

1. Automatic shuttle loom

The automatic looms have all the essential motions of weaving namely,

- ✓ Shedding,
- ✓ Picking,
- ✓ Beat-up,
- ✓ Let-off, and
- ✓ Take-up.

There are additional motions which are incorporated to make them fully automatic such as warp stop motion, automatic weft replenishing motion, automatic positive let off motion.

Weft replenishment on the automatic looms is of two types:

- ✓ Cop changing and
- ✓ Shuttle changing.

These can be run for time without stopping so long as the warp does not break. Superior quality fabrics are manufactured at minimum cost and highest level of weaving efficiency.

Additional motions such as the following are also incorporated in the loom to assist the above motions such as weft feeler motion, weft fork motion, shuttle protector motion, weft cutter, etc. speed of these looms can be as high as 200-250ppm (rpm).

1.1. Warp Protection

Introduction

It is possible that the shuttle may fail to reach the opposite box as a result of a faulty pick or some obstruction in the warp shed. In this case, many ends may be broken if the sley comes forward to the beat-up position with the shuttle lying between the top and bottom shed lines and resting against the reed. It is desirable to prevent this from occurring.

The most popular motion available for this purpose is the fast-reed warp protector, although a method known as the loose-reed warp protector which is very popular for many years, particularly on Lancashire looms.

1.1.1 Fast-reed Warp Protector

This mechanism utilizes the fact that the swell, acting as a brake, is displaced by the shuttle in bringing it to rest. The swell will normally attain its maximum displacement, but, if the shuttle fails to reach its correct rest position or if it rebounds owing to insufficient checking or too much picking force, then the swell will not receive its maximum displacement, so that the finger shown in Fig. 1.1 a will not be pushed back as far as it should be. This will not let the stop-rod rotate sufficiently to allow the dagger to clear the frog steel.

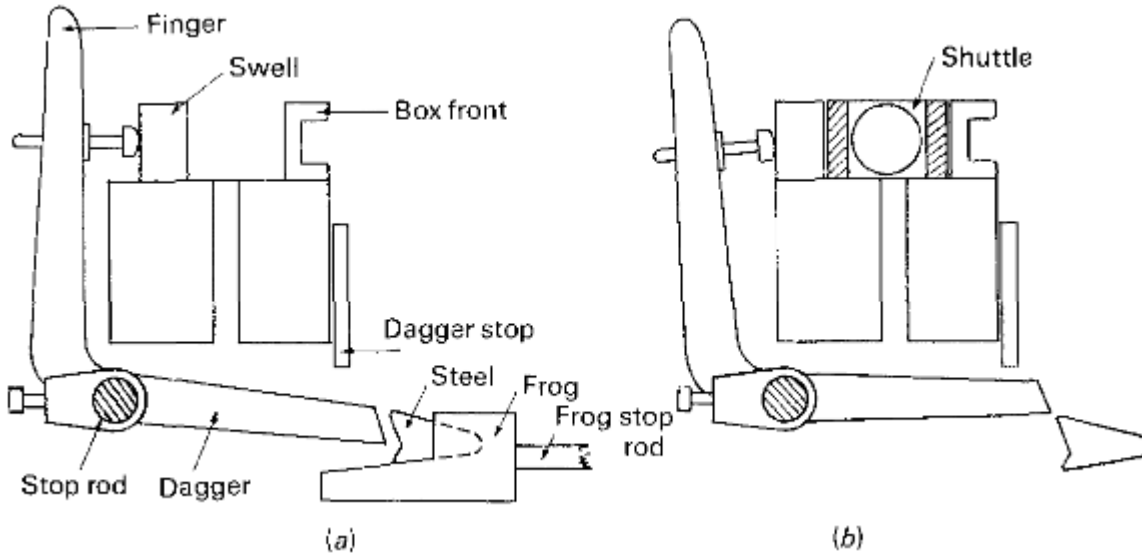


Fig. 1.1 A fast-reed warp-protector motion

The sudden impact of the dagger on the steel will bring the loom to an almost instantaneous halt which is commonly known as the *bang-off* because of the resulting noise. The steel is directly connected to the starting handle, so that the loom brake is immediately applied to disengage the clutch or switch off the motor depending on the method of drive, and thus overheating of these parts will be prevented.

Absorbing the shock of the sudden stop presents a much greater problem, which is overcome in older Northrop and Riiti looms by the use of a pair of heavy flat springs at each side of the loom. These are fixed to the bottom of the front of the loom frame, and the frog stop-rod is in contact with them near to their top end. In other looms, such as the Picanol, Draper, and Crompton & Knowles looms, the heavy coil springs are built into the crank arms. If the shuttle is correctly boxed at the end of its flight, then the swell and thus the finger will be pushed back, the rod will rotate, and the dagger will be raised clear of the steel (Fig. 1.b), so that the loom will continue running. A dagger stop is introduced to limit the amount of upward movement of the dagger to ensure that the swell will not be forced out of contact with the shuttle for too long owing to the sudden force of impact.

Bang-off actually occurs when the sley is travelling at its maximum velocity, and, although the brake is applied very quickly and the shock is absorbed, problems can arise if the sley is allowed to dwell in its back position for a longer period of time than is usual (as for example, when the sley is cam-driven), or if the speed of the loom is increased without any improvement in the performance of the shock absorbers. The force of bang-off will increase considerably because the sley will have to reach a higher maximum velocity, and this may cause the parts that are taking the full force of the shock to fracture.

1.1.2 Loose-reed Warp Protector

The shuttle must come to rest in the box of a fast-reed loom by 270° if a trap is to be avoided, and for this purpose the shuttle must make its initial contact with the swell by 250° . This presents a very serious limitation to the amount of time available for shuttle flight, which was not present to the same extent with the loose-reed warp protector. With this mechanism, the reed was supported at beat-up by the dagger passing under a heater fixed to the loom frame. In the back position, a light spring was sufficient to support the reed while the shuttle passed from one side

of the loom to the other. If a shuttle became trapped, however, the bottom baulk of the reed was forced out of its support, and beat-up was no longer possible. The time of arrival of the shuttle in the opposite box was no longer dependent on the checking mechanism, and up to another 20° became available for shuttle flight, which thus made higher loom speeds possible or alternatively allowed lower shuttle speeds to be used for the same loom speed.

Although this method has the obvious disadvantage of straining the threads in the area in which the shuttle is trapped because of the presence of the shuttle and because the loom does not stop instantly but continues to turn over for a few picks until the weft fork stops it) there are certain attractions that have been incorporated by Riiti in their BANL and C looms. The loose reed hinged at its top baulk is still used to detect the presence of the shuttle as the reed comes forward to beat-up, but, if the reed receives the slightest pressure from a trapped shuttle, then the dagger will be raised to strike the heater, which is part of the starting-handle unit, and the loom will be knocked off instantly. The reed is again supported during shuttle flight by a spring on the finger that supports the back arm of the dagger, and at the front position the dagger passes under the heater, so that the reed is supported to withstand the full force of the beat-up. The extra time for shuttle flight is therefore gained, and it is possible to have a softer or gentler pick, which will reduce wear, or higher loom speeds, or a combination of both.

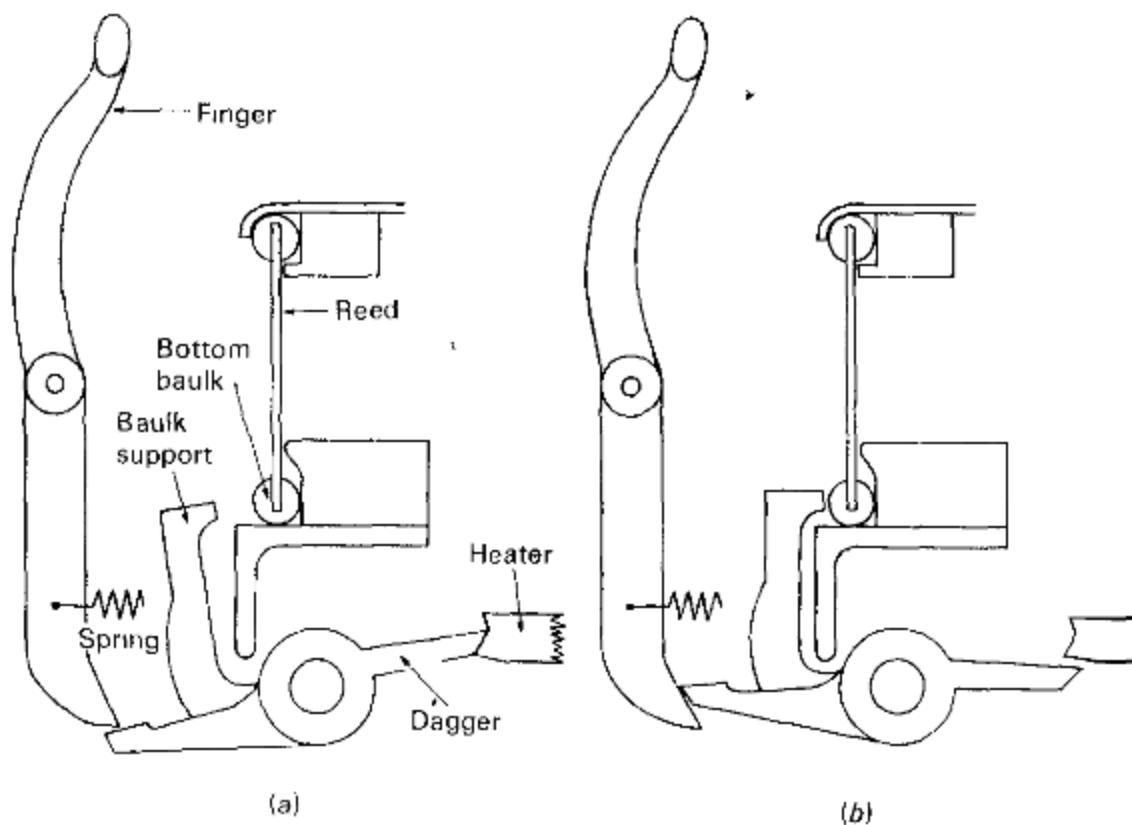


Fig 1.2 A loose-reed warp-protector motion

1.1.3 Electromagnetic Warp Protection

The relatively short time available for stopping the loom after detection will always provide a problem, and, in an effort to find the answer, Crompton & Knowles developed in their C 7 loom a system that used a magnet to energize a coil in the sley at a point at which the shuttle should

pass at the same time on each pick, irrespective of its direction of flight. More recently, the idea has regained favour, first with Northrop in the Sensamatic loom and then with Picanol (MDC), Saurer (Versa speed), and Riiti (C 1001), using variations of the principle.

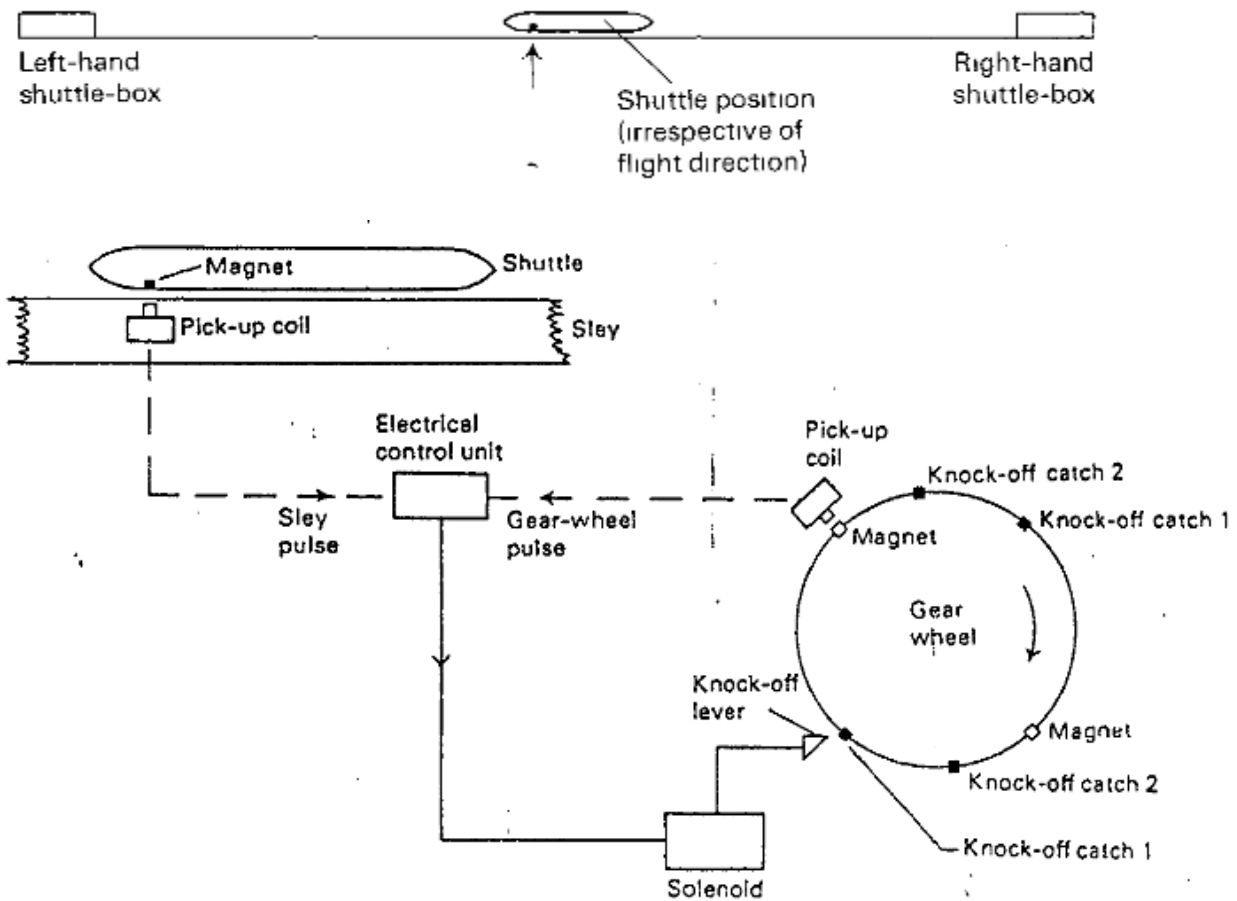


Fig.1.3 An electromagnetic warp-protector motion

The position of the coil in the sley must be offset from the centre of the sley because it is only possible to carry the magnet in the end of the shuttle opposite to the shuttle eye. In the Sensamatic loom, the passage of the shuttle over the coil causes a pulse to be fed to the electrical control unit (Fig. 1.3). This pulse must alternate with a second pulse, generated by a magnet mounted on the loom-shaft gear wheel and thus occurring at a fixed time in each loom cycle.

Any break in the sequence of these pulses caused by a late passage or non passage of the shuttle will activate the solenoid, so that the knock-off lever will be positioned in the path of knock-off catch I, and the loom will be brought to rest. Other electrical feeds to the solenoid will cause the same catch to bring the loom to rest in the same position for a warp break or as a result of operating the manual push-button. A second knock-off catch (2) is used for the weft stop motion. The knock-off-catch positions are adjustable and dependent on the type of loom and the loom-timings, which govern the position at which it is desirable to bring the loom to rest.

Since the gear wheel used is mounted on the bottom shaft of the loom, it is necessary to have two magnets and four knock-off catches, which are diametrically opposed to each other in pairs.

The efficiency of the warp-protector motion is now no longer dependent on the shuttle's being in a specific position at a specific time to operate the mechanism instantly, so that, not only is the bang-off shock eliminated, but there is also more time available for shuttle flight. The governing factor regarding the time of shuttle arrival in the box is now the amount of space available for the shuttle as it leaves the shed. Furthermore, in the fast- and loose reed methods of warp protection, there is always the possibility of some carnage to the cloth fell when the shuttle is trapped. This is completely avoided with electromagnetic warp protection because the loom is stopped before trapping can occur.

Electromagnetic warp protection:

- a magnet in the end of the shuttle opposite to the shuttle eye.
- As the shuttle passes over the coil B, a pulse generated which is fed to an electrical control unit G
- a second pulse is generated by a coil C and magnet D mounted on the disc E on the bottom shaft F and this occurs at a fixed time in each loom cycle.
- A late passage or non-passage of the shuttle causes a break in the sequence of the two pulses.

Advantages:

- Banging-off shock is eliminated since there more time is available for stopping of the loom.
- Unlike loose and fast reed methods of warp protection, there is no possibility of damage to the fell of the cloth since the loom is stopped before shuttle trapping can occur.

1.2 Warp Stop-motions

General Operation

The purpose of warp stop-motions is to stop the loom when a warp end breaks so that an unrepairable fault is avoided. It is a fact that a slight fault is left in the cloth after a warp break because the broken end is not pieced to the thread that has already been woven into the cloth, and this thread is therefore not continuous in the fabric. In high-quality worsted fabrics, such faults must be repaired after weaving. If the breaking of the warp thread is not detected immediately, then the loose thread will tend to become entangled round adjacent threads, which will cause more threads to break and possibly create a fault known as *afloat* in the fabric.

Warp stop-motions may be mechanically or electrically operated, but, whichever system is chosen, it is necessary to support a thin strip of metal, known as a *drop wire*, *dropper*, or *pin*, on each end so that, when the thread breaks, the drop wire will fall and operate the mechanism.

The drop wire may vary in design depending on two entirely different sets of circumstances" Fig. 1.4a shows a drop wire suitable for use when the thread is drawn through the wire in the drawing-in department, whereas the drop wire in Fig. 1.4b is used when the wires are dropped onto the ends on a special pinning machine after the ends have been drawn through the healds and reed or after the warp has been gaited in the loom. These open-ended droppers are more quickly placed on the threads, but they may tend to spread over more than one thread, so that

they will not fall if only one of the threads breaks. This circumstance will only occur as a result of operative carelessness, but it is nevertheless an obvious disadvantage. ∴~"

If the drop wire is to be threaded on a Barber-Colman drawing-in machine, then it is necessary for a key-way to be cut into the drop wire, as shown in Fig. 1.4c. When drop wires are to be used in association with an electrical warp stop motion, a modified shape of cut-out is essential so that contact between the two parts of the electrode is ensured. Two common shapes are illustrated in Fig. 1.4d and e, but the shape of the cut-out is dependent on the design of the electrode. The shape of this top cut-out is entirely independent of whether the drop wire is of the closed or open-end type, and a key-way may again be necessary if the wire is to be used on warps to be drawn on the Barber-Colman machine.

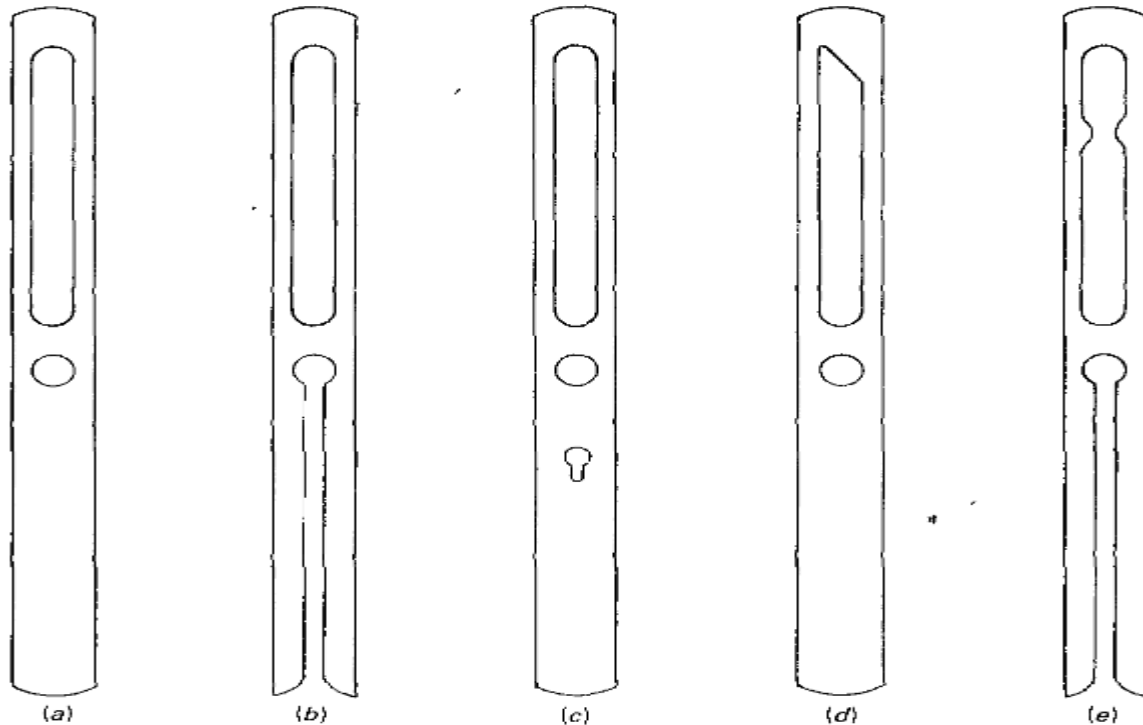


Fig. 1.4 Types of drop wire

The size of a drop wire can vary quite considerably depending on the type of loom, some wires for terry looms being quite long. The weight of a wire should be such that it will fall quickly but should not be so great that it will damage the thread.

1.2.1 Mechanical Warp Stop-motion

The bar unit of the stop-motion passes through the large cut-out at the top of the drop wire. The bar is in three parts, the top of each being castellated. The two outside ones are fixed, and the inside one is made to reciprocate. The amount of reciprocation should be equal to one complete castellation, and, in order to ensure that a wire will fall into the lowest cut-out point of both bars, it is necessary for the centre moving bar to be slightly higher than the two outside ones. When the wire falls into this lowest position, it limits the movement of the centre bar and thus the parts of the mechanism that have been causing the reciprocation, which, on a Northrop loom, originate from an eccentric on the bottom shaft, whereas Saurer use a cam method of drive.

In the Northrop method, shown in Fig. 1.5, the centre bar is reciprocated by the fulcrum lever, which is held in the bottom of the rocking diamond-shaped cut-out of the cam lever by spring-

loading. When the bar is trapped, this lever is pushed up against its spring-loading because it cannot rock sideways, and this raises the release-catch trip lever so that the outside end of this lever falls and allows the lifting catch to slip over the outside end of the cam lever. As this end of the cam lever rises, it raises the lifting catch and thus the knock-off slide, and through a wire a further catch attached to the sley at the front of the loom is raised into line with a projection of the starting-handle unit for the loom to be knocked off. If the movement of the bar is not interrupted, then it will not be limited, and the lifting catch will not be allowed to slip over the end of the cam lever, so that the slide bracket will be undisturbed and the loom will continue running. Probably the major disadvantage of this mechanism is that, if the wire falls onto a raised castellation of the centre bar, it may take a complete two-pick cycle for the adjacent supported wires to push it into a sunken portion and then a further two-pick cycle before the wire becomes trapped and the loom is thus knocked off. No manufacturer is therefore able to give the desirable assurance that his mechanical warp stop-motion will be able to stop the loom in fewer than four picks, and this means that the hole that is created in the cloth could be quite a problem, especially in quality fabrics.

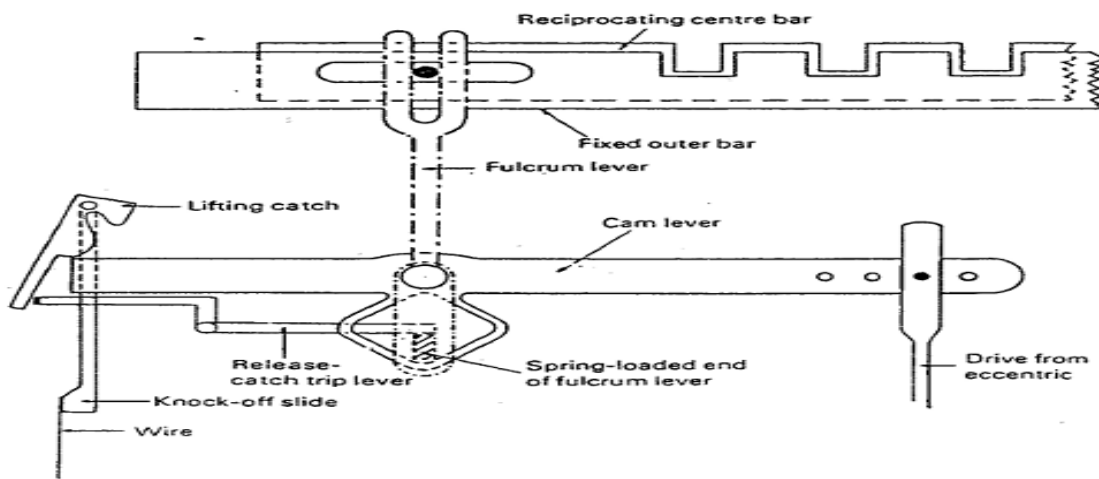


Fig 1.5 a mechanical warp stop-motion

1.2.2 Electrical Warp Stop-motion

The inset in Fig. 1.6 shows one possible construction of an electrode. If a normal rounded-shaped wire were to fall onto the top of the copper strip, it might be supported without making immediate contact with the iron. The special inclined shape. However will cause the wire to tilt to the right and ensure contact.

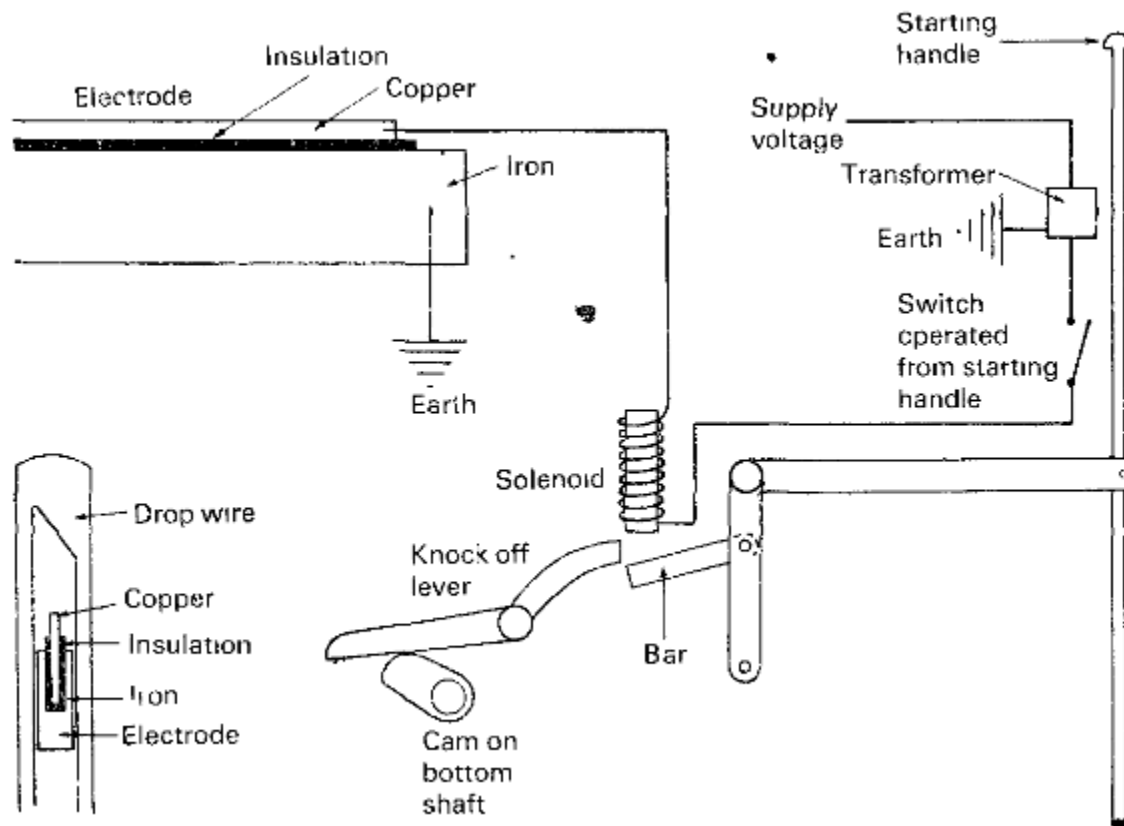


Fig. 1.6 An electrical warp stop-motion

When this contact is made, the electric circuit is completed, and the core of the solenoid (Fig. 1.6) will be magnetized so that the bar will be attracted up-wards into the path of the knock-off lever. This lever is activated by a cam on the bottom shaft, which may be single- or double acting. The latter type is obviously quicker, since it operates on each pick, but it may cause the loom to be stopped with the shuttle in the in-convenient right-hand box, in which case it may be necessary to turn the loom over for one pick before it is possible to start repairing the broken end. When the knock-off lever pushes the bar, the starting handle will be pushed off and the loom stopped, and a switch in the electric circuit will then open to cut off the current. Such a switch is desirable, since, although the current has been reduced by a transformer from the mains voltage to the much safer and more practical level of 12, 14, or 24 V and there is no danger to operatives, sparks still tend to occur, and these can easily set fire to the dust and fluff that accumulate around the drop wires as a result of the threads rubbing against the wires.

This fire hazard is probably the biggest disadvantage of an electrical warp stop-motion, and it makes it totally unsuitable for use on looms that are intended for the weaving of soft-spun fibrous warp yarns. Its quick action makes it ideal, however, for looms weaving continuous-filament yarn and relatively fine (probably combed) cotton and worsted yarns, which are generally used in quality fabrics.

The mechanical warp stop-motion of the Riiti C loom breaks a completed electric circuit if the movement of the centre reciprocating bar is limited by a fallen wire. This circuit is very similar to the one used with the electric warp stop motion, and in both instances it results in the demagnetization of a solenoid, which allows a catch to fall into the path of an oscillating knock-off lever.

The particular virtue of this mechanism arises because it depends on the breaking of a circuit, as distinct from the more usual method of making a circuit to stop a loom. Under these circumstances, the loom will knock-off instantly by the same action if there is a power failure for any reason. This is obviously preferable to allowing the loom to run at a reducing speed until a bang-off occurs because, if this happens, the shuttle may become trapped in the shed following a weak pick.

1.3 Weft Stop-motions

The importance of stopping a loom immediately after a weft break is probably greater than is the case after a warp break, since it is necessary before restarting the loom to adjust the position of the cloth fell if the shuttle has traversed the loom without inserting a pick. To restart the loom after a weft break without leaving some indication of the starting place involves one of the primary skills of weaving, and, although it is relatively easily acquired on coarse hairy yarns, for which slight variations in pick-spacing are not so easily discernible, it is one of the most difficult tasks to perform on light, open-structure fabrics produced from continuous-filament or fine spun yarns, such as voiles and super-combed yarns.

Weft stop-motions use the principle of a feeler (commonly called a fork) to detect the presence of the yarn. This fork is held clear of a knock-off mechanism only if it is supported by a thread.

1.3.1 Side-weft-fork Motion

In order to be able to operate this mechanism, it is necessary to have a grid set into the back of the sley adjacent to the reed and opposite to the fork. The raceboard should also have a groove opposite the forks so that the prongs can be operated below raceboard level and it is impossible for the weft thread to pass underneath them.

The side weft fork is situated at the starting-handle Side of the loom, which is invariably the left-hand side on modern automatic looms, and, under these circumstances, the weft fork will operate as the sley comes forward to beat-up the pick after the shuttle has entered the left-hand box. If a trail of weft extends from the selvedge to the shuttle in the box, it will be supported against the grid, and the fork will be tilted about its fulcrum so that the loop of the fork is clear of the knock-off mechanism as shown in Fig. 7.7.

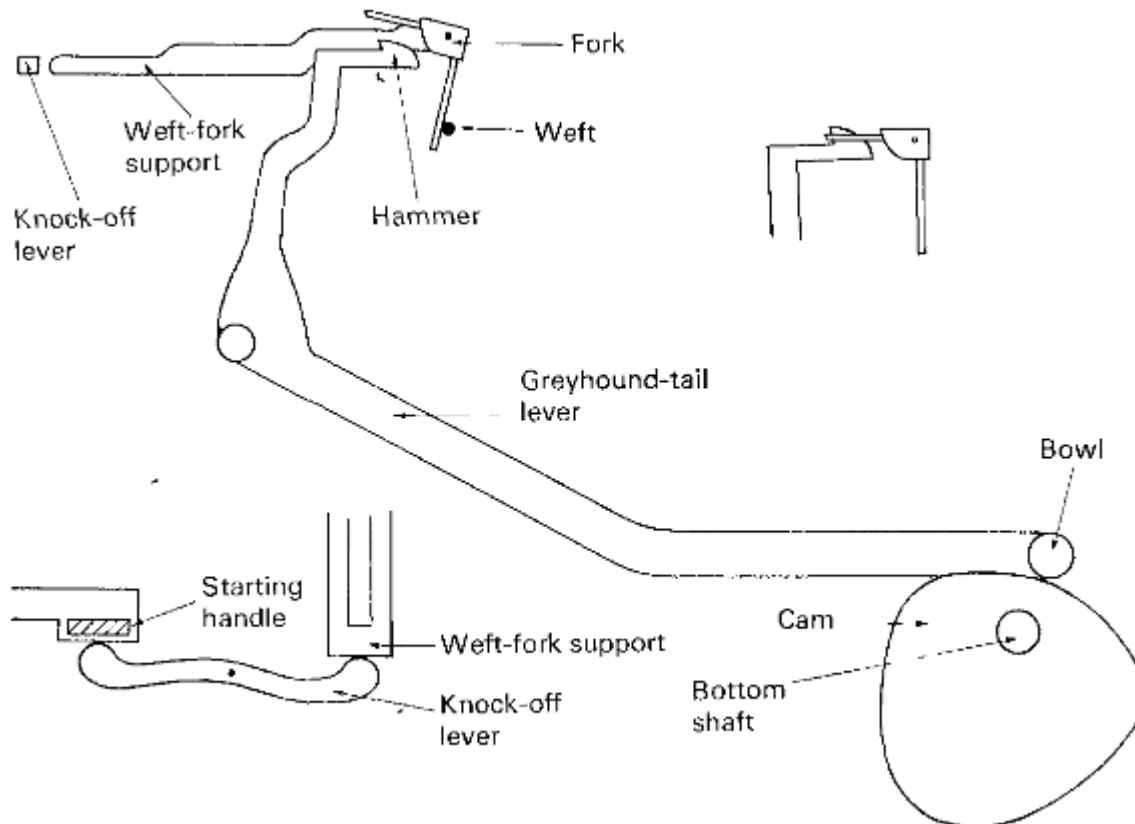


Fig.1.7 A side-weft-fork mechanism

When the weft breaks, the fork passes through the gaps in the grid and remains undisturbed.

A cam on the bottom shaft raises a greyhound-tail lever every two picks, and it is timed so that it causes the weft-fork hammer to rock towards the front of the loom just after the fork reaches the grid. If the fork is undisturbed, it will be pulled by the weft-fork hammer (top inset in Fig. 1.7), which will thus cause the whole of the weft-fork support to slide towards the front of the loom. In doing so, the knock-off lever will be pushed and will displace the starting handle (bottom inset in Fig. 1.7) for the loom to be stopped.

The whole of this action delays the stopping of the loom by at least *one* pick, and, since the fork operates at only one side of the loom, the shuttle may have made two traverses without inserting any Weft before the fork detects the absence of yarn. "

This relatively simple and robust mechanism therefore demands adjustment of the cloth fell, which always provides the likelihood of a bad setting-on place. In addition to the undesirability of setting-on places in quality fabrics, there is the possibility that a weft break may occur if the weft runs out as the shuttle is travelling to the right-hand box on the last pick before a bobbin change. Under these circumstances, the loom will continue running, but only a part-pick will have been inserted, so that a broken pattern results. A box change may occur on a multi-box loom under similar circumstances, and the loom will not stop until the shuttle with the broken weft is in use again

1.3.2 Centre-weft-fork Motion

All these circumstances make it desirable to be able to stop the loom on the pick in which the weft break occurs. This is made possible by housing the weft fork in a cut-out in the raceboard, somewhere near the centre of the loom. So that, if it is operated in conjunction with a good brake, the loom can be brought -to a stop before the broken pick is beaten-up into the fell of the

cloth . Centre-weft-fork mechanisms are much more delicate to set, and access is difficult, so that, whereas they are essential for certain types of loom, they are not universally desirable. They are, in fact, used when the shortcomings of the side-weft-fork mechanism are unacceptable. The weft fork should be as near as possible to the side of the loom at which the faults are most likely to be created by a change of the pirn being used owing to a box change or bobbin change, but, if a multibox loom is being used, a ' major problem arises because these two mechanisms are at opposite sides. The actual position should be as near to the chosen side as possible but not so close that it is impossible to knock off the loom before beat-up. The desire to avoid broken picks, especially in wider looms weaving quality (e.g., woolen and worsted) fabrics or in very wide looms weaving fabrics from continuous-filament yarns, has resulted in the incorporation of two individual or coupled centre-weft fork units situated as near as possible to each side of the loom.

The fork in the cut-out must be raised for the shuttle to pass underneath it on each pick, and the most convenient method is to allow an attachment from the fork prongs to rest on a flat cam attached to the face of the race board. The movement of the sley is commonly used to reciprocate this cam by having the knock-off rod fixed to a point on the 100m frame, which is often somewhere on the breast beam.

On Draper looms, however, the driving rod is often. Attached to the inside of the loom frame near its base, so that, as the sley reciprocates, the distance from the fulcrum varies, which causes the rod to be driven to the left in the arrangement shown in Fig. 7.8, the return being achieved by the spring.

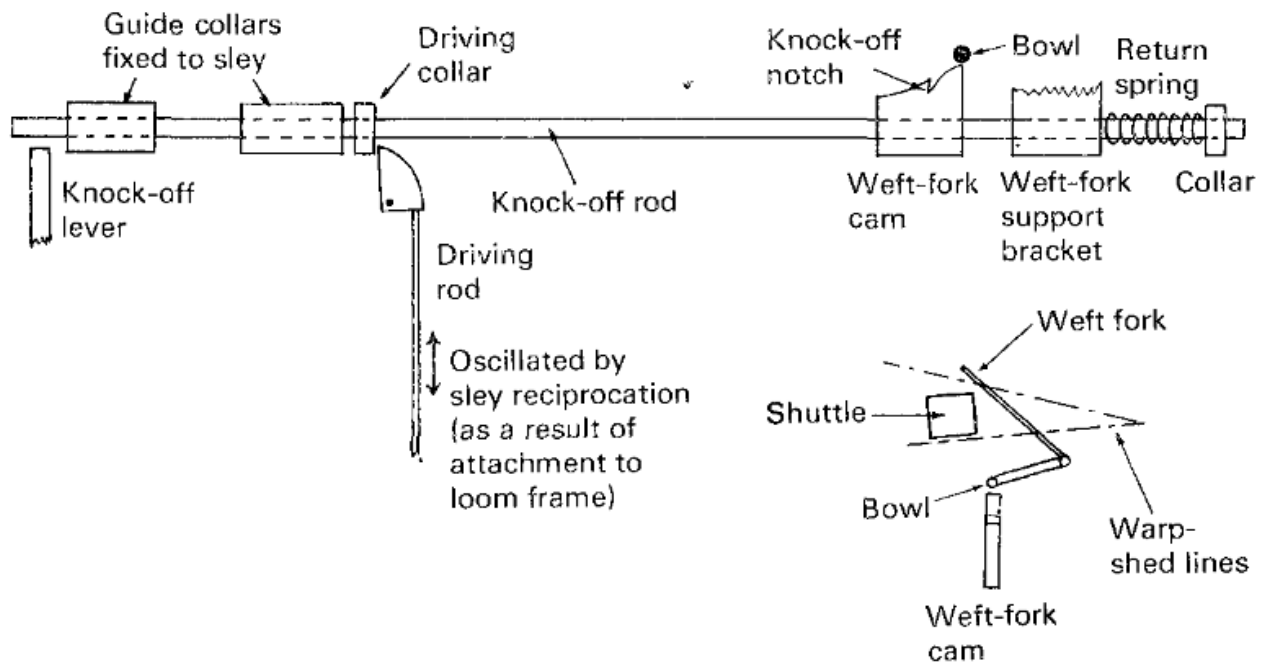


Fig. 1.8 A. centre-welt-fork mechanism

As the cam moves to the left, the bowl of the fork rides up the cam surface and causes the prongs to lift. After the shuttle has passed and as the sley starts to move forward, the cam moves to the right, and, if there is no yarn supporting the prongs, then the bowl will be trapped in the knock-off notch, which thus limits the distance that the knock-off rod can move to the right. A small length of rod is now protruding from the left-hand guide collar as the sley comes forward to beat-up. This portion of rod will strike a projection from the starting handle and knock-off the

100m, when the fork is supported by weft, the bowl is carried over the notch, and the rod makes a complete movement to the right, so that there is no protrusion to knock -off the starting handle. The need to pick-find after a weft break is always liable to cause a setting-on place if the sley has passed its most forward position when the loom comes to rest. It will be necessary to turn the 100m over at least twice (for plain weave) and probably four times (after turning the dobbie or jacquard cylinder backwards) without inserting weft. A setting-on place will then occur if the weaver fails to judge accurately the required amount of cloth let-back, especially in weaving continuous-filament yarns. Since the correct amount of let-back is very difficult to assess, it is desirable to bring the loom to rest before the sley reaches its most forward position, i.e., before the broken pick is locked in the fell. The fork mechanism can be made quick-acting by introducing a system of electric contacts at the fork itself, but a stop-on-pick motion is also essential.

This motion improves the efficiency of the loom's braking system by using a wider and longer brake-band. It is also common practice to introduce a simple foot- or hand-controlled reverse drive so that the sley can be returned to its back position without undue effort on the part of the weaver. When the loom is restarted, it may again knock-off if there is no weft under the fork. To avoid this annoying occurrence, most centre-weft-fork motions are fitted with an attachment to prevent first-pick knock-off.

1.3.3 Other Weft Stop-motions

The need to detect a weft break still exists on non-shuttle looms, and the technique adopted must be related to the method of weft insertion. In most instances, the basic principle of the presence of weft limiting the movement of a single fork prong is used. The absence of weft will allow a further movement of the prong, which will result in a mechanical or electrical contact's being made to bring the loom to rest. One unusual method is used on the Nissan (formerly Prince) water-Jet loom.

Two prongs are mounted on, but are insulated from, the reed between the leno threads and the dummy selvedge. As the reed beats up, the weft makes contact across the prongs, and the presence of water on the weft allows the circuit to be completed. If there is no weft and thus no water, the circuit will not be completed, and the loom will be brought to rest.

1.4 Weft Replenishment

The Work of the Weaver

When the duties of the weaver involved weft- and cloth-carrying oiling And greasing, as well as the major duties of weaving, it was obvious that a great deal of time was being wasted on unskilled jobs and that a reassessment of duties would have to be made to obtain more effective use of labour. After extensive redeployment, the main work of the weaver on non automatic looms involved

(a) General supervision and inspection of the yarn cloth, and machine,

(b) Repairing warp and weft breaks, and

(c) Stopping the loom to replace the weft package when the yarn on the pirn was almost used up.

It is not feasible to envisage any automation of the first two of these duties but the time involved in watching for a pirn weaving down to the last few coils of yarn and then stopping the loom, removing the shuttle, replacing the shuttle in the loom, restarting the loom, and placing a full pirn in the spare shuttle in readiness for the next change severely limited the number of looms to which a weaver could attend while maintaining a reasonable loom efficiency. In addition to this major drawback, if the loom was stopped too soon it would have to be restarted and then stopped again within a few picks or alternatively the pirn would have to be removed with an excess of

yarn that could only become waste. On the other hand if the weaver did not stop the loom at the correct time then the weft would be completely used up, and the weft fork would operate so that, on restarting, pick-finding would be necessary and a setting on place possible.

These circumstances indicate an obvious need to replace the weft package automatically, and two main methods,

- (i) the shuttle change and
- (ii) The bobbin change, were eventually developed.

The technique of replacing one shuttle containing an almost empty pirn with another shuttle containing a full pirn involved stopping the loom for a few seconds on each occasion, and, although eventual improvements overcame this problem, there was still a limitation in machine speed. Replacing the bobbin in the shuttle while the loom is running has always been a much more attractive proposition, since there are fewer moving parts, and the transfer can be completed in a relatively short time. The time required for a transfer is limited by the fact that the sley can move only a limited distance while the transfer is taking place.

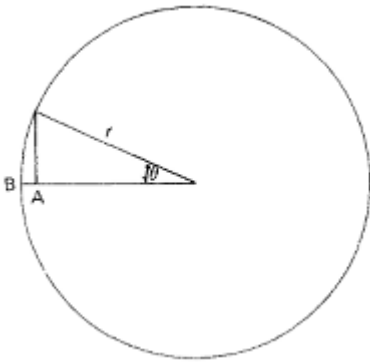


Fig. 1.9 The time for transfer

If a loom is running at 216 picks/min and has a crank radius of 140 mm and the distance AB in Fig. 1.9 is 1.3 mm, then:

$$\cos \theta = \frac{140 - 1.3}{140} = 0.9907.$$

Hence $e = 7^\circ 48'$, and transfer must therefore be complete in $2 \times 7^\circ 48' = 15^\circ 36'$, which represents:

$$\frac{15.6}{360} \times \frac{60}{216} = 0.012 \text{ s.}$$

This is less than the time involved in accelerating the shuttle, but it seems reasonable in view of the fact that smaller masses and distances are involved.

There were many initial limitations to the bobbin-change method of transfer, and these were mainly associated with the weaving of delicate continuous-filament yarns and lively yarns, but gradual improvements have now made the bobbin-change mechanism universally acceptable and the shuttle-change method obsolescent.

With the bobbin-change mechanism, the bobbins or pirns for the loom are wound on pirn winding machines in the preparation department and are then transported to the loom by a weft carrier. Each pirn is placed individually in the magazine of the rotary battery, where it is held by spring-loading at its tip, and the weft from the tip of the pirn is anchored by wrapping it around a boss on the magazine so that it will not be dragged into the cloth when the first pick is inserted after a bobbin transfer. These operations are called battery-filling, and, for medium and coarse

weft yarns, it may be necessary to have as many battery fillers as weavers. Although the rate of pay for the personnel who usually do the job will be somewhat less than that of the weaver, the cost of battery filling is an appreciable fraction of the weaver's wage. It is therefore worthwhile to try to eliminate battery-filling, and this can be achieved by either the bobbin loader or the loom-winder.

Instead of a rotary battery holding a maximum of about 24 bobbins, with the bobbin loader it is possible to use a metal box with a slot at one end of the base.

The box may hold between 72 and 190 bobbins depending on the box size and pirn diameter. The bobbins are then fed through the slot to the weft-replenishing mechanism as required. Each loom has two boxes, one in use and the other in reserve, so that, when the box in use becomes empty, the weaver can replace it with a full one, the empty one being left to be filled up or replaced by the weft carrier when convenient. This requires much less time than battery-filling, and thus a saving in labour costs can be expected. This saving must be balanced against the extra cost of the bobbin loader. Now the cost per 100m per hour of battery-filling is determined by the number of bobbins battery filler can deal with per hour. The coarser the weft and the higher the weft-insertion rate (i.e., the wider the loom and the higher the loom speed), the more bobbins the 100m will require and the higher will be the cost of battery-filling. The potential savings by using the bobbin loader are therefore greater with relatively coarse yarns and wide fabrics (e.g., sheeting's), than with finer yarns and narrower fabrics (e.g., shirting's).

The automatic loom-winder (Unifil) has a higher capital cost than the bobbin loader, but it eliminates pirn winding as a separate operation, and, when other savings are taken into account, it may show an even greater net saving than the bobbin loader. The bobbins are wound at the loom by an automatic pirn-winder from large cones, or, for continuous-filament yarns, from the supplier's packages. Two packages are tied tip to tail as in magazine-creeling for warping so that, when one is exhausted, winding can commence from the other automatically and the empty package can be replaced at a convenient opportunity. There is therefore a very similar saving with battery-filling to that with bobbin-loading. It is usually considered necessary to have in circulation (at the loom, in the pirn-winding department, in the weft store, in stripping, and in reserve) between 200 and 300 bobbins for each battery loom. About the same number or possibly slightly more are likely to be required for each bobbin loader. With the Unifil (Fig. 9.11), each loom operates with only twelve or fourteen bobbins, which never leave the loom and of which only half contain yarn. There is therefore a considerable saving on the outlay on bobbins and also in replacement costs, since the bobbins are less likely to be damaged. Again, the loom winder strips the ejected bobbin of the short length of yarn left on it at the change and thus eliminates bobbin-stripping as a separate operation and also the need to transport empty pirns. Servicing and maintenance of the units are done by specially trained mechanics who can look after several hundred units, and there is no need for a separate pirn winding department with all its ancillary requirements (e.g., heating, lighting). All the pirns woven on the loom are wound under identical conditions of tension and bunch length, which thus eliminates the possibility of mixed weft, irregularity in fabric appearance as a result of weft-tension variation, and excessive waste. When all these considerations are taken into account, the unit will pay for itself under favorable conditions inside three years. This is the chief reason for its notable success.

The unit is claimed to be suitable for spun staple-fibre yarns ranging from 5 to 150ex and for continuous-filament yarns ranging from 3 to 55tex, and, for the same reasons as for the bobbin loader, it will justify itself economically, mainly with coarse and medium yarns, but it is widely used for weaving continuous-filament yarns of the order of 7-17tex, for which the economic

advantages are not so obvious. One reason for this is that it ensures that the bobbins will be woven in the same order as that in which they are wound from the supply package. This is very desirable in order to minimize weft bars caused by weaving, in succession, packages wound either from different parts of the same package or from different packages.

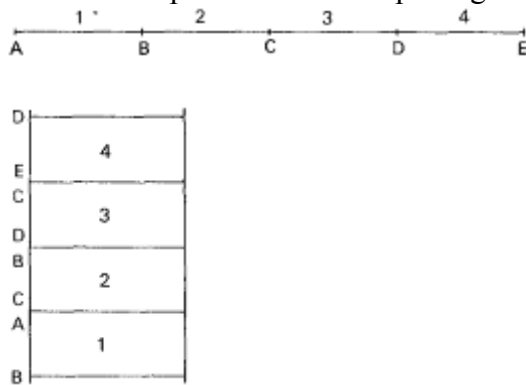


Fig. 1.10 The order of weaving pirns

It is perhaps worth mentioning that, although the bobbins are woven in sequence, the weft in the fabric is not arranged precisely as it was on the supply package. Consider the length of yarn AE in Fig. 1.10, which is wound onto four pirns. The first yarn, A, is wound onto the base of the first pirn and the yarn wound onto the tip of the pirn is from point B. The remaining pirns wind yarn from B to C, from C to D, and from D to E. During weaving, however, the first yarn to be wound off the pirn will be from the tip, so that the length of fabric will have the last yarn wound off the first pirn (A) next to the first yarn wound off the second pirn (C). In order to weave the yarn in perfect sequential order, it is necessary to weave the pirns in the reverse order to that in which they were wound, i.e., 4, 3, 2, and 1, but this is not possible with Unifil or with the bobbin loader, where one cannot guarantee any precise order. It is only possible if the bobbins are placed manually or automatically on a pin tray in a particular sequential order as they come from the pirn-winder. The weaver or battery filler must then exactly reverse this order as the pirns are fed to the loom. There are circumstances in which this elaborate procedure may be justified.

1.5 Feelers

It is necessary to have some means of indicating when the yarn has been almost used up on a pirn, and until recently this was done by a mechanism making contact with the pirn by a probing action to detect if yarn was present or not. The action of probing gave these mechanisms the obvious name of *feelers* and this name has even been retained for the latest types, which do not actually make a physical contact with the pirn but use a beam of light.

The principle behind any feeler action is that, once every two picks, the presence of yarn on the stem of the pirn about 4 cm from the pirn butt is investigated. If yarn is present, the feeler will allow the loom to continue running normally, but, if there is no yarn at this point, then the feeler will activate the start of a change procedure.

On a single-shuttle automatic loom, it is usual to have the feeler mounted at the left hand side of the loom, whereas the automatic-change mechanism is normally at the right-hand side.)

1.5.1 Weft Reserve

The bobbin change may take place approximately one or even two complete pick cycles after the feeler has indicated the need for a change, and, since it is obviously undesirable that the shuttle should be traversing the loom without leaving a trail of weft, then it is necessary to have a

special reserve store of yarn on the pirn that may be used at this time. This reserve store is known as a 'bunch' and it is wound onto the stem of the pirn adjacent to the butt. During winding, it is given a very limited traverse so that it will not spread and interfere with the feeler action. The length of yarn on the bunch is dependent on whether the change will take place on the first or the second pick after feeler detection. Let it be assumed, however, that, when a feeler makes contact with a pirn. It is prevented from activating a change by the very last coil of yarn on the pirn before the bunch. By the time the shuttle has traversed about 30-45 cm across the sley, this coil of yarn will have been used, and yarn will be being withdrawn From the bunch for the whole of the remainder of that pick and for the whole of the next pick, at the end of which the feeler will indicate the need for a change. Another pick has to be withdrawn from the bunch as the shuttle traverses to the change side, and there must still be sufficient yarn for the thread to reach from the selvage to the shuttle eye and onto the pirn so that it will be held under tension and thus in position to be held and cut by a part of the mechanism. If this total length of yarn is added up, it will be realized that something between three and four pick lengths will be needed in a bunch, and, if the change is to take place two picks after detection, then the bunch length will have to be from four to five times as long as the cloth width in the reed.

These figures are quite independent of the width of the loom and the linear density of the yarn, and the waste percentage will be considerably higher in wide looms or when coarse yarns are used. The average amount of waste is equivalent to 1.5 pick lengths provided that the minimum amount of yarn is wound onto the bunch without allowing any possibility of the weft's running out before the change.

1.5.2 Feeler Position

Any feeler that has to make contact with the pirn for the purpose of detection must either (a) let the pirn advance to it or (b) rise or fall to make contact with the pirn.

The first instance is probably the more common, since the natural reciprocation of the sley can be effectively utilized. As the sley comes forward to front centre, the feeler that is mounted on the loom frame is allowed to penetrate holes in the shuttle-box front and the shuttle wall to make contact with the pirn at the appropriate point. When detection is made by this method, it has to be held for rather a long time before the change operates and it may be necessary to modify the design of the drive to the change mechanism for this purpose.

This explains the advantage of the second method, which carries the feeler unit on the sley and in which the feeler is raised and lowered by cam operation make contact at the most appropriate time in the pick cycle.

The latter method requires more moving parts and is quite unsuitable when the feeler has to be situated at the change side of the loom, as in multiple-box looms but it does not require any weakening of the box front or shuttle wall.

1.5.3 Types of Feeler

Classification

Feelers may be classified as follows:

- (I) mechanical:
 - a. side-sweep;
 - b. depth
 - i. diameter gauge
 - ii. penetration
- (II) Electrical:
 - a. Two prong

b. Photo-electric

(III) Mechanical-electrical.

Mechanical feelers are generally more robust and cheaper, but the yarn is given a rather rough treatment because the contact that the feeler blade must make with the weft package must be strong enough to give sufficient movement to the feeler in order to instigate a change. This type of feeler is quite Unsuitable for the more delicate continuous-filament yarns, for which the lightly sprung two-prong feeler is favoured. Even this light contact may be undesirable with certain delicate monofilament yarns, and a photo-electric feeler, which does not need to make any contact, may then be necessary.

A. The Side-sweep Mechanical Feeler

This mechanism is also known as the 'midget feeler'. The feeler blade makes contact with yarn on the pirn when the loom is nearing its most forward position by penetrating holes in the shuttle-box front and the shuttle wall. It will be pushed in the direction of arrow A (Fig. 9.3) because the serrations in the tip of the blade will have become embedded in the yarn. As the sley recedes, the blade will be returned to its original position by the spring.

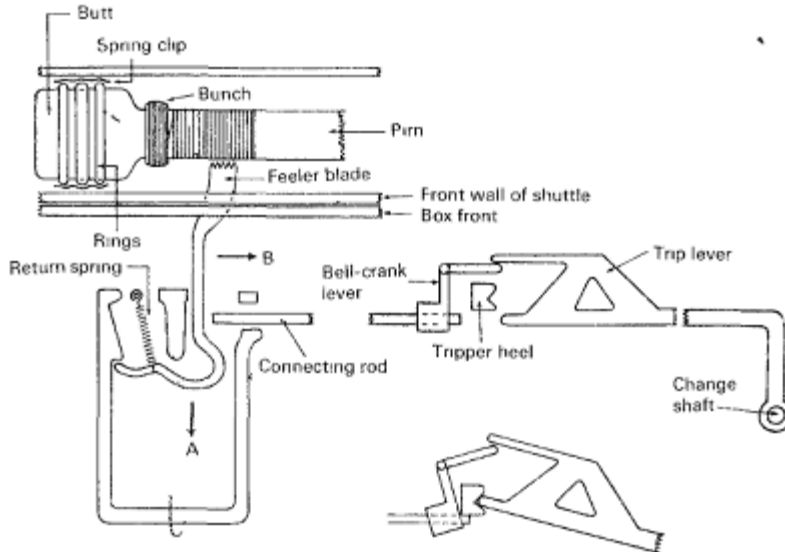


Fig. 1.11 A side-sweep feeler

When yarn is being withdrawn from the bunch, the feeler blade will slide to the right (arrow B) on the smooth polished surface of the pirn as the sley approaches front centre. This will cause the connecting rod to push the bell-crank lever, whose upper arm will then raise the trip lever.

The tripper heel, which is attached to, and therefore oscillates with, the weft fork hammer, will now push the lower arm of the trip lever and thus cause a sufficient rotation of the change shaft to effect a bobbin change when the shuttle arrives in the box on the opposite side of the loom.

The feeler blade is returned to its normal position by its spring, the other parts being returned by a spring on the change mechanism. It is important to note at this stage that the shape of the weft-fork cam is very important in executing a bobbin change because it must not only be capable of oscillating the weft-fork hammer but must also hold the change mechanism's parts in position at the opposite Side of the loom until they are locked in readiness for a change almost a pick later.

B. Depth Feelers

For many years, a feeler that is lowered onto the pirn by a cam action has been used on Saurer 100W cotton looms.

If there is yarn on the pirn stem adjacent to the bunch, then the feeler rod's downward movement is limited, as shown in Fig. 1.12, but, as soon as the yarn has been used, the feeler can make a complete downward movement, and the projection from the feeler rod will strike the trip lever to cause a partial rotation of the change shaft and thus ensure a bobbin change when the shuttle arrives in the opposite box.

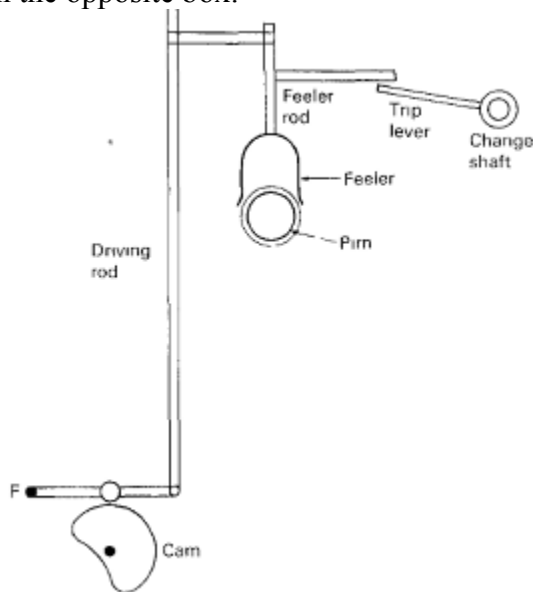


Fig.1.12 A depth feeler

An alternative type of depth feeler uses a blade that makes contact with a pirn opposite a hole in the pirn stem. The presence of yarn limits the feeler movement, but, if sufficient yarn has been used to reveal the hole, then the feeler will penetrate the hole and subsequently bring the change mechanism into operation. The main weakness of this mechanism is that the position of the hole in the pirn must be guaranteed by ensuring that a cut-out in the butt of the pirn fits on a projection in the shuttle. This obviously precludes the bobbin change, but this type of feeler has been used successfully on shuttle-change and semi-automatic looms.

C. The Two-prong Electric Feeler

The current supply is reduced from mains voltage by a transformer; it could even be the same transformer.

The circuit is incomplete until contact is made across the feeler prongs. This contact is made when the sley is approaching its most forward position and a metal band set into the stem of the pirn adjacent to the butt has been uncovered (i.e., yarn is being withdrawn from the bunch). The completed circuit energizes the solenoid so that the magnetized core attracts the trip lever into a position opposite to a suitable driving point, which, in Fig. 1.13A, is an oscillating tripper heel. Since yarn does not conduct electricity, the circuit is not completed when the metal band is covered with yarn.

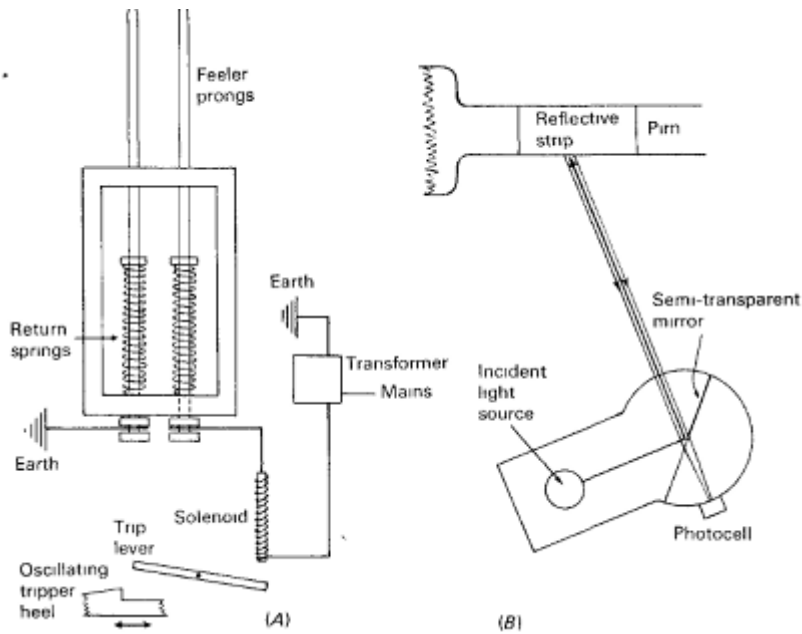


Fig. 1.13 Electric feelers

D. The Photo-electric Feeler

When this type of feeler is used, it is necessary to cover the pirn stem adjacent to the butt with a reflective strip.

Incident light is redirected onto a point that is in line with the path of the shuttle. Since this system can operate from a momentary reflexion of a light ray, it is possible to inspect the pirn by the feeler when the shuttle is in flight across the loom. When the light ray is thrown back to the feeler head by the uncovered reflective strip on the pirn (Fig. 1.13B), it passes through a semi-transparent mirror to the photocell, where it produces a photo-electric impulse that is amplified by a fully transistorized electronic unit, which in turn activates an electrical circuit and solenoid very similar in principle to those used in the two-prong electric feeler.

1.6 Single-shuttle Automatic Bobbin Change

1.6.1 The Bobbin-change Mechanism

A very high percentage of single-shuttle automatic looms are equipped with the feeler unit at the left-hand starting-handle side of the loom, so that the weft-fork hammer movement can be utilized to assist the bobbin change that takes place one pick later at the right-hand side of the loom.

The partial rotation of the change shaft that results from the tripper heel's pushing on the trip lever causes the swan neck and thus the shuttle-protector lever to swing in an anti-clockwise direction from their normal position, and this lifts the pillar and protector arm. The depressor thus releases its hold on the latch, which then rises by virtue of its coil-spring-loading into a horizontal position.

As the sley approaches front centre, the shuttle having arrived in the right-hand box, the bunter pushes the latch, which now forms a rigid connexion with the hammer. As the hammer moves in a downward direction, it forces the bottom bobbin out of its spring-held position in the magazine onto the top of the bobbin in the shuttle. The hammer pressure continues until the almost-empty

Pirn is forced out of the shuttle (Fig. 1.14A) and through holes in the bottom of the shuttle and the box base, and the new full pirn is positioned in the shuttle.

The weft-fork cam, which has been designed to give a full throw for a period of just over 180 of crankshaft rotation (many more degrees than are required to stop the loom for a weft break), allows the tripper heel to release its pressure on the trip lever as the sley recedes, and this permits the return spring to pull the protector arm and thus the latch back into their normal positions (Fig.1.14B).

When the hammer makes its downward movement, the feed pawl slips down one tooth on the ratchet, so that, when the other parts are being returned and the hammer coil spring raises the hammer to its original position, the magazine will be pushed round one section to leave the next bobbin in position for the next change.

Complete efficiency of the bobbin-change mechanism can only be guaranteed if:

- (i) The shuttle is in the correct position for a bobbin transfer;
- (ii) The tension in the picks immediately before and after a change is satisfactorily maintained;
- (iii) The ejected bobbin is guided into a storage can;
- (iv) The weft yarn from the new pirn is guided into the shuttle eye.

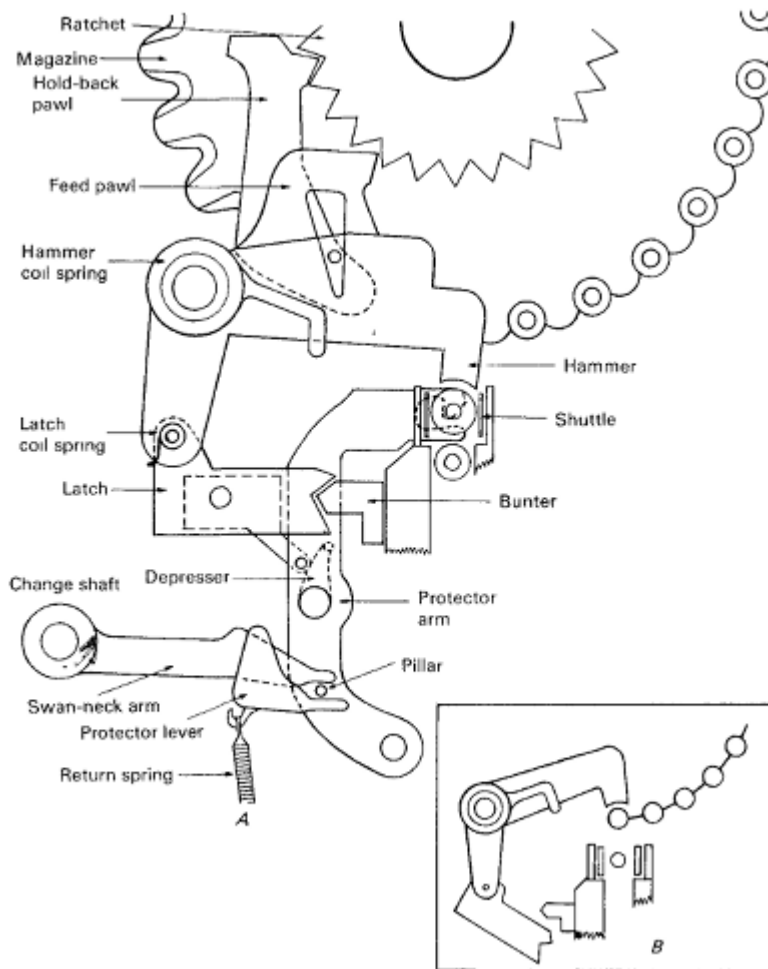


Fig. 1.14 A bobbin-change mechanism

1.6.2 Shuttle Protection

The position of the shuttle in the box may vary depending on several factors, but, if it is too far into the box, the new bobbin will be forced onto an inclined plate in the shuttle that holds the bobbin clip in position, so that the incline will allow the bobbin to slide *into* position. The possibility of damage under these circumstances is therefore very slight, but, if the shuttle fails to travel far enough into the box, the new pirn may be forced onto shuttle eye, straight through the shuttle, or into a position where it is supported by one ring only. Each of these circumstances presents its own problems: the first one will certainly cause damage to the pirn and probably the shuttle eye, and the second will probably result only in a loom stop due to the absence of weft, although the pirn may be left hanging in a vertical position through the shuttle and box base, which will cause damage when picking takes place. A pirn held with one ring is also undesirable, since it may move up and down in the shuttle and cause weft breaks, or it is possible that the pirn may be pointing upwards out of the shuttle, so that it will attempt to pass over the top shed while the shuttle is passing under it in picking from the left, so that many ends are caused to break out. These problems exist because a uniform rest position of the shuttle cannot be guaranteed and because of the limited time available to perform the actual transfer. With this in mind, Riiti, who have run their model C loom at 360 picks/min at exhibitions, introduced a shuttle in which the back wall springs back at the time of actual transfer and then returns under spring-loading to trap a pirn that does not have rings around the butt. The shuttle is tapered inwards at the point of butt entry to allow an increased degree of latitude in the shuttle rest position. The pirn is thus held in a constant position in the shuttle and also in a much more rigid manner than is the case when rings are used. It is not possible to avoid a change if the shuttle is too far into the box, but regular examination of the shuttle and picker will indicate whether this is happening. When the protector arm is raised, it takes up a position that allows it to be opposite the entrance to the shuttle-box when the sley approaches its front centre position.

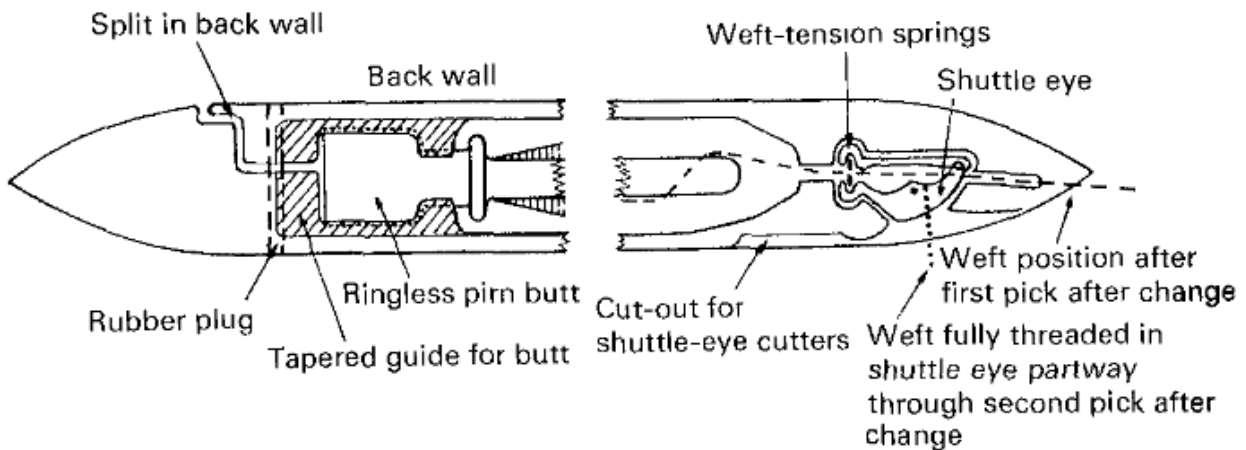


Fig. 1.15 shuttle with its specific parts.

If the shuttle is correctly boxed, there will be a gap of approximately 3 mm between the shuttle tip and the tip of the protector arm, but, if the shuttle is protruding from the box, it will make contact with the protector arm, which will be pushed towards the front of the loom and cause the depressor to lower the latch out of the path of the approaching bunter so that a change will be avoided. The loom will then be stopped either by a 'bang-off' or by the weft's running out.

1.7 Weft-tension Control

The yarn from each pirn loaded into the magazine is wrapped round the mandrelle of the magazine so that the first pick inserted from that pirn will be at a tension that is approximately the same as that of all the other picks. Securing the weft in this way is, of course, essential in the

first place to ensure that a trail of yarn is left behind the shuttle. The last pick of yarn from the old pirn presents a more difficult problem, which has really only been overcome with the development of shuttle-eye cutters. This unit is mounted on a shaft that oscillates as a result of the protector arm's rocking backwards and forward

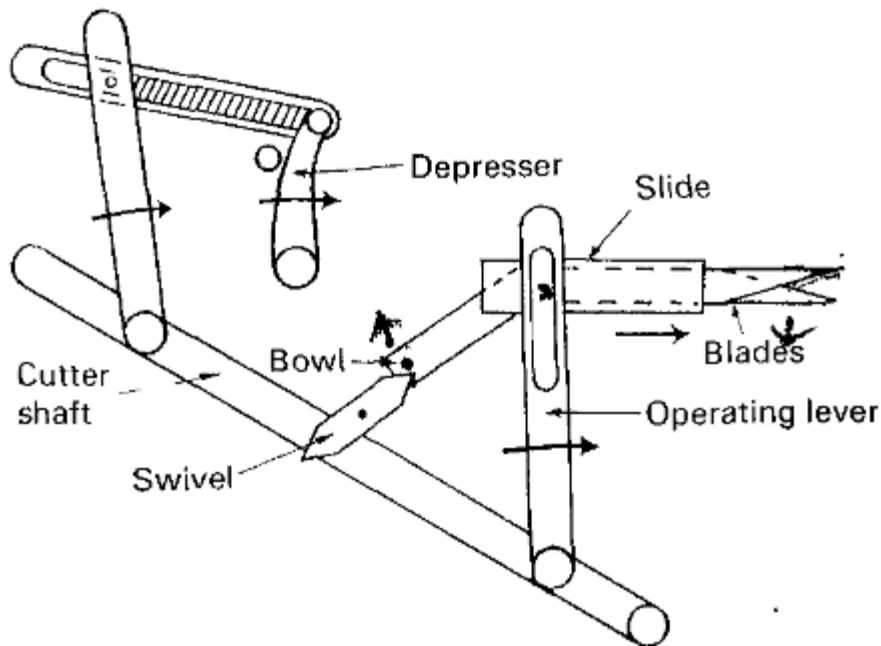


Fig. 1.16 weft tension control

As the depressor swings clockwise, it causes the cutter shaft to rock forwards towards the box, so that the cutter unit, which consists of four blades, moves forward in its slide bracket, and, as the bowl passes over the swivel, the blades open so that they are round the weft behind the shuttle eye just before the change takes place. When the sley reaches its most forward position, the pair of blades nearest to the selvage closes and traps the yarn just before the other pair of blades closes and cuts it. The slide bracket is inclined to the selvage so that the distance from the holding blades to the cloth fell at the selvage is always constant and the thread will not break because of any increase in tension. The two outside blades of the unit of four are fixed, and the opening and closing of the two centre blades are achieved either by a bowl passing over a T-lever or, in more recent looms, by a bowl passing round a spring-loaded swivel plate as in Fig. 1.16.

1.8 Bobbin Loaders

The bobbin loader is gradually becoming obsolete, mainly because it has only a limited advantage over the rotary magazine as compared with the loom winder. Several machinery-makers produced bobbin-loader units, but the Fischer ALV system appeared to enjoy the widest popularity. It replaced the battery of the automatic loom, but it can operate only if the following conditions exist.

- I. The pirn boxes have a special sliding base. This base covers the slot in the bottom of the box during transportation, but, when the box is placed in the operating position, a handle is raised to slide the base back so that the pirns can fall through the slot and roll down the pirn guide.

- II. The empty pirn is completely smooth for about 2 cm at its tip, and the wound pirn has a bunch of yarn near to its tip.
- III. The pirn-winding machines are equipped with a nose-bunching attachment.
- IV. There is a supply of compressed air to operate the unit. .

When the transfer hammer is depressed to operate a bobbin change in the normal manner, it releases the pneumatic control to the bobbin loader (Fig.9. 10) so that the compressed air can activate the various parts of the unit and thus prepare the next pirn for transfer. Four valves are used for this purpose:

Valve 1:

- a) lowers the clamp so that the hole in the plate is in line with the tube;
- b) opens the air valve to the vacuum pump to produce air suction;
- c) Causes the pair of stripping jaws to move to the left and close onto the pirn behind the nose bunch;

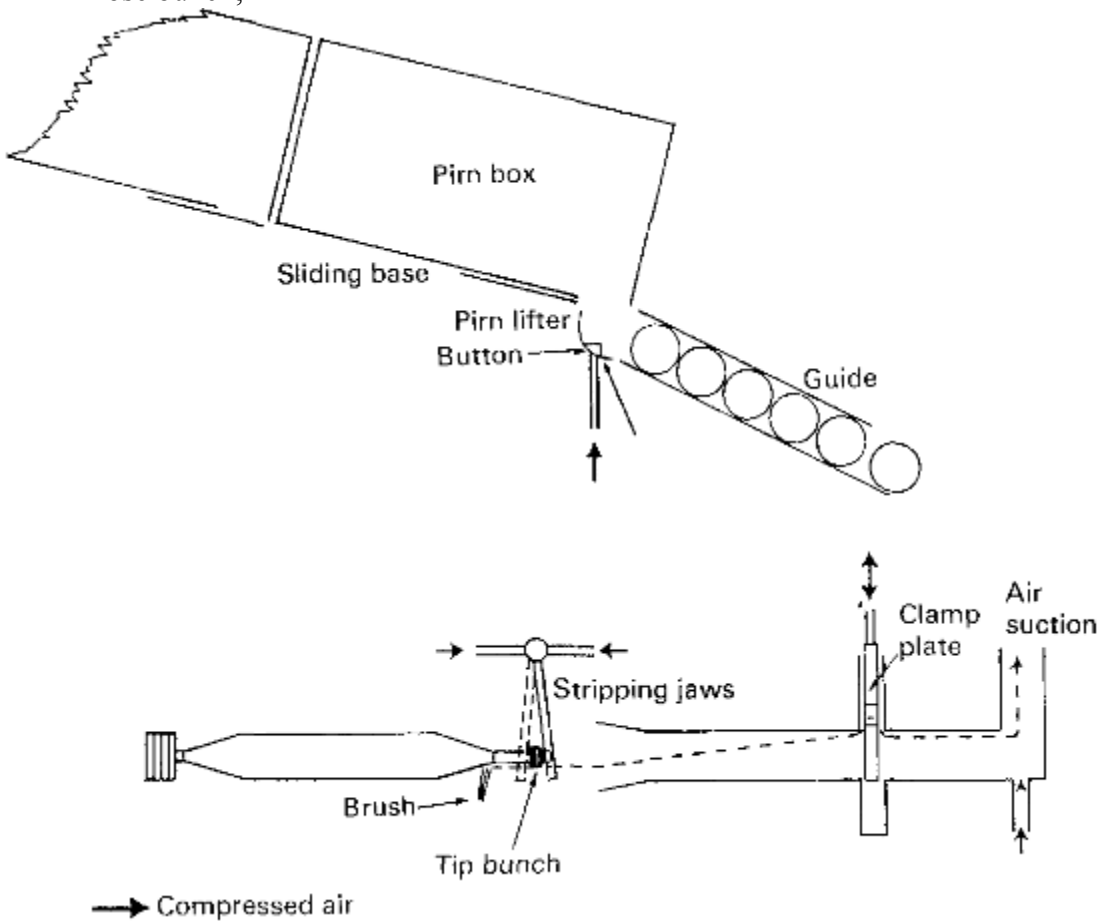


Fig.1.17 A bobbin loader

valve 2: activates the pirn lifter if the button on the lifter plate is not depressed; this will happen if the pirns do not fall freely from the box into the pirn guide, i.e., its function is to release any blockage that is causing the pirns to jam in the box and thus preventing them from falling freely;

valve3: returns the closed stripping jaws to their original position which thus removes the nose bunch from the pirn: the yarn from this bunch is sucked down the tube. but excessive yarn cannot be sucked to waste because of the presence of a brush that is resting on the chase of the pirn: and

valve 4: raises the clamp plate to trap the weft in readiness for the next pirn transfer.

The bobbin loader is relatively simple to maintain, but it takes time to prepare a bobbin, and a second transfer cannot take place within 3-5 s. Furthermore, it is not advisable to refeed part-used pirns since they may roll sideways in the pirn guide and cause a jam. For a successful transfer the bobbin loader relies on the other bobbins in the pirn guide to hold the bobbin to be transferred steady at the time of transfer, and, if for some reason there are no other bobbins in the guide at the actual time of transfer, then it may jump and be broken if the hammer comes down to strike it in the wrong position

1.9 Loom-winders

The magazine-creeling of the supply cones, and the yarn is tensioned for winding by a series of disc tensioners mounted on a plate, which is suspended from the loom frame on springs so that vibration from the loom will not cause the yarn to be shaken out of the tension unit.

Pirn-winding is done on a spindleless, feelerless machine. The absence of a spindle makes the pirn-transfer operation much simpler, and the gear-driven reciprocating-traverse guide avoids the need to use a feeler to determine the pirn diameter, so that any possibility of damage to the pirn from abrasion between the feeler wheel and yarn is eliminated. An adjustment to the gear driving mechanism is needed every time there is a change of weft, but any variation in weft tension or linear density during normal running will immediately show up as a change in pirn diameter.

When a bobbin transfer takes place, the bobbins in the loom magazine fall, and, if there is a full pirn waiting at the winder, it will be positively transferred to the vertical stack magazine. This can only happen if there is at least one empty pirn in the winding magazine.

The weft yarn trailing between the tension unit and the loom magazine is picked up by two gripper plates. The lower plate moves from left to right, and, after cutting the yarn, carries the end of weft from the wound bobbin to the yarn-ends drum, where it holds the yarn until the rotating drum picks up the yarn, traps it, and holds it parallel to the pirn throughout its time in the magazine. The upper plate, moving from right to left, carries the other end of the yarn to a point opposite the butt of the new pirn in the winding position.

Wire loops on the shoulder of the pirn (known as *cleats*) then pick up the yarn so that winding of the next pirn can commence. It is necessary to arrange for the winding rate to be in excess of the weaving rate so that any stoppages in winding will not result in the loom's being stopped while it is waiting for weft. This excess, or reserve, winding capacity is usually in the range of 10-20%. There will thus be a time when the loom magazine is full, and this is detected by the bobbin-support plate, which assists the wound bobbin from the winding position to the loom magazine. If this plate is held flat against the back of the loom magazine by the top bobbin in the stack, then the transfer of the next fully wound bobbin cannot take place until the plate rises again, i.e., after the next pirn transfer.

When such a transfer is signaled, the clamps trap the weft that has been lightly held under control by the yarn-ends drum while the pirn has been in the magazine. The transfer can then take place in the usual manner. When the temple cutter has severed the two lengths of weft extending from the selvedge, the threads are picked up by a cut-out on a reciprocating nylon rod and fed into a suction tube to eliminate any possibility of backlashing.

The butt of the ejected bobbin will pass over a non-slip surface just below the box base, which will cause the pirn to spin and release yarn as it falls down the chute and through a horizontally rotating brush into the stripping unit.

It is essential that the trailing yarn should extend through this brush if it is to be picked up for successful stripping. When the pirn reaches the stripping unit it must first be pushed sideways into the stripping position. By this time The rotating brush should be transferring the yarn to a

revolving cone with a brushed-nylon surface, and it is this cone which then unwinds the yarn from the bobbin. The cone has three toothed reciprocating arms set into its surface to give the unit a self-cleaning action.

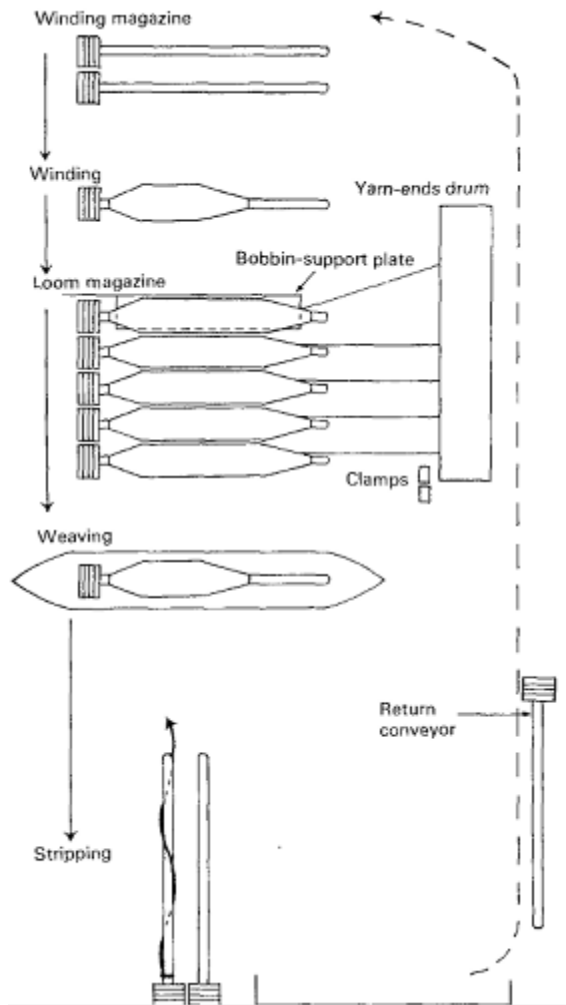


Fig. 1.18 A loom-winder

There are usually two pirns in the stripping unit at any one time, i.e., the one actually being stripped and the one that has already been stripped. This second bobbin helps to hold the new one steady during stripping so that there is less chance of the yarn's breaking during unwinding and thus leaving an unstripped bobbin. When the next pirn enters the stripping unit, the bobbins are pushed sideways, and the right-hand bobbin will fall into a tray from which it will be picked up by a magnet (acting on the rings on the butt) and carried back to the winding-unit magazine on a conveyor chain. If for any reason there is still some yarn on the extreme right-hand pirn in the stripping unit, it will be supported by a brush until after the next change, when it will be pushed even further to the right before being allowed to fall into a reject tray. It is necessary and possible to refeed these pirns to the stripping unit by hand.

The factors that are most likely to interfere with the efficiency of the loom winder are an excess of unstripped bobbins and bobbin jams in the stripper chute resulting from a bobbin's being ejected tip first. The efficiency of the clamps has also caused problems at times, and there is the further possibility that bobbins may break at the time of transfer if there is not more than one

bobbin in the loom magazine. It is a simple matter to calculate how long the winder will be stopped between the winding of successive pirns if both units are running at 100% efficiency. For example a loom running at 192 picks/min weaving a fabric of 130 cm wide in the reed is equipped with a loom-winder with a spindle speed of 6000 rev/min. During winding, 50 cm of yarn are wound onto a five-wind pirn chase for each double traverse. Each pirn contains 25 g of 40-tex yarn. We have:

$$\text{yarn per pirn} = \frac{1000}{40} \times 25 = 625 \text{ m.}$$

yarn wound per minute (100% efficiency assumed)

$$= \frac{50}{5 \times 2} \times \frac{1}{100} \times 6000 = 300 \text{ m,}$$

$$\text{time to wind pirn} = \frac{625}{300} = 2.083 \text{ min,}$$

$$\text{yarn woven per minute (100% efficiency assumed)} = 192 \times \frac{130}{100} = 249.6 \text{ m.}$$

1.18 Multiple box motion

Multiple box motions are used to insert yarns of different colour, linear density, fibers or twists across the fabric. With conventional looms, for each variety of weft one shuttle is required and there must be an empty box on the opposite side to receive the shuttle.

A loom may have two, four, six boxes one side and one box on the opposite side, normally referred as 2x1, 4x1, 6x1 box motions respectively. There may be box motions on both sides such as 2x2 or 4x4. Multiple box looms may be classified under the following groups.

- a. 2x1 looms, continuous acting type, for mixing weft in pair of picks. These are known as weft-mixing looms which intend to reduce the possibility of weft bars which occur specially with filament weft due to the change in the weft package and variation in package diameter. This motion is also suitable when cloths are to be woven with alternate double picks of s and z twist.
- b. 2x2 weft mixing looms, continuous acting type, for mixing in single picks.
- c. 2x1, 4x1, or 6x1 shuttle looms for inserting colored weft or different types of weft as per weft pattern. The main limitation of this type of box motions is that picks must be inserted in multiple of two. This is because the shuttle has to travel from multiple box inside to the opposite and back before a change can take place.
- d. 2x2, 3x3, 4x4, box motions in which multiple boxes are situated on both sides. Insertion of single picks in odd or even numbered groups can be effected.
- e. With 4x4 box looms, pick-at-will motions are applied to permit two or more shuttles to be driven from one end before a return movement is made from the other end. On this loom, with judicious choice, single picks of different colors upto seven colors of weft can be inserted, when it becomes a pick and pick loom.

It may be mentioned here that pick and pick weft insertion is more easily achieved in looms with gripper shuttles or rapiers. Now a days this facility is also available in air and water jet looms.

1.18.1 Types of box motions

Multiple box motions for shuttles are of two types:

1. Circular box
2. Drop box

1. Circular box

With this type of box motion, the boxes are arranged on a spindle in the form of a cylinder which is rotated to bring the required shuttle in line with the race board. The most common number of boxes is six, although five and seven boxes are also available.

Although, circular box motion was extensively used for producing light woolen dresses, and for silk weaving, now-a-days it has become obsolete. Main reasons are,

1. Generally it is possible to rotate from one box to its one of the adjacent boxes, nevertheless skip boxes are available for random selection. The latter motion is not used in practice because of considerable reduction in the speed.
2. Fast reed cannot be used with this type of loom, because of the arrangement of boxes. So, the cloth made on circular box loom is limited to light or medium weight.
3. Under pick motion cannot be also used. So, this motion cannot be used on automatic loom.
4. Since the size of the boxes are fixed, it is difficult to adjust for worn out shuttles
5. Special small shuttles used on this loom reduce the efficiency.

2. Drop box

In drop box (sometimes also called as rising box) motion there is an arrangement of flat steel shelves, each shelf carrying a shuttle, which rises or falls in a predetermined order to bring a particular shuttle in line with the race board and picker. 2x1 box is used for weft mixing; 4x1 is the most popular type of shuttle loom for weft patterning, although 6x1 box motion is also available.

Since diggle invented a drop box motion, for a power loom, over a hundred and fifty years ago, a number of box motions are used of which cowburn and peck, and Eccle's box motions were extensively used. Now a day, these motions are also replaced by sliding gear type box motions.