 1850, fitted for driving by power.

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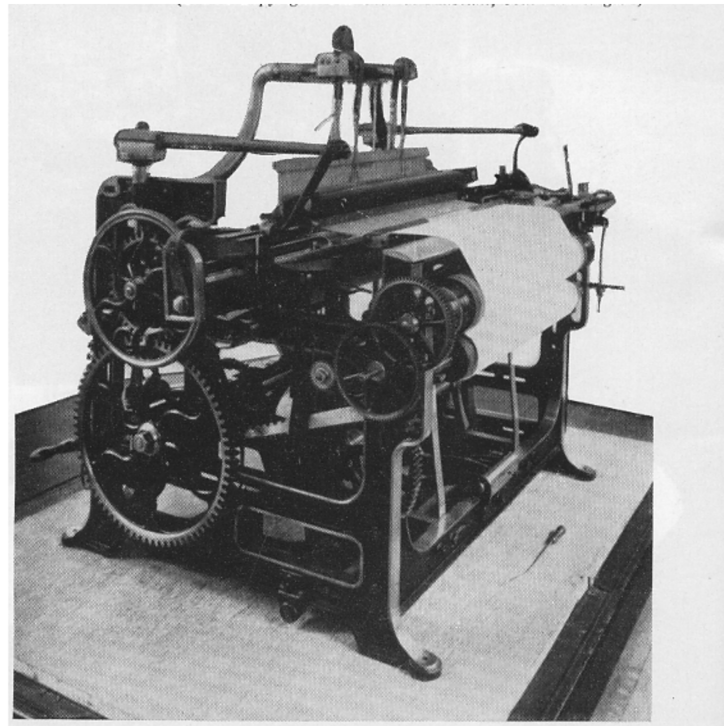
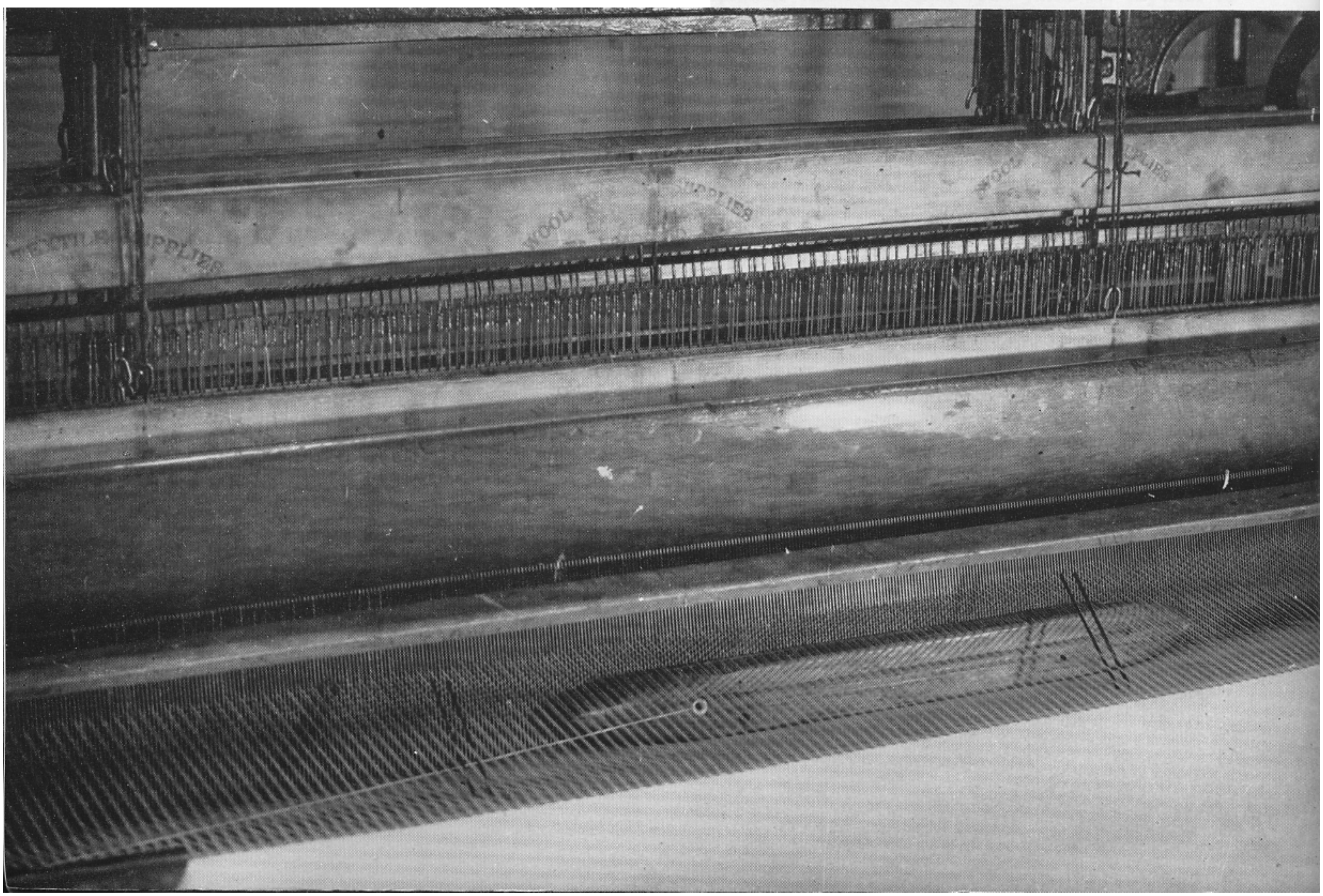


The weft thread and shuttle are shown passing through the shed created by the raising or lowering of the warp threads.



In a hand-loom, of course, the cloth can be built up for a considerable number of picks between stages of letting-off[5] the warp and taking the cloth forward, because the beating-up frame can be manipulated forward by hand to a decreasing degree as pick after pick is inserted. In hand-loom weaving, only when the space between the cloth fell[6] and the healds or harness has decreased to an extent which makes it difficult to pass a shuttle across between the separated warp threads is it necessary to slacken off the warp and wind the cloth forward.

The rest of the mechanisms of power-looms can be classed as auxiliary. Without them a power-loom could continue to produce cloth, but they are helpful in that they carry out a part of the operative's work, stop the loom to prevent damage to yarn, cloth or mechanism when there is breakage of material or a failure of the mechanism, and perform similar operations auxiliary to the interlacing of weft with warp and beating-up. Refinement of the primary and secondary motions may also be classed as auxiliary mechanisms of the power-loom.

Having described shedding and picking in their simplest forms and beating-up as the three primary motions of the loom, we can now consider the actual forms of the mechanisms for carrying out these operations in power-loom weaving and some of the possible refinements in detail and design.

Refinements in shedding include making it positive, that is converting mechanically the return of the warp threads to their neutral position as well as the separation of the threads, the provision of reversing devices for unweaving to correct a weft break, a wrong lift in shedding or some such fault, and the design of the mechanism so that a greater number of different warp thread interlacings can be woven.

TAPPET AND DOBBY MECHANISMS

The many types of mechanism for shedding on power-looms can be grouped into three classes – tappet, dobby and Jacquard. Tappet and dobby mechanisms operate heald shafts, that is, frames which carry the healds, through the eyes of which the warp threads are passed or drawn, and which are raised or lowered according to the interlacing required for the warp threads they control. The number of heald shafts which can be controlled by the mechanism decides the limiting number of different warp thread interlacings that can be arranged in the design. This is greater with dobby than with tappet shedding mechanisms.

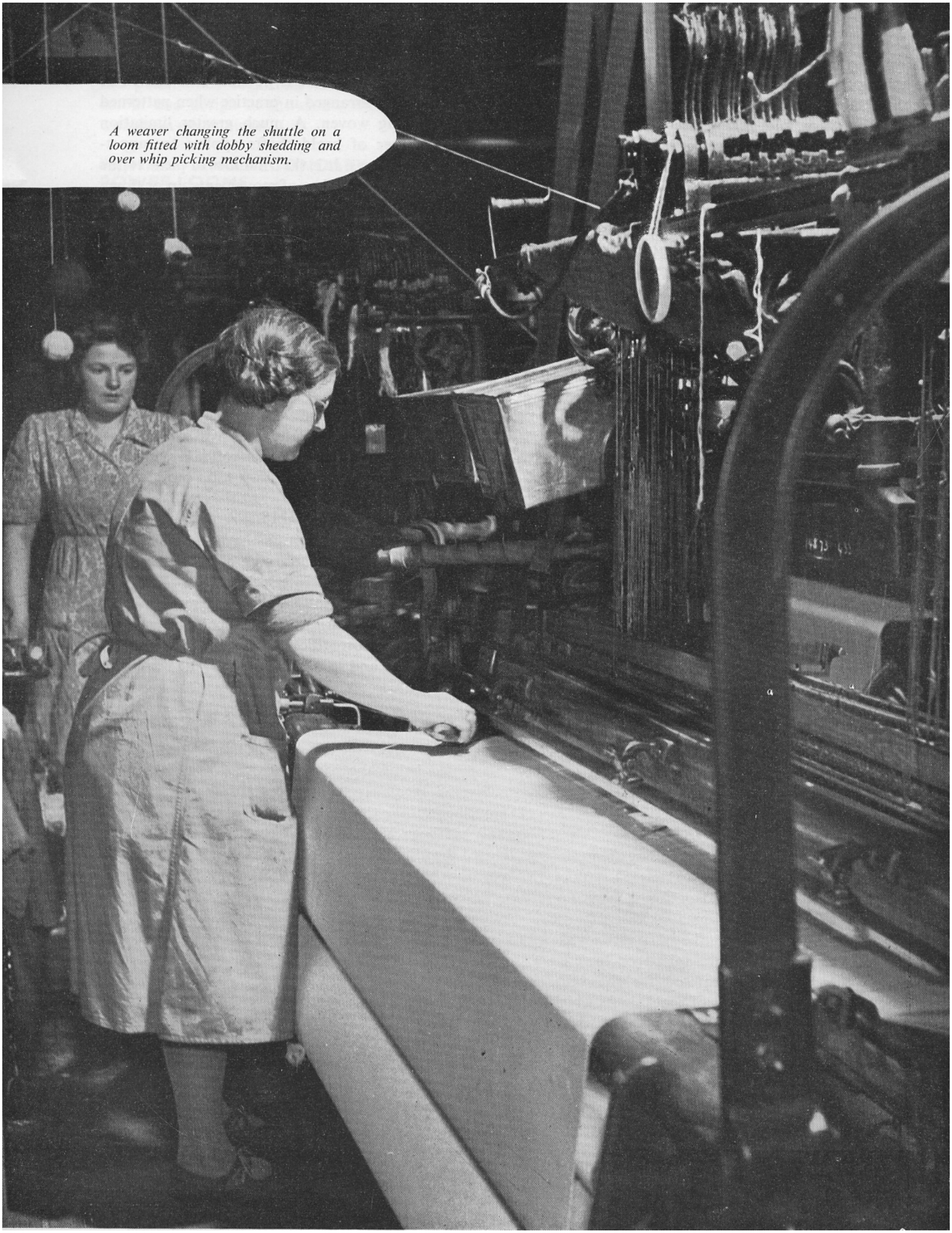
Dobbies are available for controlling up to thirty-six heald shafts, but twenty-four and sixteen are common limits. It should be noted, however, that by "drafting" or passing the threads through the heald shafts in various reversing, skipping and other orders, extension of the weave repeat well beyond the limit of the number of heald shafts is possible and this is, of course, very often arranged in practice when patterned fabrics are being woven. A much greater limitation than the number of heald shafts applies to tappet-shedding mechanisms. It is the "number of picks to the round", that is, the number of movements up or down of the heald shaft possible in one revolution of the tappet, which decides the number of picks covered by the weave interlacing. There is considerable difficulty in obtaining smooth movement of the heald shafts if too many picks to the round are attempted, so that eight picks is the common limit for tappets, although some types operate for twelve or even sixteen picks to the round. With dobby shedding, practically any number of picks to the warp interlacing can be arranged, limited only by the length of pegged lags that can be accommodated at the end of the loom. For large repeats weft-ways, it is useful to have a paper-roll controlled dobby because the paper-roll takes up much less space than pegged lags.

JACQUARD MECHANISMS

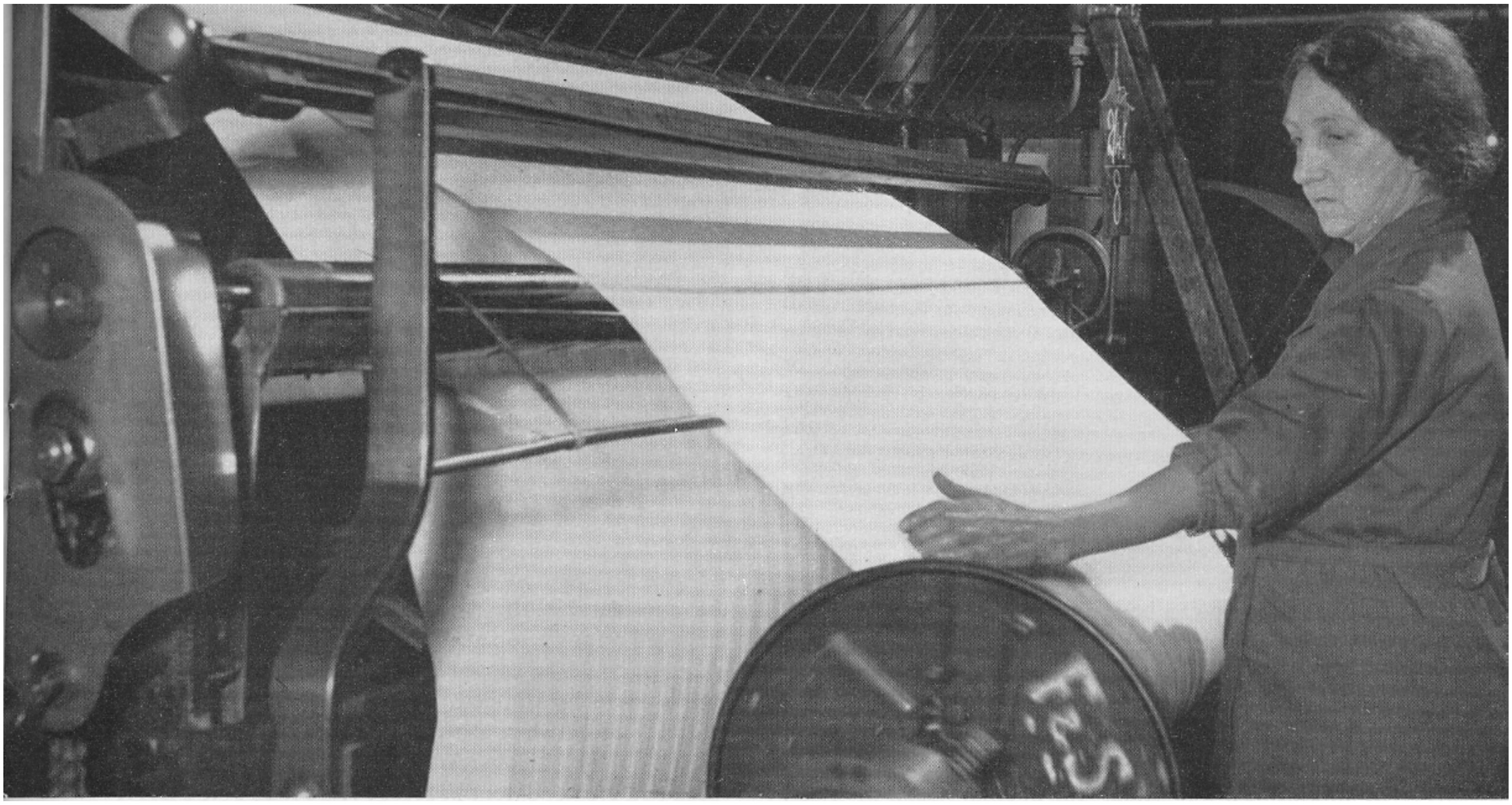
Jacquard shedding mechanisms have the great merit of extending the limit of patterning to allow hundreds of different warp thread interlacings, but there is a slight limitation to this type of mechanism in that fancy "ties" of the harness restrict patterning scope to the particular form dictated by the tie, such as reversed, border, and so on. In addition, the warp sett[7] cannot be varied so conveniently with Jacquard shedding as it can be with the heald shaft control of the warp threads in tappet and dobby shedding.

Shedding may be closed, open or semi-open, the last-mentioned being the natural feature of a double lift action in Jacquard shedding rather than a planned movement of the threads in forming the shed. After the weft has been inserted between the separated threads, closed shedding returns all the warp threads to a neutral position before the next shed is formed, whereas in open shedding only those threads move which are required to change position, up to down or vice versa. The other threads remain up or down for the successive picks. It is often claimed of open shedding that it allows greater loom speeds, but this is open to question. Compared with open shedding closed shedding has the advantage that it spreads the beating-up force over all the warp and reduces thread breakages.

There are so many designs and forms of mechanisms for picking or driving the shuttle through the shed that it is impossible to mention them all, and any mention would be of little value in a general article of this nature. However, the casual observer can easily note that the stick, straps, etc., which move to propel the shuttle through the shed, may be situated over or under the boxes, and that some mechanisms "whip"



A weaver changing the shuttle on a loom fitted with dobby shedding and over whip picking mechanism.



Beaming off from a warping mill on to a beam.

the shuttle whereas others "push" the shuttle. The important feature to note about picking is whether or not it can be arranged "at will", that is, from either side as required. The value of picking-at-will is that, in conjunction with multiple boxes at both sides of the loom, several shuttles can be used: (i) for mixing weft yarn – this is very important with irregular weft yarn which contrasts markedly in colour or shade with the warp yarn – and (ii) for the weaving of very fancy colour patterns.

OTHER METHODS OF INSERTING WEFT

It is of interest to mention briefly methods devised to displace the crude picking of shuttles as the means of inserting weft between separated warp threads. Rapiers, rigid or flexible, have been used to carry the weft across between the raised and lowered warp threads. One rapier may carry the weft all the way across and then return for insertion of the next pick. Alternatively two rapiers may be utilised, one taking the weft half-way across and "giving" it to the other which has moved to meet it and which completes the insertion of the pick as the two rapiers return to their original position. This method of weft insertion can operate with a smaller depth of shed, is less noisy, has greater colouring scope than that of ordinary picking and box looms, and is virtually automatic in weft supply because tip-to-tail link-up of cones from which the rapiers take the weft can be arranged to give an endless supply of weft. However, it may slow the loom a little and requires "tucked-in" or leno edges.

Another method, which also feeds the weft from cones situated at the side of the loom, is applied on the Sulzer weaving machine. Small carriers, which are torsion rod propelled, pick up the weft yarn and take it through the shed. They then release the yarn and are dropped on to an endless belt conveyor which takes them back to the side of the loom from which they came. Much greater speeds of weaving with increased widths of cloth are possible when the weft is inserted by this method but it, too, has the disadvantage of requiring a tucked-in or leno edge to take the place of the natural edge or selvedge obtained with weft insertion by the more usual shuttle method.

Yet another recently developed method of inserting weft from cone packages (placed at both sides of the loom in this case) utilises a single gripper shuttle which is much lighter in weight than the normal pirn-carrying shuttles but is heavier than the multiple gripper shuttles used on the Sulzer machine. This single gripper shuttle is torsion spring propelled from each side alternately and picks up the weft as it enters and releases it as it leaves the shed.

Other developments are air or water jet methods of weft insertion. In spite of the merits of all these newer methods of weft insertion in increasing loom speed, decrease of noise, etc., when compared with the crude mechanical picking of shuttles, the latter continues as the main method on present-day weaving machinery.

Beating-up on modern power-looms has not changed in principle and design of mechanism, other than to switch to the underswinging sley[8] as compared with the overswinging sley which was common on earlier power-looms and which is still used on hand-looms and on some weaving frames.

In the secondary motions of power-looms, "negative" let-off, or the mere retardation of rotation of the warp beam by the friction of ropes, chains or brakes, is still used to a very large extent on power-looms for cotton and silk weaving. However, most of the looms for woollen and worsted weaving are fitted with gear let-off motions. In these, the control for the amount of warp let-off on successive picks and the compensation for the decreasing diameter of warp on beam as weaving progresses, is by means of a vibrating back rest which determines the sweep of pawls on a ratchet wheel.

Cloth take-up can be somewhat similarly controlled, but the more usual take-up on present-day looms is by a friction beam or roller. This is gear driven, has a constant surface speed, and is covered with crêpe rubber, emery or perforated tin so that it grips the cloth to pull it forward efficiently. The cloth then passes to another beam or roller, the angular speed of which is decreased as the diameter of the cloth on the beam increases. The decreasing angular speed of the cloth roller is produced either by having it contact-driven by the friction roller or by incorporating a slipping collar arrangement in a gear-drive from the friction roller to the cloth roller. The gear-drive to the friction beam in such positive cloth take-up mechanisms may incorporate either a pawl and ratchet or a worm and wheel as the main reduction which is necessary in the gears to obtain the very small movement of cloth per pick woven. The ratchet-type can "cram", that is, cease taking up for certain figuring picks, by merely lifting the pawl. When weaving extra weft spot effects and hungback check styles with worm take-up motions, however, a special "cramming attachment" must be fitted.

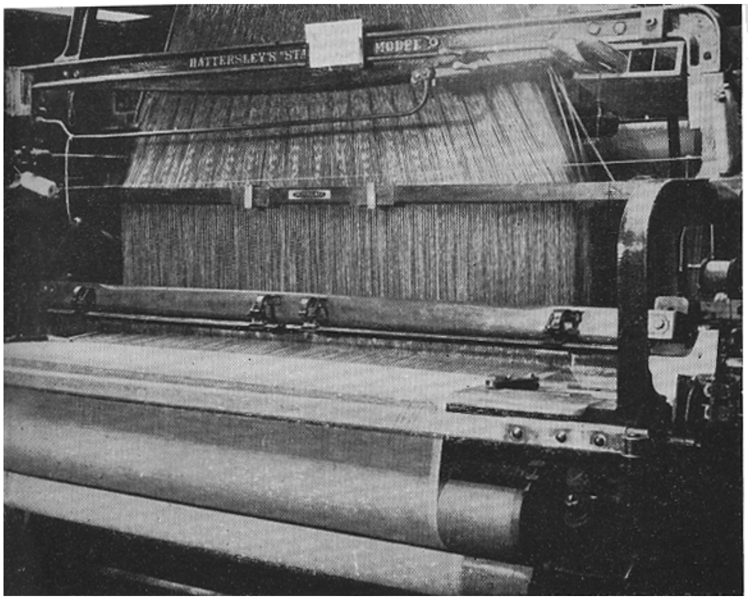
In comparatively recent years the Wool Industries Research Association has developed a roller let-off motion which is a considerable improvement on previous attempts to deliver warp in an absolutely positive manner by means of rollers. Naturally this motion introduces a slight degree of complication as regards deciding the amount of warp to be delivered per pick to suit the variety of counts, weave interlacings and picks per inch which may be required in the different structures to be woven. Nevertheless it is a valuable motion in that the crimp in the warp yarn at the weaving stage can be controlled and modified as desired. A change wheel is incorporated in the train of gears driving the pair of rubber-covered and fluted rollers which deliver the warp and the gears operate forward or in reverse, or stop for the cramming of weft, in synchronisation with the take-up gears.

AUTOMATIC STOP MECHANISMS

Auxiliary mechanisms are designed to save the weaver time and labour, and to assist in production as regards quantity or quality of product or as regards prevention of damage to the material or the machine. The value of escape features in the various mechanisms is so obvious that any detail regarding them is scarcely merited. One "escape" can be mentioned to give readers the general idea of where and how they apply, i.e., in dobby shedding the lag cylinder drive has an escape mechanism. If the pegging legs pile up or otherwise foul to prevent easy rotation of the lag cylinder, the damage to the lags and to the dobby mechanism if there were no escape in the gear drive would be very serious and the time spent in extricating the parts would be considerable. In addition, should the weaver be engaged on some job at the time the lags fouled, serious damage could be caused to warp and cloth before the loom could be stopped. The value of motions which stop the loom when a warp or a weft thread breaks is likewise very obvious. Warp stop motions have been used to a greater extent in recent years than ever before, because of the practice of having more and more looms under the care of one weaver. Briefly, warp stop motions consist of "droppers" or thin pieces of metal, one of which is placed on each warp thread. If a thread breaks, its dropper will fall and interfere with a reciprocating device or complete an electrical circuit. In either case a knock-off lever will move the starting handle of the loom to its "off" position.

Weft stop motions consist of a fork or feeler placed to sense the presence or absence of weft. When the weft is absent due to a break or to the pirn[9] running empty in a shuttle, the feeler senses this and operates a mechanism which moves the starting handle to the "off" position. On alternate picking looms the weft fork must be placed so that it feels for the weft pick between the cloth selvedge and the shuttle boxes, but it must be placed between the selvedges on looms fitted with picking-at-will. The latter positioning gives what is commonly known as the "centre" weft fork and is the more usual for woollen and worsted weaving, because so many of the looms in this section of cloth manufacture have multiple boxes and pickings-at-will so that they can cope with fancy colourings. A centre-weft fork feels for the weft as the reed moves forward to the beat-up, and it may be linked with the stop mechanism to stop the loom either on the pick following or before the reed reaches its beating-up position.

Yet another arrangement links the fork with an automatic reversing device. In the course of the few revolutions of the crank-shaft following the sensing of absence of weft, the picking is put out of action, and the dobby mechanism operates the pattern lags forward and in reverse, so that the heald shafts and box positions



A Jacquard loom, which is particularly useful for intricate patterns.

Drawing in. The operator pulls the warp ends through the healds and reed, so as to get the threads in the required order in the heald shafts.

at the stopping of the loom a few picks later are those of the pick on which the break in weft supply occurred. With ordinary stop motions the weaver has to "reverse" the shedding and box movements to find the broken pick and restart weaving so that no fault shows in the cloth. Some looms provide a hand-wheel for such reversing, while others are power manipulated. It is obvious that ordinary stop motions save a great deal of time and waste, because the absence of weft for possibly inches of cloth "woven" while the weaver is engaged on other duties is avoided. Stop-on-pick or automatic pick-finding are even better, however, as the weaver saves time in not having to reverse. All she has to do is to complete the broken pick which is in the shed, pick up the end of the weft from the shuttle, or replace with another shuttle if the pirn is empty, and re-start the loom.

Warp protector motions prevent damage to the warp if a shuttle is trapped in the shed instead of continuing to the box to which it has been picked. Fast-reed[10] types are more usual for woollen and worsted looms with drop boxes and they consist simply of a stop rod, the daggers of which strike against powerfully sprung parts to prevent the lay, or going part, moving forward to the beat-up position, at the same time knocking the starting handle to the "off" position. Loose-reed warp protector motions must be fitted to looms which have circular or rotary boxes, because these boxes cannot be fitted with the "swells" or levers which are necessary to control the position of the stop-rod of the fast-reed mechanisms. Loose-reed motions allow the reed to slip back when a shuttle is trapped, with the result that no beat-up takes place and damage to the warp is avoided. A lever is positioned to move the starting handle to the "off" position as the going part with its loosened reed moves to its furthest forward position.

One of the most important developments in auxiliary weaving mechanisms occurred over fifty years ago in the designing and fitting to looms of automatic means of weft supply. Instead of the weaver having to watch shuttles for the weft running nearly empty on the pirn and then stopping the loom and replenishing the weft, all that is required now is to maintain a battery or magazine supply of pirns or replenished shuttles. When the loom senses the need for replenishment of weft, it either inserts a full shuttle in place of a nearly empty one or presses a full pirn into the shuttle to take the place of the nearly empty pirn. Shuttle-changing automatic weft supply is not so common as pirn-changing on woollen and worsted looms. Both types nowadays may be single or multiple colour. Multiple colour automatic weft supply requires a fairly complex system of selection to ensure that the correct colour of weft pirn (or shuttle with the correct colour of weft) is placed in position for change

There are many different designs of mechanism to supply weft automatically during weaving but, as with the other mechanisms discussed, the detail is not important in an article such as this. It is useful to mention, however, that recent designs of mechanisms are considerably improved compared with earlier mechanisms, in respect of weft mixing and colouring, cutting of the weft ends, prevention of the ends of weft trailing into the cloth, etc. Automatic looms with two-twos and three-ones weft mixing are available and multi-colour automatics which will weave elaborate check patterns with up to four colours in any even-picking order have been perfected by all the leading loom-makers. Doubtless most loom-makers are working toward the production of the single and odd-pick colouring automatic loom and some, e.g., the Crompton and Knowles PAPA and the Schwabe have been available for some time but used only to a very limited extent.

TRENDS IN LOOM DESIGN

In conclusion, it may be interesting to make some comments on the possible trends in loom design in the next twenty years or so. It is unlikely that there will be any sweeping changes in the general form of looms for woollen and worsted weaving compared with present-day looms. Circular looms have again had a minor wave of publicity over the past few years, but this form of machine is not likely to supercede the orthodox loom, for woollens and worsteds at least, unless it can be designed to produce closely set fabrics and structures which are more elaborate both from the weave interlacing and weft colouring points of view.

Looms using the newer methods of weft insertion, particularly the Sulzer carrier principle, have a better chance of success, particularly as they are now being developed to give better edges to the cloth during weaving. Other likely changes in the fairly near future are the production of new and better automatic looms capable of introducing single or odd-pick groups of different weft colours, and the improving of the existing orthodox mechanisms to increase loom speed, and to render the loom even more efficient and independent of the operative than it already is.

GLOSSARY

1. Pick — the thread of weft carried across the warp in the loom by one passage of the shuttle.
2. Shed — the triangular opening formed for the passage of the loom shuttle by raising some warp threads and depressing the others.
3. Beating-up — the third primary movement of the loom when making cloth. It is the action of the reed as it drives each pick of weft to the fell of the cloth.
4. Take-up — the winding of the woven cloth forward pick by pick as weaving proceeds.
5. Let-off motion — the mechanism on a loom for regulating the delivery of the warp from the warp beam, and for maintaining the necessary tension on the warp.
6. Fell — the woven edge of the cloth against which the reed beats each weft thread.
7. Warp sett — the number of warp threads per inch or other standard of measurement. The sett systems vary according to the locality in which they are used.
8. Sley — the part of a loom mechanism in which the reed is fixed and which moves the reed forward to beat up the weft.
9. Pirn — a wooden or paper spool carrying the length of weft yarn ready for weaving. May also refer to the bare spool.
10. Reed — a metal comb fixed in a frame. The closeness of its wires determines the fineness of a cloth. It keeps the warp threads spaced evenly, forms a guide for the back of the shuttle, and beats up the weft to the fell of the cloth.

Cloth Weaving. *A modern automatic high speed weaving machine now being widely introduced into the worsted side of the industry. This is the stage where the warp and weft come together in the form envisaged by the cloth designer.* (*Photograph taken at Salt's Saltaire Ltd.*)