11. Weaving technologies and structures

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Learning objectives

By the end of this lecture, you should be able to:

- Briefly explain the basic stages in the weaving of fabric
- Draw a diagram of a basic loom, showing the key parts
- Outline the warping and drawing-in steps
- Explain why yarn sizing is required and how this is carried out
- Outline the sequence of steps in the weaving cycle and the purpose of each step
- Describe the different shedding mechanisms and the advantages and disadvantages of each
- Describe and compare the various mechanisms used for weft insertion, both shuttle and shuttleless weaving
- Discuss the main yarn interlacing structures in woven fabrics, their characteristics and uses

Key terms and concepts

Warp, weft, warping, drawing in, sizing, shedding, heald, reed, shed, harness, picking, weft insertion, beat-up, let-off, tappet, dobby, Jacquard mechanism, shuttle, pirn, shuttleless weaving, projectile, rapier, air-jet, water-jet, multiphase insertion, selvedge, plain weave, sett, balanced and unbalanced weave, twill, wale, satin, sateen.

Introduction to the topic

While the term 'weaving' is mostly used for the process of interlacing two sets of yarns (warp and weft) on a loom to form a woven fabric, it is actually a series of processes which converts yarn into a fabric that is suitable for tailoring (Ormerod and Sondhelm, 1995). The sequence of processing steps is

- Winding and clearing of yarns
- Weft winding
- Warping
- Sizing and other applications
- Entering and knotting
- Loom operation (weaving)
- Finishing of fabric
- Inspection and measuring.

Shuttle looms have been the traditional machines for weaving over many centuries, and are still widely used around the world today, especially in developing countries. However, over the past three decades, shuttle-less looms have taken the lead position in weaving machinery. Speed and versatility have been the main thrust of the developments. Examples of recent technological advances are unprecedented weaving speeds, sophisticated automation systems, highly efficient Jacquard mechanisms, waste reduction and on-line quality monitoring. In addition, new fibres for quality apparel and for use in high performance industrial fabrics continue to become available. A number of papers reviewing these advances are available: (Ghandi and Pearson, 2000).

This topic first outlines the preparations of the yarns used for weaving and then proceeds to discuss the steps in the weaving cycle and the key mechanisms involved at each stage. These steps include shedding, weft insertion, beating up and let off. Various types of mechanisms are used for producing the shedding action and for inserting the weft yarn. The topic concludes by describing the main woven fabric structures: plain, twill, satin and sateen, and variations of these structures. From the choice of warp and weft yarns, different degrees of sett and a variety of interlacing patterns, a wide range of fabrics with different appearance, handle and performance properties can be produced.

The principle reference for this lecture is *"Weaving Technology and Operations"* by A Ormerod and W. S. Sondhelm (Ormerod and Sondhelm, 1995). Other useful general references on weaving technologies and structures are (Gohl and Vilensky, 1985), (Lord and Mohamed, 1982) and (Hollen and Saddler, 1975). The forward-looking review article (Gandi and Pearson, 2000) is also worthwhile reading.

11.1 The basics of weaving

Woven fabric is produced on a loom, whether it be a simple hand loom or a sophisticated machine loom. The basic operating principles are the same; to explain these the essential parts of a simple shuttle loom are shown in Figure 11.1. This is a two-harness loom in which adjacent warp yarns are threaded through alternate healds so that the weft thread passes over and then under alternate warp threads in a plain weave fabric.

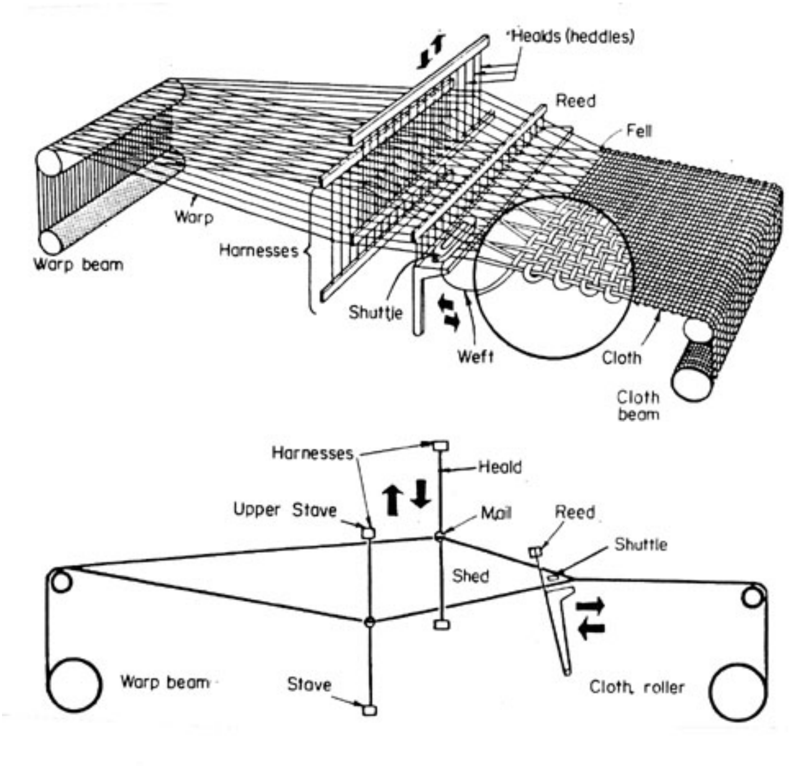


Figure 11.1 The key parts of a loom. Source: Wood, 2006.

The basic steps in yarn preparation and weaving are as follows:

1. *Warping:* The warp yarn is wound onto a beam
2. *Sizing*: This involves treating the beamed yarns with starch to improve the weaving performance
3. *Drawing-in*: The warp threads are drawn off the *beam* and threaded through the *heald shafts*

The following three steps are repeated in rapid succession in the weaving sequence:

4. *Shedding*: By raising and lowering the heald shafts the warp threads are divided into two layers to create an open space called a *shed*. The weave pattern is determined by the sequence in which threads are raised or lowered. For example, to produce a plain weave alternate warp threads are successively raised or lowered by the two shafts after each weft insertion.
5. *Picking (or weft insertion)*: When a shed has been formed, the *shuttle* (or alternatively a rapier, air jet or water jet) carries the weft yarn through the shed
6. *Beat-up*: After picking, the weft yarn is pushed against the already woven fabric by the movement of the *reed*. At the same time the shed is formed again and the process repeats.

While in the traditional loom a shuttle is used to insert the weft yarns, in modern high speed machines a variety of insertion mechanisms are used, in particular, air-jet, water-jet, rapier and projectile insertion systems.

11.2 Woven fabric construction parameters

Woven fabrics comprise two or more sets of yarns interlaced at right angles to each other.

Warp: The yarns which run the length of the fabric are called *warp yarns* or ends.

These yarns need to be strong, elastics and with low hairiness. Therefore, two-fold yarns with high levels of folding twist are generally used. Where singles yarns are used for lightweight fabrics their hairiness should be reduced by waxing or sizing.

Weft: Yarns which cross the warp are called *weft yarns*, filling, or picks. The right-angle interlacing of yarns gives woven cloth more firmness and rigidity than knitted, braided, or lace fabrics

The strength requirements for these yarns are less stringent than for warp yarns. Therefore, singles yarns are often used for reasons of economy.

Woven fabrics vary in:

1. the interlacing pattern
2. the colour of interlacing threads
3. the ***sett***, which is the amount of ends and/or picks in a cloth and is expressed as number of threads per centimetre, and
4. the ***balance***, which is the ratio of warp to weft in relation to the number of threads per centimetre and their counts.

11.3 Preparations for weaving

Warp preparation

Good warp preparation is an essential requirement for achieving efficiency and fabric quality from modern high-speed weaving machines.

Sectional warping is the commonly used system for producing woollen and worsted warps. The yarn in each section is first wound on to a *swift* or *mill*. From there, all threads are drawn off together on to a warp beam. Figure 11.2 shows how the first section of warp yarns are wound up an incline at the left-hand end of the swift. The inclined build-up prevents sections from collapsing, which is likely to occur if sections are built up vertically.

One end of the drum is conical in shape and may be either a fixed angle (typically 11^o or 14^o) or variable angle type. To commence warping, the yarn packages required to form the section band are mounted onto pegs in the creel. Each thread is passed through its tensioning unit, leasing device and finally through the warping reed where the threads are dented to the required sectional width.

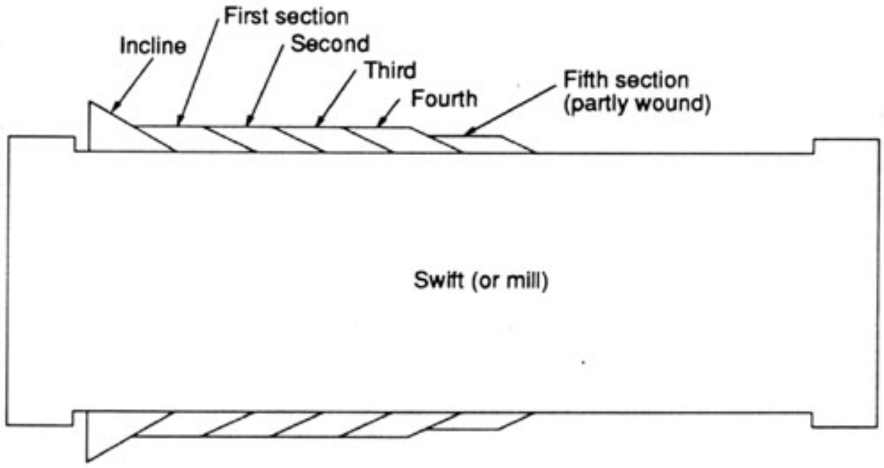


Figure 11.2 Cross section of sectional warping. Source: Wood, 2006.

During winding the section band is traversed so that the warp threads accumulate along the incline of the cone. Subsequent sections are formed on the angled platform provided by the previously formed section.

The sectional warp is then beamed off (ie, wound) onto the weaving machine's warp beam. Optional yarn waxing or sizing may be carried out at this stage.

As an alternative to sectional warping, ***beam warping*** may be used with singles yarns for light-weight plain fabrics. Usually, a number of individual warp beams with an equal number of warp ends are produced. These beams are mounted on the creel of a sizing machine (see below) and the yarns run through the sizing and drying units, then onto the weaver's beam for drawing into the loom.

Treatment of warps

Warp yarns undergo significant stresses in weaving. For this reason, warp threads are sometimes *sized* during or after warping. ***Sizing*** binds the fibres in the yarn together increasing the strength and resistance to mechanical action during weaving, and to make the yarn smooth, thus minimising chafing. It is important that the sizing materials do not interfere with the processes following weaving.

The ingredients used in sizing are usually starches, gums or synthetic adhesives and fatty or oily substances (to act as plasticizers or softeners). Starch solutions are generally used for sizing natural yarns, while synthetic finishes are used for manufactured fibres such as nylon.

To apply the size, the yarns pass through a size bath, then are dried and rewound on to a warp beam (Figure 11.3). Size must be removed before piece dyeing.

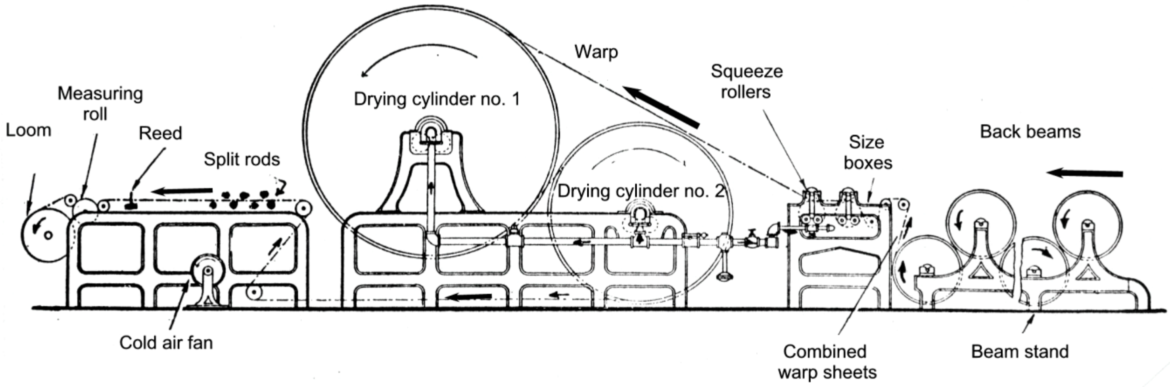


Figure 11.3 Sizing Machine

Synthetic wax compounds can be added to the warp to act as a mild size, to smooth the yarns, and to act as a lubricant. By reducing the friction between the parts of the weaving machine and the warp, wear on the warp and the shedding of fibres is reduced, thus improving weaving efficiency.

Antistatic agents can be added to reduce problems associated with static generation during the weaving process.

Drawing-in of the warp threads

Drawing-in is the threading of ends individually in a specified order through a set of healds (Figure 11.4). This has traditionally been a time-consuming, manual process, however modern automatic systems for drawing-in are now available.

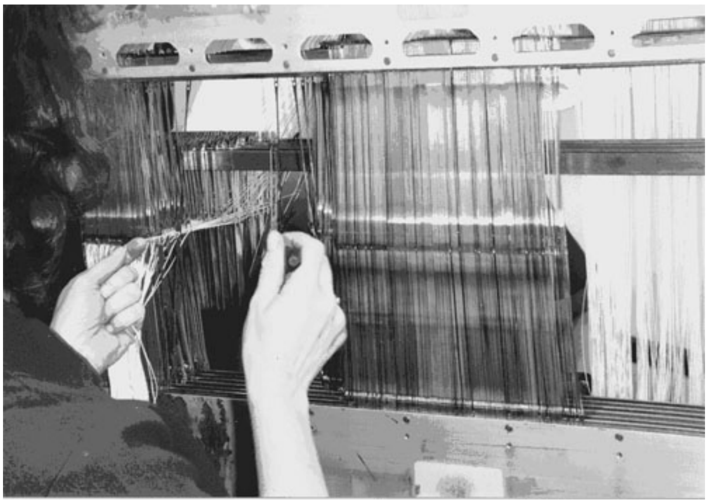


Figure 11.4 Manual drawing-in of warp threads. Source: Staubli, Switzerland.

Healds are flat steel strips or shaped wires with an eye (called a mail) in the middle. They are held in position on a ***Heald frame***. Heald frames are also referred to as shafts or staves.

The number of shafts that make up the set required for a weaving job are known as a ***Gear Harness.***

The ***Draft*** is the plan which is prepared by the designer to show the sequence in which the warp yarns are drawn-in to the heald shafts. This process determines the way in which the structure of the fabric will be formed.

Once the ends of yarn have been drawn through the healds, they pass through the ***Reed***. The reed controls the width of the warp and assists in placing the pick during weaving.

Different circumstances require three different ways in which the warps are drawn into the loom for weaving.

1. Follow-on warp

When the warp is identical in quality (total number of ends, width and pattern repeat) to the one previously woven, it is tied in at the loom by means of a knotting machine as shown in Figure 11.5.

Figure 11.5 Use of a knotting machine to tie in warp yarns.

Photograph supplied by E. Wood courtesy Canesis Network Ltd.

2. Prior preparation

The warp is knotted into a previously prepared harness set, off the loom.

3. Empty loom

Each individual yarn end is drawn through an eye of a heald wire (or jacquard harness) in the sequence required by the design, and then through the weaving reed. While this has traditionally been a labour-intensive operation, automatic machines are now able to accomplish the entire drawing-in operation under computer control, facilitating short runs.

11.3 The weaving process

Each warp thread passes through an eyelet (or mail) in a heald (a vertical wire). Healds are mounted in staves (or a heald frame) to make a ***harness***.

Figure 11.1 shows a two-harness loom in which adjacent warp yarns are threaded through mails in different harnesses. Alternate warp threads pass through alternate healds so that the weft thread passes over and then under alternate warp threads in a plain weave fabric.

The ***reed frame*** contains evenly spaced wires. Each warp yarn passes through one space in the reed, and so the yarns are kept evenly separated. The ***shed*** is the space between warp threads through which the weft yarn passes.

Looms raise and lower the harnesses. In a two-harness loom, as one heald rises, the other lowers to form another shed for the next weft insertion, thus forming a plain weave fabric. Looms can have more than two harnesses; the more harnesses a loom has, the more complex the patterns that can be woven.

In multi-harness looms, individual warp yarns are threaded through no more than one heald mail. In Jacquard looms, each warp yarn is in an individual heald. The healds are not in harnesses but can move independently under the control of the Jacquard mechanism. Hence these looms can make a great variety of patterns.

The weaving cycle

Weaving has four basic steps. Each step is carried out in sequence, and is constantly repeated until the length of cloth is completed. The main parts of the loom - warp beam, harnesses, weft insertion device (such as a shuttle), reed, and cloth beam - are involved in these steps, that is,

1. ***Shedding*** by the harnesses
2. ***Picking*** or weft insertion
3. ***Beating-up*** by the reed, and
4. ***Let-off*** by the warp beam, and take-up by the cloth beam.

1. Shedding

Shedding is the first operation of the weaving cycle. Depending on the design to be woven, one or more of the shafts (or healds) in the loom are raised, while the remainder stay in the lowered position. A space between the two sets of warp yarns, a shed, is thus formed, where the weft is inserted.

In shedding in a two-harness loom, alternate warp yarns are raised and lowered to form the shed through which the weft passes. The healds raise or lower the warp yarns. The raised warp yarns go over the weft yarn - the lowered warp yarns go under the weft. In a two-harness loom, the weft yarn goes over one warp and under the next.

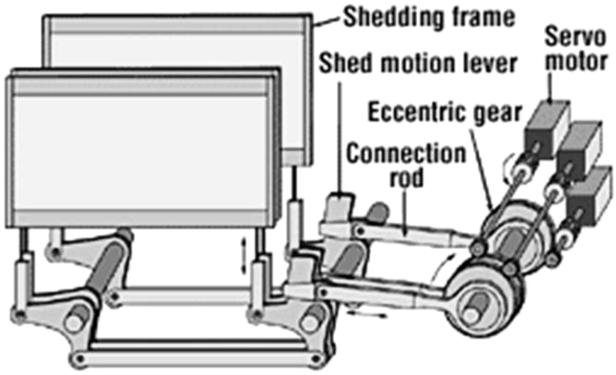
In multi-harness looms, each shedding and different combinations of overs and unders make the woven pattern. (The different weave structures are discussed later in this lecture.)

Table 11.1 compares the three main types of shedding mechanisms available, and the different types of fabric produced by looms using these mechanisms.

Table 11.1 Shedding mechanisms. Source: Wood (2006).

Tappet	Dobby	Jacquard
This shedding device is a system of tappets and cams that cause shafts to be raised and lowered in a pre-set sequence to form the shed.	This is a compact, electronically-controlled shedding device with servo motors to produce the motions of the shafts	This device has no shafts, instead it has a harness with as many cords as there are ends in the warp sheet. These connect each end to the Jacquard mechanism above the loom.
The bulkiness of the arrangement limits the loom to a maximum of eight shafts.	It is capable of having up to 28 shafts.	Each warp yarn can be raised independently of all the others by the computer-controlled Jacquard mechanism.
The simplest but least versatile of the shedding mechanisms.	More complex, more versatile shedding mechanism than tappets	The most complex and versatile of shedding mechanisms.
As a tappet loom usually has no more than eight shafts, this represented the maximum size of its weave repeat.	Since a dobby loom can have up to 28 shafts, a much greater weave repeat is possible, permitting more complicated designs.	With a Jacquard shedding motion the greatest weave repeat is possible as each warp yarn is individually controlled.
Weave structures are restricted to plain weaves, simple twills and simple satin and sateen weaves.	Designs may incorporate two or more basic weaves and/or their variations – referred to as dobby cloths or dobby weaves.	The versatile system for patterns. All forms and shapes in designs and highly intricate patterns can be created. Examples are brocades, damask, tapestry, figured towels etc.

Figure 11.6 shows the Dobby mechanism and a Jacquard-controlled rapier loom



Dobby mechanism

Jacquard rapier loom

Figure 11.6 Dobby mechanism (left) and Jacquard-controlled rapier loom (right)

2. Picking

Picking is inserting the weft yarn once the shed has been formed. A single weft yarn, passed from one side of the loom to the other, is called one pick. The various methods of inserting a weft yarn are discussed in Section 11.4.

3. Beating-up

After each weft insertion, the comb-like reed pushes the weft yarn against the woven edge (or ***fell***) of the fabric. This beating-up motion firms the fabric. The reed determines the set of the warp through the reed gauge and the number of ends per ***dent*** (which is the space between the metal reed wires and depends on the gauge).

4. Let-off and take-up

After each shedding, picking, and beating-up, the cloth advances one pick-space. Mechanical drives unwind, or let-off a little yarn from the warp beam to deliver yarn to the weaving zone at a constant rate. They also wind, or take-up, an equivalent amount of woven fabric on to the cloth beam. Thus, weaving is a continuous process.

11.4 Weft insertion mechanisms

Shuttle insertion

In traditional looms, the shuttle is flung by a lever action (or drawn by hand) across the loom on the ledge part of the reed frame (Figure 11.7). This part is called the ***sley***.

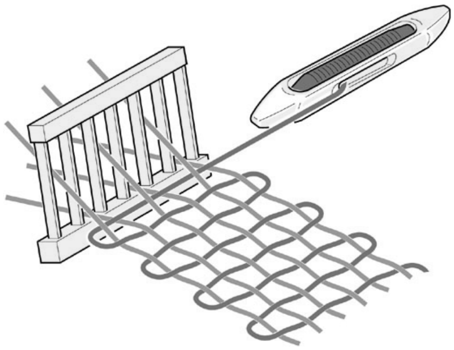


Figure 11.7 Weft insertion by a shuttle. Source: Sulzer Textil.

This method of weft insertion forms a non-fraying selvedge. Yarn is drawn off from a small package carried by the shuttle (the pirn) until it runs out. The loom then stops for pirn replacement. Mechanisms have been developed for automatically changing the pirns. Full pirns are kept in magazines and load into the shuttle automatically at the side of the fabric.

Modern shuttleless methods of weft insertion, such as water jet, air jet, rapier, and projectile looms, have no pirn winding. The weft yarn comes from cones positioned at the side of the loom, goes to a measuring device, passes through the shed, and is cut to the required width. Table 11.2 compares shuttle and shuttleless weaving.

Table 11.2 Comparison of shuttle and shuttleless weaving. Source: Wood, 2006.

Uses the traditional shuttle	Uses one of the different weft insertion systems
The weft yarn is wound onto a pirn, which is mounted in the body of the shuttle	The weft yarn is mounted on a creel to the side of the loom
Requires a pirn winding machine which adds to the cost of weaving	Does not require a pirn winding machine; the weft is taken directly from the cone of yarn by the weft carrier
Slower in production for plain weaves and simple twill weaves	Faster in production for plain weaves and simple twill weaves
Economic in production when used for multicolour weft and/or dobby weaves	Loses most of its economic advantage when weaving multicoloured weft or dobby weaves
Weaves a distinct selvedge	Does not weave a distinct selvedge
Tends to be more noisy	Tends to be less noisy
Overall costs of weaving tend be higher	Overall costs of weaving tend to be lower

Shuttleless weaving

In all shuttleless weaving looms, cones of various colours or kinds of yarn (usually up to eight) are creel mounted on one side of the loom. By computer control, the correct weft thread is chosen and the end transferred to a weft insertion mechanism such as a projectile.

(a) Projectile insertion

Projectile looms were the first machines to displace shuttle weaving and are widely used today for weaving woollen and worsted yarns. Figure 11.8 shows weft insertion by a projectile.

Pick lengths of weft yarn are drawn from large cones by weft accumulators. The free end is held in the jaws of a weft carrier gripper (the projectile, which has a mass of around 40 g) and the accumulated yarn is threaded to a sophisticated tensioning and breaking system. The projectile is lifted to the picking position and is propelled across the warp shed by a torsion bar system. At the other side of the loom, the projectile is received, the yarn released and the projectile is ejected for eventual return to the picking side of the loom. The weft is cut at the picking side and is held at both sides by selvedge grippers during beat-up and shed change. During the next machine cycle, tucking needles draw the outer ends of the weft yarn into the fabric to form selvedges on each side. Usually 10-12 projectiles are associated with a loom.

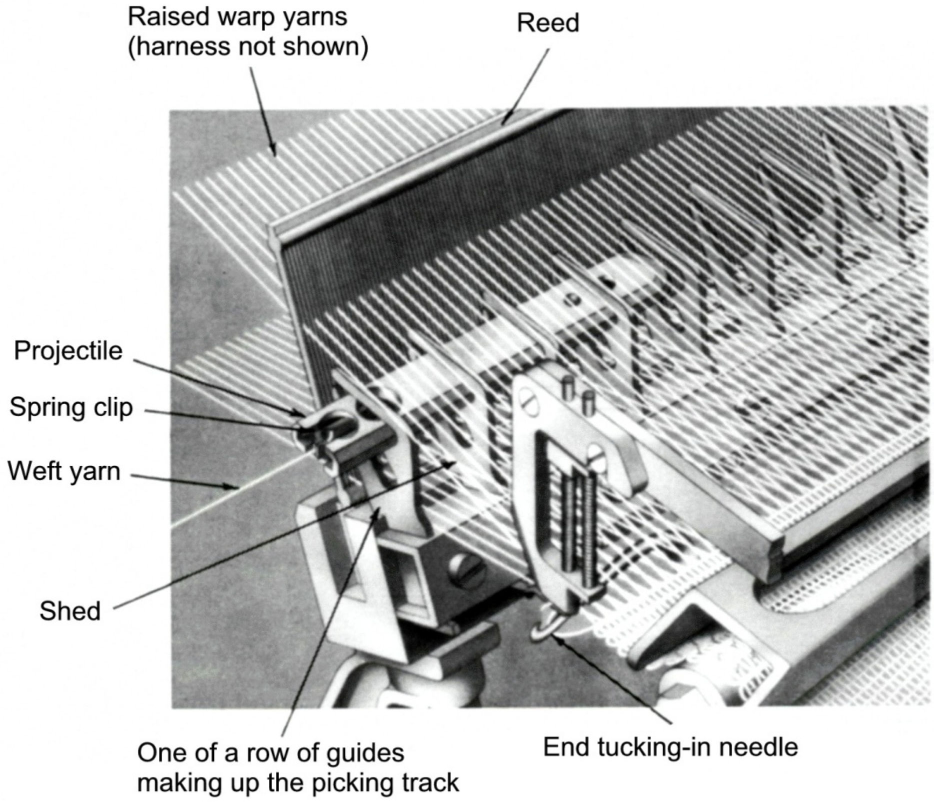


Figure 11.8 Projectile weft insertion.

Photograph supplied by E. Wood courtesy Canesis Network Ltd.

(b) Rapier insertion

Rapier weaving has widespread use in the woollen and worsted industry. It offers the same advantages as projectile weaving in terms of large weft supply packages linked on the creel for continuous operation and supply of weft yarns at minimum tension.

Rapier weaving looms use either one or two sword-like, large metal needles to capture and move the weft thread across the shed. The rapiers can be either rigid or flexible. The rigid rapier loom requires space for the rapier to be withdrawn from the shed. This space is less for a flexible rapier loom where the rapier can be coiled into a smaller area as it is withdrawn.

A single rapier moves empty through the shed to the other side of the loom where its needle picks up the weft yarn and withdraws, pulling the weft through the shed. In a two-rapier system (Figure 11.9) the needle of the left rapier picks up the chosen weft thread, carries it to the middle of the shed, and transfers it to needle of the right rapier This needle then carries the weft thread to the other side of the shed where it is held.

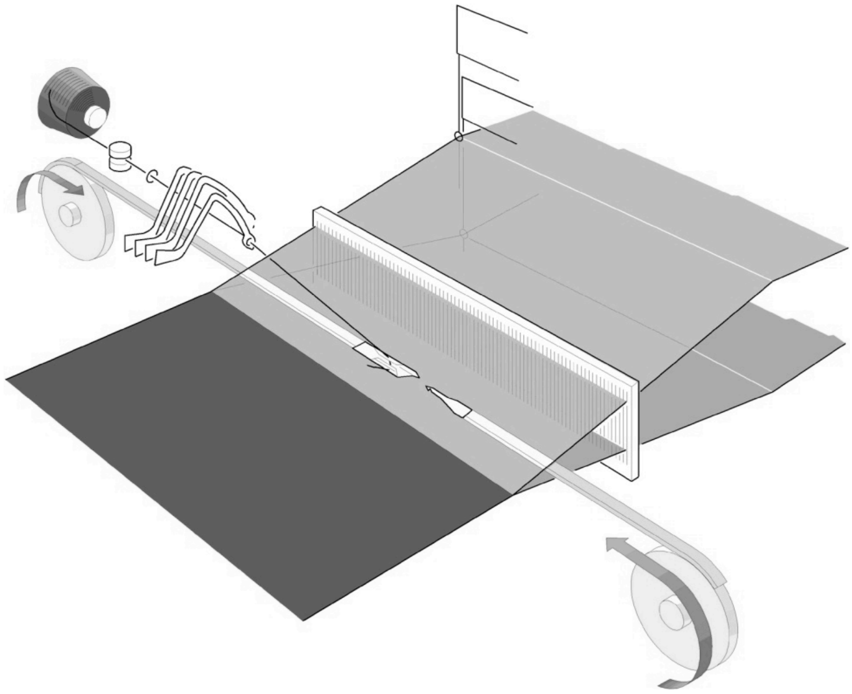


Figure 11.9 Twin flexible rapier mechanism. Source: Sulzer Textil.

(c) Water and air jet insertion

Water jet and *air jet* weft insertion systems are similar. A jet of water, or blast of air, carries the weft across the shed. Water jet looms are not used to weave wool fabrics.

In air jet looms (Vangheluwe, 1999), the blast of air carries the weft thread through guides called confusors. The advantages of the air jet system are that it is very clean and less noisy than other methods of weft insertion. Figure 11.10 shows how the air jet system works.

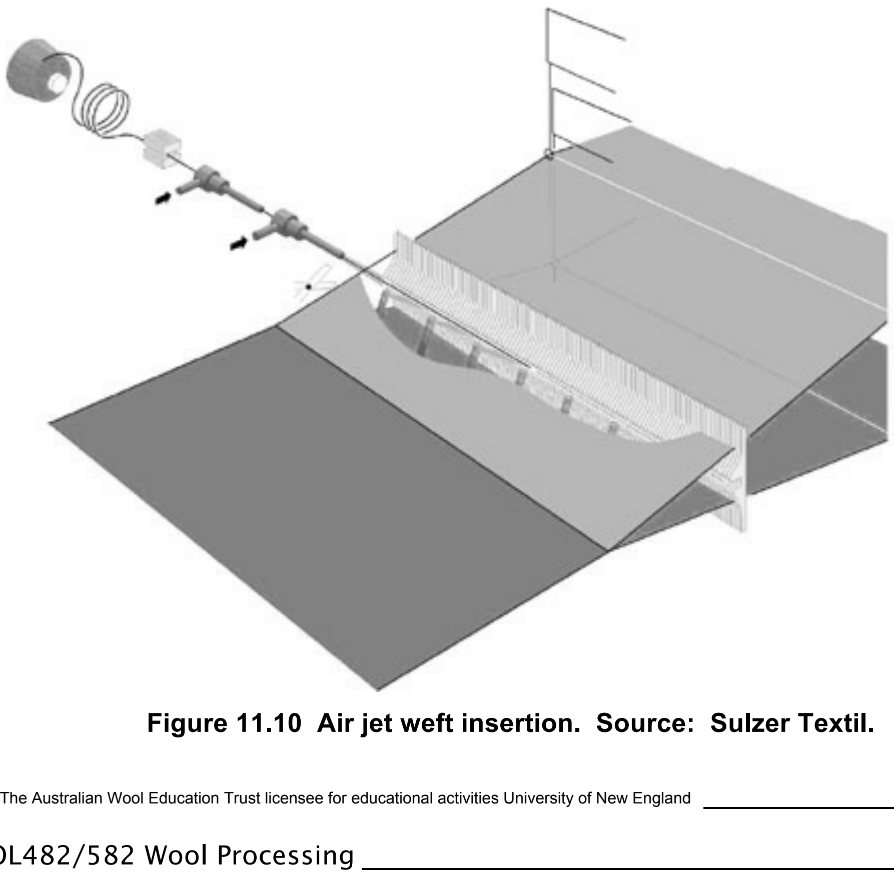


Figure 11.10 Air jet weft insertion. Source: Sulzer Textil.

Selvedge formation

Shuttleless weaving is much faster than shuttle weaving. However, special devices are needed to prevent the selvedges from fraying. Figure 11.7 shows a conventional shuttle selvedge. Because the shuttle returns from side to side without a break in the yarn, a selvedge is formed automatically.

Figure 11.11 shows a **tuck-in selvedge**, where the thread end is tucked in to the next shed. This will be required when the weft is inserted by projectile or rapier.

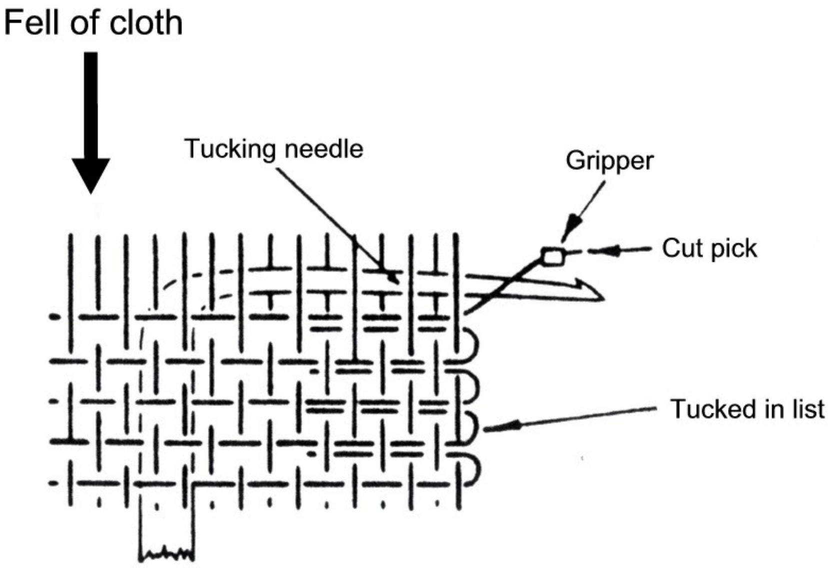


Figure 11.11 Tuck-in selvedge. Source: Wood, 2006.

The end is cut just before the pick is beaten up to the cloth fell, and the tail which is about 1.5 cm long is held tight by a gripper. The shed changes, and the tucking needle takes the end and tucks it into the shed where it is held by the next pick.

11.5 Woven fabric structures

The sequence of raising and lowering warp yarn groups by harnesses, and the insertion of weft yarns after the shedding motion determine the weave pattern and the kind of fabric produced. The three basic weaves commonly used for most fabrics are ***plain, twill,*** and ***satin/sateen***.

A **float**, which is a feature of satin and warp fabrics, is a length of warp or weft yarn which passes over more than one weft or warp yarn respectively before being interlaced again. Such a length of yarn is said to be a float as it lies on the surface of the fabric. The longer the float the greater is the risk of the float becoming snagged and broken during wear. This damage to yarns will detract from the appearance of the fabric.

Plain weave

Plain weave, the simplest weave, is formed by yarns at right angles passing alternately over and under each other (Figure 11.12). Plain weave has the maximum possible number of interlacings.

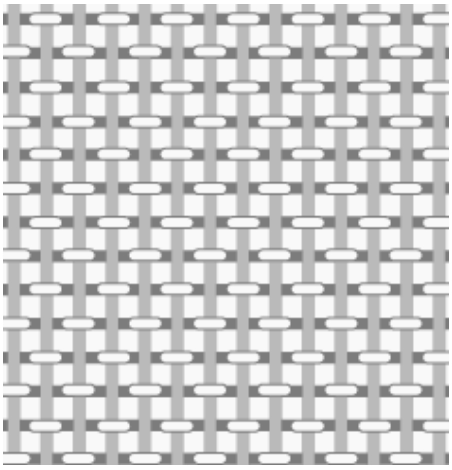


Figure 11.12 Plain weave. Source: Wood, 2006.

The plain weave is recognisable by its simple, chess board-like yarn interlacings. It needs only a two harness loom, and is the least expensive weave to produce. Plain-weave fabrics have no right or wrong side unless they are printed or given a surface finish. Their plain flat surface is a good background for printing and takes printed designs well. Because there are many interlacings per square centimetre, plain weave fabrics tend to wrinkle more, and be less absorbent than other weave structures.

Figure 11.12 is an example of a *balanced* plain weave, where the weft and warp yarns are equally visible and equally-spaced (ie, the setts of the weft and warp yarns are very similar). Balanced plain weave fabrics have a wider range of end uses than fabrics of any other weave; hence they form the largest group of woven fabrics.

An *unbalanced* weave is where there is a much closer sett in one direction than the other. If the warp is close sett and the weft is wider sett, the weft yarn will be almost hidden. On the other hand, if the weft is close sett and the warp is a much wider sett, the warp yarn will be almost hidden.

Variations of the plain weave

Plain fabrics can be made in any weight, from sheer through to heavy.

Suiting weight fabrics are heavy enough to tailor well. The thicker yarns make them more durable and more resistant to creasing than sheer or medium weight fabrics.

Tweed is a suiting which has *knops* of different colours in the weft yarn. *Knops* are regular or irregular bunches of fibres within the yarn.

The *basket weave* structure is a variation on plain weave. It is made by using two or more threads in the warp or the weft, or in both the warp and weft. Using more threads gives more pliability to fabric, less wrinkling, lower durability, and more absorbency than a singly interlaced plain weave. Figure 11.13 shows a standard basket weave with two warp threads and two weft threads interlaced. This is a 2 x 2 basket weave, but 2 x 1, 2 x 3, and 3 x 3 threads can also be used.

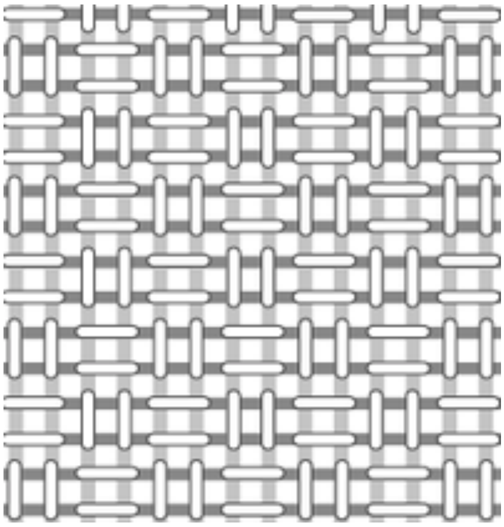


Figure 11.13 Basket weave. Source: Wood, 2006.

Twill weave

Twill weave is recognisable by its diagonal line effect where:

1. Each warp yarn float across two or more weft yarns, **or**
2. Each weft yarn float over two or more warp yarns.

The progression of interlacings moves by one thread up, and by one thread to the left or right, to form a distinct diagonal line or *wale*.

Twill weaves vary according to

1. The number of threads that warp yarns and weft yarns float over. For example, in a 2/2 twill (as shown in Figure 11.14), each warp yarn floats over two wefts and each weft floats over two warps
2. The direction in which the twill progresses, either to the right or to the left
3. Whether the twill is even-sided or uneven-sided. Even twills have equal amounts of warp and weft on both sides of the fabric. Uneven twills are either warp-faced or weft-faced.

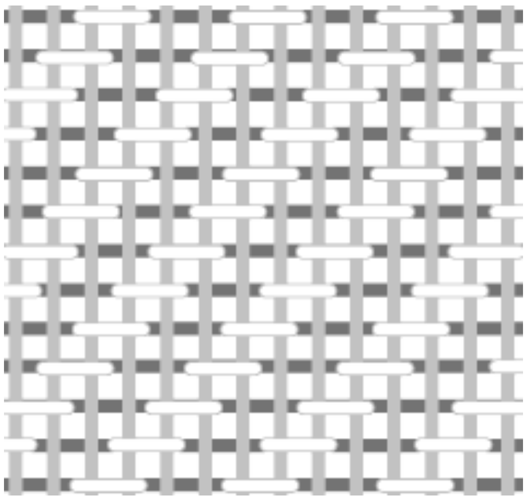


Figure 11.14 A 2/2 twill weave. Source: Wood, 2006.

Even-sided twills: These are sometimes called *reversible* twills, although the twill direction differs from one side of the fabric to the other. Good-quality weft is needed, since both warp and weft are exposed to wear.

Serge is a 2/2 twill.

Twill flannel is sometimes a 2/2 twill with low-twist weft yarns specially for raising.

Worsted flannels retain shape, hold a crease, and are more durable, but have less nap than equivalent woollen flannels.

Uneven-sided twills: Weft-faced twills are seldom used because they are less durable than warp-faced twills. They are used, however, when a good nap is wanted. The lower twist put into weft yarns makes raising easier. Warp-faced twills have more warp yarns on the right side of the cloth. The high twist of warp yarns gives good abrasion resistance.

Gabardine is a warp-faced *steep* twill. The steepness of twill depends on the ratio of the warp sett to weft sett.

Denim is a yarn-dyed, medium weight, warp-faced twill.

Herringbone, shown in Figure 11.15, has the twill direction reversed at regular intervals.

Figure 11.15 Herringbone fabric. Source: Wood, 2006.

Features of twill fabrics: Twill fabrics have a 'right' and a 'wrong' side. If warp floats dominate the right side, weft floats dominate the wrong side. If the twill *wale* is to the right on one side, it is to the left on the other side.

Twill fabrics are seldom printed because of their interesting texture and design. Soiling shows less on twill fabric than on smooth surfaces such as plain woven cloth.

Fewer interlacings allow the yarns to move more freely and give fabric more softness, pliability, and wrinkle recovery than a comparable plain weave fabric. With fewer interlacings, yarns can be packed closer together to produce a higher-sett fabric. For example, *cavalry twill* has a high warp sett, and so is quite a thick or heavy fabric.

Satin and sateen weaves

The satin and sateen weaves may be considered to be opposites of each other. They are characterised by their smooth lustrous surfaces due to warp floats in satin and weft floats in sateen.

In satin weave, each warp yarn floats over four or more weft yarns (up to about 12) and interlaces with the next weft yarn. Interlacing progresses by one thread up, and by at least two threads either to the right or to the left. (Figure 11.16, left).

Alternatively, in a sateen weave, each weft yarn floats over four (or more) warp yarns, and interlaces with the next warp yarn, with interlacings progressing two or more either to the left or to the right (Figure 11.16, right).

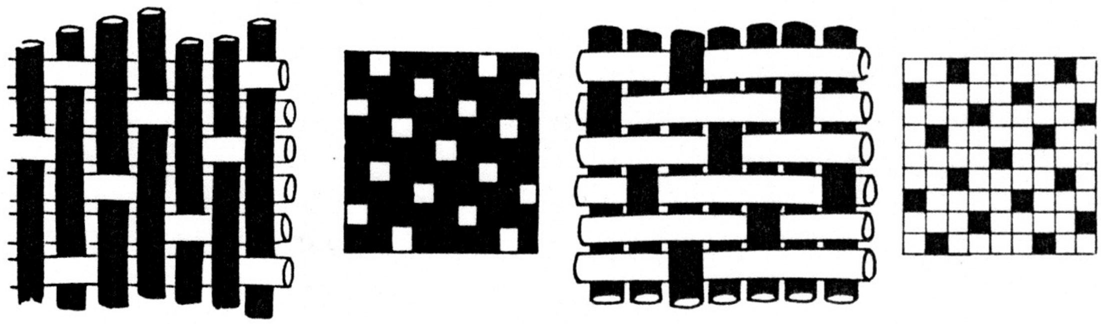


Figure 11.16 Satin (left) and sateen (right) weaves. Source: Wood, 2006.

Satin weave is similar to twill weave, except for the following:

1. No two interlacings are adjacent in satin weaves. So, satin weaves have no prominent line as the interlacings progress, unlike twill. Satin weave interlacings progress two or more to the left or right, not one, as with twill weaves
2. Fewer interlacings are made, and so the yarn can be packed close together to make a very close sett fabric
3. Satins can be uneven-sided, that is, warp- or weft-faced, but not even-sided.

Satin and sateen weaves have high lustre because of the long floats that cover the surface.

Table 11.3 summarises the basic weaves.

Table 11.3 Summary of the basic weaves. Source: Wood, 2006.

Name	Interlacing pattern	General characteristics
Plain 1/1	Each warp interlaces with each weft. No distinctive design unless contrasting colours or count variations used	Most interlacings per square cm May be balanced or unbalanced Wrinkles most Less absorbent Cheapest, easiest weave to produce
Basket 2/1 2/2 4/4	Two or more yarns in either warp or weft or both woven as one in a plain weave Woven basket design	Looks balanced Fewer interlacings than plain weave Flat looking Absorbent Wrinkles less Good drape
Twill 2/1 2/2 3/1	Warp and weft yarns float over two or more yarns from the other direction in a regular progression to the right or left Interesting designs	Diagonal lines Fewer interlacings than plain weave Wrinkles less Strong firm texture More pliable than plain weave Can have higher sett
Satin and sateen 4/1 1/4	Warp and weft yarns float over four or more yarns from the other direction in a progression of two to the right or left Diagonal design is interrupted	Flat surface Most are smooth and lustrous because of long floats Can have a high sett Long floats are prone to snagging Maximum drapability

Readings

The following readings are available on the web learning management system

1. Features and uses of woven fabrics – a glossary compiled by E J Wood, Canesis Network Ltd.
2. Noonan, K., 2002. CAD/CAM's effect of the Jacquard weaving industry and what can be expected in the future: USA - An excerpt from a paper given by Karl Noonan, Technical Director, Sophis Systems NV, at a Textile Institute meeting. Gent, March, 2002.
3. Seyam, A.M., 2003. Weaving Technology - Advances and challenges. Journal of Textile and Apparel, Technology and Management, vol. 3, issue 1, 2003. North Carolina State University, NC, USA.
4. Weaving machines for home textiles – a technology review.

Summary

While the term 'weaving' is mostly used for the process of interlacing warp and weft yarns on a loom to form a woven fabric, it is actually a sequence of integrated processes for converting yarn into a fabric which is suitable for tailoring. The processing steps are as follows:

- Winding and clearing
- Weft winding
- Warping
- Sizing and other applications
- Entering and knotting
- Loom operation
- Finishing
- Inspection and measuring.

The selection of suitable yarns and the preparation of yarn for weaving have a considerable influence on weaving efficiency. Yarn breakage at the loom must be minimised and this is only possible if (1) the yarn is of uniform quality, (2) it is wound onto a suitable package in the best possible way, and (3) the yarn is suitably treated before use. These requirements apply to varying extents to the warp and weft yarns, respectively.

Shuttle looms have been the traditional machines for weaving, and are still widely used around the world today, especially in developing countries. However, over the past three decades, shuttle-less looms have taken the lead position in weaving machinery. Speed and versatility have been the main thrust of the developments. Despite major advances in weaving technologies, the international weaving industry is faced with serious competition from other fabric forming systems such as needle punching and hydro-entanglement nonwoven technologies.

The steps in the weaving cycle and the key mechanisms involved at each stage are described. These steps include shedding, weft insertion, beating up and let off. Various types of mechanism are used for producing the shedding action and for inserting the weft yarn, in particular, air-jet, water-jet, rapier and projectile insertion systems. The weaving of a selvedge to prevent fraying in the fabrics produced by shuttleless looms is also discussed.

The final section describes the main woven fabric structures: plain, twill, satin and sateen, and variations of these structures. From the choice of warp and weft yarns, different degrees of sett and a variety of interlacing patterns, a wide range of fabrics with different appearance, handle and performance properties can be produced.

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Glossary of terms

Air jet	A weft insertion mechanism where a weft thread is carried through the shed by a strong current of air
Balanced weave	A weave structure in which the average float is the same in the weft and warp directions, and in which the warp and weft floats are equally distributed between the two sides of the fabric
Basket weave	A variation of the plain weave structure using two or more threads in the warp or the weft, or in both the warp and weft
Beam	A large cylinder, with flanges at each end, onto which warp yarns are wound for weaving
Beating-up	The third in the series of basic weaving actions where the pick of the weft yarn left in the warp shed is forced up to the fell of the cloth
Creel	A structure for holding packages in textile processing
Dent	The unit of a reed comprising a reed wire and the space between adjacent wires
Dobby	A mechanism for controlling the movement of the heald shaft of a loom. It is required when the number of heald shafts or the number of picks in a repeat of the pattern are beyond the capacity of tappet shedding
Drape	The ability of a fabric to hang in graceful folds, under the influence of gravity
Drawing-in	The process of drawing the threads of a warp into a loom, through the eyes of a heald and the dents of a reed.
End	An individual warp thread
Fell	The line of termination of the fabric in the loom formed by the last weft thread
Float	A length of yarn on the surface of a woven fabric between adjacent intersections
Harness	Healds and heald frames and/or Jacquard cords used for forming a shed
Heald	A metal strip or wire with an eye in the centre through which a warp yarn is threaded, so that its movement can be controlled in weaving. The wires are held in place by the heald frame (or shaft or stave)
Jacquard mechanism	A shedding mechanism, attached to a loom, that gives individual control of up to several hundred warp threads and thus enables complex designs to be produced
Let-off motion	A mechanism controlling the rotation of the beam, either by driving the beam mechanically, or the beam is pulled by the warp against a braking force applied to the beam
Multiphase insertion	Involves several phases of the weaving cycle taking place at any instant so that several picks are inserted simultaneously
Nap	A fibrous surface, produced on a fabric, in which part of the fibre is raised from the basic structure
Pick	A single weft thread in a woven fabric. A single operation of the weft insertion mechanism in weaving (also called a shot)
Picking	The operation of passing the weft through the warp shed during weaving
Pirn	A slightly tapered support on which yarn is wound to form a small

	package for use as weft. The full pirn of yarn is inserted in a shuttle
Plain weave	The simplest of all weave interlacings in which the odd warp threads operate over and under one weft thread throughout the fabric, with the even warp threads reversing this order to under one, over one throughout
Projectile	A method of weft insertion where the thread is gripped by jaws and is carried through the shed at high speed by a small metal block
Reed	A set of closely spaced parallel wires for separating the warp threads, determining the spacing of the warp threads, guiding the shuttle or rapier, and beating-up the weft
Rapier	A method of weft insertion where the thread is carried through the shed in the end of a rigid rod, telescopic rod or flexible ribbon. A single rapier may be used, or a pair of rapiers which enter the shed from each side
Reed (or sley)	A device, consisting of a series of parallel wires closely set between two slats, that may serve any or all of the following purposes: separating the warp threads, determining the spacing of the warp threads, guiding the shuttle or rapier, and beating up the weft
Sateen	A weft-faced weave in which the binding places are arranged to produce a smooth fabric surface
Satin	A warp-faced weave in which the binding places are arranged to produce a smooth fabric surface
Sectional warping	A two-stage method of preparing a warp on a beam
Selvedge	The longitudinal edges of the fabric formed during weaving, with their main purpose being to give strength to the edges of the fabric so that it will behave satisfactorily in weaving and subsequent processes
Sett	A term used to indicate the density of ends or picks or both in woven fabric, usually expressed as the number of threads per centimetre
Shed	The opening formed when warp threads are separated in the weaving operation
Shedding	The operation of forming a shed in weaving
Shuttle	A yarn-package carrier that is passed through the shed to insert weft during weaving. It carries sufficient yarn for many picks
Sizing	The application of a compound to the warp threads (and sometimes the weft threads) before weaving to give them better abrasion resistance
Take-up motion	A mechanism for controlling the winding forward of fabric during weaving
Tappet shedding	The operation of levers by a cam mechanism to control the movement of the heald shafts in the weaving of simple fabrics
Twill	A weave that repeats on three or more ends or picks and produces diagonal lines on the face of the fabric
Unbalanced sett	A fabric in which there is an appreciable difference between the numbers of ends and picks per centimetre
Warp	The threads across the length of a woven fabric
Warping	The winding of weaving yarns onto a beam
Weft	The threads across the width of a woven fabric
Weft insertion	The step in weaving of taking a weft yarn through the shed, using any of several methods – shuttle, projectile, rapier, air jet or water jet