18. Weaving Technologies and Structures

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Learning objectives

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

- Draw a diagram of a basic loom, showing the key parts
- Outline the steps involved in the weaving cycle and the purpose of each step
- Explain 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
- Explain the purpose and method of selvedge formation
- Define and compare the main yarn interlacing structures used for woven fabrics

Key terms and concepts

Warp, weft, 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

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. 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).

Despite these major advances, the international weaving industry is faced with serious competition from other fabric forming systems such as needle punching and hydro-entanglement non-woven technologies.

This lecture first outlines 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 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 fabrics produced by shuttleless looms is also discussed.
The second part of the lecture 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.

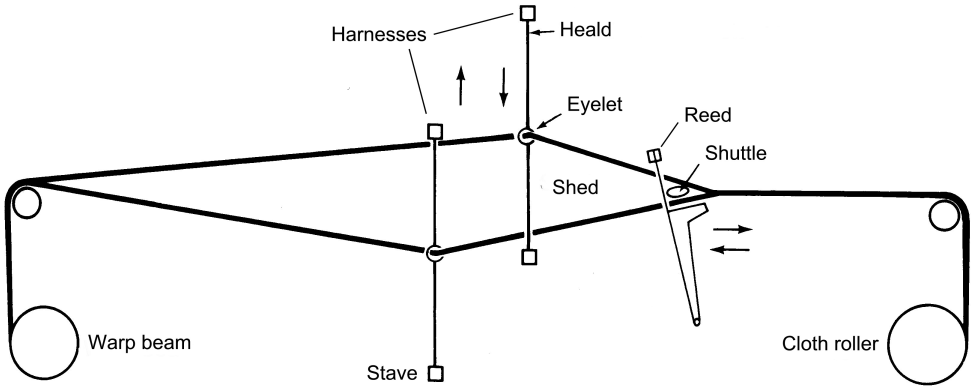
The principle reference for this lecture is *"Weaving Technology and Operations"* by A Ormerod and W. S. Sondhelm (Ormerod and Sondhelm, 1995). Other useful general references on weaving technologies and structures are (Gohl and Vilensky, 1985), (Lord and Mohamed, 1982) and (Hollen and Saddler, 1975).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

18.1 The weaving process

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

Figure 18.1 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.

Figure 18.1 A basic weaving loom. Source: Wood, 2006.



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. Looms can have two or more 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 Jacquard 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.

The two-harness loom in Figure 18.1 will be used to illustrate each step in weaving.

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

Table 18.1 Shedding mechanisms. Source: Wood (2006).

Tappet	Dobby	Jacquard
This device is a system of tappets and cams that cause shafts to be raised to form the shed.	This is a compact, electronically controlled shedding device.	This device has no shafts, instead a harness consisting of as many cords as there are ends in the warp sheet connects 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.
The simplest, least versatile of the shedding mechanisms.	More complex, more versatile shedding mechanism.	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.	All forms and shapes in designs and highly intricate patterns can be created. Examples are brocades, damask, tapestry, figured towels etc.

Figure 18.2 shows how different cams can produce different simple weave structures.

Figure 18.2 The use of cams in a tappet system to produce different weave structures Source: Sulzer Textil.

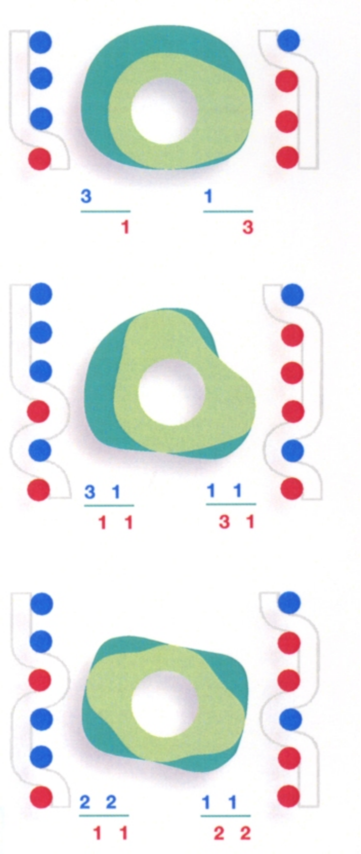
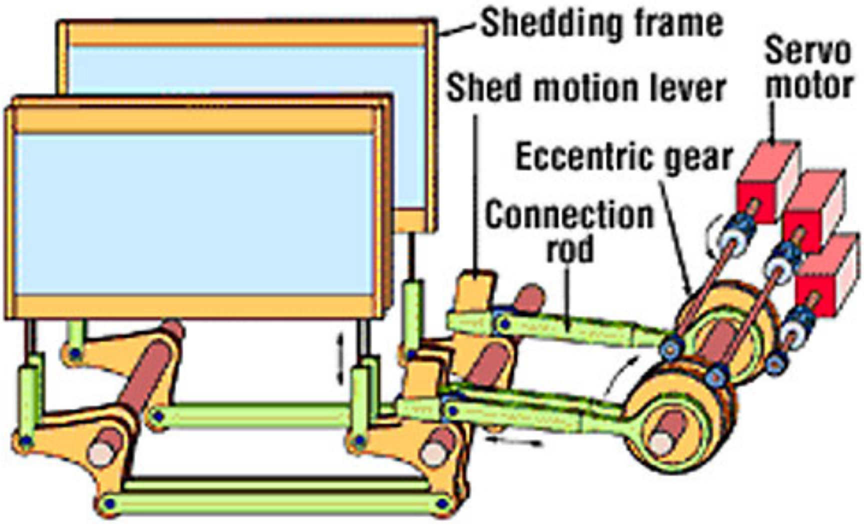


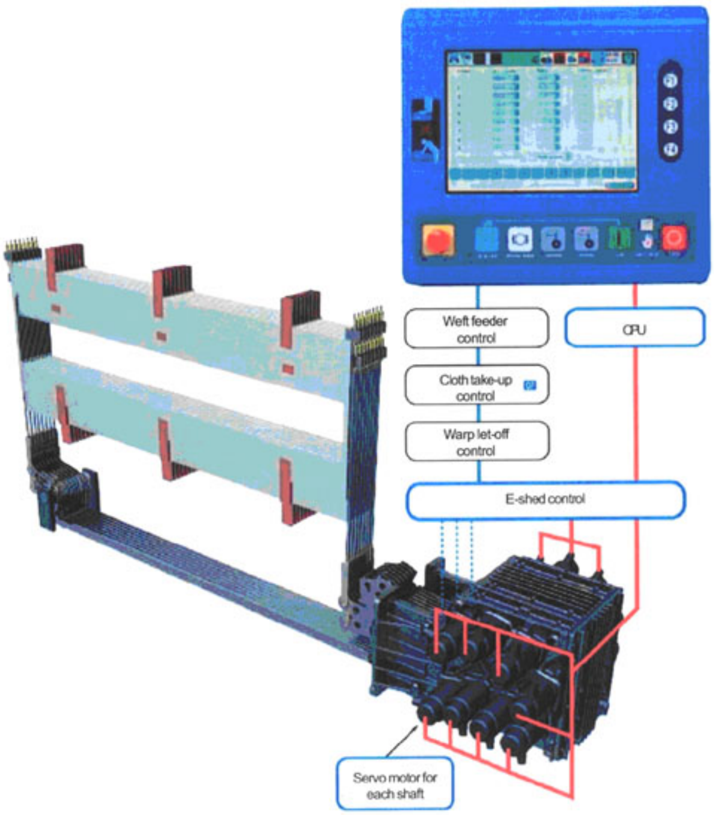
Figure 18.3 shows the mechanism of an electronic mechanism (dobby) for shed formation. Each servo motor, which controls the movement of one harness, is controlled by computer.

Figure 18,3 Electronic shedding by a dobby. Source: Sulzer Textil.



The Sulzer electronic dobby is shown in Figure 18.4.

Figure 18.4 Electronic dobby system. Source: Sulzer Textil.



Jacquard mechanisms provide the most versatile patterning options in weaving.

The lift mechanism for a jacquard system is shown in Figure 18.5. Rotating cams cause this to oscillate back and forth, and the knives (shown as red and blue) raise and lower the cords on the pulley system (Figure 18.6). Magnets control whether a hook is activated. When a hook is released, the harness cord drops to its lower position; when a hook is retained by the magnet the harness is maintained in its upper position.

Figure 18.5 Cam system for raising and lowering the knives in a Jacquard mechanism Source: Staubli.

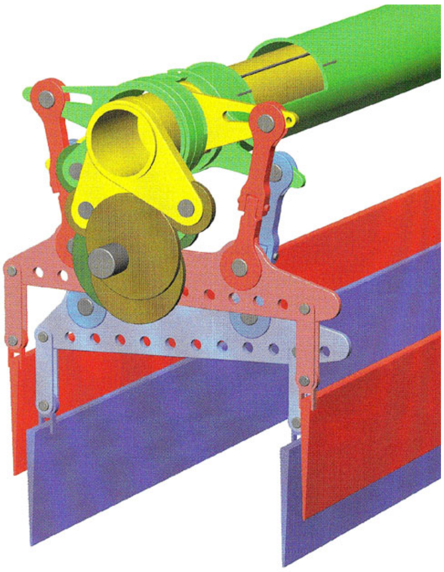


Figure 18.6 Device for raising and lowering the a harness cord on a Jacquard mechanism Source: Staubli.

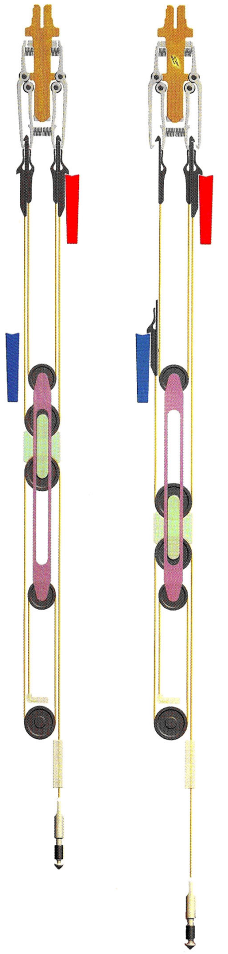
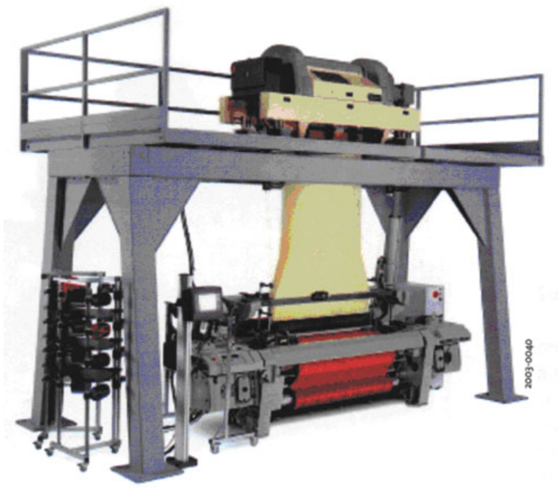


Figure 18.7 shows a weaving loom fitted with an electronic jacquard mechanism. The jacquard unit and the harness above the machine are clearly visible.

Figure 18.7 Projectile loom with Jacquard system fitted. Source: Sulzer Textil.



(Brochures on cam, dobby and Jacquard systems for warp shedding can be downloaded from the Staubli web site.)

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 weft insertion are discussed later.

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).

Let-off and take-up

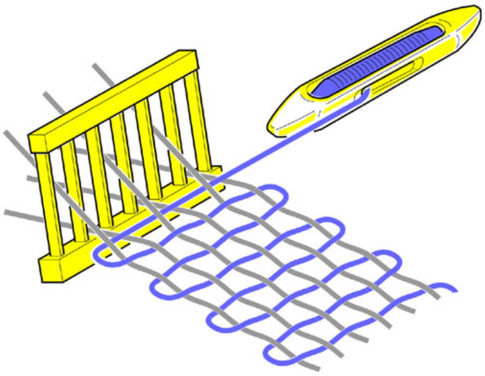
After each shedding, picking, and beating-up, the cloth advances one pick-space. Mechanical drives unwind, or let-off a little yarn from the warp beam to deliver yarn to the weaving zone at a constant rate. They also wind, or take-up, an equivalent amount of woven fabric on to the cloth beam. Thus, weaving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

18.2 Weft insertion mechanisms

Shuttle insertion

In traditional looms, the shuttle is flung by a lever action across the loom on the ledge part of the reed frame (Figure 18.8). This part is called the ***sley***.

Figure 18.8 Weft insertion by a shuttle. Source: Sulzer Textil.



This method of weft insertion forms a non-fraying selvedge. Yarn is drawn off from the pirn until it runs out. The loom then stops for pirn replacement.

Figure 18.9 shows an automatic shuttle and the pirn. Mechanisms have been developed for automatically changing the pirns. They are kept in magazines and load into the shuttle automatically at the side of the fabric. The pirns can be wound separately and loaded into the magazine or wound on the loom. Figure 18.10 shows how the pirn magazine and replacement mechanisms operate.

Figure 18.9 Automatic Shuttle. Source: Wood, 2006.

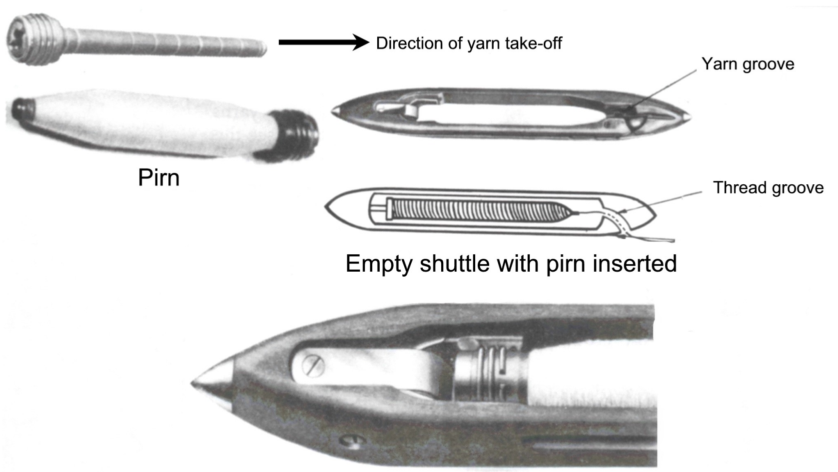
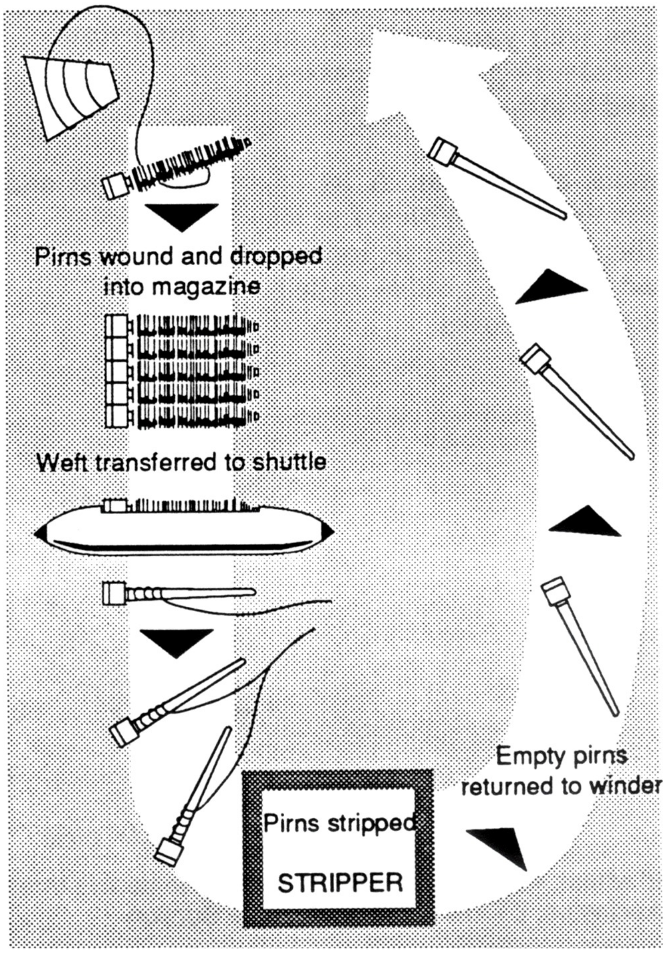


Figure 18.10 Magazine loading of pirns. Source: Wood, 2006.



Modern **shuttleless** methods of weft insertion, such as water jet, air jet, rapier, and projectile, have no pirn winding. The weft yarn comes from cones at the side of the loom, goes to a measuring device, passes through the shed, and is cut to the required width. Table 18.2 compares shuttle and shuttleless weaving.

Table 18.2 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.

Projectile insertion

Projectile weaving looms were the first machines to displace shuttle weaving and are widely used for woollen and worsted yarns.

Figure 18.11 Projectile weaving. Source: Sulzer Textil.

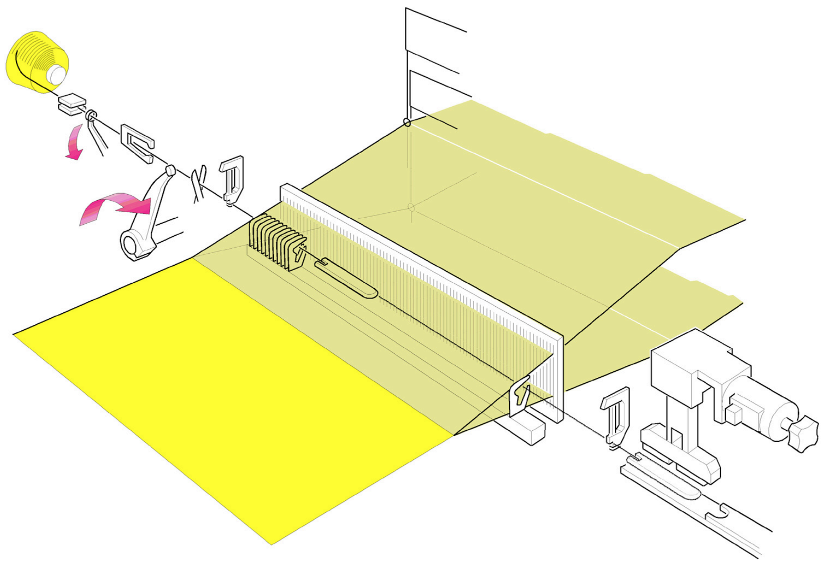
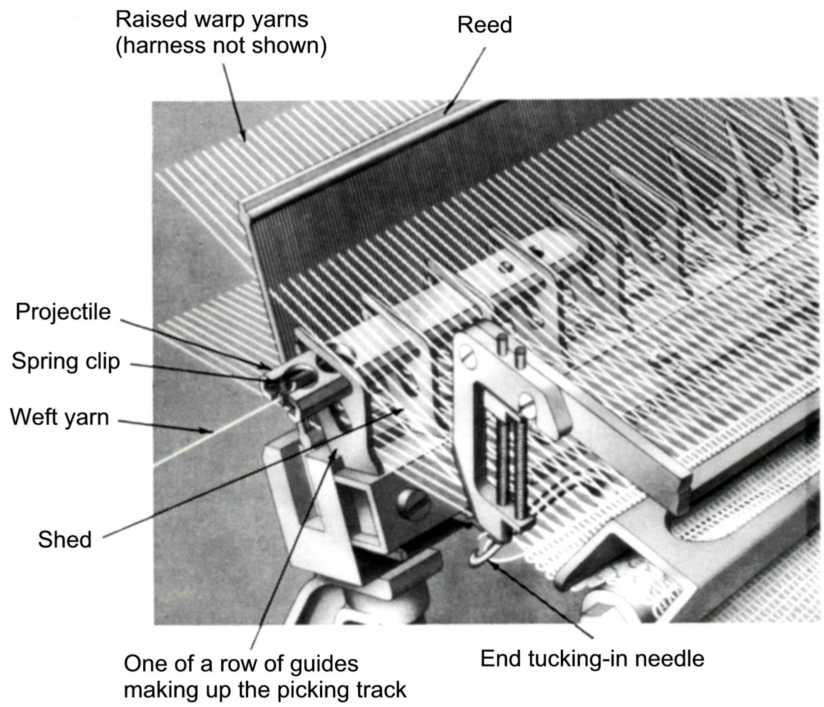


Figure 18.12 shows *projectile* weft insertion in more detail.

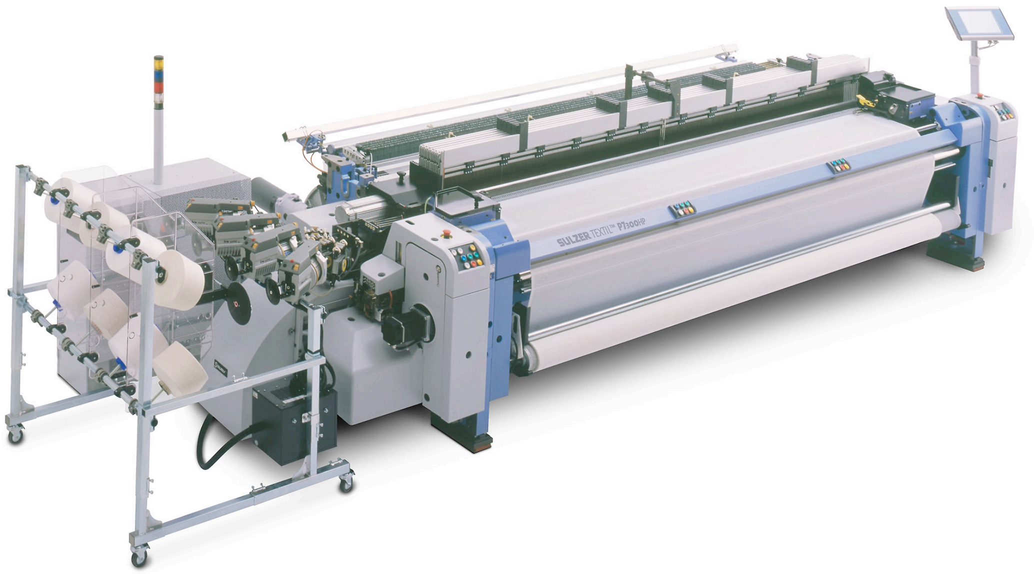
Figure 18.12 Projectile weft insertion.
Photograph supplied by E. Wood courtesy Canesis Network Ltd.



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 18.13 shows a modern Sulzer P7300HP projectile loom, which has a maximum weft insertion rate of 1570 metres/minute. For shed formation it is available with up to 14 heald shafts for tappet motion, or a maximum of 18 heald shafts with an electronically controlled dobby.

Figure 18.13 Modern projectile loom. Source: Sulzer Textil.



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.

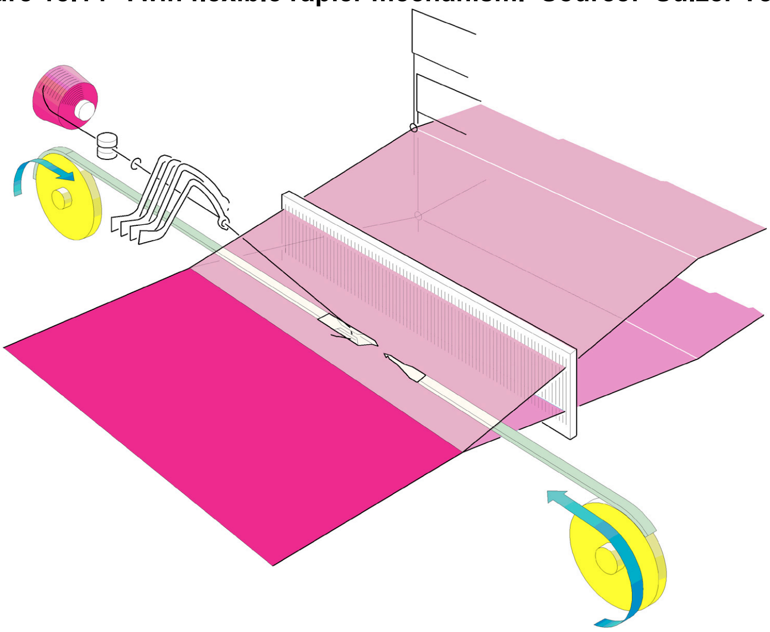
Rapier weaving looms use either one or two sword-like, large metal needles to move the weft across the shed. The rapiers can be either rigid or flexible. The rigid rapier loom requires space for the rapier to be withdrawn from the shed. This space is less for a flexible rapier loom where the rapier can 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 it picks up the weft yarn and withdraws, pulling the weft through the shed.

In a two-needle system using the *Dewas* transfer method, the needle on the left rapier picks up the chosen weft thread, carries it to the middle of the shed, and transfers it to the right needle. The right needle carries the weft thread to the other side of the shed where it is held. Figure 18.14 shows this mechanism.

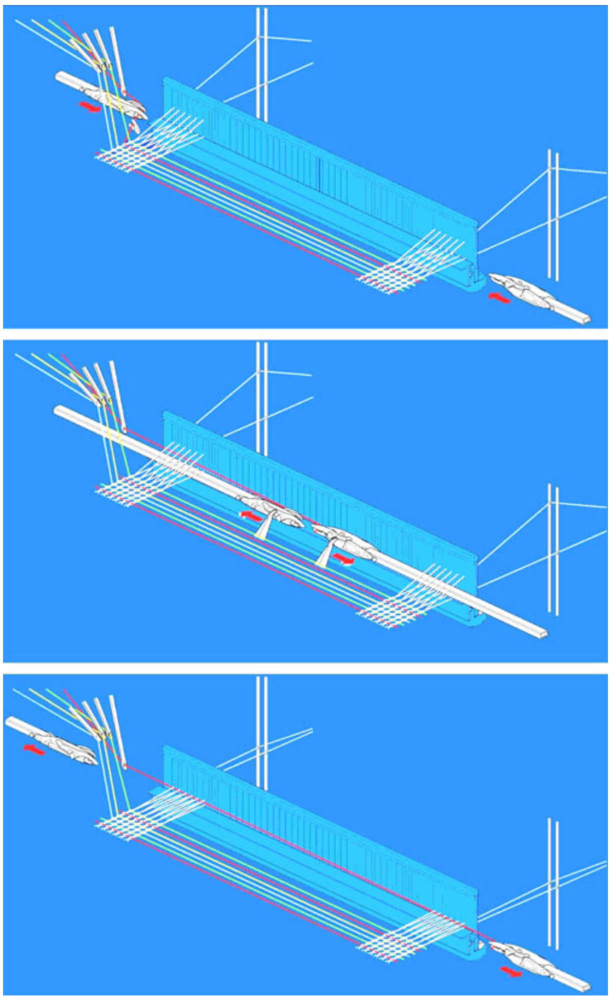
Weft yarn stress is minimised by gentle acceleration of the rapiers during critical stages of the insertion cycle.

Figure 18.14 Twin flexible rapier mechanism. Source: Sulzer Textil.



The sequence of operations is shown in Figure 18.15.

Figure 18.15 Sequence of operations in twin rapier weaving. Source: Dornier.



The Sulzer Textil web site provides informative downloadable brochures on rapier looms.

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.

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 18.16 shows how the air jet system works. Figure 18.17 shows the reed for air jet insertion.

Figure 18.16 Air jet weft insertion. Source: Sulzer Textil.

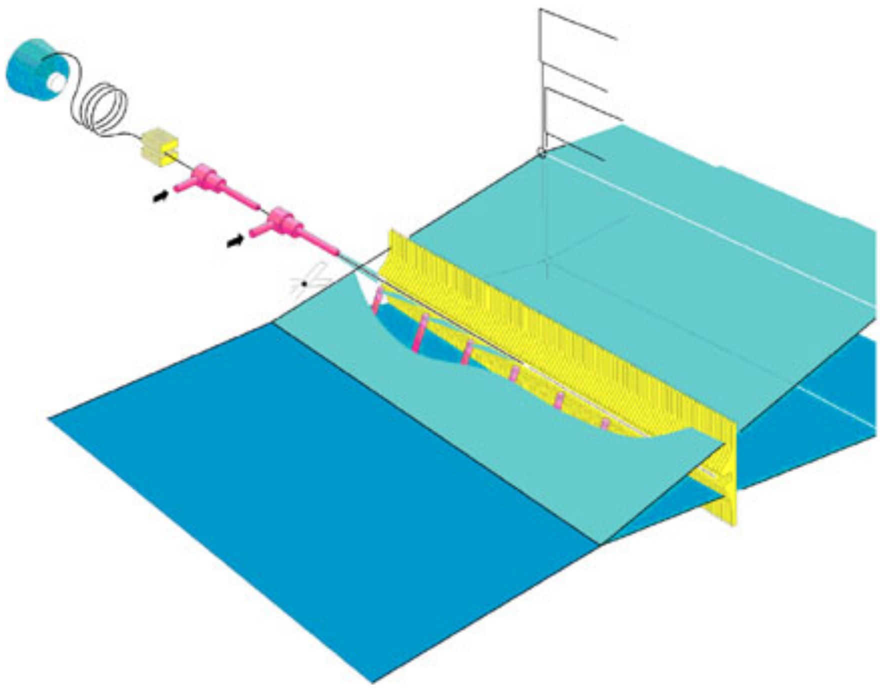


Figure 18.17 Air jet reed. Source: Wood, 2006.

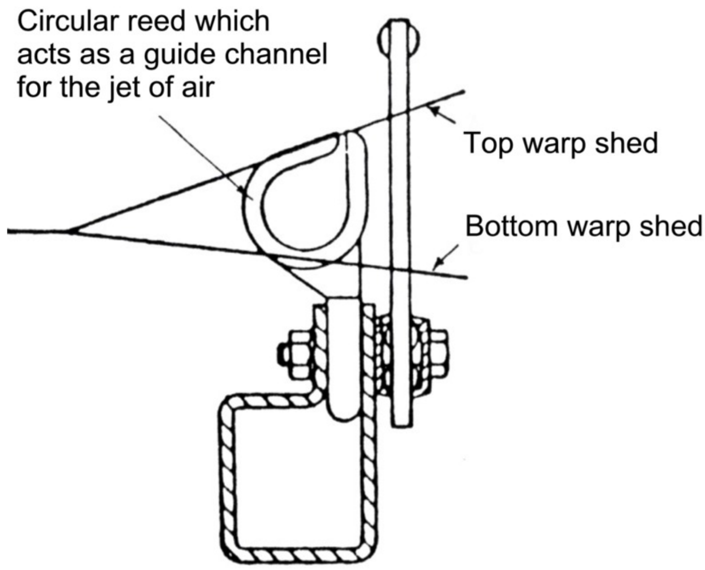
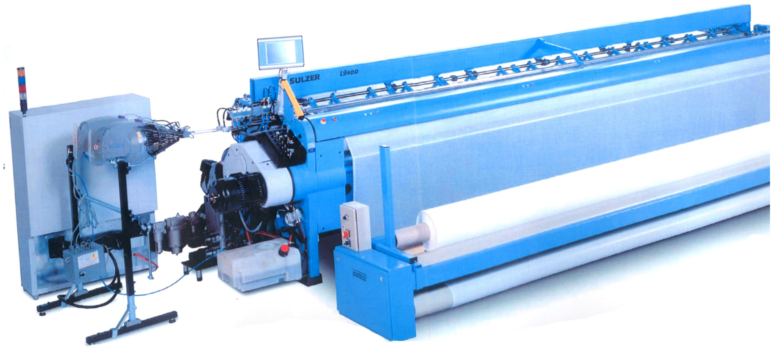


Figure 18.18 shows the Sulzer Textil L9400 air-jet weaving machine, which can produce fabrics up to 5.4 metres wide and with a weft insertion rate of 2700 metres per minute.

Figure 18.18 Modern air-jet weaving loom. Source: Sulzer Textil.

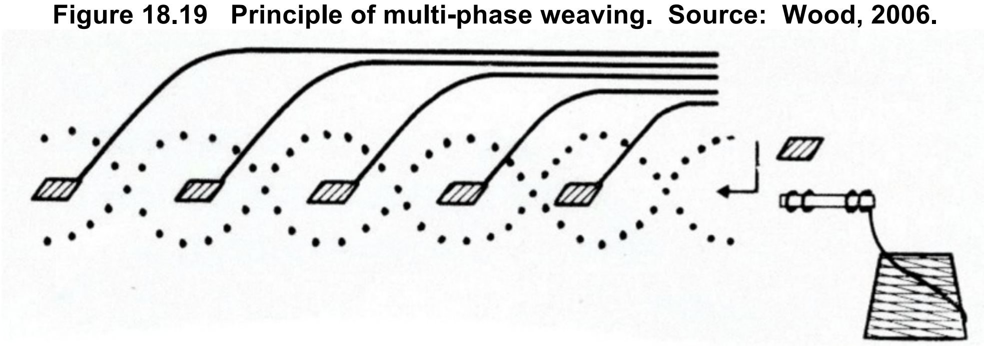


With water jet insertion, the water is recycled back to the pump. Due to the presence of water, only hydrophobic fibre yarns such as polyester and polypropylene lend themselves to this system of weaving. While nylon and acrylic may be used the water they absorb can lead to weaving problems. Monofilament and multifilament yarn structures are preferred over staple yarns.

Rotary or multi-phase insertion

Unlike the previous systems that only insert one pick at a time, a multi-phase system inserts a number of picks continuously. The weaving motions of shedding, picking, beating up, and let off are all taking place at more than one position across the width of the fabric at any time. The principle of multiphase weaving is shown in Figure 18.19.

Figure 18.19 Principle of multi-phase weaving. Source: Wood, 2006.



Multi-phase weaving is a wave-like action. The individual weft carriers are each wound with one pick length of weft and projected into the weaving zone, synchronised with the wave form of the shedding motion. The individual motions of the weaving cycle take place in each weaving position across the loom and follow continuously, similar to sea waves approaching the shore. Thus a number of weft carriers, placed about 10 cm apart, are inserting weft yarns simultaneously.

Figure 18.20 shows the Sulzer M8300 multi-phase loom, which has the following claimed advantages over single-phase air-jet weaving:

- Increased weft insertion rate (5000 metres/minute compared with 2000 metres per minute)
- Constant speed leads to lower weft tension (compared with high accelerations with single-phase air jet system)
- Weaving costs reduced by 30%
- 3-4 fold increase in productivity
- Up to 30% lower energy consumption per square metre of fabric produced
- 60% lower space requirement
- Personnel requirement reduced by up to 25%
- Noise reduced by 50%
- Reduced floor vibrations
- Improved fabric quality due to a more uniform surface.

This 1.9 metre machine has no healds and a non-reciprocating beat-up. It inserts weft by a main jet and back-up jets on four channels. The weft is inserted at 23 metres per second on 3 – 4 channels, so the weft insertion rate is 3.5 x 23 or 80.5 m/s or 4830 metres per minute, with a picking speed of 2452 picks per minute.

Figure 18.20 Multi-phase weaving loom. Source: Sulzer Textil.

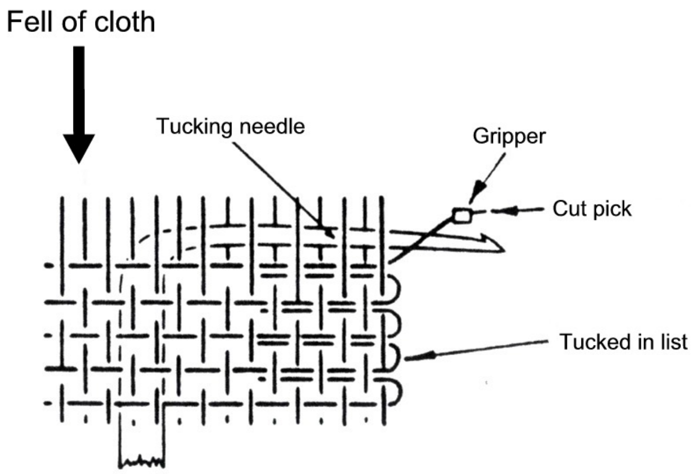
Selvedge formation

Shuttleless weaving is much faster than shuttle weaving. However, special devices are needed to make the selvedges non-fraying.

Selvedges: Refer back to Figure 18.8, which 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 18.21 shows a **tuck-in selvedge**, where the thread end is tucked in to the next shed.

Figure 18.21 Tuck-in selvedge. Source: Wood, 2006.

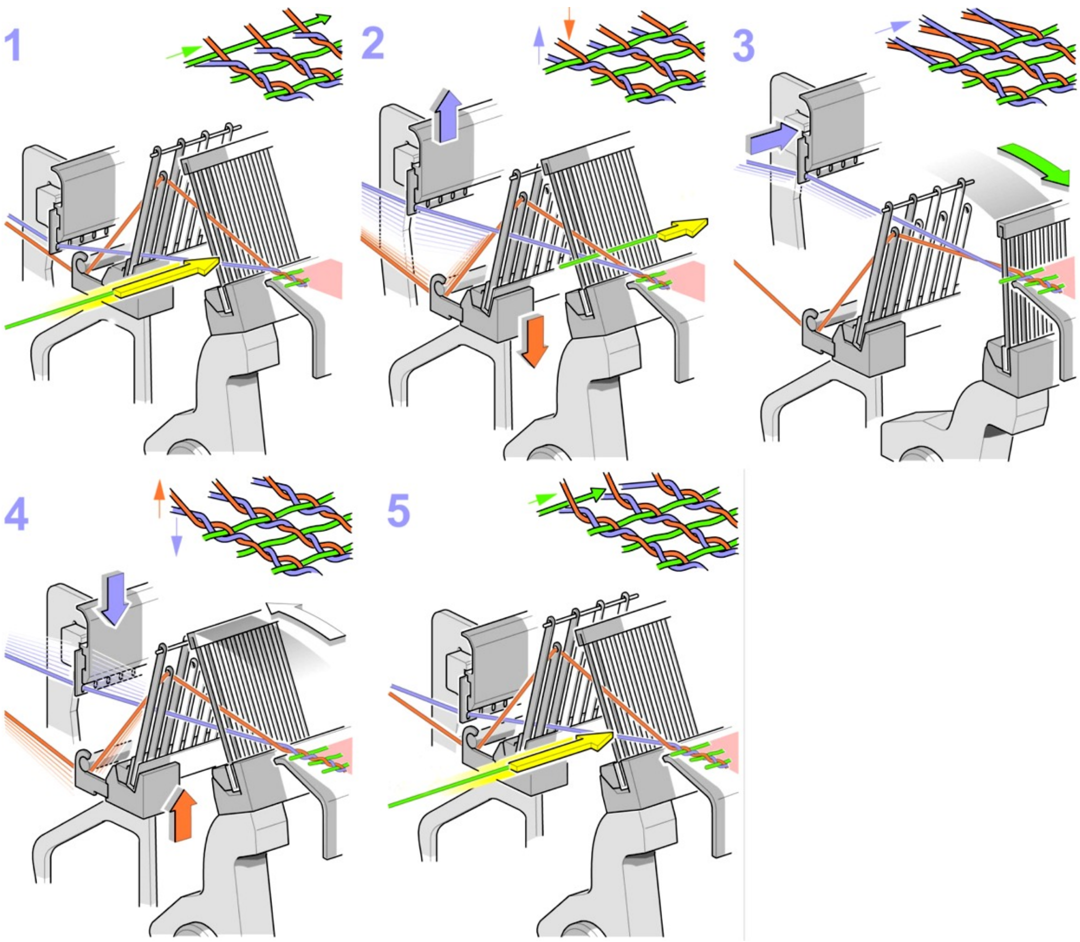


The end is cut just before the pick is beaten up to the cloth fell, and the tail which is about 1.5 cm long is held tight by a gripper. The shed changes, and the tucking needle takes the end and tucks it into the shed where it is held by the next pick.

Figure 18.22 shows a ***leno woven selvedge***. This needs a special attachment at each side of the loom to weave in the fine locking yarn.

To ensure that the selvedges are not too thick for uniform winding of rolls, the locking yarn (green) and the outer warp yarns (blue) are finer than the normal warp yarns (red).

Figure 18.22 Leno selvedge formation. Source: Sulzer Textil.

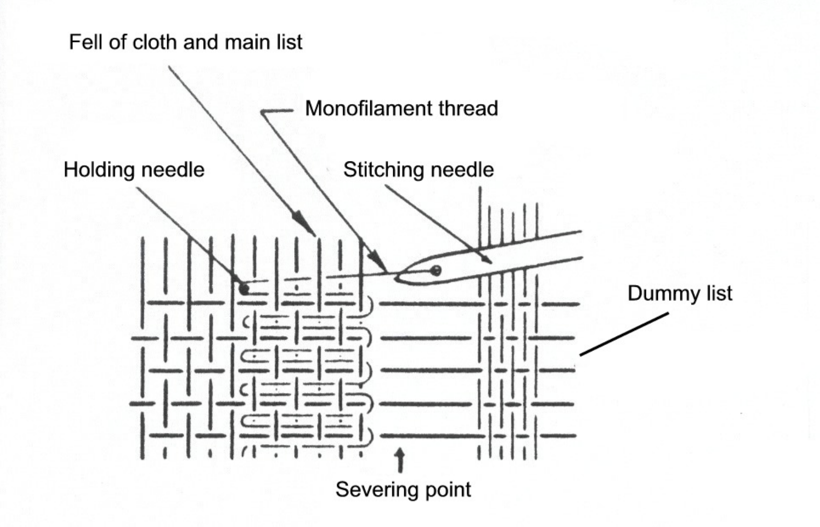


Fabrics made from thermoplastic yarns sometimes have the selvedges ***fused*** or ***thermosealed*** by heating the fabric edges to heat fuse the selvedge.

The characteristics of selvedge formed can affect dyeing and finishing. For example, if the selvedge is much thicker than the body of the cloth, it will not wind uniformly for jig or beam dyeing. In brushing, a weak selvedge may come apart.

A **stitched** or **bound list** is produced by stitching the edge of the cloth with a fine monofilament to secure the edge. Once bound, the picks are cut to produce a neat fringe. To ensure that the picks can be held under tension while they are cut, a dummy list of about 6 ends of plain weave is woven at the edge a short distance away from the main list. The stitching needle oscillates every one or two picks depending on the firmness of picks and a holding needle rises to catch the thread and hold it until the stitching needle withdraws and the next pick is inserted. A cutting device then severs the picks between the main and dummy list to make a neat fringe. The dummy list is discarded as loom waste. Figure 18.23 shows the formation of a stitched or bound list.

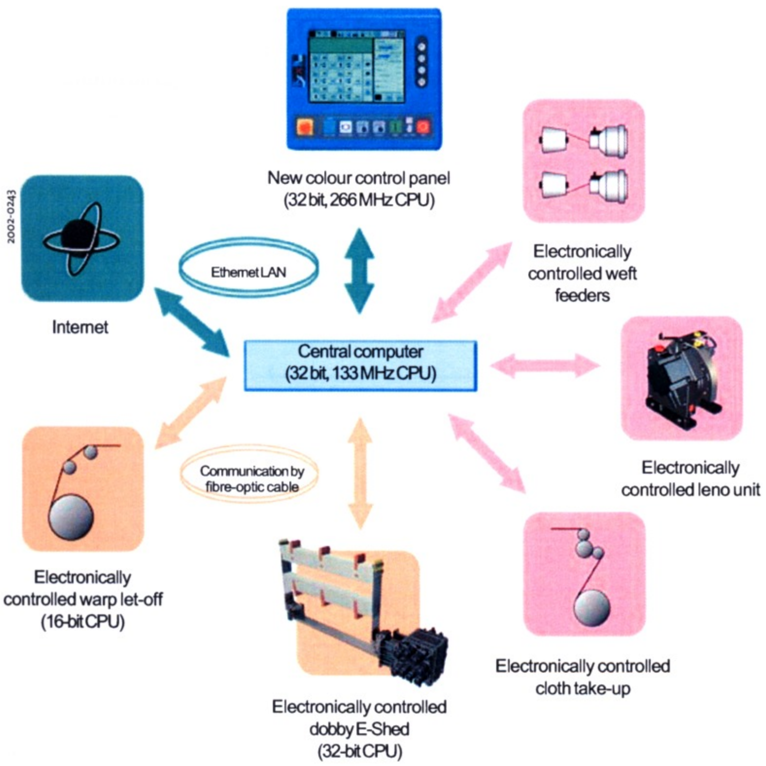
Figure 18.23 Stitched list formation. Source: Wood, 2006.



Weaving control systems

Most modern weaving looms are computer controlled, with highly integrated systems to control all aspects of the operation. For example, in the Sulzer L5400 air jet weaving machine, a microprocessor monitors and controls all key functions.

Figure 18.24 Computer-based control system for air jet weaving. Source: Sulzer Textil.



Malfunctions are rectified by menu-assisted problem analysis, and service via the internet offers on-line support. The machine control system can be integrated with the plant computer network, enabling machine and weave design data to be compiled on a personal computer and transferred to the machine either on-line or using a memory card.

18.6 Woven fabric structure

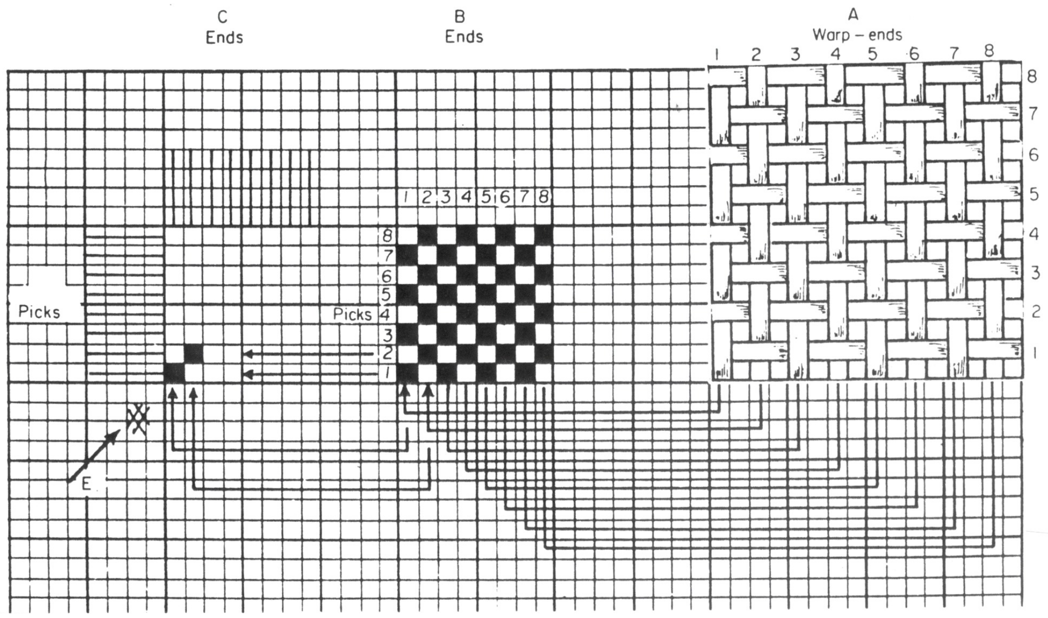
The order of raising and lowering yarn groups by harnesses, and the weft yarns inserted after the shedding motion determine the *weave pattern* and the kind of fabric produced. The three basic weaves commonly used for most fabrics are ***plain, twill,*** and ***satin/sateen***.

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. Plain weave has the maximum possible number of interlacings. Figure 18.25 shows the interlacing on *point paper*.

Figure 18.25 Plain weave on point paper. Source: Wood, 2006.



Woven designs are drawn on point paper, which is similar to graph paper. When analysing any pattern of warp and weft interlacing, the term *float* is used. A warp float is where the warp and weft intersect, and where the warp is over the weft. A weft float is where the warp is under the weft.

In Figure 18.25, **A** shows the pattern of interlacing. **B** shows the floats. Each black square indicates one warp thread *floating* over a weft thread. White squares are where the warp passes under the weft. At **C**, four interlacings make up the pattern of the plain weave. The symbol at **E** indicates the starting point of patterns.

The plain weave is recognisable by its 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 fabric tend to wrinkle more, ravel less and be less absorbent than other weave structures. Figure 18.26 shows an example of a plain weave fabric.

Figure 18.26 Plain weave fabric. Source: Wood, 2006.

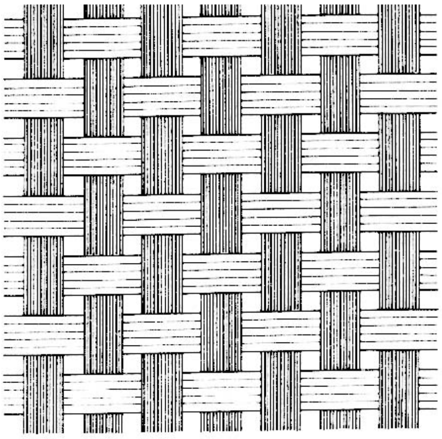


Figure 18.26 is an example of a *balanced* plain weave, where the weft and warp yarns are equally visible as a chess-board appearance. The setts of the weft and warp yarns are very similar. Balanced plain weave fabrics have a wider range of end uses than fabrics of any other weave; hence they form the 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 to heavy.

Sheer fabrics can be made in two ways:

1. In *high sett using fine yarn*, transparency comes from the fine yarns. *Lawn* is an example made from staple yarn
2. In *low sett*, sheerness comes from spaces between the warp and weft yarns. *Cheesecloth* and *crinolines* are examples. These fabrics are neither strong nor durable. Unlike close (or high) sett fabrics, they are not usually suitable for printing.

Medium weight plain weaves are the most useful. *Muslin* is an unbleached, medium weight, plain woven, cotton fabric.

Ginghams are yarn-dyed fabrics with checks and plaids. *Taffeta* is made from filament rayon.

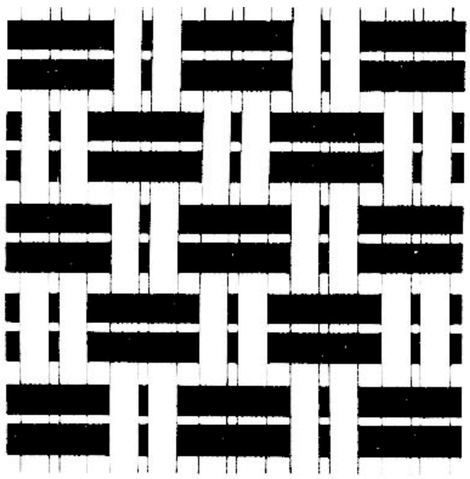
Suiting weight fabrics are heavy enough to tailor well. The thicker yarns make them more durable and more resistant to creasing than sheer or medium weight fabrics.

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 18.27 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 18.27 Basket weave. Source: Wood, 2006.



Twill weave

Twill weave is recognisable by its diagonal line effect. It is made by having:

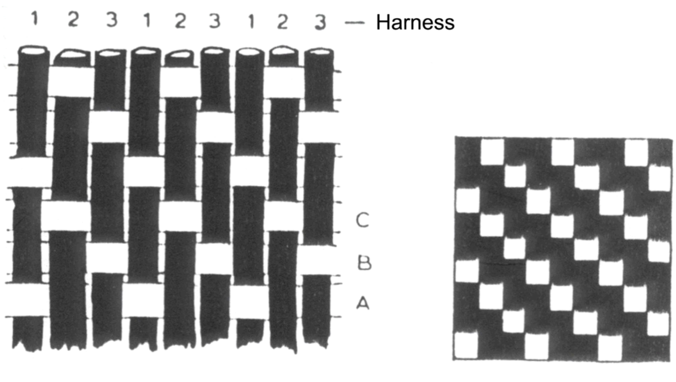
1. Each warp yarn float across two or more weft yarns, **or**
2. Each weft yarn float over two or more warp yarns.

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*.

Figure 18.28 shows a 2/1 twill. This is the simplest twill, because only three warp harnesses are used. The left hand diagram shows which warp yarns are held by harness 1, harness 2, and harness 3. The 2/1 notation indicates that two harnesses are up and one harness is down for each weft insertion.

When weft yarn **A** in Figure 18.28 (left) is inserted, harnesses 2 and 3 are raised while 1 is lowered. When weft yarn **B** is inserted, harnesses 1 and 2 are raised, and 3 is lowered. Yarn **C** has harnesses 3 and 1 raised and 2 lowered. The interlacings progress to the left from 2, to 1 2, 3 1, 2 3 and so on. Shown here is a left-hand twill that is warp-faced.

Figure 18.28 A 2/1 twill weave. Source: Wood, 2006.



Variations of the twill weave

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, 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.

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.

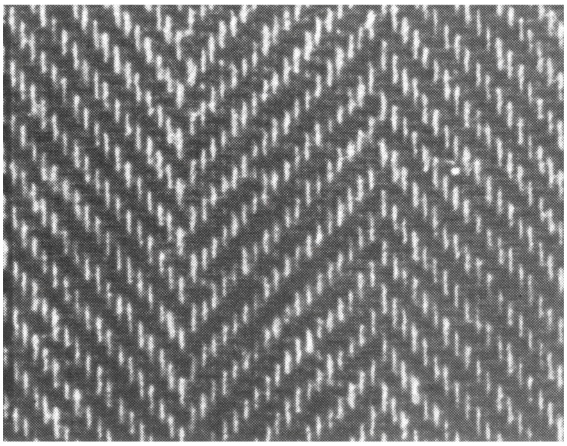
Uneven-sided twills: Weft-faced twills are seldom used because they are less durable than warp-faced twills. They are used, however, when a good nap is wanted. The lower twist put into weft yarns makes raising easier. Warp-faced twills have more warp yarns on the right side of the cloth. The high twist 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 18.29, has the twill direction reversed at regular intervals.

Figure 18.29 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.

To make a twill wale more *prominent* it is possible to have:

1. Longer floats
2. Combed yarns
3. Ply yarns
4. Closer fabric sett
5. Hard twist yarns
6. Z-twist yarn with left-hand twill, and
7. S-twist yarn with right-hand twill.

Traditionally, wool and wool-like fabrics have right-hand twills. Cotton and cotton-like fabrics have left-hand twills. This assists in identifying the right side of a twill fabric.

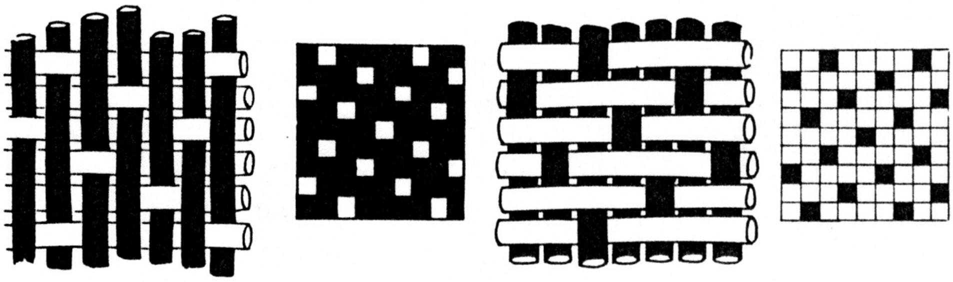
Satin and sateen weaves

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 18.30, 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 18.30, right).

Figure 18.30 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 weaves have high lustre because of the long floats that cover the surface.

Warp-faced satin: This fabric is made with a higher warp sett than weft sett so that the warp covers the fabric surface. (The reverse is true of weft-faced satin. Weft-faced satins are also called sateens.) Because of the high ratio of warp sett to weft sett, or weft sett to warp sett, satin weaves are unbalanced. However, the higher overall fabric sett compensates for this.

High fabric sett gives satin weaves strength, durability, body, firmness, and good wind repellancy. Few interlacings give high pliability and wrinkling resistance, but may allow thread slippage and fraying.

Weft-faced sateens: Satin weaves are made of spun staple yarns or continuous filament yarns. When a spun yarn satin weave is wanted, it is usual to weave a weft-faced sateen. This is because the low twist needed to give lustre to a spun yarn is only practical in the weft. If warp yarns were made with twist low enough to have lustre, the yarns would not resist the tensions of weaving.

Sateen is a smooth, lustrous fabric, often used for drapes and dress fabrics. Added lustre can be achieved by *shreinering*. In shreinering, the fabric passes between heated rollers under pressure. The top roller is engraved with extremely fine lines at a slight angle from the circumference. This embosses the fabric surface. Cotton sateens made from combed weft yarns may be mercerised to increase lustre.

Satin fabrics are usually made of bright continuous filament yarns with low twist. Filament yarns, even of low twist, have enough strength to withstand the tensions of weaving.

Table 18.3 summarises the basic weaves.

Table 18.3 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 lustrous Smooth Can have a high sett Fewer interlacings Long floats – subject to slippage and snagging Maximum drapability

Readings

The following readings are available on CD

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.

Activities — Available on WebCT

Multi-Choice Questions — Submit answers via WebCT

Useful Web Links — Available on WebCT

Assignment Questions — Choose ONE question from ONE of the topics as your assignment. Short answer questions appear on WebCT. Submit your answer via WebCt

Summary

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.

This lecture first outlines 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 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 second part of the lecture 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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http://www.staubli.com as PDF brochure.
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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
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
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 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
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
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
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
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
Water jet	A weft insertion mechanism where a weft thread is carried through the shed by a fine jet of water
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