9

WOVEN FABRIC DESIGN

Key words: *abrasion resistance, basket weave, balanced twill, counter, crease resistance, crimp removal, cross-section, crowns, decrimping, design, drape, drawing-in draft, fabric count, fancy rib weave, filling face twill, filling rib weave, filling satins, floats, lifting plan, pattern, reclining twill, reed number, reed plan, repeat, satin, sateen, selvage motion, square construction, square design paper, square weave, steep twill, stitched basket weave, thread diagram,* 45° *twill, twill weave, warp, warp face twill, warp rib, weave, width in reed, yarn count.*

The fabric weave or design is the manner in which the warp and filling are interlaced. The *pattern* or *repeat* is the smallest unit of the weave which when repeated will produce the design required in the fabric. There are many ways of representing a weave, a most familiar method being to use *square design paper*. The use of *thread diagrams* and *cross-sections* is another effective method of representation. Figure 9.1 shows a thread diagram, warp and filling cross-section and square paper representation of a plain weave.

On the design paper, the vertical rows of squares represent warp ends and the horizontal rows of squares represent filling picks. A mark in a small square indicates that at this particular intersection, the warp end is shown on the face of the fabric with the pick beneath. It is normal to use a filled in square to indicate that the end is over the pick and a blank square to indicate that the pick is over the end.

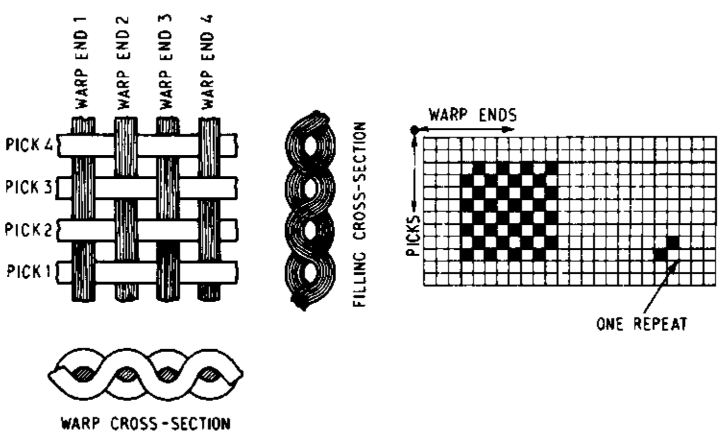


Fig. 9.1. Plain weave

Plain Weave

From Fig. 9.1 it can be seen that the plain weave repeats on 2 ends × 2 picks. The plain fabric comprises a high percentage of the total production of woven fabrics and it can be produced on a loom with 2 harnesses. It has the highest number of interlacings as compared with other weaves and therefore it produces the firmest fabrics.

Ornamentation of Plain Cloth

The appearance of a plain fabric can be changed in many ways, which can be summarized as follows:

1. *The Use of Color*

In the warp direction, color stripes are produced along the length of the fabric; in the filling direction, colour stripes are produced across the width of the fabric. When used in both warp and filling directions a check effect is produced.

2. *Changing Yarn and Fabric Counts*

Stripes and check effects can be produced by using different *fabric count* or *yarn count* in one or both directions. Also rib effects can be produced by using different yarn counts and different tensions as shown in Fig. 9.2(a).

3. *Changing the Yarn Twist*

Using combinations of different twist levels and directions in the warp or filling (or both warp and filling), different effects can be produced in the fabric due to the changes in orientation of the fibers, as shown in Fig. 9.2(b). Also different amounts of twist produce different shrinkage characteristics in different parts of the fabric and so change the appearance.

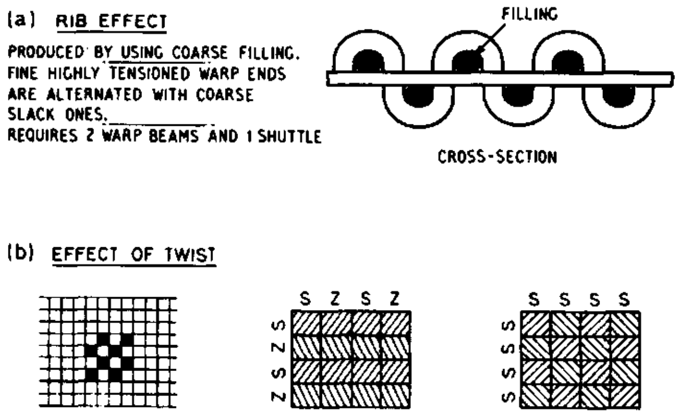


Fig. 9.2. Effect of yarn count and twist on plain weave fabrics

4. *Different Finishing Techniques*

Treatments such as dyeing, mercerizing with caustic soda or coating can change the characteristics of the plain fabric.

5. *Any Combination of the Above*

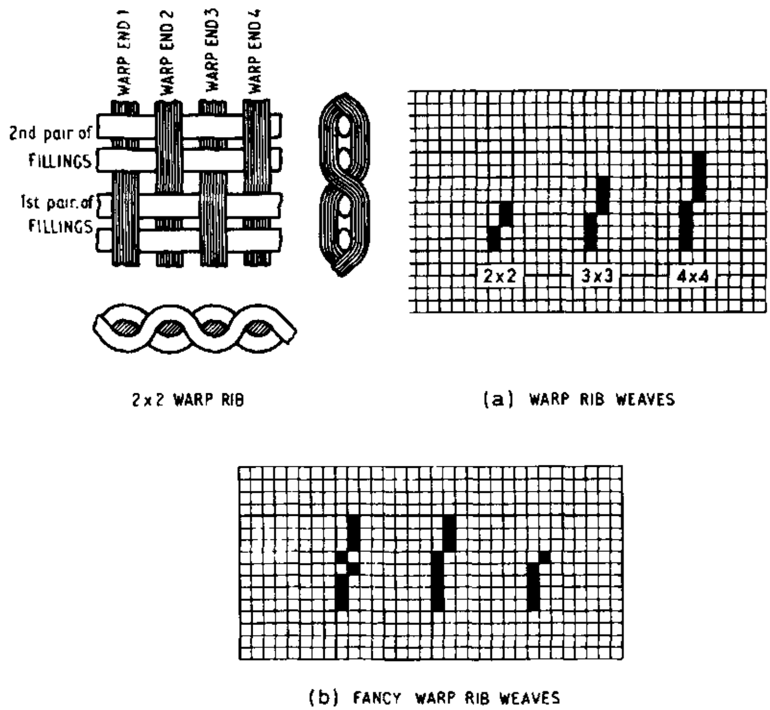


Fig. 9.3. Warp rib weaves.

Variations of the Plain Weave

Some fabrics are considered to be derivatives of the plain weave. These are, in effect, extensions of the simple interlacing and, like plain weave, they can be produced on a loom with two harnesses.

Warp Rib Weave

In this, the extension of the plain weave is in the warp direction, as shown by Fig. 9.3(a); the warp weaves in the same order as in the plain fabric, namely, every two adjacent ends weave opposite to each other. The filling weaves in groups of 2, 3 or more and every group weaves opposite to the adjacent groups; the repeat is always on 2 ends but any number of picks may be involved. The *weave* is denoted by showing the number of picks in the group above and below a line, i.e., as $\frac{2}{2}$ warp rib weave or sometimes as 2 × 2 warp rib weave. Although the weave is called *warp rib* it actually produces ribs in the filling direction. To obtain the best results it is usual to use fine warp and coarse filling in order to show the rib more clearly. The fabrics are normally lighter in weight than plain weave fabrics because of the lower level of crimp. The fabrics are also softer and more flexible than the plain fabrics.

In weaving warp rib weave on a single shuttle loom, it is necessary to use a *selvage motion* to ensure proper binding between the picks and the selvage warp. This is because more than one pick is inserted in one shed and unless the pick is bound at the selvage, the shuttle will pull the pick out of the shed on its second traverse.

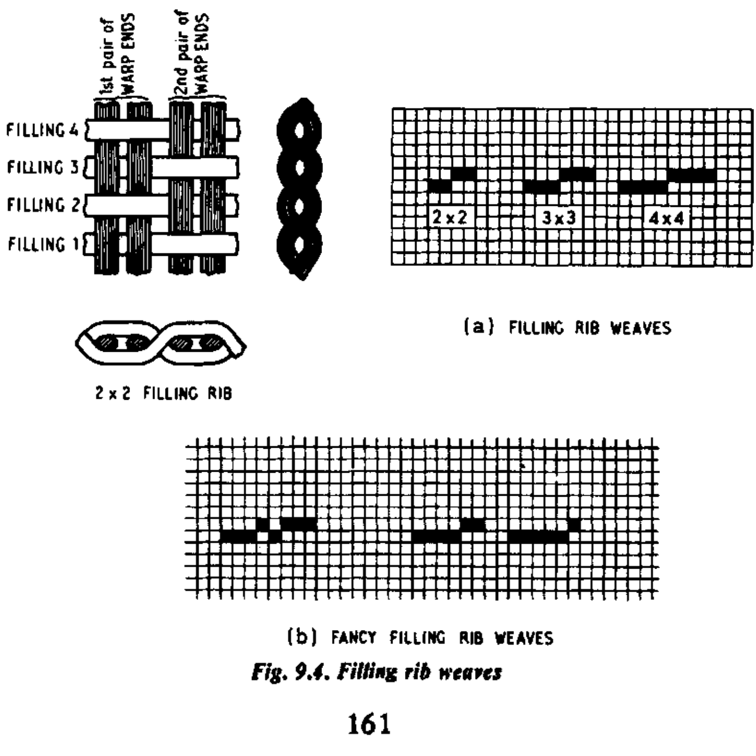
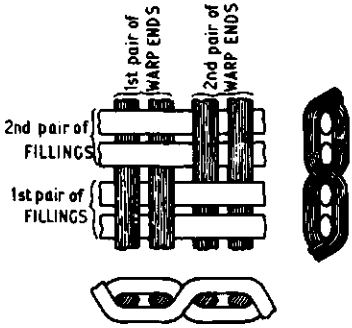
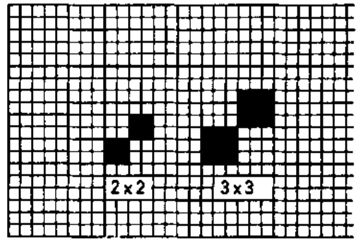


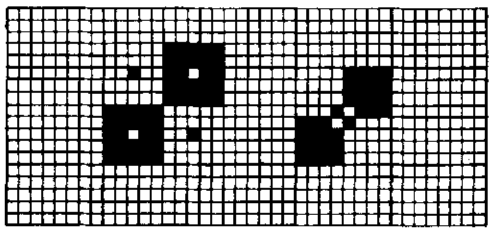
Fig. 9.4. Filling rib weaves



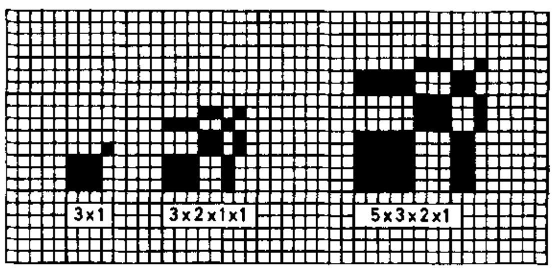
2 x 2 BASKET



(a) REGULAR BASKET WEAVES



(b) STITCHED BASKET WEAVES



(c) FANCY BASKET WEAVES

Fig. 9.5. Basket weaves

Fancy rib weaves can be produced simply by changing the number of picks in the groups, which changes the width of the rib in the fabric as shown in Fig. 9.3(b).

Filling Rib Weave

In this case groups of ends are woven with each group in direct opposition to the adjacent groups. The repeat is always on 2 picks × any number of ends as shown in Fig. 9.4(a). The ribs produced in the fabric run in the direction of the warp. It is usual to use coarse warp and fine filling to emphasize the rib. The fabrics are normally stronger than the plain fabrics because of the low crimp level.

There is no need to use a selvage motion, since there is only one pick inserted in every shed.

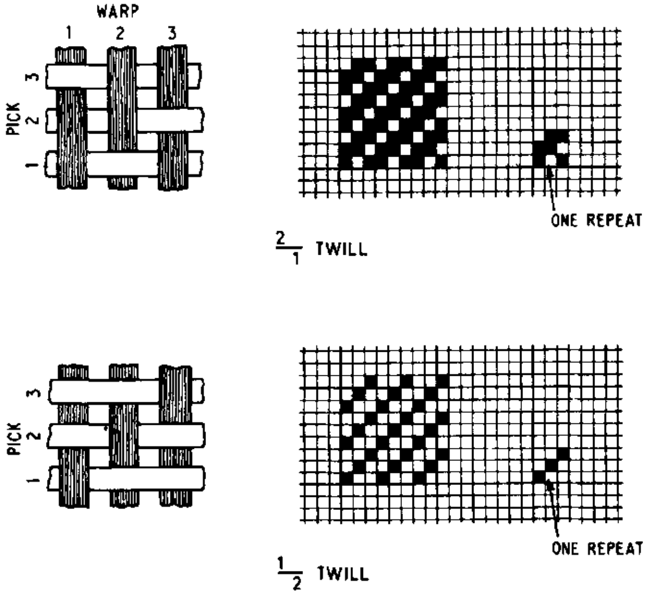
Fancy ribs can be produced in the manner already described, but by changing the number of ends in the group, as shown by Fig. 9.4(b).

Basket Weave (Matt Weave)

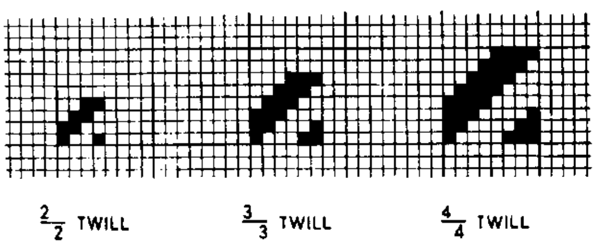
In this weave the extension is made in both directions so that groups of ends and picks are woven in the same way as single ends and picks are woven in the plain weave. The weave is denoted in the manner used for rib weaves, i.e. as $\frac{2}{2}$ basket or 2 × 2 basket. Fig. 9.5(a) shows the designs for 2 × 2 and 3 × 3 *basket weaves*. The numbers of ends and picks in the repeat are always equal to the addition of the two numbers denoting the weave. Thus a 2 × 2 basket repeats on 4 ends × 4 picks, a 3 × 3 basket repeats on 6 ends × 6 picks and so on. The *weave is square* and is mostly used with *square constructions*.

The fabrics are normally smoother and more flexible than plain fabrics, mainly because of the longer *floats* and fewer number of intersections. As the length of the float is increased more than (say) 1/2 cm, it is desirable to use the stitching shown in Fig. 9.5(b). This *stitched basket weave* produces a much firmer fabric than the regular basket weave.

It is also possible to change the number of ends and picks in the groups to produce fancy basket weaves as shown in Fig. 9.5(c).



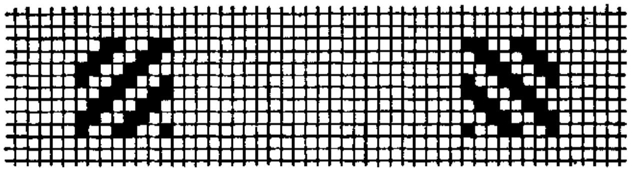
(a)



(b)

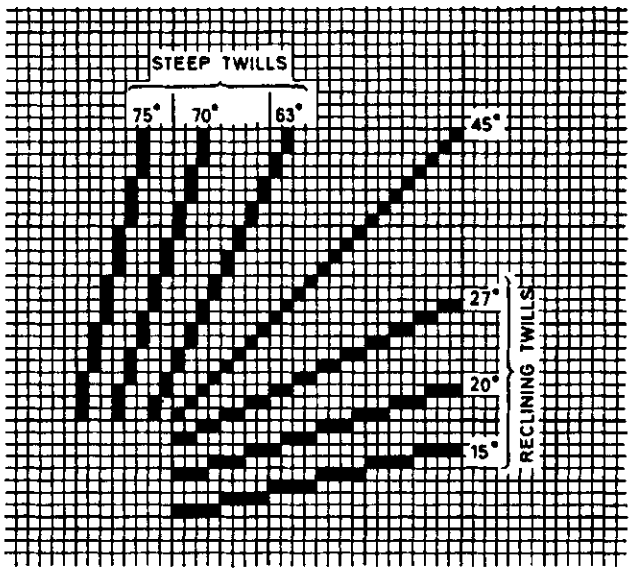
Fig. 9.6.(a) $\frac{2}{1}$ *and* $\frac{1}{2}$ *twills. (b) Balanced twills.*

Fig. 9.6.(c) Twill angle and direction and (d) $\frac{2\ 1}{2\ 1}$ *twill shown on page 165.*

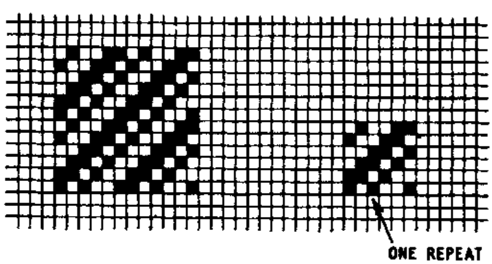


$\frac{2}{2}$ R.H. TWILL

$\frac{2}{2}$ L.H. TWILL



(c)



$\frac{2\ \ 1}{2\ \ 1}$ TWILL

(d)

In weaving basket weaves, the use of a selvage motion is also necessary to bind the picks at the selvage. Normally the selvage design is different and rib or plain selvage can be used.

With all plain weave derivatives, the fabrics have higher tensile strength, better abrasion resistance and higher tear strength than the same construction in the plain weave. This is mainly attributed to the high degree of freedom for the yarns to move. A rib fabric has a higher tear strength in one direction than in the other direction, due to the grouping of yarns in one direction; a basket fabric has a high tear strength in both directions.

A combination of the plain weave and its derivatives is sometimes used in the fabric to produce a fancy effect with cords or checks which may be of the same or different yarns.

Twill Weave

Twill Weave, the second basic weave, is characterized by diagonal lines running at angles varying between 15° and 75°. A twill weave is denoted by using numbers above and below a line (such as $\frac{2}{1}$ twill which may be interpreted as two up and one down in the shedding sequence). Fig. 9.6 shows some basic twill weaves. At (a) the $\frac{2}{1}$ twill and the $\frac{1}{2}$ twill are shown; these represent the smallest possible repeat of twill weaves, and one is the opposite side of the other. The repeat is always on a number of ends and picks equal to the addition of the two numbers above and below the line denoting the weave.

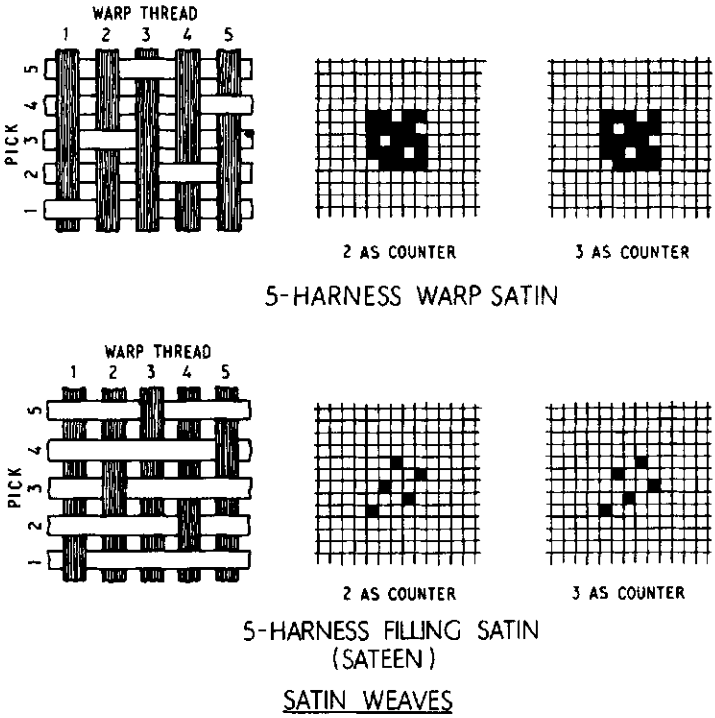
A $\frac{2}{1}$ twill or a $\frac{1}{2}$ twill repeats on 3 ends × 3 picks. If the number above the line is greater than the number below the line, the weave is known as *warp face twill*. If the opposite is true, it is a *filling face twill*. There is a third alternative in which the numbers above and below the line are equal $\left(\text{such as } \frac{2}{2} \text{ twill}\right)$; this is called *balanced twill*. Most twill fabrics are made with warp face weaves. Fig. 9.6(b) shows some balanced twill weaves.

The twill weave is always given a direction; a right-hand twill is one in which the twill line runs from bottom left to top right and a left-hand twill is one in which the twill line runs from bottom right to top left. The angle of the twill is determined by the amount of shift in the points of interlacing. A one pick-one end shift twill weave is called *45° twill*, as shown by Fig. 9.6(c). A twill weave which has more than one pick shift and one end shift is called *steep twill*; if the shift is more than one end and one pick it is called a *reclining twill*. A steep twill will have twill angles more than 45° and a reclining twill will have angles less than 45°, as shown in Fig. 9.6(c). However, the angle of the twill line in the fabric depends on the pick and end densities in the fabric. A 45° twill woven with the same yarn in warp and filling, but with the ends/inch different from the picks/in., will not have an actual twill angle in the fabric of 45°.

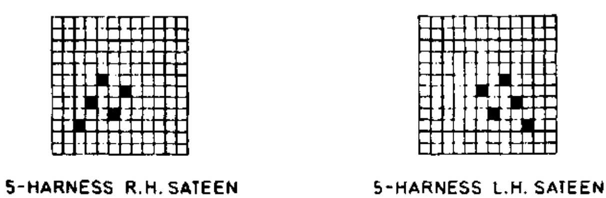
Twill weaves can be produced with more than one twill line in the weave. In this case, more than one number is used above and below the line. Fig. 9.6(d) shows a $\frac{2\ 1}{2\ 1}$ 45° right-hand twill. Many variations can be produced by this method of design. Also, there is a vast range of twill weave derivatives which are not covered here. In all these derivatives the twill lines are arranged in different patterns, such as to reverse the direction of the twill or to skip some ends to form broken twill lines.

Satin and Sateen Weaves

This is the third basic weave, in which the interlacing points are arranged in a similar way to twill weaves but without showing the twill line. The *satin* weave is a warp face weave and the *sateen* is a filling face weave. Sateens are sometimes called *filling satins* weave. Fig. 9.7(a) shows a 5-end (or



(a)



(b)

Fig. 9.7. (Above and opposite). (a) 5-harness satins and sateens. (b) Direction of sateens. (c) 7-harness sateens

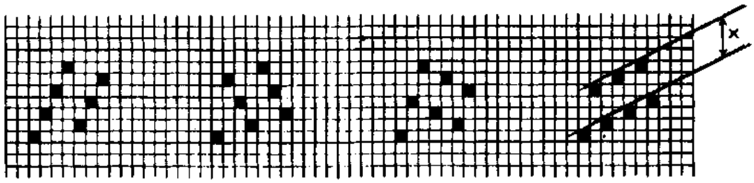


Fig. 9.7. (Above and opposite). (a) 5-harness satins and sateens. (b) Direction of sateens. (c) 7-harness sateens
Note: x = counter

5 harness) satin and 5-end sateen. In this case, the repeat is on 5 ends × 5 picks and it is clear that one design is the back side of the other. There are two different ways of arranging the interlacing points, one by using a *counter* (or move number) of 2 picks and the second by using 3 picks as counter (see Fig. 9.7). It can be seen that in a warp face satin the ends float over all the picks but one in the repeat. The interlacing can be arranged to be in the right-hand direction or in the left-hand direction as shown in Fig. 9.7(b).

For every number of ends and picks in the repeat there is more than one arrangement for the interlacing points. For example, in the case of a 7-end sateen, the possible arrangements are obtained by using counters of 2, 5, 3, and 4, as shown by Fig. 9.7(c). An important condition must be satisfied to produce a so-called regular satin; that is, no interlacing point must touch another. This can usually be achieved by avoiding the use of 1 and its complementary number of ends in the repeat. There are exceptions to this rule, for example, it is impossible to make a regular 6-end satin because the combination of numbers would be 5 and 1, 2 and 4, 3 and 3. In the case of an 8-end satin, the only combination which gives regular satin is 3 and 5, and so on.

Although the satin weave is the back side of the sateen weave produced on the same number of harnesses, it is not true to say that the fabric produced as a satin can be used as sateen. This is mainly because for a satin fabric to be smooth and lustrous, the end density must be higher than the pick density but the opposite is true for sateen fabrics. The sateen fabrics are normally softer and more lustrous than satins, but satins are usually stronger than sateens. In both fabrics, if a heavy construction of filament yarns is used, the fabric tends to be stiff and does not drape easily. However, the length of the float can balance the effect of the construction, but longer floats have disadvantages in that they have an adverse effect on fabric serviceability. Long float satins and sateens are useful in jacquard designing or in combination with other weaves, but are rarely used elsewhere.

Drawing-in Draft, Lifting and Reed Plans

As in engineering, projections which are planar representation of bodies can be used to represent the woven fabric on point paper. These projections are called *design*, *drawing-in draft*, *lifting plan*, and the *reed plan*.

The design represents the manner in which the interlacing between the warp and filling yarns takes place. The drawing-in draft shows the arrangement of the warp yarns on the different harness frames. The lifting (or chain plan) represents the pattern in which the harness frames are lifted or lowered at every pick in the repeat. The reed plan shows the arrangements of the warp yarns in the reed dent. A sketch of a four-harness straight-draw arrangement of warp ends with a two-ends-per-dent reed plan is shown in Fig. 9.8(a) and this is reduced to diagrammatic form in Fig. 9.8(b). The drawing-in draft (D.I.D.) (shown at B) determines the relationship between the design (shown at C) and the lifting or chain plan (shown at A). For example, if harness number 4 has to be lifted on pick number II in the sequence, then the lifting plan must be marked by filling in the square at

P, the arrows indicating the paths by which one arrives at point P.

Should the drawing-in draft be straight, then the design and the lifting plan are similar (see Fig. 9.8(c)), but if the drawing-in draft (D.I.D.) be in any other form (e.g. pointed or skip draw), then the lifting plan will be dissimilar to the design. It is then absolutely necessary to make projections similar to those drawn by the arrows in Fig. 9.8(b) to establish the correct relationships between the lifting plan and the design.

Normally, the drawing-in draft is placed either above or below the design with a space in between them. It can be shown by filling in the squares or by using crosses. The lifting plan is usually placed to the right-hand side of the design and it is always based on the filling in of the squares; again, a space between the design and the lifting plan is necessary. The reed plan is normally placed below the design and can be indicated either by filling in squares or by using brackets.

Figure 9.8(c) shows the design, drawing-in draft, lifting plan and reed plan for an 8-end sateen weave. In this case the draft has to be straight, because every end in the repeat is woven differently, and there are eight harnesses. The ends are dented 2 ends/dent. The *reed number* (number of dents/inch or dents/cm) and the end density determine the *width in the reed* (WIR) of the warp.

Fig. 9.8(d) is similar to Fig. 9.8(c), but different methods of indication are used. As already indicated, the drawing-in draft can be one of three types depending on the design and the density of the warp. If any two of the projections—design, drawing-in draft, and lifting plan—are given, the third can be deduced from them.

In many cases the selvage design and denting are different from those of the main body of the fabric; they are sometimes included in the representation.

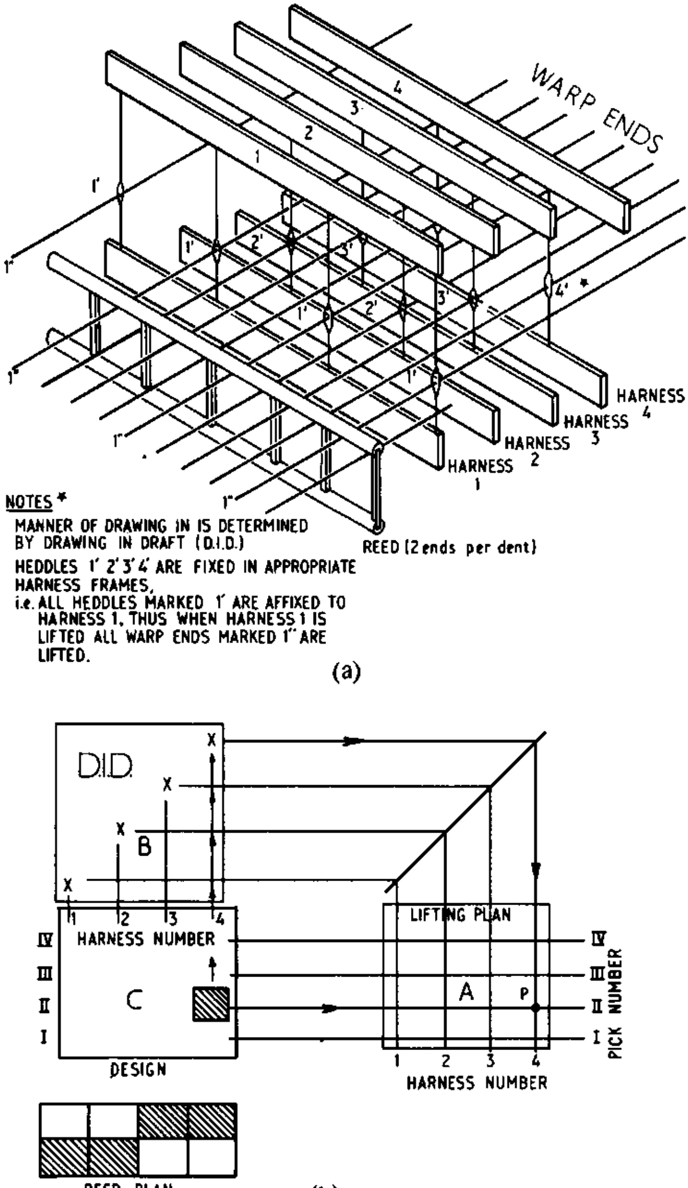
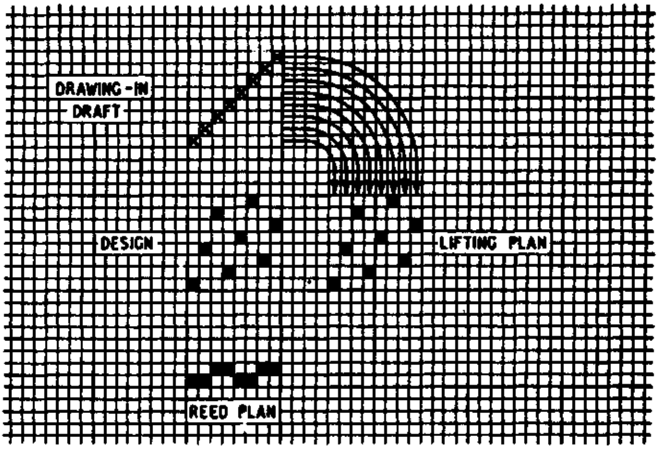
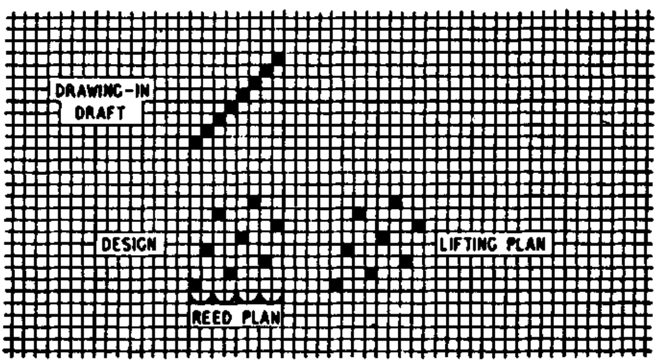


Fig. 9.8. Drawing-in.



(c)



(d)

Fig. 9.8. Drawing-in draft, lifting and reed plans

Effect of Woven Fabric Structure on Fabric Properties

The design of a fabric to meet the requirements of a certain end use is a complicated engineering problem. There are many factors involved in the fabric design (such as fiber type, yarn geometry, fabric structure, and methods of finishing) and it is difficult to predict the properties of woven fabrics. However, there are empirical relationships between some of the fabric parameters and the fabric properties. There are also some theoretical relationships (mostly for the plain weave) but theory becomes very complicated when applied to other weaves.

Tensile Strength

The tensile strength of a fabric is a reflection of the strength of the yarn and of the fabric structure. Sometimes, because of the crimp, the fabric strength is less than the strength of twisted yarns; because of the twist in the yarn, the yarn strength is less than the strength of the fibers. However, it is possible to increase the fabric strength over the yarn strength by means of the compacting forces developed in the woven fabric. These can prevent fibers from slipping within the yarn. Other things being equal, plain weave fabrics which have the highest crimp will have the lowest strength.

Extensibility

Equally important to the fabric strength is its ability to extend under load. When the fabric is subjected to tension in one direction, the extension takes place in two main phases. The first phase is *decrimping* or *crimp removal* in the direction of the load. The removal of the crimp is accompanied by a slow rate of increase of the load. The second phase is the extension of the yarn, during which the fabric becomes stiffer, the stiffness depending mainly on the character of the yarn. The more crimp there is in the yarn, the more extensible is the fabric. Therefore, the longer the floats, the less extensible is the fabric.

Surface Friction

Surface friction of the fabric is affected by the crimp and the fabric structure, in addition to the surface friction of the component yarns. Designs which have a high number of intersections in the repeat tend to have high crimp and produce a rough fabric. Long floats, however, produce smooth fabrics with low crimp levels.

Tear Strength

The tear strength of a woven fabric is very important, since it is more closely related to serviceability than is the tensile strength. The behavior of woven fabrics under tearing loads is quite different from their behavior under tensile loading. In the case of tensile loading, all the yarns in the direction of loading share the load; in tear loading, only one, two, or at most a few yarns share the load. The yarn and fabric structures play very important roles in determining the fabric tear strength. The movement of a hairy weak yarn will be restricted during loading, and yarns will be presented to the load one by one; this results in a low tearing strength. Tight constructions will produce the same effect. Loose, open constructions allow more freedom for the yarns to move and group together, thus presenting bundles of yarns to the tearing load; in consequence, the tear strength is high. Designs which have groups of yarns woven together, such as rib weaves and basket weaves will have high tear strengths. Finishing, easy care treatments and coating tend to reduce the tear strength of woven fabrics, especially if they restrict the freedom of movement of the yarns under loading.

Abrasion Resistance

The *abrasion resistance* of woven fabrics is greatly affected by the yarn properties, fabric geometry and construction. The most important factors are the crimp levels and the height of the *crowns* caused by the crimp. The extent to which the crowns are displaced out of the plane of the fabric depends on the weave, yarn number, yarn crimp and fabric count. The greater the number of the crowns per unit area or the greater the area of each crown, the less will be the stress concentration on the crowns, and this leads to higher abrasion resistance. The weave also has a considerable effect on the abrasion resistance of the fabric. Where there are floats, the longer these are, the less restricted are the yarns to move. Also the longer the floats, the larger is the area of contact between the yarn and the abraidant and the higher is the abrasion resistance.

Drape

The *drape* of the fabric is usually defined in terms of the shape or the way in which the fabric hangs down in folds. Bending and shear stiffness have a significant effect on the fabric drapeability. The yarn number, fabric count and the weave are important factors. Heavy fabrics from coarse yarns and dense constructions have poor drape characteristics. Fabrics with long floats in the weave permit the yarns to move freely; this reduces the bending and shear resistance of the fabric, leading to better drape behavior.

Crease Resistance

The *crease resistance* of the woven fabric is affected greatly by the weave. The most important factor is the freedom of yarns and fibers to relax. A plain woven fabric with high fabric count puts a heavy strain on the fibers and limits the recovery of the fabric. The longer the floats, the higher will be the crease resistance of the fabric.

Pilling Resistance

Hairs on the surface of a fabric tend to collect into little balls (pills) and if the fibers are strong, these balls do not break off; this spoils the appearance of the fabric. Low twist yarns are usually hairy and the hairs form sites for the pills to form, especially when strong synthetic fibers are used. Fabric structure plays a part and plain weaves give a higher pill resistance than fabrics with floats, proper crimp balance can minimise the problem for a given structure.

It is apparent that the structure of a woven fabric has a significant effect on fabric properties. It is only possible to engineer the fabric to meet specific requirements by establishing a thorough understanding of the behavior of the fabric in actual use.

10

THE SIMPLE SHUTTLE LOOM

Key words: *auxiliary shaft, bottom shaft, camshaft, closed warp shed, crankshaft, crossed shed, crossing point, dwell, fell, filling insertion rate, flying shuttle, lay, open shed, picking bowls, picking cams, race board, reed, selvage motions, shedding cams, shuttle box, tappets, temples, top shaft, weaving cycle.*

The Weaving Cycle

The functions of the loom (see Chapter 2) are:

(1) Warpwise control.
(2) Shedding.
(3) Picking.
(4) Beat-up and lay movement.

These functions must be synchronized so that the operations occur in their correct sequence and do not interfere with one another. The relative timing can also affect the nature and quality of the fabric. Consider the case of a two harness loom in which the shedding pattern is very simple. Let the harnesses be designated A and B; the shedding sequence is then as shown in Fig. 10.1(a). In passing from time 1 to time 2, the sheets of warp become level and at this point (the crossing point) the warp shed is said to be closed. Obviously no shuttle could pass at that time and it is necessary to ensure that it passes while the shed is at least partly open.

More complicated multi-harness shedding patterns are possible but the fundamental concept is similar.

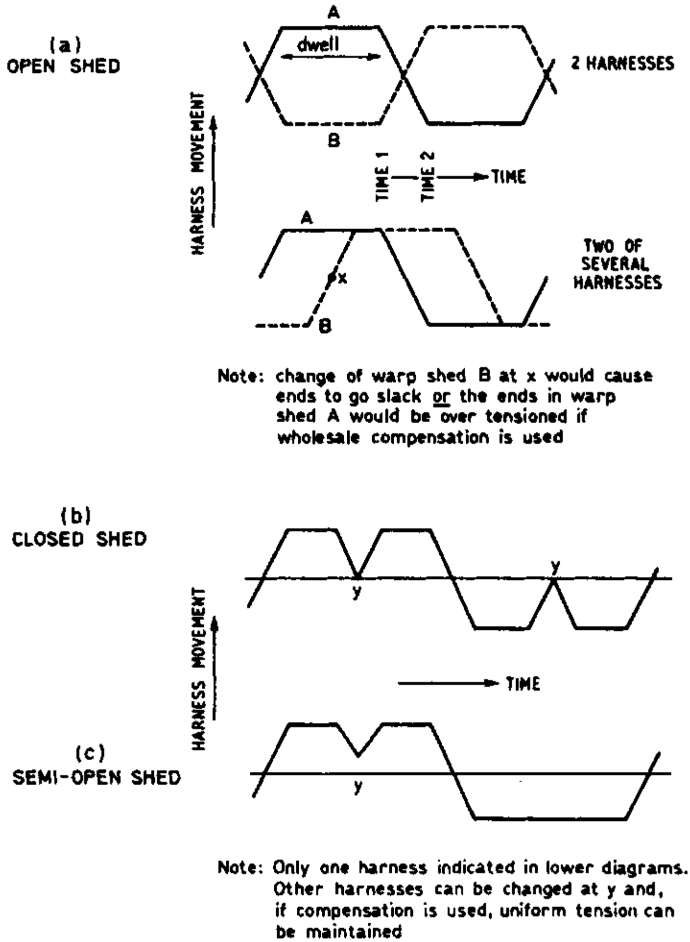


Fig. 10.1. Types of warp shed (diagrams (b) and (c) are discussed on p. 195).

The transit time of the shuttle

$$t_s = W \div \bar{V}_s$$

where W = effective width of the loom in meters,

$\bar{V}_s$ = average shuttle speed in meters/second,

t_s = transit time in seconds.

Thus the shed has to remain at least partly open for a limited but adequate time and must not open or close at the wrong time. The shed does not have to be fully open at the time of shuttle entry or exit. After the shuttle has passed, it is necessary to rearrange the warps to give the desired fabric structure before the shuttle returns.

There must be a definite time between the completion of one pick and the start of the next. In a shuttle loom, a good deal of this time is spent in stopping the shuttle and then accelerating it in the other direction. Actions other than those relating to picking and checking must also be completed in the same time in a concurrent manner. In theory, the longest of these sets of actions determines the delay time (t_d) but in practice the delay time is determined by the shuttle reversal. Let the average *weaving cycle* time be t_w; since this time varies from one cycle to the next and it is fairly regular over a pair of picks, let the state be defined in terms of $2t_w$. This value $2t_w$ may be defined as the time needed for the shuttle to pass a given point in successive traverses in the same direction. From the foregoing

$$2t_w = t_{s1} + t_{s2} + t_{d1} + t_{d2}$$

where the subscripts 1 and 2 refer to successive picks. The weaving speed is $60 \div t_w$ picks/min, the theoretical filling insertion rate is $\frac{60W}{t_w}$ meters/minute and the actual filling insertion rate is $\frac{60W\eta_w}{t_w}$ meters/minute (where η_w is the weaving efficiency).

It is apparent that the permissible loom speed is a function of the loom width and of the characteristics of the picking and checking mechanisms. It is also affected by other mechanisms.

During time t_d the warp shed has to be changed into a new configuration in order to generate the desired weave, but

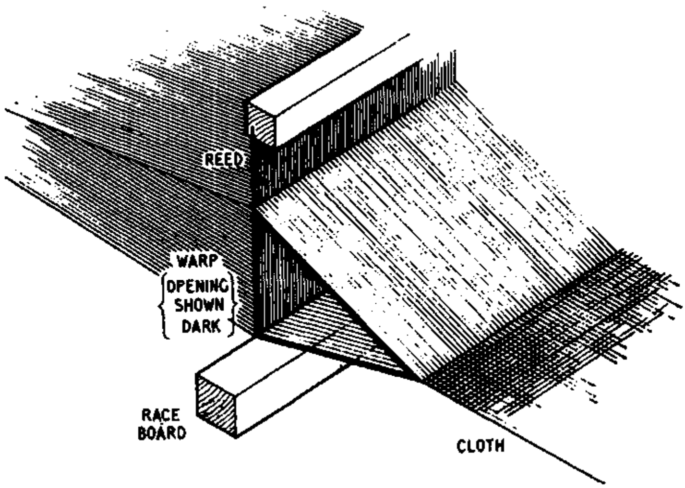


Fig. 10.2. Race board and warp shed

it is also necessary to position the filling by means of the *reed* in the beating motion. These two actions must be co-ordinated exactly with the weaving cycle. The reed has to be withdrawn rearwards after beating the filling into the *fell* of the cloth and this must be completed (or nearly so) before the next pick can be inserted. The shedding and beating have to be carefully co-ordinated to give the most effective positioning of the filling without undue strain on the warp; hence exact synchronization and proper timing are essential for good weaving.

In a shuttle loom, the reed and a so-called *race board* are used as restraints to control the shuttle flight, as shown in Fig. 10.2. The path of the shuttle is important because if it does not enter the *shuttle box* cleanly it will adversely affect the picking and checking, which in turn will affect the whole cycle. If, because of this, the shuttle deviates from its intended path, it might fly out of the loom; this can be very dangerous (such an occurrence is called a *flying shuttle*).

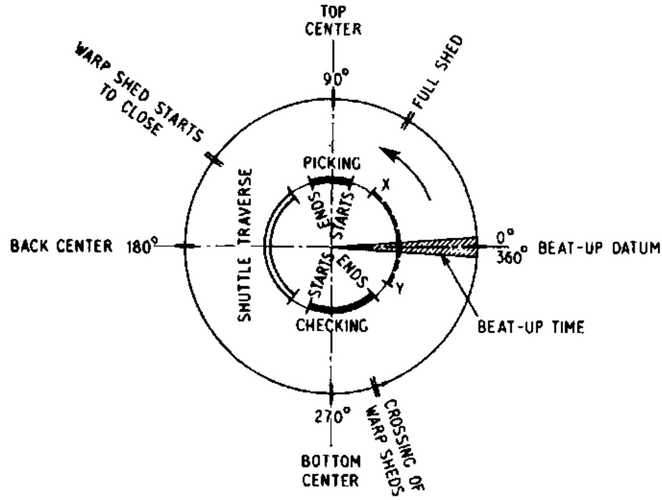


Fig. 10.3. Timing diagram

The beating and shedding cause cyclic tension variations in the warp which, if not controlled, would lead to unacceptable end breakage rates. With high production looms, this is usually controlled by various mechanisms which alter the path of the warp ends so as to relieve the tensions. This too must be synchronized with other mechanisms.

The various mechanisms which have to be synchronized operate in a cyclic manner and they may be described by a timing diagram (see Fig. 10.3).

Mechanisms of Timing

For simplicity, let only the two-harness looms be considered at this stage.

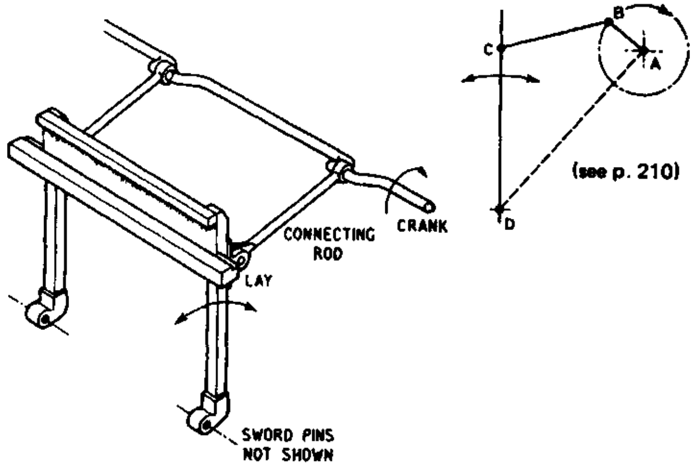


Fig. 10.4. Schematic arrangement of lay mechanism

The *lay* has to operate once per weaving cycle to beat up the newly inserted lengths of filling. During one weaving cycle, a given harness moves from the up to the down position or vice versa. The whole shedding cycle (i.e. from top position to bottom position and back) takes two weaving cycles to complete, thus there must be two drives, one of which operates at half the speed of the other. A loom has two picking mechanisms, one on each side. Each operates every other weaving cycle and therefore it is driven from the same shaft as the shedding motion.

In the normal loom there is a main shaft (or *top shaft* or *crank shaft*) which operates the lay mechanisms as shown in Fig. 10.4. The main shaft is connected by means of gearing or other toothed drive to a second shaft called a *cam shaft* (or *bottom shaft*). This cam shaft drives the shedding motion by means of *shedding cams* (or *tappets*) as shown in Fig. 10.5; it also operates the picking mechanisms by means of *picking cams* (or *picking bowls*) together with various linkages (a typical system is shown in Fig. 10.6).

For more complicated weaves it is necessary to use a

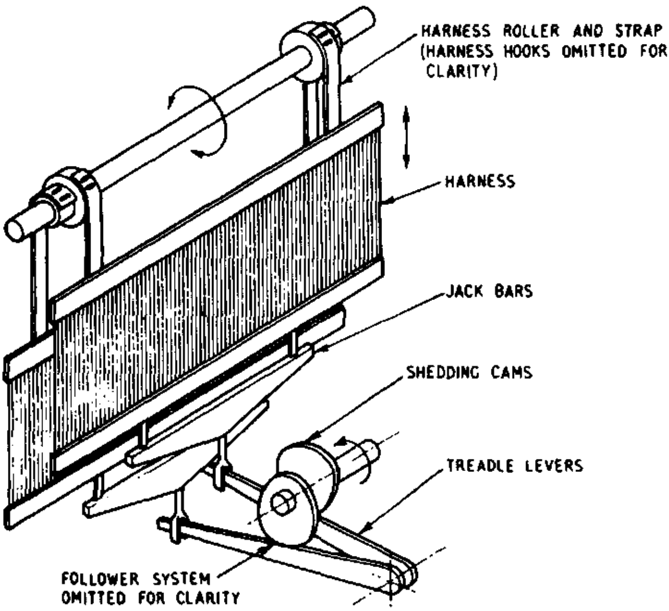


Fig. 10.5. Schematic arrangement of shedding mechanism.

large number of harnesses because of the complex shedding pattern and a separate shaft is usually required for the shedding cams (this is termed an *auxiliary shaft*). For the most complex weaves it is necessary to use a different type of loom but this need not be discussed here.

Timing

Let the point at which the reed reaches its most forward position be the datum. In other words, this point will be represented as O° crank angle and the other mechanisms can be related to this. One complete revolution of the crank shaft is one weaving cycle and this can be represented as 360° of movement.

For convenience the datum will be referred to as beat-up, even though this occupies a finite angular displacement. A typical set of timings is given in Fig. 10.3 but actual timings depend upon the design of both loom and fabric and there

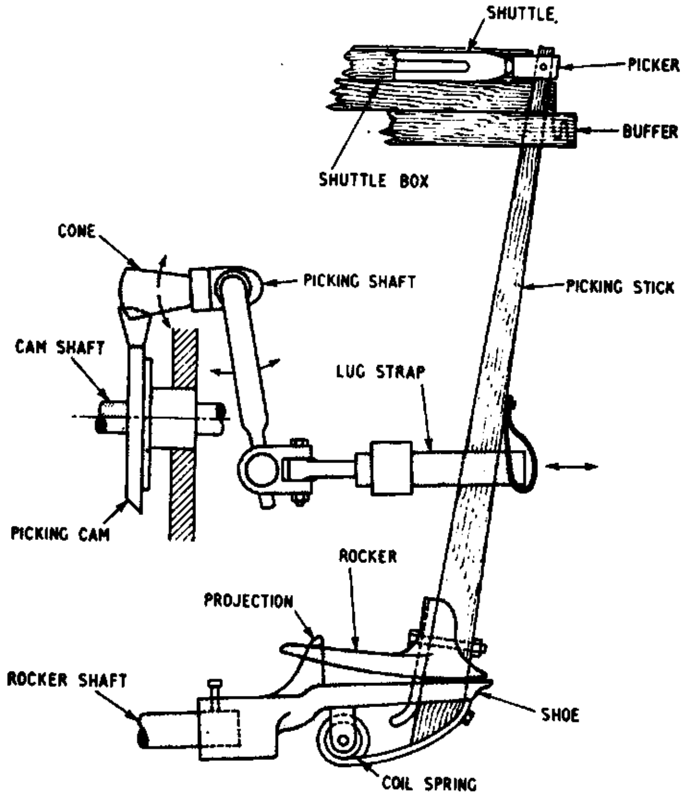
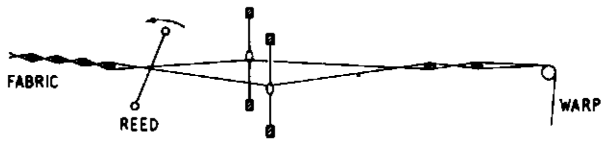
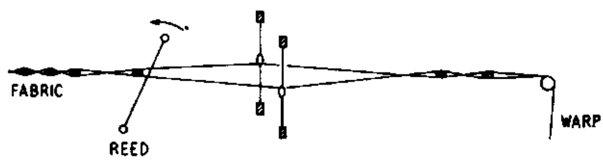


Fig. 10.6. Cone underpick mechanism.

is no unique timing diagram. In the diagram the shuttle movement is related to one circle and shedding to the other. The motion of the lay is a continuous harmonic motion which is directly related to the crank angle. Let the shedding motion be considered first in relation to beat-up. Beat-up is intended to force the filling into its proper position in the fabric by a sort of wedge action and it is exceptional for beat up to take place at the time the warp sheets cross. With



(a) BEATING ON CLOSED SHED



(b) BEATING ON OPEN SHED

Fig. 10.7

staple fiber warp yarns, it is normal to beat up on a *crossed shed* as shown in Fig. 10.7(a), whereas with filament warp it is more normal to beat up on an *open shed* as shown in Fig. 10.7(b). For illustration, the harness movements for the former case are shown in Fig. 10.1(a); it is normal that beat up takes place on a crossed shed, and that the shuttle enters and leaves with the shed partly open. The *dwell* is controlled by the cam profile and must be such as to permit passage of the shuttle for the particular width and speed of the loom.

Consider next the shuttle motion. The shuttle starts from rest at about 80° after beat up and then must be accelerated up to speed, which takes a definite time. It has to change from zero to some 15m/sec (35 mph) after travelling less than 30 cm (1 ft). This imposes high stresses on the mechanism and usually it is necessary for this phase to occupy some 20–30°. After transit, which normally takes some 150°, the shuttle has to be stopped in a like distance and time. The balance of the time (XY in Fig. 10.3) is available to permit the automatic changing of the quill.

The question of the position at which the loom should stop is relevant. It is desirable that it should stop at back center so as to give the best access to the warp shed. It is necessary to stop it before the crossing of shed to permit repair without fault in the fabric. Once the shed is crossed and there is a warp break, the repair will give a wrong shedding for the end unless the loom is turned back, which is undesirable.

It is essential to stop the loom before beat-up to permit the repair of broken filling yarns which otherwise would be beaten into the fabric and probably cause damage.

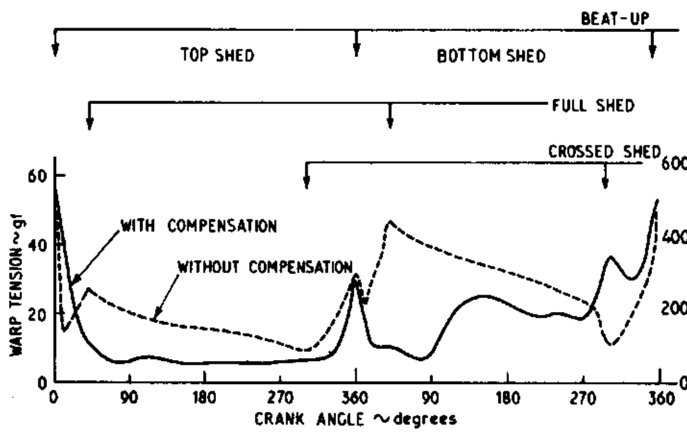


Fig. 10.8. Typical warp tension diagrams.

Interaction between the Textile Material and Loom Parts

The action of shedding causes the length of the warp to vary; this, in turn, causes the warp tension to vary. In the absence of any compensating motion, the tension would vary in sympathy with the harness motion. Thus there would be a tension cycle somewhat similar in shape to the shedding diagram shown in Fig. 10.8. In practice, this is reduced

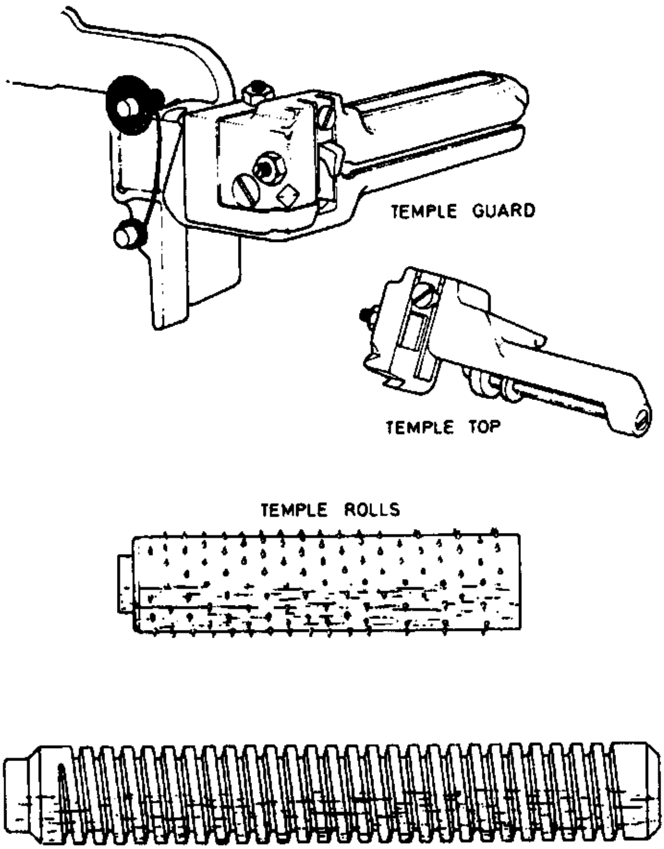


Fig. 10.9. Temple parts.

by having a synchronized compensating motion which reduces the tension peak to give a tension diagram similar to that shown in Fig. 10.8 (full line).

Superimposed upon this is a tension pulse arising from beat-up. For a very light open fabric this pulse is small, but with a heavy dense fabric the pulse can be very large.

There is crimp interchange between warp and filling which is a function of the respective tensions (see Chapter 8). To get a good crimp balance, it is necessary to apply a tension in the filling direction. It is not possible to do this prior to beat-up and therefore the whole fabric has to be tensioned. This is achieved by using *temples*, of which there are numerous types; a fairly common one is shown in Fig. 10.9.

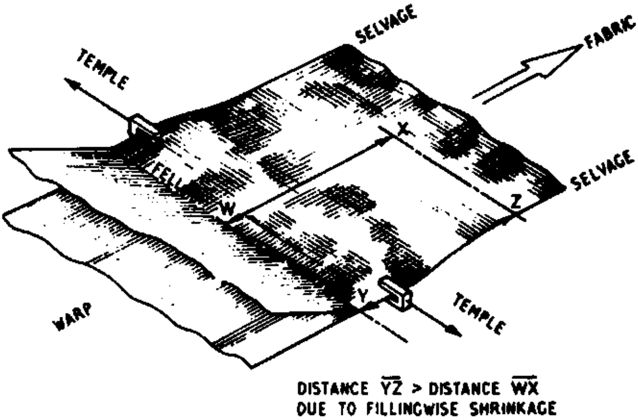


Fig. 10.10. Action of temples.

For several reasons, the warp tensions vary from the center to the selvages. Firstly, the shuttle entering or leaving the shed rubs the outermost yarns, causing local peaks in tension; this effect is commonly controlled by using *selvage motions* or separate heddles for the selvage warp ends. Secondly, the crimp in the yarn causes a widthwise contraction of the fabric after leaving the temples. The path length of the outermost warp threads is therefore longer than the central ones (see Fig. 10.10). In addition, it is normal to alter the fabric construction at the selvages to give a durable fabric and this alters the crimp behavior, which in turn affects the tension in the yarn. This can cause damage and increase the end breakage rate, and it may occur in such a way as to cause irregular local damage which spoils the appearance of the fabric.

The frictional forces arising from the movement of the filling during beat-up can play a significant part. With filament yarns which have a high coefficient of friction, the forces generated in trying to beat-up on a crossed shed would cause very high end breakage rates. Friction between the warps and the reed wire, heddle wires, lease rods, drop wires and shuttle can also cause end breaks.

Generally, the action of the machine on the material is more important than the action of the material on the machine. Under normal conditions the material has relatively little direct effect on the performance of the loom, but since the loom can certainly affect the cloth, it is necessary to understand each of the component systems thoroughly if the best is to be obtained from the loom. The following chapters deal with these component systems.