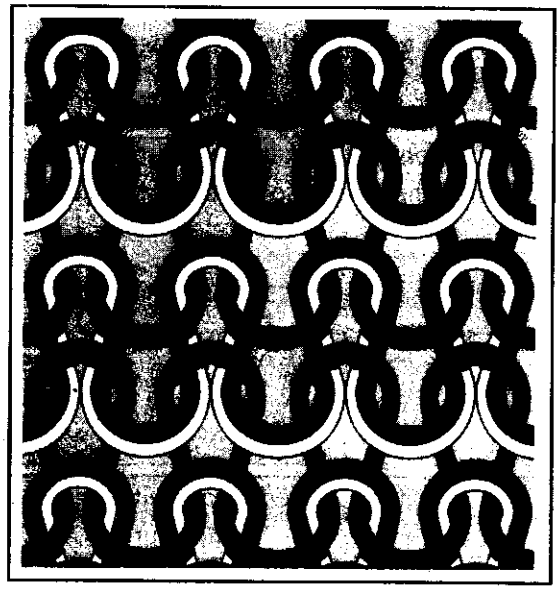
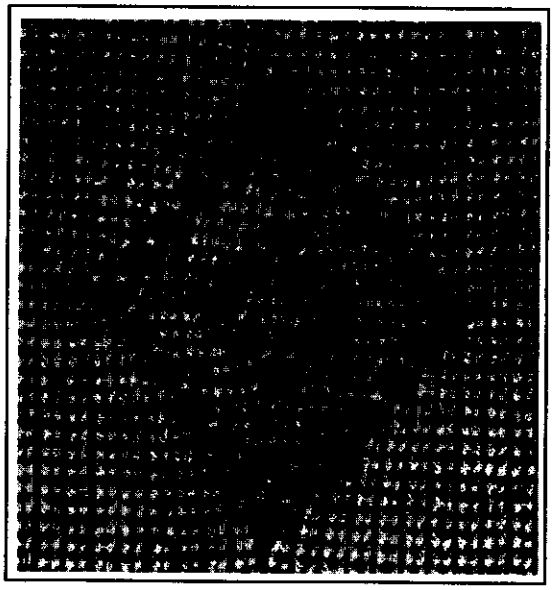
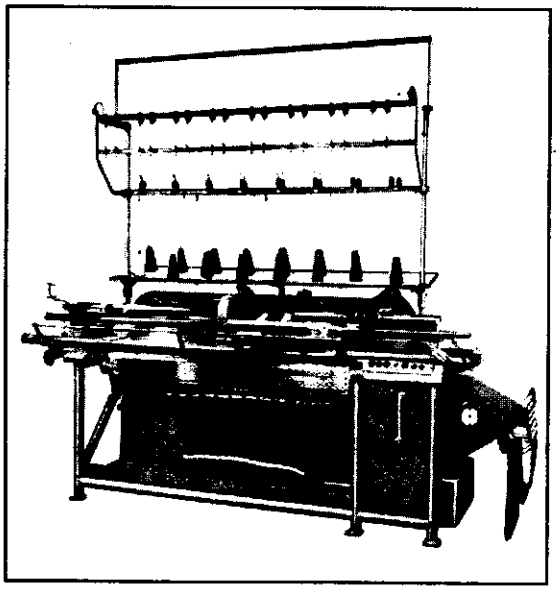
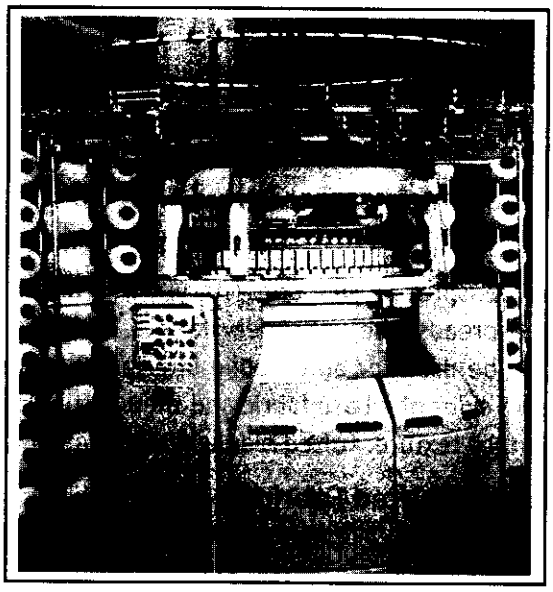




KNITTED FABRIC AND KNITTING TECHNOLOGY



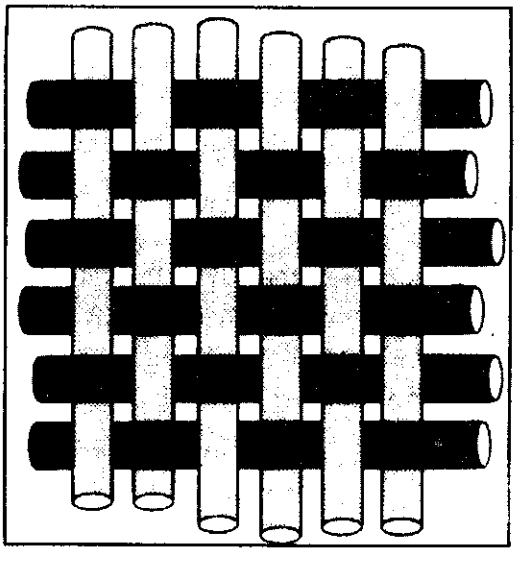


INTRODUCTION

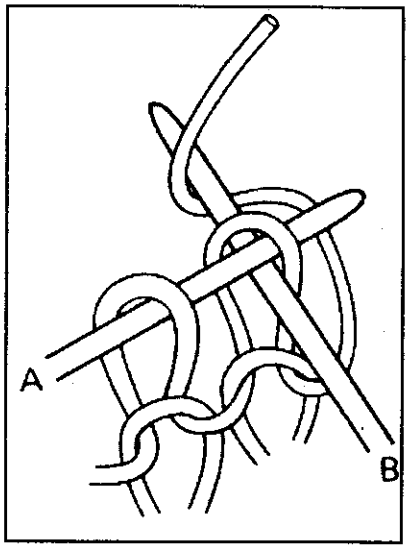
AND

HISTORICAL BACKGROUND OF KNITTING TECHNOLOGY

Knitted fabric differs vastly from woven fabrics. Woven fabric is formed substantially by interlacing of a series of lengthwise and crosswise threads. Knitting, in its simplest form, consists in forming loops through those previously formed. This interloping and the continuous formation of more loops into each other produce the knitted fabric structure. In machine knitting, a multiplicity of needles, needle holders and yarn feeders replace the pins, hand and fingers used in hand knitting.



Woven Fabric

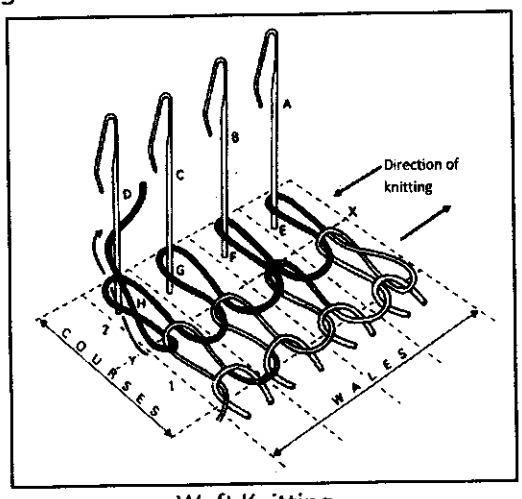


Hand knitting by Two Pins

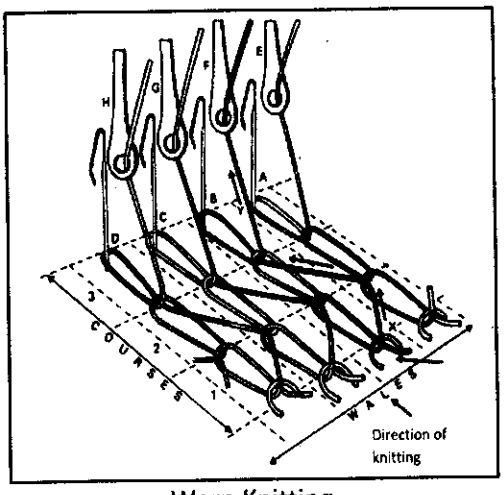
Knitting is the method of creating fabric by transforming continuous strands of yarn into a series of interlocking loops, each row of such loops hanging from the one immediately preceding it. The basic element of a knit fabric structure is the loop intermeshed with the loops adjacent to it on both sides and above and below it.

Knitted fabrics are divided into two main groups, weft and warp knitted fabrics.

The weft knitted structure is very different from the warp knitted one. The difference is apparent from both warp and weft knitted structures are shown in simplest forms in below. It is seen from this figure that in a weft knitted structure a horizontal row of loops can be made using one thread and the thread runs in horizontal direction.



Weft Knitting



Warp Knitting

In a warp knitted structure, each loop in the horizontal direction is made from a different thread and the number of threads used to produce such a fabric is at least equal to the number of loops in a horizontal row. One can say that in a warp knitted fabric the threads run roughly in a vertical direction.

The knitting industry belongs to the branches of the textile industry with long tradition and the knitted goods have been known for centuries. In the early days they were made by hand and the first hand operated knitting machine was not invented until the sixteenth century. This invention is usually attributed to a certain English clergyman (1589) William Lee. Since that time knitting machines have been developed and redesigned so that nowadays they present the most complicated and most automated machinery in the textile industry.

A skilled hand knitter produced 120 to 150 stitches per minute. In comparison, a modern high speed circular knitting machine makes about 20 million stitches per minute.

1589: William Lee, the inventor of the mechanical stitch formation technique.

1758: Jedediah Strutt, the inventor of the double knit (rechts – rechts) technique. This invention refers to an attachment for the hand knitting frame, which became world famous under the name "Derby rib machine".

1798: Monsieur Decroix arranges the needles radially into a corona, which rotates and thus moves the needles one after the other through the knitting stages. The circular knitting frame is born.

1805: Joseph Marie Jacquard presented his control apparatus for shed building on weaving looms in Lyon. It is not clear as to when Jacquard started getting interested in the problems of the knitting industry after his success in the weaving field. But today we do encounter the jacquard device in different variations on knitting machines for the same purposes: individual movement of knitting and transfer needles, sinkers or guide needles for patterning.

1847: Matthew Townsend obtains a patent for his invention of the latch needle. A new epoch in the knitting technique begins. With the help of these needles stitch formation became easier, because the press was no longer necessary. The result was: simplification of the mechanism, increase in production speeds, and reduction of costs.

1850: The circular knitting machine has been developed from the English circular knitting frame. It was initially equipped with stationary bearded needles in vertical position. Later on, it was built with latched needles, which can be individually moved; this is characteristic for a circular knitting machine.

1852: Theodor Groz. Opened his workshop in Ebingen in the Swabian Alb and Ernst Beckert started making needles in Chemnitz. Both of them wanted to assist the manufacturers of knitted stockings by presenting them with needles, which would not get bent or broken. This meant that the needles were no longer made from iron but from steel. Today the concern Groz – Beckert delivers exactly adapted needles for every kind of knitting machine.

1878: D. Griswold gets a patent for a circular knitting machine, which can produce plain or ribbed fabric tubes in any desired distribution. The vertical cylinder needles are enhanced by horizontal dial needles, also individually moveable in radial slots. This leads for the first time to two new denotions: small rib machine and large rib machine.

1910: The firm Robert Walter Scott in Philadelphia was granted a patent for "interlock fabrics". The interlock fabric is a double faced fabric composed of two crossed double knit fabrics.

1918: The first double cylinder, small circular knitting machine with a double hook needle and sliders (needle pushers) was built in England by the firm Wildt.

1920: Besides flat knitting machines, increasing use is made of circular knitting machines for the fabrication of colour patterned fabrics. This is done with the help of yarn changer devices and needle selection via pattern wheels and punched tapes made from steel or paper.

1935: After the production of circular sinker wheel machines was started in 1906, the firm Mayer & Cie. began producing circular knitting machines. Mayer & Cie. introduced mass-line production of these machines in 1939.

1946: After this period noteable further developments were made in circular knitting with regard to higher performance and new products as a result of an increase in feeder numbers, a raise in the production speeds and the use of new needle technologies. The old pinion feed wheel units were replaced by new yarn delivery devices like tape feeders and measuring meters with yarn reserve for smooth fabrics and knit patterns as well as storage feeders for jacquards. These new devices have increasingly taken over the control and monitoring of yarn delivery. Such peripheral equipment is continually gaining significance in order to cope up with the demands placed on high speed circular knitting machines and fabric quality.

1963: The era the electronics begins at the International Textile Machinery Exhibition ITMA 1963 in Hanover. The first electronic needle selection is demonstrated by the firm Morat on its

film-taper-controlled "Moratronik", which later on gets into serial production. Today a computer is used for data storage and a diskette is the data carrier.

1967: The legendary OVJA 36, which is probably world-wide the most successful circular knitting machine so far, is exhibited at the ITMA in Basle. More than 7000 machines of this type were built in the following years.

1987: The firm Mayer & Cie begins with the serial production of the RELANIT, a plain (rechts-links) circular knitting machine having a relative movement between needles and sinkers. It will be producing more than 1000 machines till the ITMA 1991.

Modern circular knitting technology will be determined by increases in performance, reductions in setting-up times and flexible utilization. The technical designer will have to deal with this challenge now and in the future..

Knitting is the most common method of interloping and is second only to weaving as a method of manufacturing textile structures. It is estimated that over seven million tons of knitted goods are produced annually throughout the world. Although the unique capability of knitting to manufacture shaped and form-fitting articles has been utilized for centuries, modern technology has enabled knitted constructions in shaped and unshaped fabric form to expand into a wide range of apparel, domestic and industrial end-uses.

Knitted fabrics of a wide variety of types are presently enjoying unprecedented consumer demand. In many end-uses, where formerly woven fabrics held undisputed away, knitted cloth has taken a commanding lead, while in those end-uses where the knitted fabric traditionally has been supreme, production advanced by leaps and bounds.

To most people, knitted fabric is somewhat of an unknown quantity. Few people can distinguish it readily from woven fabrics; fewer still have any conception how it is produced.

GENERAL TERMS RELATED TO KNITTING TECHNOLOGY

Kink of yarn:

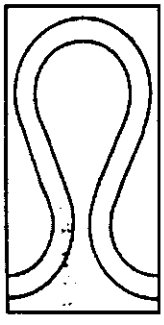
A length of yarn that has been bent into a shape appropriate for its transformation into a weft knitted loop.

Knitted loop:

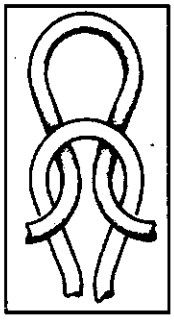
A kink of yarn that is intermeshed at its base i.e. when intermeshed two kink of yarn is called loop.

Knitted stitch:

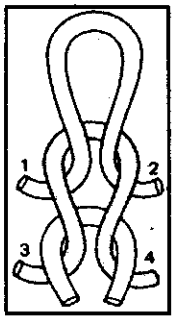
Stitch is a kink of yarn that is intermeshed at its base and at its top. The knitted stitch is the basic unit of intermeshing and usually consists of three or more intermeshed loops, the centre loop having been drawn through the head of the lower loop which had in turn been intermeshed through its head by the loop which appears above it.



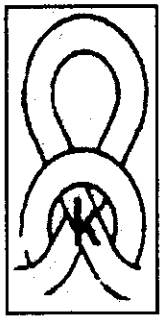
Kink of yarn



Knitted loop



Knitted Stitch



Closed loop

Open loop

Top arc:

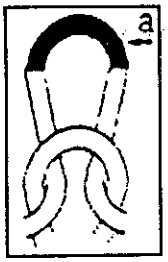
The upper curved portion of the knitted loop is called top arc.

Bottom half-arc:

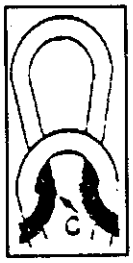
The lower curved portion that constitutes in a weft knitted loop, half of the connection to the adjacent loop in the same course.

Legs or side limbs:

The lateral parts of the knitted loop that connect the top arc to the bottom half-arcs.

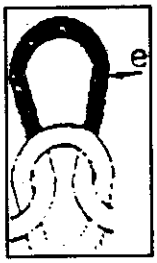


Top arc



Bottom half arc

Legs



Needle loop


Sinker loop

Needle loop:

The needle loop is the simplest unit of knitted structure. Needle loop formed by the top arc and the two legs of the weft knitted loop

Needle loop = Top arc + Two legs

Sinker loop:

The yarn portion that connects two adjacent needle loops belonging in the same knitted course. Bottom arc also called sinker loop.

Open loop:

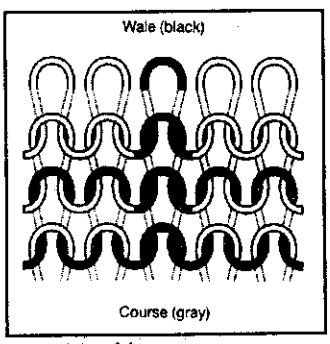
A knitted loop of which a thread enters and leaves at the opposite sides without crossing over itself.

Closed loop:

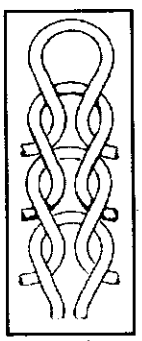
A knitted loop of which a thread enters and leaves at the opposite sides with crossing over itself. It is made by special needle.

Knitted loop structure:

The properties of a knitted structure are largely determined by the interdependence of each stitch with its neighbours on either side and above and below it. Knitted loops are arranged in rows and columns roughly equivalent to the weft and warp of woven structures termed "courses" and "wales" respectively.

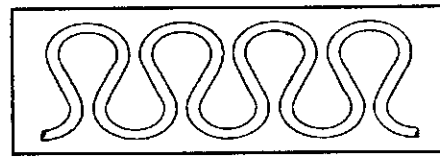


Knitted loop structure


Wale

Course:

A course is a predominantly horizontal row of loops (in an upright fabric) produced by adjacent needles during the same knitting cycle.



In weft knitted fabrics a course is composed of yarn from a single supply termed a course length. A pattern row is a horizontal row of cleared loops produced by one bed of adjacent needles. In a plain weft knitted fabric this is identical to a course but in more complex fabrics a pattern row may be composed of two or more course lengths.

In warp knitting each loop in a course is normally composed of a separate yarn.

Wale:

A wale is a predominantly vertical column of needle loops produced by the same needle knitting at successive knitting cycles and thus intermeshing each new loop through the previous loop. In warp knitting a wale can be produced from the same yarn if a warp guide laps around the same needle at successive knitting cycles thus are making a pillar or chain stitch lapping movement. Wales are joined to each other by the sinker loops or underlaps.

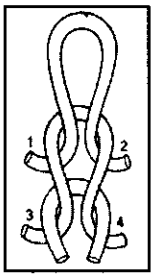
Stitch density:

The term stitch density is frequently used in knitting instead of a linear measurement of courses or wales, it is the total number of needle loops in a square area measurement such as a square inch or square centimeter. It is obtained by multiplying, for example, the number of courses and wales, per inch together. Stitch density tends to be a more accurate measurement because tension acting in one direction in the fabric may, for example, produce a low reading for the courses and a high reading for the wales, which when multiplied together cancels the effect out. Usually pattern rows and courses are, for convenience, considered to be synonymous when counting courses per unit of linear measurement.

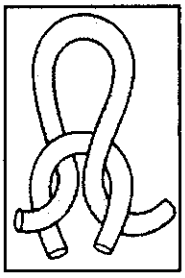
Stitch density = Wales per inch (wpi) × Courses per inch (cpi).

Intermeshing points or cross over point of a needle loop:

All needle loops or overlaps have four possible intermeshing or cross-over points, two at the head, where the next new loop will be drawn through by that needle and another two at the base where the loop has intermeshed with the head of the previously formed loop. Any one of the four points at which stitches are intermeshed. The intermeshings at the head are always identical with each other as are intermeshings at the base with each other.



Four intermeshing points



An impossible intermeshing

It is impossible to draw a new loop through the old loop so that its two feet are alternately intermeshed. A new loop can thus only be intermeshed through the head of the old loop in a manner which will show a face loop stitch on one side and a reverse loop stitch on the other side, because the needle hook is unidirectional and can only draw a new loop down through an old loop. Bottom cross-over point is situated at the base and top cross-over point is situated at the head.

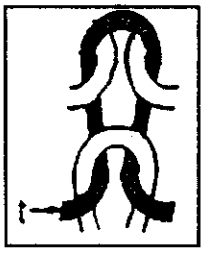
Loop or Stitch length:

The length of yarn knitted into one stitch in a weft knitted fabric. Stitch length is theoretically a single length of yarn which includes one needle loop and half the length of yarn (half a sinker loop) between that needle loop and the adjacent needle loops on either side of it. Generally, the larger the stitch length the more elastic and lighter the fabric, and the poorer its cover opacity and bursting strength.

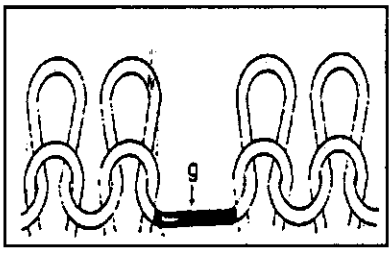
Stitch Length, l = one needle loop + two half a sinker loop.

Extended sinker loop:

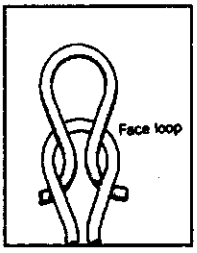
A sinker loop that is wider than the other sinker loops in the fabric and that is produced when a needle is inactive or has been removed from the needle bed or needle bar.



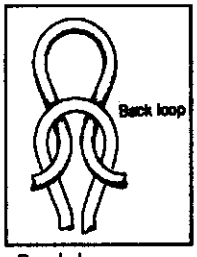
Stitch length



Extended sinker loop



Face loop



Back loop

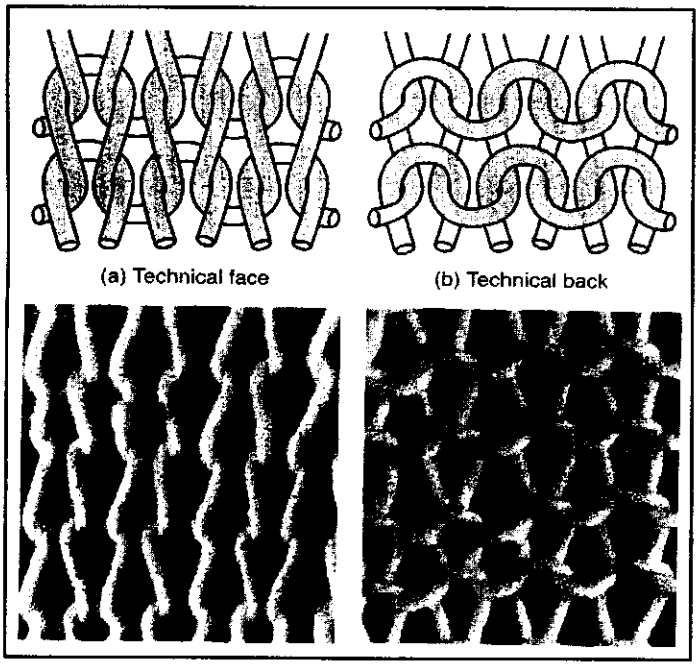
Face loop or stitch:

Also called plain stitch or jersey stitch or flat stitch. A stitch that is so intermeshed in the fabric that its legs are situated above the top arc of the stitch formed in the same wale in the previous course. This side of the stitch shows the new loop coming through towards the viewer as it passes over and covers the head of the old loop. Face loop stitches tend to show the side limbs

or legs of the needle loops or over laps as a series of inter fitting "V_s". The notation of the face loop is ⟒ and by graph paper is × .

Technical face or right side:

The under surface of the fabric on the needles will thus only show the face stitches in the form of the side limbs or legs of the loops or over laps as a series of interfitting "V_s".



Reverse or back loop or stitch:

Also called purl stitch. A stitch that is so intermeshed in the fabric that the top arc and the bottom arcs are situated above the legs of the stitch formed in the same wale in the previous and in the following course. This is the opposite side of the stitch to the face loop side and shows the new loop meshing away from the viewer as it passes under the head of the old loop. Reverse stitches show the sinker loops in weft knitting and the under laps in warp knitting most prominently on the surface. The reverse loop side is the nearest to the head of the needle because the needle draws the new loops downwards through the old loops. The notation of back loop is ⟓ and by graph paper is O.

Technical back or left side:

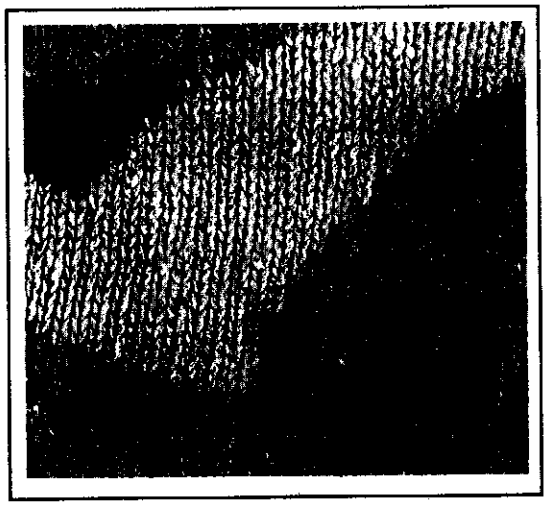
The upper surface of the fabric on the needles will only show reverse stitches in the form of sinker loops or under laps and the heads of the loops.

Double thread stitch:

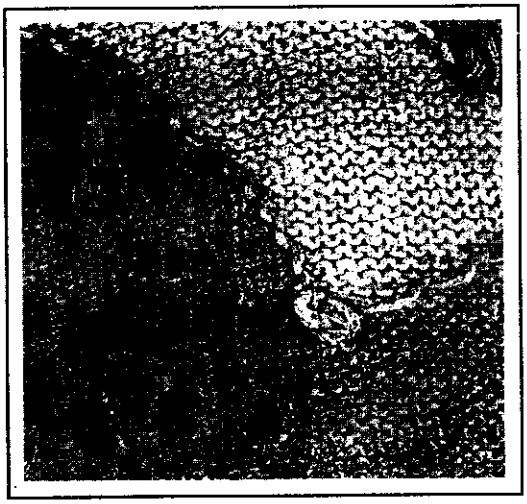
Also called double loop stitch or spliced stitch. A stitch formed from two ends of yarn.

Single faced structures:

Single faced structures are produced in warp and weft knitting by the needles (arranged either in a straight line or in a circle) operating as a single set. Adjacent needles will thus have their hooks facing towards the same direction and the heads of the needles will always draw the new loops downwards through the old loops in the same direction so that intermeshing points 3 and 4 will be identical with intermeshing points 1 and 2.



Technical face side



Technical back side

Double faced structures:

Double faced structures are produced in weft and warp knitting when two sets of independently controlled needles are employed with the hooks of one set knitting or facing in the opposite direction to the other set. The two sets of needles thus draw their loops from the same yarn in opposite directions, so that the fabric, formed in the gap between the two sets, shows the face loops of one set on one side and the face loops of the other set on the opposite side. The two faces of the fabric are held together by the sinker loops or under laps which are inside the fabric so that the reverse stitches tend to be hidden.

Balanced structure:

This is a double faced structure which has an identical number of each type of stitch produced on each needle bed and therefore showing on each fabric surface usually in the same sequence. These structures do not normally show curling at their edges.

Face and reverse stitches on the same surface:

These are normally produced on purl weft knitting machines which have double headed needles capable of drawing a face stitch with one hook and a reverse stitch on the other, so that intermeshing points 3 and 4 will not always be identical with intermeshing points 1 and 2.

Fabric draw-off:

Fabric is always drawn from the needles on the side remote from their hooks. When two sets of needles are employed, either arranged vertically or at some other angle to each other, each set of hooks will face away from the other set and the fabric will be produced and drawn away in the gap between the two sets.

Knitting machines:

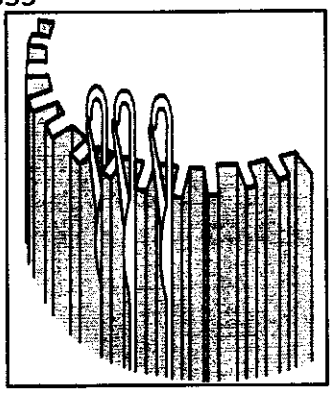
The machines those produced fabrics by intermeshing or interloping of one or one set of yarn. Knitting machines are divided as follows-

- **Weft knitting machine:**
  A machine producing a knitted fabric by intermeshing loops formed successively across the width of the fabric from a yarn fed substantially crosswise to the length of fabric.
- **Warp knitting machine:**
  A machine in which the fabric formation occurs by interlacement of loops formed simultaneously across the full width of the fabric from a system of yarns which are fed to the needles substantially in the direction of the length of fabric.
- **Other loop forming and combined technique machines:**
  Machines that form the fabric by the technique of intermeshing of yarn loops but which cannot be defined either as weft or as warp knitting machines.

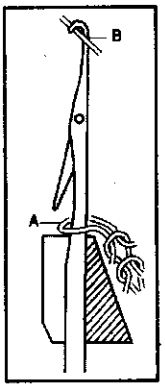
Needles:

Needle is the principal knitting element. Needles are divided into two categories according to their functions as follows-

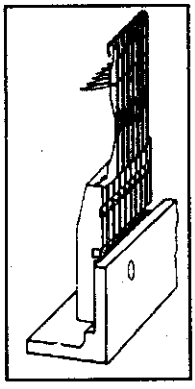
- **Independent needles:**
  Needles which can slide in the needle bed and be moved individually during the stitch or loop forming process.
- **United needles:**
  Needles which are fixed in the needle bar and which can only be moved in unison during the stitch or loop forming process.



Needle carrier



Independent needle



United needle

Needle carrier:

A part of the knitting machine containing independently moved needles in a needle bed or united needles in a needle bar. The needle carrier may be flat or circular, cylindrical or dial type.

Fabric face type:

The basic type of construction of fabrics produced on the respective knitting machines:

- **RL:** Single face fabric, also called right – left fabric; knitted on one row of needles.
- **RR:** Double face fabric, also called right – right or double right fabric; knitted on two rows of needles.
- **LL:** Links – links fabric, also called left – left or double left fabric; knitted on one or two rows of needles.

Number of feed system:

On the circumference of a circular knitting machine up to 120 knitting cam sets can be mounted, each cam set fed with a separate yarn. This results in obtaining 120 knitted loop courses in one machine revolution.

Number of feeders = Number of courses

Specification of knitting machine:

The needle beds and needle bars, and thus the knitting machines, are specified with three features, namely:

- The working diameter (Circular needle beds and needle bars)

  Or The working width (Flat needle beds and needle bars)

- The needle gauge or needle pitch.

- **The working diameter:**
  The diameter of a knitting machine is measured at the bottoms of two opposite needle grooves in a cylinder or at the tops of two opposite needles in a circular bar, and is usually expressed in inches.

- **The working width:**
  The working width of the machine should not be miss used with the "actual working width". The working width of a knitting machine is a measure (in cm or inches) describing the distance between the first and last needle in a flat needle bed, whilst the "actual working width" is the distance between the first and last needle actually used in the needle bed during knitting.

- **Machine or needle gauge:**
  The needle gauge of a knitting machine (also called cut or gage) is a measure expressing the number of needles per a unit of the needle bed (bar) width.

  Gauge, N = How many needles are used in one English inch.

$$N = \frac{\text{Number of needles}}{\text{One English inch.}}$$

  Highest needle gauge is about 60 and lowest needle gauge is about 2 to 2.5.

The needle pitch is the distance between two neighbouring needles in the same needle bed (bar), from the centre of a needle to the centre of the neighbouring needle.

Relationship between the needle gauge and the needle pitch is as follows:

$$\text{Needle pitch (Length units / needle)} = \frac{1}{\text{Needle gauge (length unit)}}$$

The pitch or distance between one needle and another is proportional to the needle gauge or thickness and therefore to the space available for the yarn. As the diameter of a yarn is proportional to its count, a relationship exists between the range of optimum counts of yarn which may be knitted on a particular machine and its machine gauge. Machine gauge thus influences choice of yarn and count, and affects fabric properties such as appearance and weight. For a given machine diameter or width, finer gauge machines tend to knit a wider fabric as more wales are involved. For example a 30" diameter circular machine might have 1716 cylinder needles in 18 G and 1872 cylinder needles in 20 G. Coarse gauge machines have latch needles with larger dimensions requiring greater movements. During knitting the size of the knitting cams are correspondingly large so less cam systems can be accommodated

around a given machine diameter (for example 30") so therefore coarser gauge machines often have fewer feeders.

Selvedged fabric:

A selvedged fabric is one having a "self – edge" to it and can only be produced on machines whose yarn reciprocates backwards and forwards across the needle bed so that a selvedge is formed as the yarn rises up to the next course at the edge of the fabric.

Cut edge fabric:

Cut edge fabric is usually produced by slitting open a tube of fabric produced on a circular machine. A slit tube of fabric from a 30" diameter machine will have an open width of 94" (πd) at knitting and before relaxation.

Tubular fabric:

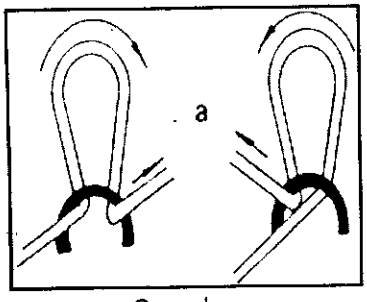
This may be produced in double faced or single faced structures on circular machines, or in a single faced form on straight machines with two sets of needles provided each needle set only knits at alternate cycles and that the yarn only passes across from one needle bed to the other at the two selvedge needles at each end, thus closing the edges of the tube by joining the two single faced fabrics produced on each needle set together.

Warp knitted laps:

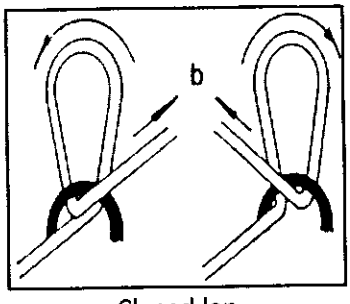
Loops are termed laps in warp knitting because the guides lap the warp yarn around the needles in order to form the loops, the laps may be either open or closed. So, lap is a length of yarn in a warp knitted fabric that consists of an overlap and of an underlap.

Open lap:

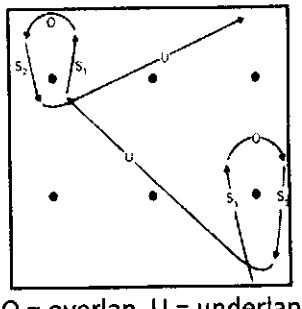
An open lap is produced either when the underlap is in the same direction as the overlap, or it is omitted so that the next overlap commences from the space where the previous overlap finished. Closed laps are heavier, more compact, opaque and less extensible than open laps produced from the same yarn and at a comparable knitting quality.



Open lap



Closed lap



O = overlap, U = underlap

Closed lap:

A closed lap is produced when an underlap follows in the opposite direction to the overlap and thus laps the thread around both sides of the needles.

The overlap:

The overlap is a shog usually across one needle hook by a warp guide which forms the warp yarn into the head of the loop. The swinging movement of the guide to the hook side and the return swing after the overlap produce the two side limbs or legs of the loop which has a very similar appearance on the face side of the fabric to a needle loop produced by weft knitting. So, overlap is a length of yarn in a warp knitted fabric that has been placed over the needle during loop formation.

The underlap:

The underlap shog occurs across the side of the needles remote from the hooks, on the front of single bar and in the centre of double bar needle machines, it supplies the yarn between one overlap and the next. So, underlap is a length of yarn in a warp knitted fabric that connects two overlaps in consecutive courses.

Underlaps as well as overlaps are essential in all warp knitted structures in order to join the wales of loops together, but they may be contributed by a different guide bar to those for the overlaps.

MECHANICAL PRINCIPLES OF KNITTING TECHNOLOGY

Basic elements of knitting:

There are three basic elements of knitting, such as needle, cam and sinker. This chapter deals with the features, functions, uses etc. of these knitting elements and also focus the principles of knitting based on these elements as follows.

The Needles:

The fundamental element in construction of knitted fabrics is the knitting needle. Needle is the main knitting tools and also the principal element of machine knitting. During yarn feeding the hook is opened to release the retained old loop and to receive the new loop which is then enclosed in the hook. The new loop is then drawn by the hook through the old loop which slides on the outside of the bridge of the closed hook. All needles must therefore have some method of closing the needle hook to retain the new loop and exclude the old loop.

There are hundreds and hundreds of different shapes of knitting needles used for production of knitted loops but all of them can be grouped in three main needle types:

The spring-bearded needles

The latch needles and

The compound needles.

- **The Spring-Bearded Needles:**

  The spring-bearded needles made of steel wire consist of the following parts:

  a. The Stem: The stem around which the needle loop is formed.
  b. The Head: Where the stem is turned into a hook to draw the newloop through the old loop.
  c. The Beard: Which is the curved downwards continuation of the hook that is used to separate the trapped new loop inside from the old loop as it slides off the needle beard.
  d. The Eye or groove: Cut in the stem to receive the pointed tip of the beard when it is pressed, thus enclosing the new loop.

The latch needle is the most widely used needle in weft knitting, because it is self – acting or loop controlled. It is also regarded as more versatile in terms of the range of materials that can be processed on latch needle machines. Bearded needles are less expensive to manufacture, can be produced in finer gauges and supposedly knit tighter and more uniform stitches compared with latch needles, but have limitations with regard to the types of material that can be processed as well as the range of structures that can be knitted on them. Bearded needle machines are faster than the equivalent latch needle machines. The compound needle has a short, smooth and simple action, and because it requires a very small displacement to form a stitch in both warp and weft knitting, its production rate is the highest of the three main types of needle. Compound needles are now the most widely used needles in warp knitting and a number of manufacturers also offer circular machines equipped with compound needles. The operation speeds of these machines are up to twice those of the equivalent latch needle machines.

The main parts of the bearded, latch and compound needle are describe and shown in the above figures respectively. Variations of latch needles include rib loop transfer needles and double – ended purl needles, which can slide through the old loop in order to knit from an opposing bed thus draw a loop from the opposite direction.

Friction and Frictionless Needles:

There are two types of latch needle, friction and frictionless. Friction needles have a slight flex, cramp or bend in the tails so that they contact the side – walls of the tricks in which they are housed. They are used in open cam systems where cams may be introduced or taken out of action to divert the needle path.

Frictionless needles are employed in closed cam – tracks which have guard or safety cams on the opposite side to the knitting cams, to produce a completely enclosed track through which the needles run, otherwise the freely moving needles would be thrown out of their tricks at high speed.

The Needle Bed:

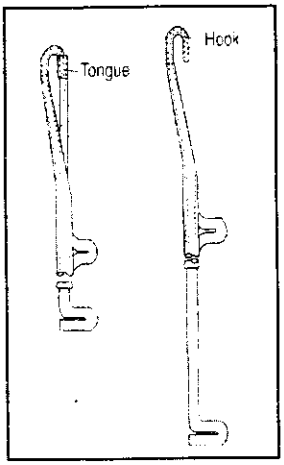
The needles are disposed in the slots of needle beds which can be flat or circular (dial and cylinder), or mounted on the needle bars. A flat needle bed consists of a steel plate with grooves. In the grooves the latch needles are inserted in such a way that their butts protrude above the plane of the steel plate. From below in the grooves, the needles are supported with special springs. Upper part of the flat needle bed is shaped in milled – off teeth helping in the process of stitch formation.

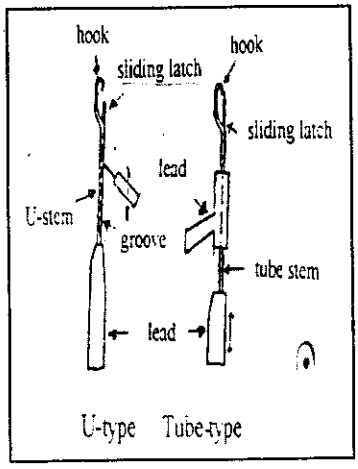
In a cylindrical needle bed the knitting needles are placed between the tricks inserted in cuts along the cylinder surface generator. The dial needle beds have the needle grooves cut radially i.e. horizontally. The butts of the needles in circular needle beds, both cylinder and dial, protrude from their surfaces. Thanks to the needle butts the needles can be driven along their grooves by cams located in cam boxes.

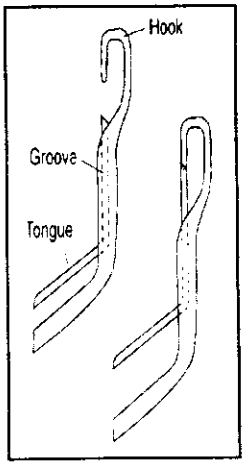
d. The Rivet: Which may be plain or threaded. This has been dispensed with on most plate metal needles by pinching in the slot walls to retain the latch blade.
e. The Slot or Saw – cut: Which receives the latch – blade.
f. The Cheeks or Slot walls: Which are either punched or riveted to fulcrum the latch blade.
g. The Butt: Which serving to displace the needle along the needle bed slot. The butt which enables the needle to be reciprocated when contacted by cam profiles on either side of it forming a track. Double – ended purl type needles have a hook at each end, whilst one hook knits, the inactive hook is controlled as a butt by a cam reciprocated element called a slider.
h. The Tail: Which is an extension below the butt giving additional support to the needle and keeping the needle in its trick. Sometimes used for the same purpose as the butt.

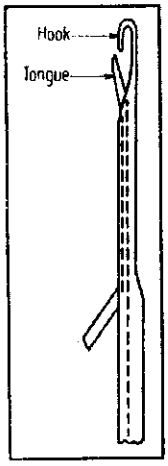
- **The Compound Needles:**

The compound needles are used in weft and warp knitting machines. In contrast to standard spring – bearded needles and latch needles the compound needle consists of two separate parts – the stem and the sliding latch. At the top of the compound needle stem there is a hook. The two parts rise and fall as a single unit but at the top of the rise the hook moves faster to open and at the start of the fall the hook descends faster to close the hook.









The compound needle stem can be made of a U – shaped steel wire or of a steel tube. The sliding latch (closing element) is made of a steel wire. During the cycle of loop or stitch formation the sliding latch slides along the groove of the U – shaped stem or in the tube – shaped stem. Prior to mounting onto a warp knitting machine the stems and latches of the compound needles are cast in leads (separately, in stem leads and latch leads).

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The Cams:

Cam is the second primary knitting element. The cams are the mechanical devices which convert the rotary machine drive into a suitable reciprocating action for the needles or other elements. Because all needles have a reciprocating action either serially or seriatim, except on the bearded needle sinker wheel and loop wheel frames where the fixed needle circle merely revolves. The cams are carefully profiled to produce precisely-timed movement and dwell periods.

The cams are of two types, Engineering cams and Knitting cams.

- **Engineering Cam:**

  It is circular cam. This circular engineering cams or high speed eccentrics indirectly control the motion of bars of elements which move en masse as single units in cottons Patent and warp knitting machines. They are attached to a rotary drive shaft situated parallel to and below the needle bar. A number of identical cams are positioned along the shaft to ensure correctly aligned movement. The drive is transmitted and adapted via cam – followers, levers, pivots and rocker shafts. One complete 360 – degree revolution of the drive shaft is equivalent to one knitting cycle and it produces all the required movements of the elements once only in their correct timing relationship.

  In warp knitting machines, four types of cam drive have been employed:

  a. Single acting cams
  b. Cam and counter cams
  c. Box cams, and
  d. Contour cams.

a. Single acting cams: This type requires a powerful spring to negatively retain the cam truck or follower in contact with the cam surface, bounce and excessive wear occurs at speed.
b. Cam and counter cams: This arrangement provides a cam and its follower in each direction of movement but is obviously more expensive to manufacture.
c. The box or enclosed cams: This employs a single cam follower which is guided by the two cam races of a groove on the face of the cam. However, change of contact from one face to the other causes the follower to turn in the opposite direction producing wear which cannot be compensated.
d. The contour, ring or pot cams: It is the reverse of the box cam as the cam profile projects out from one face of the cam in the form of lip with a cam – follower placed on either side of it. This is a popular and easily adaptable arrangement.

   Although cams are comparatively cheap, simple and accurate, at speeds above 800 courses per minute they are subject to excessive vibration. For this reason, at speeds in excess of that Eccentric drive is now employed.

Eccentric:

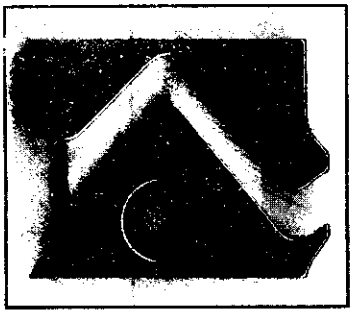
The eccentric is a form of crank which provides a simple harmonic movement with smooth acceleration and deceleration. Its wide spread use is the result of adapting this simple motion and modifying it to the requirements of the warp knitting machine so that even dwell (stationary periods) in the element cycle can be achieved. Now, however, the simpler single eccentric drive is successfully driving element bars at speeds of 2000 courses per minute or more.

- **Knitting Cam:**

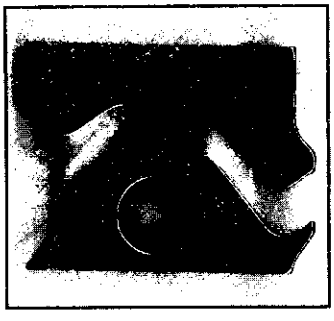
The angular knitting cam acts directly on to the butts of needles or other elements to produce individual or seriatim movement in the tricks of latch needle weft knitting machines as the butts pass through the stationary cam system (revolving cylinder machines) or the cams pass across the stationary tricks (reciprocating cam box flat machines or rotating cam – box circular machines).

On weft knitting machines, yarn feeds must move if the cams move, in order to supply yarn at the knitting point, and if the cam - boxes rotate the yarn packages and tackle must rotate with them. If, however, the yarn carriers reciprocate as on flat machines their yarn supply packages may be situated in a suitable stationary position.

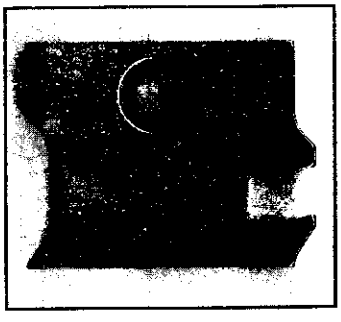
Knitting cams are attached either individually or in unit form to a cam - plate and, depending upon machine design, are fixed, exchangeable or adjustable.



Knit Cam



Tuck Cam

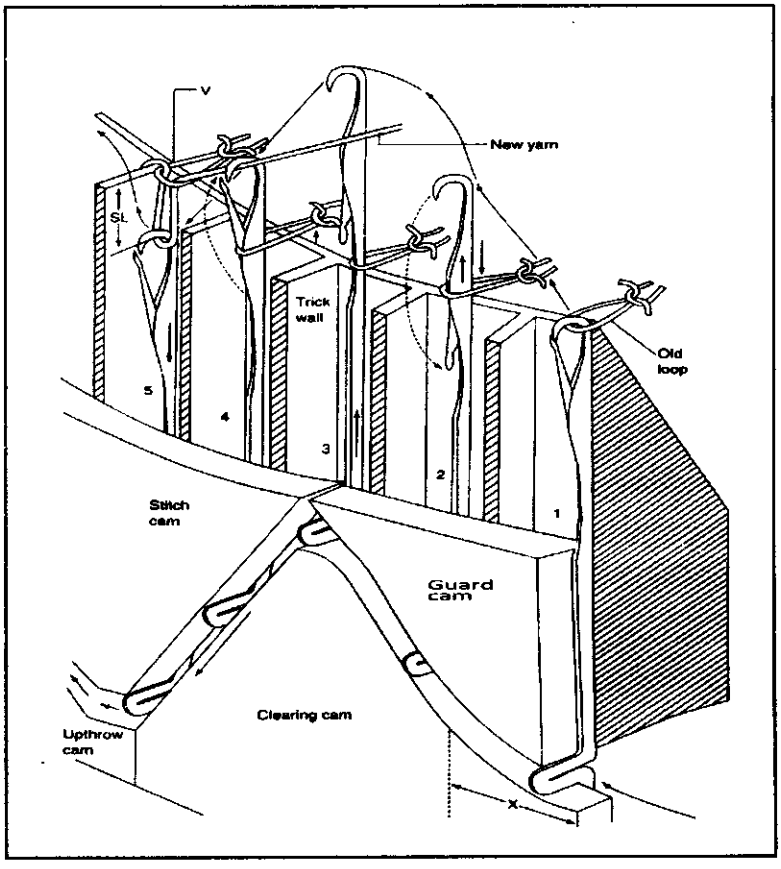


Miss Cam

The knitting cams are divided in to three groups, such as knit cam, tuck cam and miss cam. At each yarn feed position there is a set of cams (mainly knit cam) consisting of at least a raising or clearing cam, a stitch or lowering cam, guard cam and an up throw cam whose combined effect is to cause a needle to carry out a knitting cycle if required. On circular machines there is a removable cam section or door so that knitting elements can be replaced.

a. The Raising Cam: This causes the needles to be lifted to either tuck, clearing loop transfer or needle transfer height depending upon machine design. A swing cam is fulcrummed so that the butts will be unaffected when it is out of the track and may also be swing into the track to raise the butts. A bolt cam can be caused to descend into the cam track and towards the element tricks to control the butts or be withdrawn out of action so that the butts pass undisturbed across its face, it is mostly used on garment – length machines to produce changes of rib.

b. The Stitch Cam: It controls the depth to which the needle descends thus controlling the amount of yarn drawn into the needle loop, it also functions simultaneously as a knock – over cam.

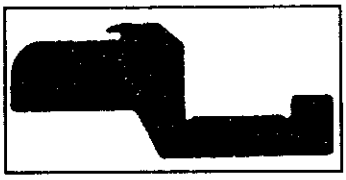
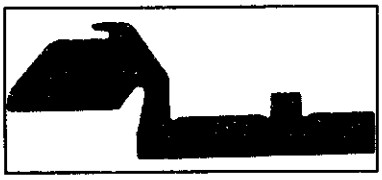


c. The Up throw Cam: It takes the needles back to the rest position and allows the newly – formed loops to relax. The stitch cam is normally adjustable for different loop lengths and it may be attached to a slide together with the upthrow cam so that the two are adjusted in unison. In the above figure there is no separate upthrow cam, section X – of the raising cam is acting as an upthrow cam.

d. The Guard Cam: These are often placed on the opposite side of the cam – race to limit the movement of the butts and to prevent needles from falling out of track.

The Sinkers:

The sinker is the third primary knitting element. It is a thin metal plate with an individual or collective action approximately at right angles from the hook side between adjoining needles.

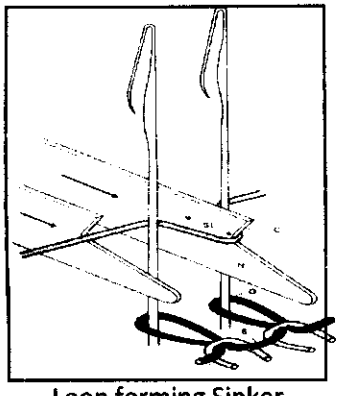

Functions of Sinker:

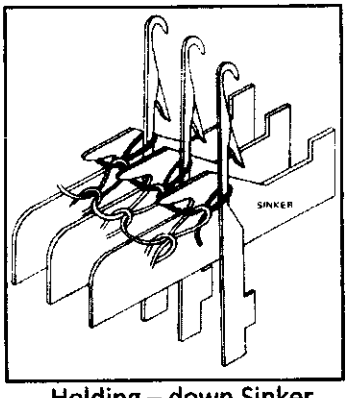
It may perform one or more of the following functions dependent upon the machines knitting action and consequent sinker shape and movement:

- Loop formation
- Holding – down and
- Knocking – over.

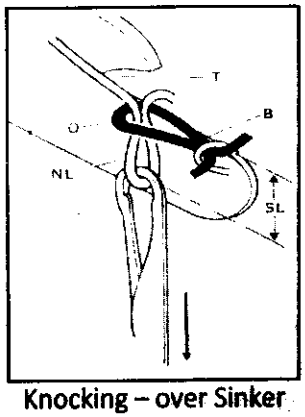
According to these functions the sinkers are also divided into three groups, such as loop forming sinker, holding-down sinker and knocking-over sinker.

- The first function of the sinker is loop formation. On bearded needle weft knitting machines of the straight bar frame and sinker wheel type the main purpose of a sinker is to sink or kink the newly laid yarn into a loop as its forward edge or catch advances between the two adjoining needles. On the bearded needle loop wheel frame, the blades of burr wheels perform this function whereas on latch needle weft knitting machines and warp knitting machines, loop formation is not a function of the sinkers.
- A second and more common function of sinkers on modern machines is to hold down the old loops at a lower level on the needle stems than the new loops which are being formed and prevent the old loops from being lifted as the needles rise to clear them from their hooks. The protruding nib or nose of the sinker is positioned over the sinker loops of the old loops preventing them from rising with the needles.


Loop forming Sinker



Holding – down Sinker



Knocking – over Sinker

On tricot warp knitting machines and single bed weft knitting machines, a slot or throat is cut to hold and control the old loop. The sole function of the sinker may be as a web holder or stitch comb as on the Raschel warp knitting machine in which case only the underside of the nose performs the function.

On latch needle weft knitting machines the holding-down sinkers have a rectangular gap cut on their upper surface remote from the nose into which the sinker cam race fits to positively control the sinker's movement.

Holding-down sinkers enable tighter structures with improved appearance to be obtained, the minimum draw-off tension is reduced, higher knitting speeds are possible and knitting can be commenced on empty needles.

Holding-down sinkers may be unnecessary when knitting with two needle beds as the second bed restrains the fabric loops whilst the other set of needles move.

- The third function of the sinker – as a knock-over surface – where its upper surface or belly supports the old loop as the new loop is drawn through it.

  On tricot warp knitting machines the sinker belly is specially shaped to assist with landing as well as knock-over.

  On latch needle machines the verge or upper surface of the trick – plate serves as the knock – over surface.

The Jack:

The jack is a secondary weft knitting element which may be used to provide flexibility of latch needle selection and movement. It is placed below and in the same trick as the needle and has its own operating butt and cam system. The needle may thus be controlled directly by its butt and cam system or indirectly by the movement of the jack.

Methods of Yarn Feeding:

There are two methods of yarn feeding. Yarn feeding involves either moving the yarn past the needles or moving the needles past a stationary yarn feed position.

When the yarn moves past the needles, the fabric will be stationary because the loops hang from the needles. This arrangement exists on all warp knitting machines and on weft knitting machines with straight beds or circular machines with stationary cylinder and dials. On straight machines of both weft and warp type the yarn carrier or guide has a reciprocating traversing movement which takes it towards and away from a suitably – placed yarn supply. On stationary cylinder and dial machines, however, the yarn supply packages must rotate in order to keep with the continuously revolving yarn feeds. Because the latch needle beds of these flat and circular weft knitting machines are stationary, it is necessary to reciprocate the cam – carriages

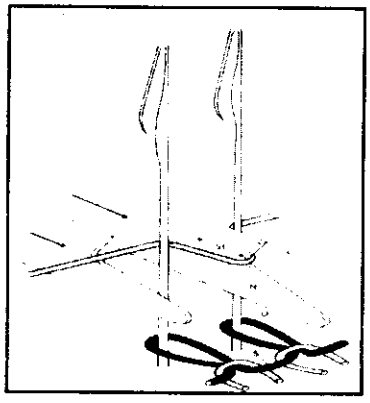
and revolve the cam – boxes so that the needle butts of the stationary tricks pass through and the needles are thus reciprocated into a knitting action at the exact moment when the traversing feed supplies a new yarn.

Most circular weft knitting machines have revolving needle cylinders and stationary cams, feeders and yarn packages. In this case, the fabric tube must revolve with the needles as must the fabric rollers and take – up mechanism.

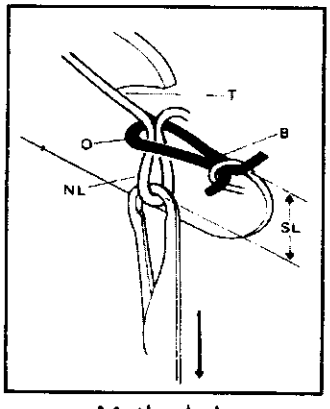
Methods of Forming Yarn into Needle Loops:

There are three methods of forming the newly – fed yarn into the shape of a needle loop:

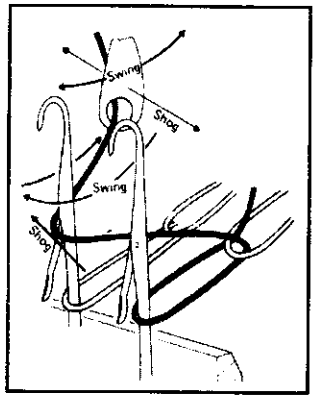
- **Method – a:**
  By sinking the yarn into the space between adjacent needles using loop forming sinkers or other elements which approach from the beard side. The action of a straight bar frame is illustrated but a similar action occurs on other bearded needle weft knitting machines. The distance SL of the following figure which the catch of the sinker moves past the hook side of the needle is approximately half the stitch length.



Method - a



Method - b



Method - c

- **Method – b:**
  By causing latch needles to draw their own needle loops down through the old loops as they descend one at a time down the stitch cam. This method is employed on all latch needle weft knitting machines. The distance SL of the above figure which the head of the latch needle descends below the knock – over surface, is approximately half the stitch length.
- **Method – c:**
  By causing a warp yarn guide to warp the yarn loop around the needle. The lapping movement of the guide is produced from the combination of two separate motions, a swinging motion which occurs between the needles from the front of the machine to the hook side and return and a lateral shogging of the guide parallel with the needle bar on the hook side and also the front of the machine. The swinging motion is fixed but the direction and extent of the shogging motion may or may not be

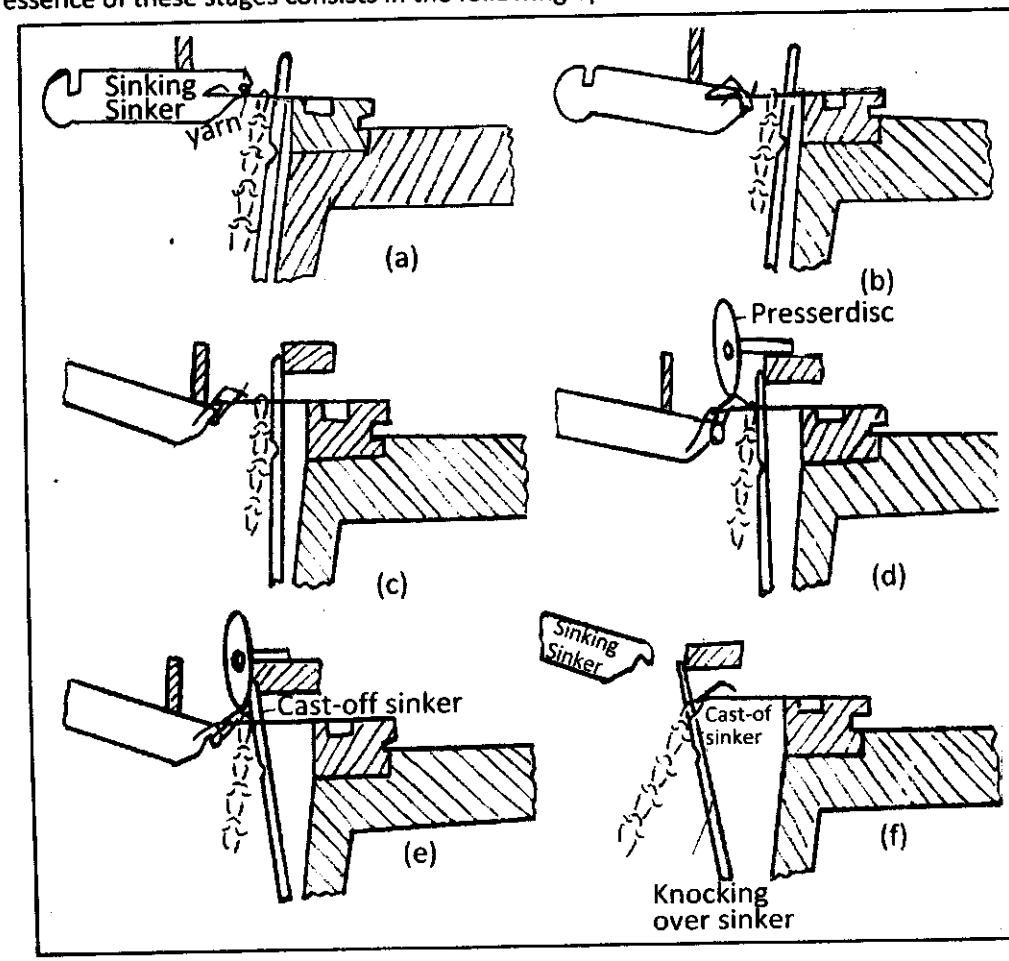
varied from a pattern mechanism. This method is employed on all warp knitting machines and for wrap patterning on weft knitting machines. The length of yarn per stitch unit is generally determined by the rate of warp yarn feed.

Knitting Action or Loop or Stitch Formation on Spring-Bearded Needles:

Loop or stitch formation on a single – needle bed weft knitting machine with spring – bearded needles consists of the following stages:

1. Yarn feeding
2. Yarn sinking or kinking
3. Under lapping
4. Pressing
5. Landing
6. Joining and casting-off
7. Clearing

The essence of these stages consists in the following operations:



Knitting Action or knitting cycle on Spring-bearded needles

1. Yarn feeding (a): The newly fed yarn is laid under the throats of kinking sinkers.

2. Yarn sinking (b): The sinkers fall down between the needles, with the yarn held in the sinker throats. Depth of sinking determines the loop length, i.e. the yarn length used to form a knitted loop.

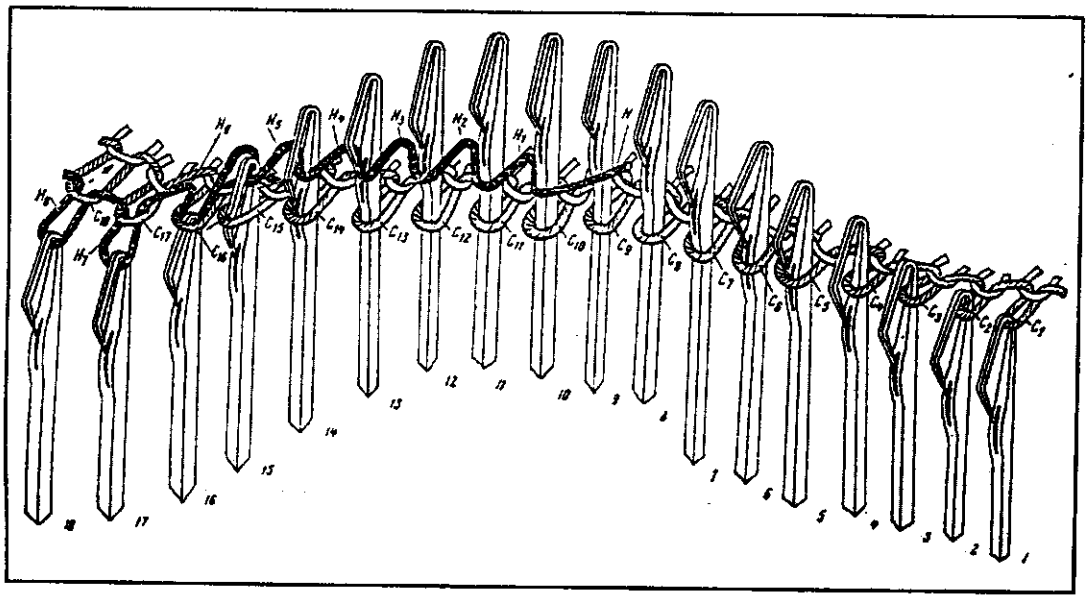
3. Under lapping (c): The yarn laid on the needle stems is withdrawn by the sinkers in direction of needle hooks and under the needle beards.

4. Pressing (d): Now, the needle beard is immersed in the needle groove by a presser disc. In this way the fed yarn is closed in the needle hook.

5. Landing (e): The knitted fabric resting on the needle stems at the needle bed is now pushed by cast-off sinkers towards the pressed needle beards, and the fabric loops (called old loops) land on the beards.

6. Joining and Casting-off (f): After passing the presser disc, the cast-off sinkers push further the knitted fabric towards the tips of the needles. At the same time the kinking sinkers leave the kinked yarn and the cast-off sinkers push the old loops off the needles on to the kinked lengths of yarn.

7. Clearing (a): At this stage the newly formed loops are pushed back along the needle stems, towards the needle bed; the knitted fabric enlarged by a new course of knitted loops, is drawn down by means of a take-down mechanism, and the process of loop formation may be started again.

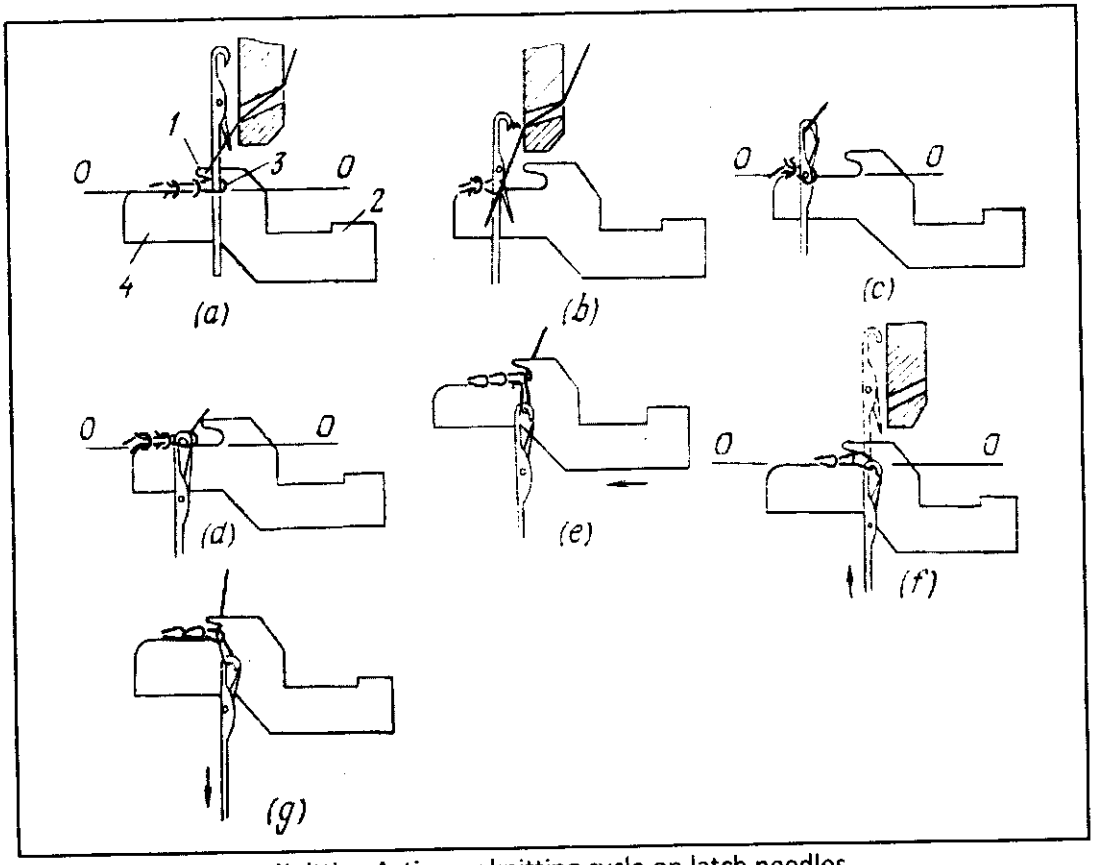


Consecutive stages of loop formation on spring-bearded needles

Knitting Action or Loop or Stitch Formation on Latch Needles:

The loop or stitch forming process in a single needle bed machine is illustrated in the following figure. The loop forming process is divided into nine operations:

1. Clearing
2. Yarn laying or feeding
3. Under lapping or yarn drawing
4. Pressing
5. Landing
6. Joining
7. Casting-off or knocking-over
8. Loop forming and sinking, and
9. Loop draw – off



Knitting Action or knitting cycle on latch needles

1. Clearing (a): The process of stitch formation is started by the clearing operation. Its aim is to draw the old loops behind the needle latch. Clearing is effected during needle lift. The old loop is retained by the beak of the sinker shifted to the cylinder centre so as to avoid its displacement together with the needle. At the time of clearing, the sinker remains immobile. Clearing is completed when the needle reaches its upper position.

2. Yarn laying or feeding (b): In the course of needle downward motion, the hook takes hold of yarn coming from the yarn guide and effects it's laying. At the moment when laying is started, the sinker beak must retreat a little from the cylinder centre so as not to further impede the loop forming process.

3. Under lapping or yarn drawing (c): Further movement of yarn just laid and its forwarding under the needle hook is called under lapping or drawing. Actually, drawing is performed simultaneously with the yarn laying when the needle starts to move down.

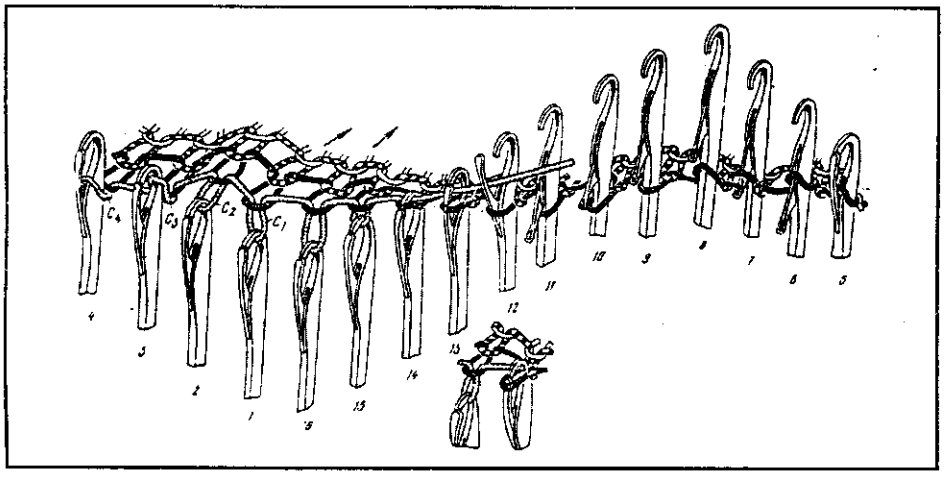
4. Pressing (c): The aim of pressing is to close the needle hook with the yarn laid in it. When the needle lowers, its latch contacts the old loop lying near the knock – off plane and retained from lowering by the sinker chin. The old loop interacts with the latch and closes it.

5. Landing (d): The essence of this operation consists in shifting the old loop on the closed latch. The landing operation in latch needle machine begins simultaneously with pressing.

6. Joining (d): At joining, the new yarn comes in contact with the old loop. Joining is accomplished simultaneously with the beginning of casting – off.

7. Casting-off or knocking-over (e): The casting-off operation consists in the retreat of the old loop from the needle hook.

8. Loop forming and sinking (e & g): Loop forming consists in drawing the yarn grasped by the needle through the old loop retained by the sinker chin. The lower the needle moves in respect to the knock – off plane at kinking, the longer is the formed loop and the less the stitch density.



Consecutive stages of loop formation on latch needles

9. Loop draw-off (f): The aim of this operation is to draw the old loop behind the needle back. Draw-off of new loops is effected by sinker throats. At the same time, exercising their action on the knitted fabric, the chins of sinkers withdraw the old loops from the knitting zone. The machine take-down mechanism promotes this operation.

   Loop draw-off is completed when the apex on the interior side of the hook head reaches the knock-off plane level, which corresponds to the initial position for the described loop forming process.

Knitting Action or Loop or Stitch Formation on a Warp Knitting machine equipped with Compound Needles:

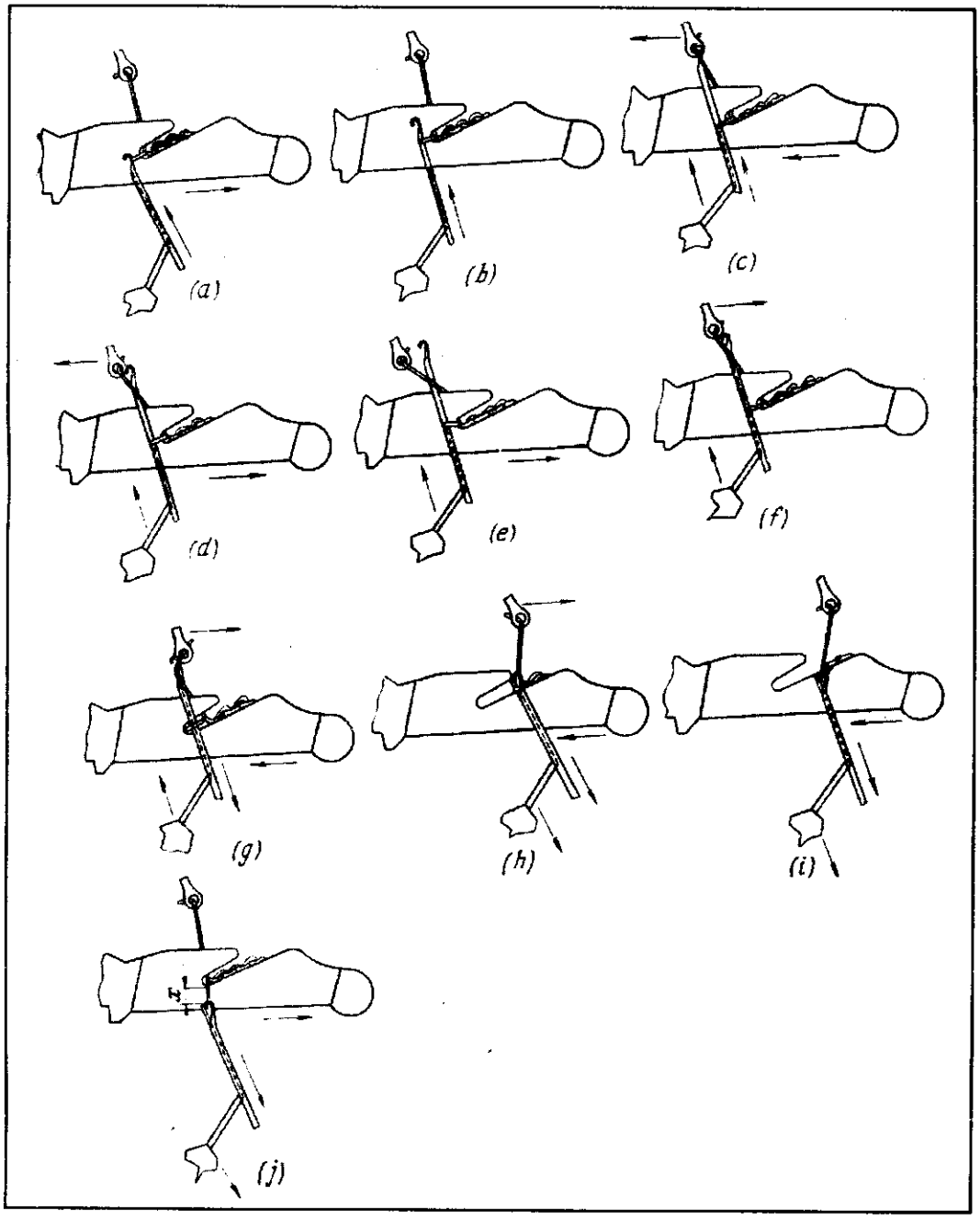
The loop forming process on single – bar warp knitting machines with compound needles may be divided into ten operations:

1. Clearing
2. Overlapping or yarn laying
3. Underlapping
4. Pressing
5. Landing – over
6. Joining or meshing
7. Sinking
8. Casting – off
9. Loop – forming and
10. Draw – off

The operations are described as follows:

1. Clearing (b): The stem of the compound needle lifts from the bottom position. The newly formed loop is under the needle hook. The guide bar is racking over one or several needle spacings (depending on the kind of interlacing) behind the needles, and occupies the initial position to form the next loop course. The sinkers retain with their nibs, the knitted fabric from lifting together with the needles. On further rotation of the machine the needles come to occupy the initial position for warp yarn laying.

2. Overlapping or yarn laying (c – g): The needle stem rises and the guide bar starts its motion, intersecting the line of needles. At the moment when the guide bar passes between the needles the hooks must reach the bottom half of the guide needle hole (d). In the farthest position from the needles, the guide bar makes a rack for yarn overlapping, usually for one needle spacing. Figure f illustrates the position of the guide needle in relation to the needles in the return swinging of the guide bars. On further rotation of the main shaft, the needle stem starts moving downward and yarn overlapping is terminated. The direction of sinker and sliding latch motion in overlapping is shown by arrows in figure c to g.



Knitting Action or knitting cycle on compound needles

3. Underlapping (g): The needles stem continues its descent. The guide needle has already intersected the line of needles and pursues its motion. The newly overlapped yarn does not move together with the needle stem being retained by the upper edge of the sinker nib. The combined motions of the guide needles and needle stems bring the new yarns under the hooks. In underlapping, the sinker starts moving backward to the machine centre.

4. Pressing (h): The needle continues its downward motion having risen to its highest position, the sliding latch overlaps the needle hook so that the hook tip engages into the groove in the upper part of the latch. The sinker continues its motion and, with its belly, brings the old loop along the sliding latch to the closed hook of the needle.

5. Landing – over (h): The sinker continues its travel and, with its belly, brings the old loop on the sliding latch. The guide needle continues to retreat. The sliding latch together with the stem moves downwards.

6. Joining or meshing (i): The needle stem with the sliding latch continues the downward motion. On the descent of the needle head to the level of the upper edge of the sinker belly, the old loop joins the new warp yarn which is under the needle hook. The guide needle continues to move away from the machine centre.

7. Sinking (I,j): This operation (i.e. bending the new warp yarn which is under the needle hook) is effected by further needle lowering.

8. Casting-off (i): The needle stem with the sliding latch lowers below the upper edge of the sinker belly. The old loop with the sliding latch is cast on to the newly formed loop which is under the needle hook.

9. Loop forming (i): The needle continues to move downward.

10. Draw – off (j): Draw – off is carried out on further rotation of the machine's main shaft and needle lift. As the needle lifts, the yarn may be drawn from the newly formed loop to the guide.

WEFT KNITTING MACHINES

Main features of a knitting machine:

A knitting machine is thus an apparatus for applying mechanical movement, either hand or power derived, to primary knitting elements, in order to convert yarn into knitted loop structures. The machine incorporates and co – ordinates the action of a number of mechanisms and devices, each performing specific functions that contribute towards the efficiency of the knitting action.

The main features of a knitting machine are listed below:

- Frame: The frame, normally free – standing and either circular or rectilinear according to needle bed shape, provides the support for the majority of the machines mechanisms.
- Power supply: The machine control and drive system co - ordinates the power for the drive of the devices and mechanisms.
- Yarn supply or feeding: The yarn supply consists of the yarn package or beam accommodation, tensioning devices, yarn feed control and yarn feed carriers or guides.
- Knitting action: The knitting system includes the knitting elements, their housing, drive and control, as well as associated pattern selection and garment – length control devices (if equipped).
- Fabric Take – away: The fabric take away mechanism includes fabric tensioning, wind – up and accommodation devices.
- Quality control: The quality control system includes stop motions, fault detectors, automatic oilers and lint removal systems.

Machines may range from high – production, limited – capability models to versatile, multi – purpose models having extensive patterning capabilities. The more complex the structure being knitted, the lower the knitting speed and efficiency. The simplest of the knitting machines would be hand – powered and manipulated whereas power – driven machines may be fully automatically – programmed and controlled from a computer system.

Classification of weft knitting machines:

Weft knitting machines are divided into the several ways as follows:

A. According to the frame design and needle bed arrangement or construction
   I. Circular knitting machine
   II. Flat knitting machine

B. According to the number of needle bed or number of needle set used
   I. Single Jersey knitting machine
   II. Double Jersey knitting machine

C. According to the end product of the weft knitting machine
   I. Fabric machine
   II. Garment length machine

D. According to the basic structure of the weft knitting
   I. Plain or Single jersey circular knitting machine
   II. Rib Circular or Flat knitting machine
   III. Interlock circular knitting machine
   IV. Links-links or Purl flat or circular knitting machine

E. According to the types of needle used
   I. Knitting machine equipped with Latch needle
      a. Circular knitting machine
         One needle bed

            Plain, Single-jersey jacquard, Pile and Sliver knit machine

         Two needle beds (Dial-cylinder machine)

            Rib, Interlock, Double-jersey jacquard machine

         Double cylinder

            Purl knitting machine

      b. Flat-bed knitting machine
         One needle bed

            Domestic type

         Two needle beds

            Vee-bed, Flat purl knitting machine

   II. Knitting machine equipped with Spring Bearded needle
      a. Circular knitting machine
         One needle bed

            Sinker wheel, Loop wheel frame

      b. Straight bar frame
         One needle bed and Two needle beds

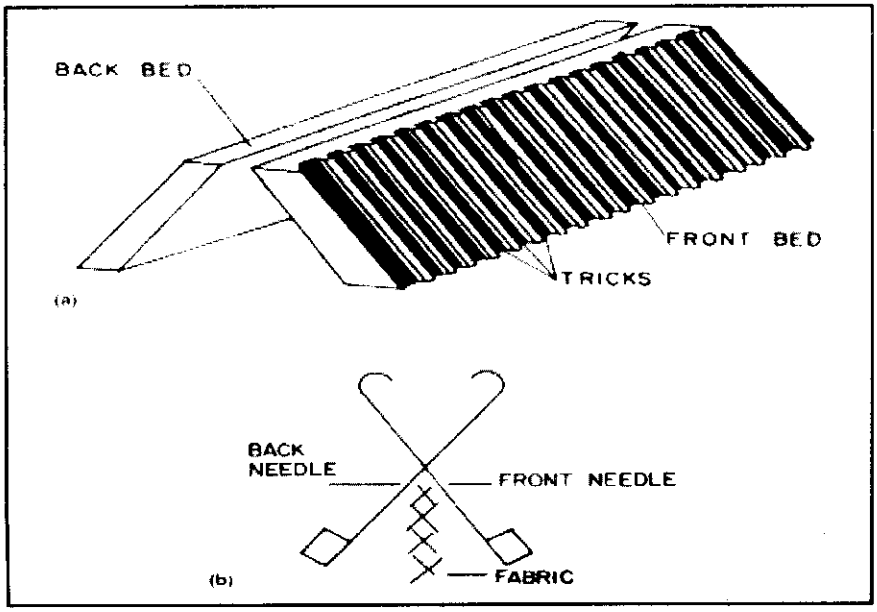
            Cotton's Patent or Fully-fashioned machine

Flat Knitting Machine:

General structure of a Flat knitting machine:

- **The Frame:**
  - The needle beds
  - Concept of machine gauge
  - The carriage and yarn guides
  - Feeding the yarn
  - The take-down device
  - Selecting the needles
  - Selection of high and low butts

- **Main Features:**
  - Flat knitting machine has two stationary needle beds
  - Latch needles are used
  - Angular cams of a bi-directional cam system is used
  - The cam system is attached to the underside of a carriage, which with its selected yarn carriers.
  - The carriage traverses in a reciprocating manner across the machine width
  - There is a separate cam system for each needle bed
  - The two cam systems are linked together by a bridge, which passes across from one needle bed to the other.
  - Normally machine gauge is 3 to 18 needles per inch and machine width up to 79 inches.



a Diagram of a V bed, and b Diagram showing relative positions of needles from front and back beds

Advantages of Flat knitting machine:

- The flat machine is the most versatile of weft knitting machines, its stitch potential includes needle selection on one or both beds, racked stitches, needle-out designs, striping, tubular knitting, changes of knitting width and loop transfer.
- A wide range of yarn counts may be knitted per machine gauge including a number of ends of yarn in one knitting system, the stitch length range is wide and there is the possibility of changing the machine gauge.
- The operation and supervision of the machines of the simpler type is relatively less arduous than for other weft knitting machines.
- The number of garments or panels simultaneously knitted across the machine is dependent upon its knitting width, yarn carrier arrangement, yarn path and package accommodation.

Uses of Flat knitting machines:

Articles knitted on flat machines range from trimmings, edgings and collars to garment panels and integrally knitted garments. The common products: jumpers, pullovers, cardigans, dresses, suits, trouser suits, hats, scarves, accessories, ribs for straight-bar machines (fully fashioned machines). Cleaning clothes, three-dimensional and fashioned products for technical applications, multiaxial machines are under development.

Classifications of Flat machines:

Machines range from hand propelled and manipulated models to fully-automated electronically controlled power driven machines. The four classes of flat knitting machines are:

a) The Vee-bed flat which is by far the largest class;
b) Flat bed purl machines which employ double ended or double headed latch needles
c) Machines having a single bed of needles which include most domestic models and the few hand manipulated intarsia machines
d) The uni-directional multi-carriage machines made by one manufacturer.

a) Vee-bed Flat knitting machine:

Vee-bed flat knitting machines are widely used for the production of sweater, collar-cuff, etc. This machine describe in details in the following chapter of sweater knitting.

b) Flat Purl knitting machine:

- Flat purl or links-links machine with double-headed latch needles are less common than Vee-bed types to which they are similar in method of operation.

- They share with Vee-bed type very good patterning scope, increasing shaping potential and relatively low productivity.
- End-uses and machine types show slightly less diversity than Vee-bed equipment but hand operated types and circular-flat purl machines exist.

c) Domestic Single bed Flat machine:

- These machines are no longer produced for industrial use.
- The needles are actuated by cams mounted in a carriage traversed by hand. Patterning and ability to shape the fabric depend upon manual operations.
- A typical machine has a 36 inch working width with 5 to 6 needles per inch.

Circular knitting machine:

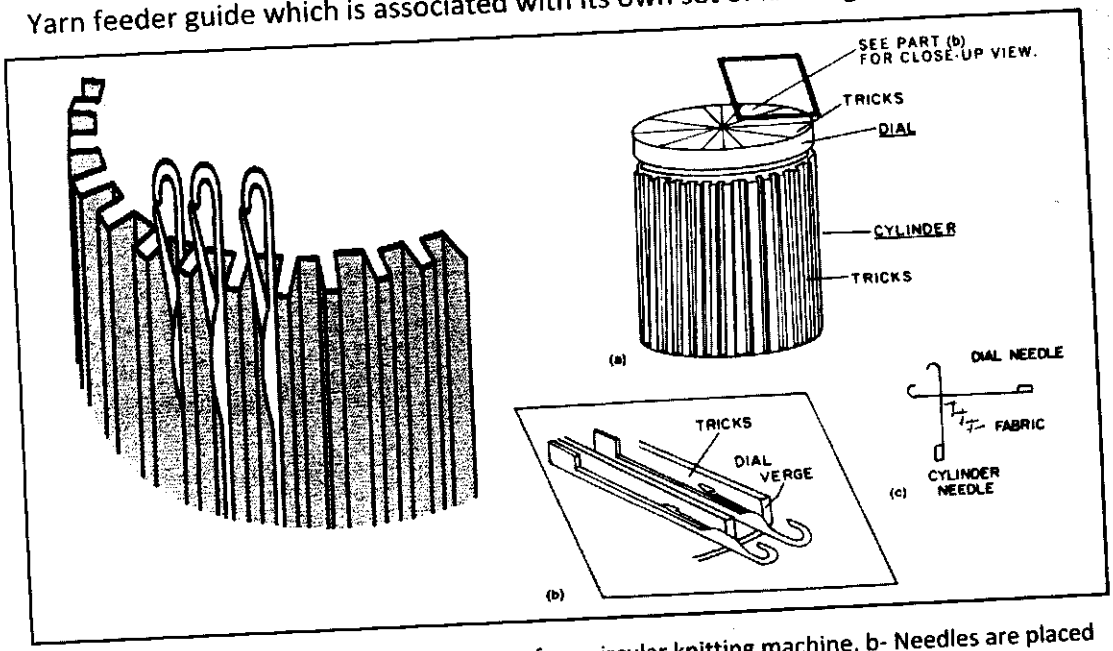
The term circular covers all those weft knitting machines whose needle beds are arranged in circular cylinders and / or dials, including latch, spring bearded and very occasionally compound needle machinery, producing a wide range of fabric structures, garments, hosiery and other articles in a variety of diameters and machine gauges.

Features of a Circular knitting machine:

The common features of a circular knitting machine as follows:

- Circular knitting machine normally has rotating (clockwise) cylindrical needle bed (s).
- On circular knitting machines latch and compound needles are used. One seldom finds bearded needles or other needle types. Normally one or two sets of Latch needles are used.
- For single-jersey machine holding down sinkers are used, one between every needle space.
- Normally stationary angular cam systems are used for needle and sinker.
- Latch needle cylinder and sinker ring (for single-jersey machine) / dial (for double-jersey rib and interlock machine) revolve through the stationary knitting cam system.
- For single-jersey machine, sinker trick ring which is simply and directly attached to the outside top of the needle cylinder thus causing the sinkers to revolve in unison with the needles.
- Needle retaining spring is also used
- Stationary yarn feeders are situated at regular intervals around the circumference of the rotating cylinder.
- Yarn is supplied from cones, placed either on an integral overhead bobbin stand or on a freestanding creel through tensioners, stop motions and yarn guide eyes down to the yarn feeder guides.

- Yarn feeder guide which is associated with its own set of knitting cams.

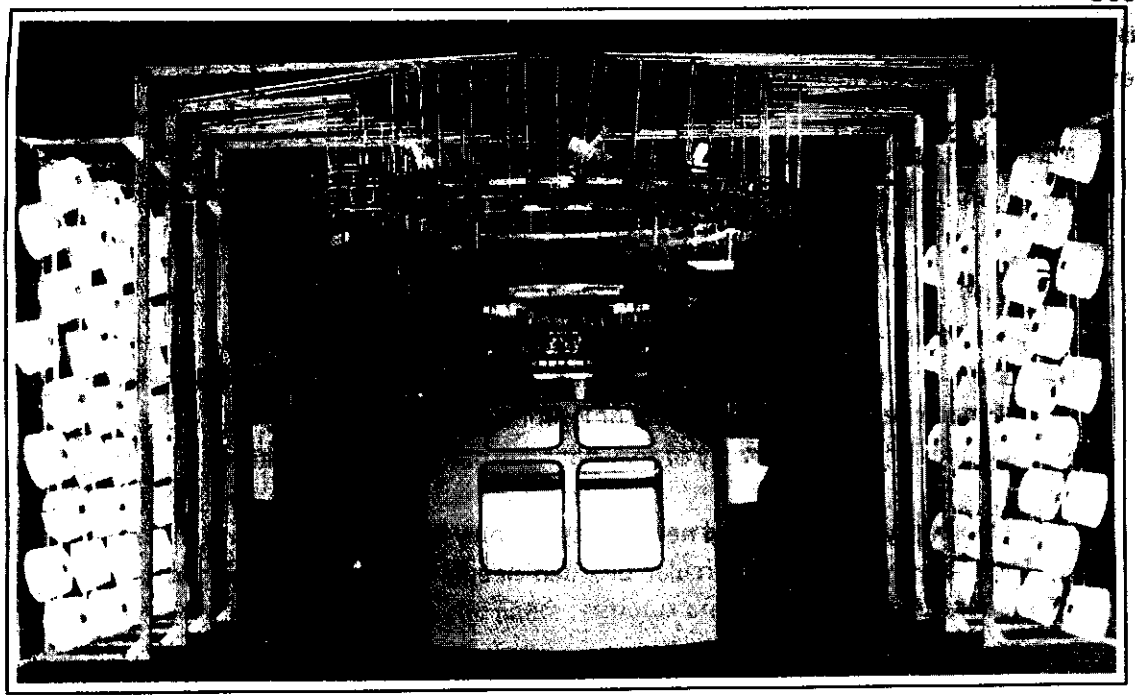


a- Diagram of a cylinder and dial arrangement for a circular knitting machine, b- Needles are placed inside the tricks in close-up, and c- Diagram of the relative positions of dial and cylinder needles.

- Machine gauge is normally used 5 to 40 needles per inch and machine diameter u to 30 inches. Up to 60 inch diameter machines are now available.

The following features of a modern circular fabric producing machine that ensure th high quality fabric is knitted at speed with the minimum of supervision:

- The top and bottom stop motions are spring-loaded yarn supports that piv downwards when the yarn end breaks or its tension is increased. This action releas the surplus yarn to the feeder, thus preventing a press-off, and simultaneou completes a circuit which stops the machine and illuminates an indicator warni light.
- Various spring-loaded detector points are carefully positioned around the cylin according to their particular function. A pointer is tripped to stop the machine b fault or malfunctioning element such as a yarn slub, fabric lump, needle head, la spoon, etc.
- The tape positive feed provides three different speeds (course lengths) and is dri and can be adjusted from the drive arrangement.
- The cylinder needle cam system for each feed is contained in a single replace section and having an exterior adjustment for the stitch cam slide.
- The automatic lubrication system.
- Start, stop and inching buttons.
- The cam-driven fabric winding down mechanism, which revolves with the fa tube.



Over all view of a Modern Circular knitting machine

- The revolution counters for each of the three shifts and a pre-set counter for stopping the machine on completion of a specific fabric length (in courses).
- Normally side creel is used.
- Lint blower is used. This reduces the incidence of knitted-in lint slubs, to improve quality when using open-end spun yarns. It also reduces cross-contamination by fibres from other machines.

Products of Circular knitting machine:

Fabric machines: rolls of fabric with the following end-uses: jackets, ladies' tops, sports and T-shirts, casual wear, suits, dresses, swimwear, bath robes, dressing gowns, track suits, jogging suits, furnishing, upholstery, automotive and technical fabrics, household fabrics.

Garment blank machines: Underwear, T-shirts, jumpers, pullovers, cardigans, dresses, suits, trouser suits, vests, briefs, thermal wear, cleaning cloths, technical fabrics.

Hose machines: seamfree hose, tights, industrial use dye bags, knit-de-knit yarns, industrial fabrics.

Half-hose machines: men's and boy's half-hose, ladies' stockings, children's tights sports socks.

Classification of circular knitting machines:

There are three types of circular knitting machines

a) **Revolving cylinder latch needle machines:**
They produce most weft knitted fabrics. They are of two main types –

I. Open top or Sinker top or Single jersey machines
II. Dial and cylinder machine

- Open top machines have one set of needles usually arranged in the cylinder.
- Except in the case of certain effect fabric machines such as pelerine, cylinder and dial machines are of either the rib or interlock type.
- Machines of both types may or may not have patterning capabilities.

b) **Revolving cylinder bearded needle single-jersey fabric machine:**
There are two types of circular bearded needle single-jersey fabric machines still manufactured,

I. The Sinker Wheel machine or French or Terrot type machine.
II. The Loop wheel frame or English type machine.

Both have the following features in common:

- Needles are fixed in needle bed.
- Revolving needle bed
- Ancillary elements moving yarn and loops along the needle stems.
- Fabric tube knitted with its technical back facing outwards.
- Less number of feeders accommodates.
- Comparatively low productivity compensated by an ability to produce unusual and superior quality knitted structures.

c) **Circular garment length machines:**
- They are generally of body-width size or larger having a cylinder and dial arrangement or a double cylinder.
- They are of the small-diameter hosiery type with either a single cylinder, a cylinder and dial or double cylinders.

Fabric Machine:

The fabric machine has the following main features:

- Circular machines, knitting tubular fabric in a continuous uninterrupted length of constant width.

- Large diameter, latch needle machines, knit fabric at high speed (also known as yard goods or piece goods machines).
- The fabric is manually cut away from the machine; usually in roll form, after a convenient length has been knitted.
- Most fabric is knitted on circular machines, either single-cylinder (single-jersey) or cylinder and dial (double-jersey), of the revolving needle cylinder type, because of their high speed and productive efficiency.
- Sinker wheel and loop wheel frames could knit high quality specialty fabrics, with bearded needles, although circular machines employing bearded needles are now obsolete. The production rates of these machines were uncompetitive.
- Unless used in tubular body-width, the fabric tube requires splitting into open width.
- The fabric is finished on continuous finishing equipment and is cut-and-sewn into garments, or it is used for household and technical fabrics.
- The productivity, versatility and patterning facilities of fabric machines vary considerably.
- Generally cam settings and needle set-outs are not altered during the knitting of the fabric.

Garment-length machines:

The garment-length machine has the following main features:

- They include straight bar frames, most flats, hosiery, leg wears and glove machines, and circular garment machines including sweater strip machines.
- They knitting garment-length sequences, which have a timing or counting device to initiate an additional garment-length programming (collectively termed "the machine control") mechanism. This co-ordinates the knitting action to produce a garment-length structural repeat sequence in a wale-wise direction. The garment width may or may not vary with in the garment length.
- They are coarser gauge machine than fabric machines.
- It automatically initiates any alteration to the other facilities on the machine needed to knit a garment-length construction sequence instead of a continuous fabric.
- The machine control may have to initiate correctly-timed changes in some or all of the following:

  Cam-settings, needle set-outs, feeders and machine speeds.

- It must be able to override and cancel the effect of the patterning mechanism in rib borders and be easily adjustable for different garment sizes.
- The fabric take-down mechanism must be more sophisticated than for continuous fabric knitting.
- This take-down mechanism has to adapt to varying rates of production during the knitting of the sequence and, on some machines be able to assist both in the setting

up on empty needles and the take-away of separate garments or pieces on completion of the sequence.

- Garments may be knitted to size either in tubular or open-width; in the latter case more than one garment panel may be knitted simultaneously across the knitting bed.
- Large-diameter circular machines and wide Vee-bed flat machines can knit garment blanks that are latter split into two or more garment widths (blanket-width knitting).
- They produce knitwear, outerwear and underwear. Underwear may be knitted either in garment-length or fabric form, whereas knitwear is normally in garment-length form, which is a generic term applied to most weft knitted outerwear garments such as pullovers, jumpers, cardigans and sweaters, usually knitted in machine gauges coarser than E14. Jersey wear is a generic name applied to weft knitted fabric (single-jersey, double-jersey). It is cut and made-up from fabric usually knitted on large circular machines (26" or 30" diameter), although there are larger and smaller diameter machines used. Generally, gauges are finer than E14.

Plain or Single-Jersey Circular Latch Needle Knitting Machine:

Description of the machine:

Plain fabric is a single jersey fabric and is produced by one set of needle. Most of single – jersey fabric is produced on circular machines whose latch needle cylinder and sinker ring revolve through the stationary knitting cam systems, which together with their yarn feeders are situated at regular intervals around the circumference of the cylinder.

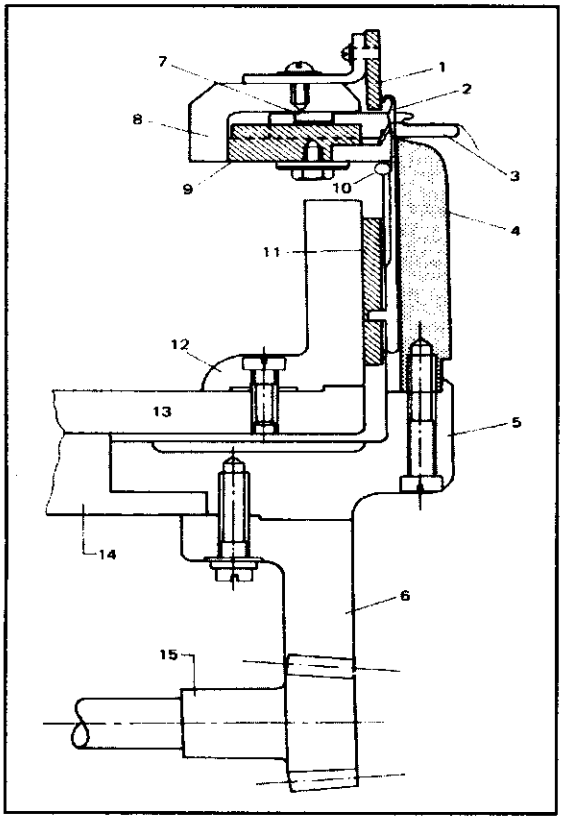
The yarn is supplied from cones, placed either on an integral overhead bobbin stand or on a free – standing creel, through tensioners, stop motions and guide eyes down to the yarn feeder guides. The fabric, in tube form, is drawn downwards from inside the needle cylinder by tension rollers and is wound onto the fabric batching roller of the winding down frame. The winding down mechanism revolves in unison with the cylinder and fabric tube and is rack – lever operated via cam – followers running on the underside of a profiled cam ring.

As the sinker cam – plate is mounted out side on the needle circle, the centre of the cylinder is open and the machine is referred to as an open top or sinker top machine. Compared with a rib machine, a plain machine is simpler and more economical with a potential of more feeders, higher running speeds and the possibility of knitting a wider range of yarn counts. The most popular diameter is 26" giving an approximate finished fabric width of 60" to 70".

An approximately suitable count may be obtained using the formula $N_e = \frac{G^2}{18}$, where N_e = cotton count or English system and G = gauge in npi. For fine gauges a heavier and stronger count may be necessary.

The following figure shows a cross-section of the knitting head all of whose stationary parts are shaded.

1. Yarn feeder guide which is associated with its own set of knitting cams.
2. Latch needle
3. Holding – down sinker, one between every needle space
4. Needle cylinder (in this case, revolving clockwise)
5. Cylinder driving wheel



6. Cylinder driving gear
7. Sinker operating cams which form a raised track operating in the recess of the sinker
8. Sinker cam – cap
9. Sinker trick ring which is simply and directly attached to the outside top of the needle cylinder thus causing the sinkers to revolve in unison with the needles
10. Needle retaining spring
11. Needle – operating cams which, like the sinker cams are stationary
12. Cam – box
13. Cam – plate
14. Head plate
15. Cylinder driving pinion attached to the main driving shaft.

Cam system:

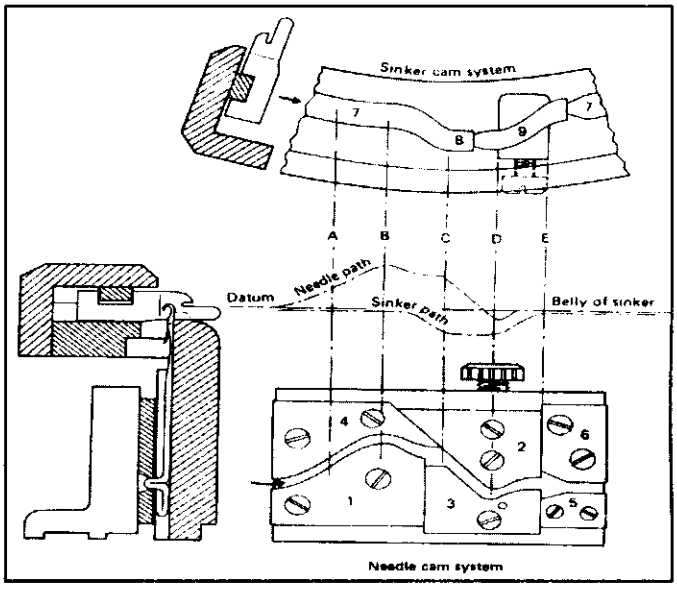
The cam system consists of needle cam system and sinker cam system. The following figure shows the arrangement and relationship between the needle cams and sinker cams as the

elements pass through in a left to right direction with the letters indicating the positions of the elements at the various points in the knitting cycle.

The needle cam race consists of the followings,

1. The clearing cam or raising cam
2. Stitch or lowering cam
3. Upthrow cam
4. Guard cam of clearing cam (1)
5. Return cam and
6. Guard cam of return cam (5)

Stitch cam (2) and upthrow cam (3) are vertically adjustable together for alteration of stitch length.



The sinker cam race consists of the followings,

7. The race cam
8. The sinker – withdrawing cam and
9. The sinker – return cam

The sinker – return cam is adjustable in accordance with the stitch length.

The arrangement of the knitting elements:

The following figures show the arrangement of the knitting elements and their combined action during stitch formation on a plain circular knitting machine. The figure (a) shows a perspective of a cylinder cam of a plain circular knitting machine as seen from outside; Figure (b) is a perspective of the related sinker cam as seen from above. In both the figures important needle and sinker (holding-down and knock-over version) positions during stitch formation are marked (position 1 to position 6).

The arrangement of the knitting elements can be seen in the figure (c). The cylinder needle 1 is housed and guided in a vertical groove 2 of a rotating cylinder. Its needle butt 4, extending into a cam track 5, is responsible for its vertical movement needed for stitch formation. The cam segments 6 and 7 are fixed to a stationary cylinder cam covering 8 and form the cam track. During the rotary movement of the cylinder the needle obtains its vertical movement depending on the shape of the cam track in figure (a). A sinker ring 9 is placed on the top part of the needle cylinder 3; it rotates with the cylinder. Holding-down or knocking-over sinkers 11 are housed in radial grooves 10 and they cross with the cylinder needles.

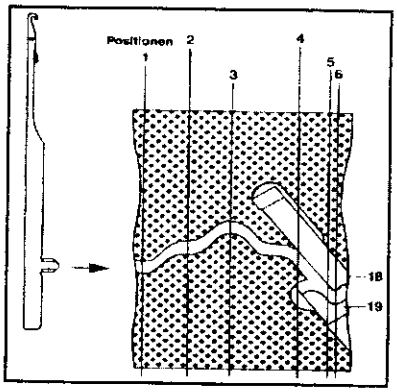


Figure – a

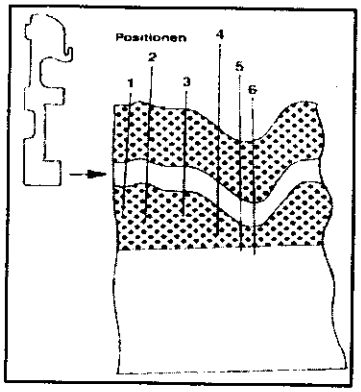


Figure – b

Position – 1 : Rest position, Position – 2 : Tucking – in position, Position – 3 : Clearing position
Position – 4 : Yarn presenting position, Position – 5 : Cast – on position, Position – 6 : Knock – over position

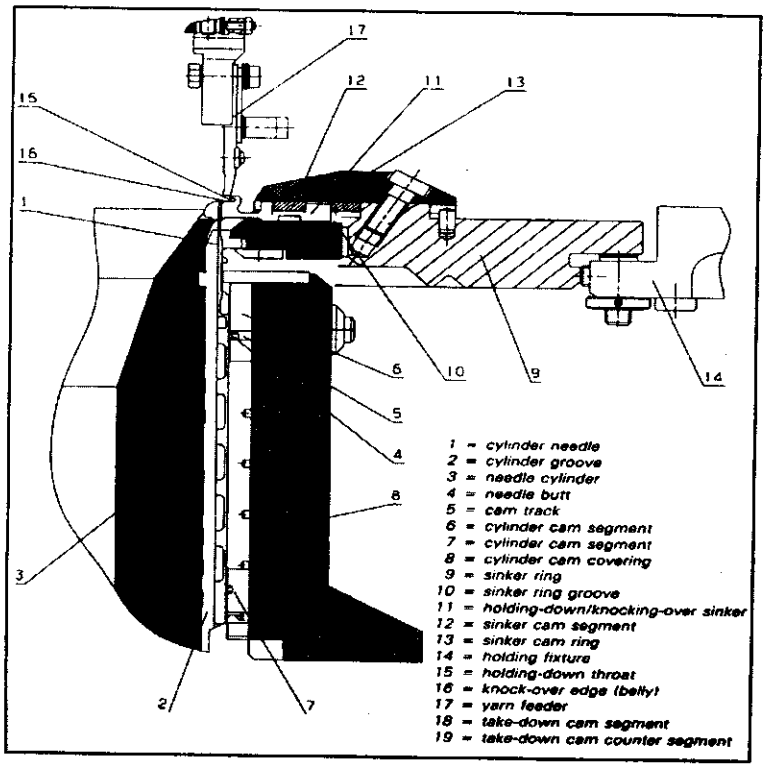
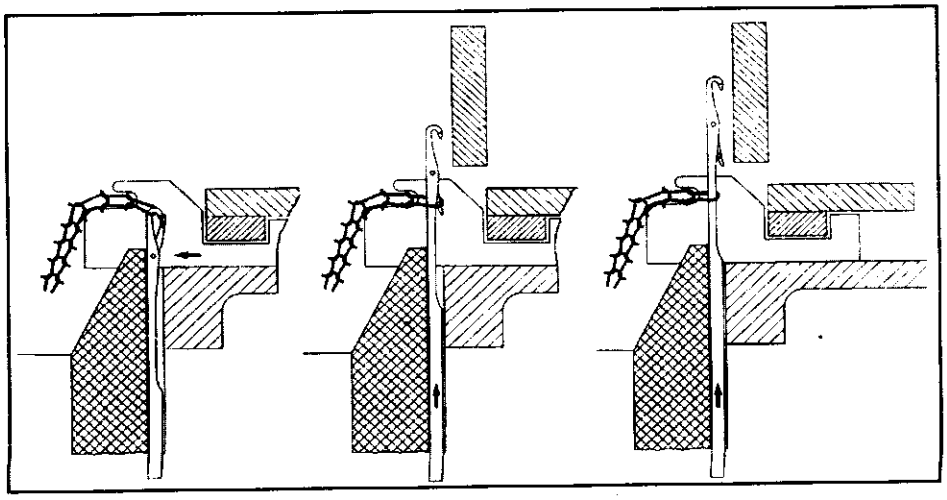
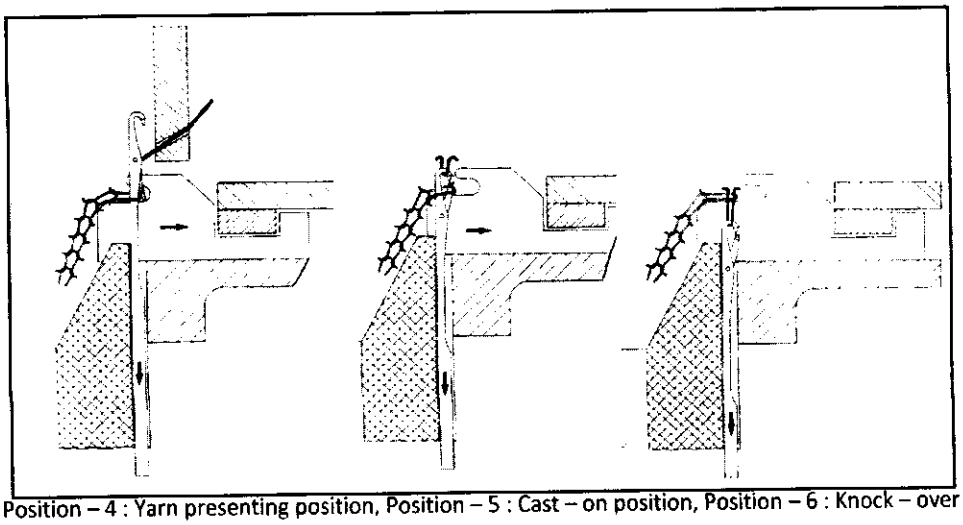


Figure – c

These sinkers obtained their movements for stitch formation by means of the sinker cam segment 12, which is fixed to a stationary sinker cam ring 13. In the construction shown, the sinker cam ring 13 is loosely housed on the sinker ring 9; the holding fixture prevents it from turning round. The sinker throat 15 of the holding-down or knocking-over sinker holds down the fabric when the needle is moved upwards. The stitches are knocked over at the knock-over edge 16. The feeder 17 presents the yarn to the needles.



Position – 1 : Rest or ground position, Position – 2 : Tucking – in position, Position – 3 : Clearing position



Position – 4 : Yarn presenting position, Position – 5 : Cast – on position, Position – 6 : Knock – over position

- Position – 1: The rest position is shown in the following figure. The top edge of the needle head is on level with the knock – over edge of the holding – down or knocking – over sinker. The latter has been moved towards the cylinder centre to such an extent, that its throat holds down the sinker loop of the kinked yarn loop, present in the needle head.
- Position - 2: This position is shown in the figure below. The needle has been moved upwards from its rest position, whereby the fabric was held down in the sinker throat.

The old loop has opened the needle latch and lies on it. The arrangement of the yarn feeder prevents the closing of the latch when the needle is moved further up. The sinker rests in this position.

- Position – 3: From the tucking-in position the needle has now been moved into its highest position. Since the fabric had been held down by the throat of the sinker, the old loop slides on the needle stem to a position beneath the latch. The yarn feeder prevents a closing of the latch. The sinker remains at rest.

- Position – 4: The needle is moved down from the clearing position. Just before the old loop begins to close the latch the new yarn must be laid into the needle head by the yarn feeder. In order that the latch can be closed by a further downward movement of the needle, yarn feeding must be completed immediately after crossing the yarn presenting position. In the figure, the sinker begins moving towards the right and away from the cylinder centre, since the fabric no longer needs to be held by the sinker throat. The vertical position of the needle is the same in the yarn presenting position and the tucking-in position. The fundamental difference, however, is that in the tucking-in position the old loop from the previous row lies on the needle latch, but is beneath the latch for stitch formation in the yarn presenting position.

- Position – 5: From the yarn presenting position the needle is moved further downwards by means of the take-down segment 18 along with the counter guide segment 19, figure (a). Now the needle latch is closed by the old loop and the new yarn is held in the closed needle head. The sinker has been moved into its extreme right position, so that the old loop lies on the knock-over edge and the new yarn can be pulled through the old loop.

- Position – 6: The needle is moved further downwards by means of the take-down cam segment 18 and the counter guide segment 19, figure (a) and it pulls the new yarn through the old loop. This is now knocked over as a new stitch. At the same time a loop is formed by the new yarn. The take-down segment 18 and the counter guide segment 19 can be shifted diagonally and be exactly set to given values with the help of a scale. Thus it is possible to precisely adjust the length of the newly formed loop.

Sinker Timing:

The most forward position of the sinker during the knitting cycle is known as the push point and its relationship to the needles is known as the sinker timing.

If the sinker cam ring is adjusted so that the sinkers are advanced to the point where they rob yarn from the new stitches being formed, a lighter-weight fabric with oversized sinker loops and smaller needle loops is produced.

If the ring is moved in the opposite direction a tighter, heavier fabric is produced having smaller sinker loops and larger needle loops. The timing is normally set between these two extremes.

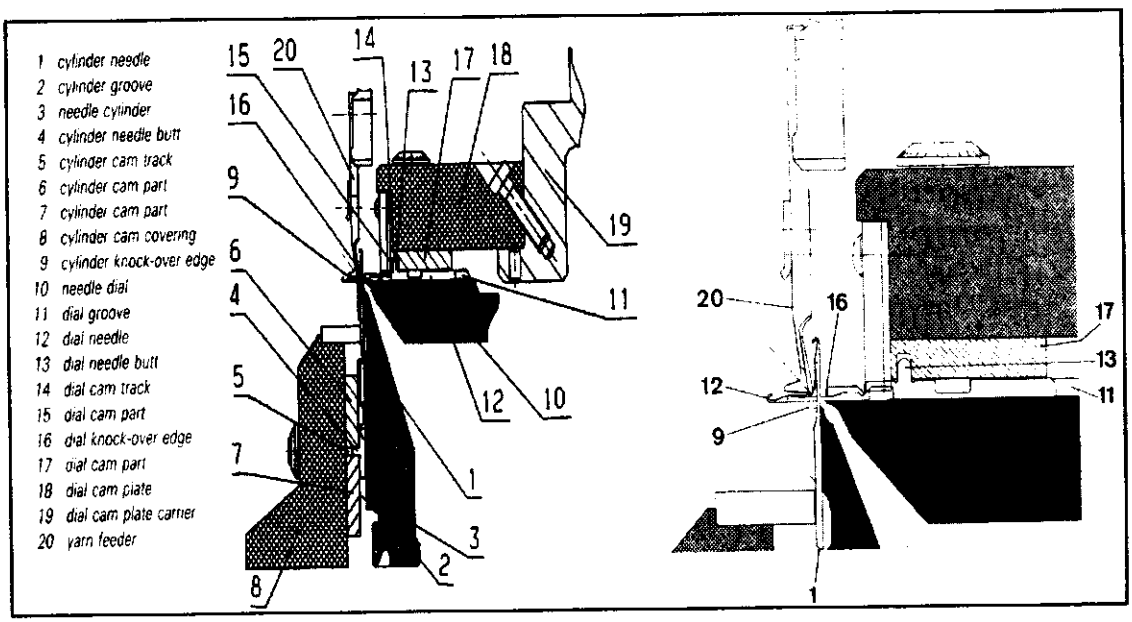
Rib Circular Knitting Machine:

Description of the machine:

In this machine group there is one set of needles on the circumference of a vertical cylinder and a second set of needles, arranged perpendicular to the first set and mounted on a horizontal dial. On most of the circular knitting machines the cylinder and dial rotate, whereas the cams with yarn feeder guides are stationary.

The following figure shows a cross-sectional view of the region containing the knitting elements of a rib (double knit) circular knitting machine. The set-up of the cylinder 3 with its knitting elements 1 to 9 is the same as with plain circular knitting machines. In a horizontal (rib) dial 10 grooves 11 are milled in. The latch needles 12 are housed and guided in these grooves. The dial needle 12 obtains its motion for stitch formation through its butt 13, which extends into a cam track 14. This cam track 14 is formed by the cam parts 15 and 17, which in turn are fixed to a dial cam plate 18. During the rotation of the cylinder and the dial the cylinder needle 1 is moved vertically and the dial needle 12 is moved horizontally, corresponding to the shape of the cam track in the cylinder and dial cams.

In a gauge range from 5 to 20 needle per inch (npi), an approximately suitable count may be obtained using the formula $N_e = \frac{G^2}{8.4}$, where N_e = cotton count or English system and G = npi.



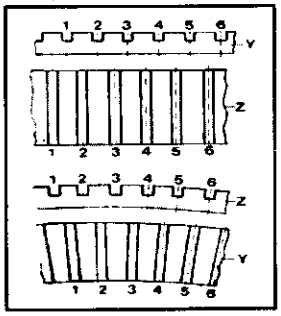
Needle gating or setting or Coordination between cylinder and dial grooves:

Depending on the coordination between the cylinder groove and the (rib) dial groove one differentiates between the rib setting for the production of double knit fabrics and the interlock setting for the production of double knit locked fabrics (interlock fabrics).

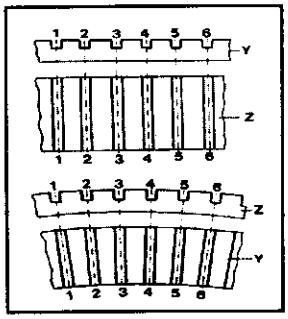
- **Rib gating:** The following figure shows this setting in a front view and in a top view. The grooves 1 to 6 of the dial (Y) and the grooves 1 to 6 of the cylinder (Z) are alternately arranged or gated. With this arrangement the cylinder and dial needles cross one another. In any given working point (feeder) all the cylinder and dial needles can be used. The majority of circular knitting machines work with a rib setting. They are generally called rib machines; those of them in the gauge range E14 to E20 are also called fine rib machines.

- **Interlock gating:** Front and top views of this setting or gating are shown in the figure below, whereas figure (with needles) illustrates it at an angle. In figure the grooves 1 to 6 of the dial (Y) are aligned directly opposite to the grooves 1 to 6 of the cylinder (Z). As such, the cylinder and dial needles are also directly one opposite to the other, figure (with needles). Therefore at any given working point (feeder), cylinder and dial needles opposite to one another can never work at the same time, because they would collide while being cleared, figure (with needles). Related to a working point (feeder), it is thus normal usage in interlock setting to work with

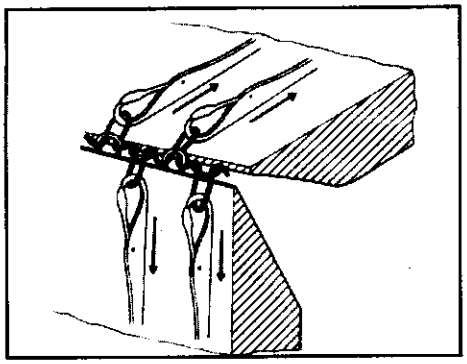
  - Dial needles in grooves 1,3,5,...
  - Cylinder needles in grooves 2,4,6,...
  - Dial needles in grooves 2,4,6,...
  - Cylinder needles in grooves 1,3,5,...
  - Dial needles only
  - Cylinder needles only.



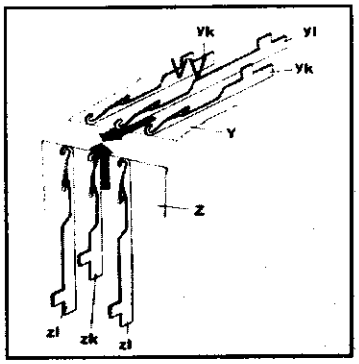
Rib gaiting for cylinder and dial on a rib circular knitting machine in front view (above) and top view (below)



Interlock gaiting for cylinder and dial on a rib circular knitting machine in front view (above) and top view (below)



Rib position of dial and cylinder needles



Interlock position of dial and cylinder needles

Working with an interlock setting therefore requires two sorts of needles in the cylinder and in the dial, and these have to be controlled and cleared independently. One sort of needle is normally present in the grooves 1,3,5,.. and the other needle sort in the grooves 2,4,6,... However, other needle combinations are also possible.

In figure (with needles) the needle types zl and zk in the cylinder (Z) and the needle types yk and yl in the dial (Y) have differently arranged needle butts. The distance between needle head and needle butt (working length) is not the same. One also refers to a short dial needle yk and a long dial needle yl or to a short cylinder needle zk and a long cylinder needle zl. The needle arrangement in figure (with needle) is such, that a long cylinder needle zl is directly opposite to a short dial needle yk and a short cylinder needle zk is directly opposite to a long dial needle yl. As a result, the short dial and cylinder needles are gated towards one another, and similarly the long dial and cylinder needles. At any given working point (feeder) one can work either with all the short needles or with all the long needles. Correspondingly, one also refers to a short or to a long feeder. Double knit (rechts – rechts) interlock machines are normally built as rib machines with finer gauges.

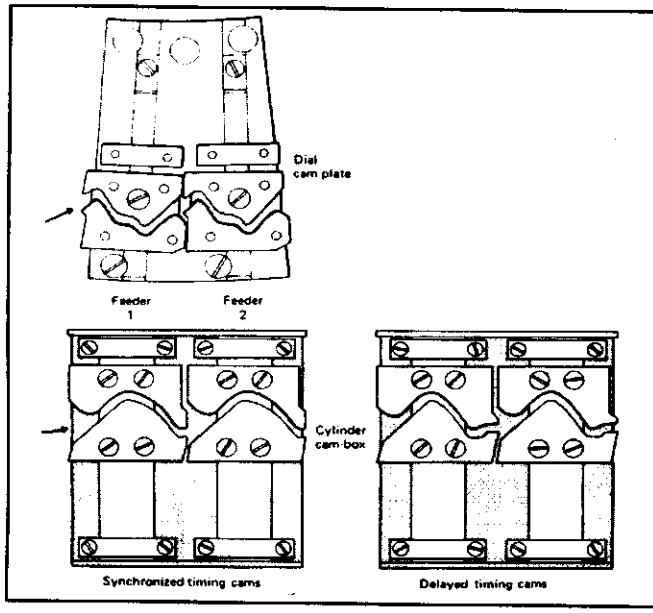
Conversion from Rib to Interlock gating:

As a rule rib machines can be converted into interlock machines when they have at least two different needle types both in the cylinder and in the dial, whereby these needles can be independently controlled. A clutch in the drive for the cylinder and the dial is used to turn either the cylinder or the dial over half a needle pitch, so that the cylinder and dial needles are directly opposite to one another. The working procedure at any given feeder is now the same as in the usual interlock setting. Theoretically, interlock machines can also be converted into rib machines in the same manner. Interlock machines are however normally in a finer gauge range. When cylinder and dial needles cross one another in rib setting, there would be very little space in between, and this could lead to strain and damage of yarns. Generally double knit (rechts – rechts) circular knitting machines with an interlock setting have gauges finer than E24.

Needle Timing or Coordination between cylinder and dial cams:

Needle timing is the position of the dial needle knock-over point relative to the cylinder needle knock-over point measured as a distance between the knock-over points of the two lowering cams, i.e. the cylinder and dial stitch cams, in needles. Collective timing adjustment is achieved by moving the dial camplate clockwise or anti-clockwise relative to the cylinder, individual adjustment at particular feeders as required is obtained by moving or exchanging the stitch cam profile. Depending on the coordination between the cylinder and dial cams, one differentiates between synchronized timing (also known as point, jacquard or 2×2 timing) and delayed timing (also referred to as rib or interlock timing).

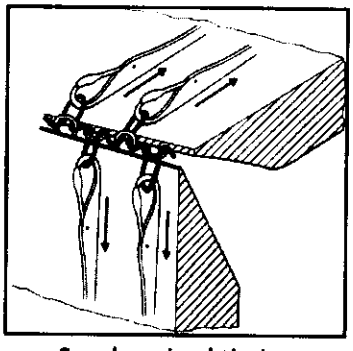
Needle timing influence the appearance, the quality and properties of the fabric produced on a rib circular knitting machine.



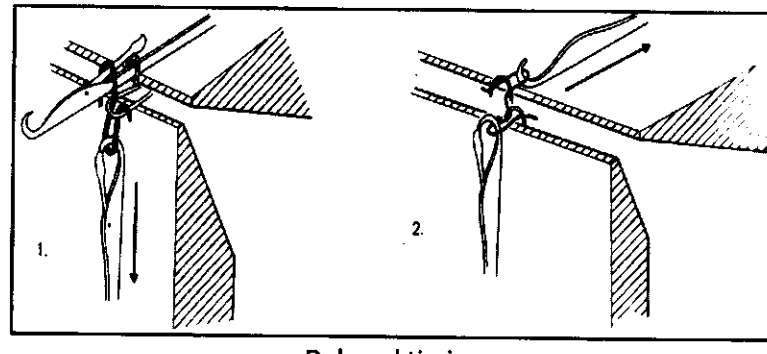
Synchronized timing:

The cylinder and the dial needles knock-over their knitted loops at the same time. It is the term used when the two positions coincide with the yarn being pulled in an alternating manner in two directions by the needles thus creating a high tension during loop formation.

In this case the important things that "the knocking-over depth of the cylinder needles is equal to the knocking-over depth of the dial needles.



Synchronized timing



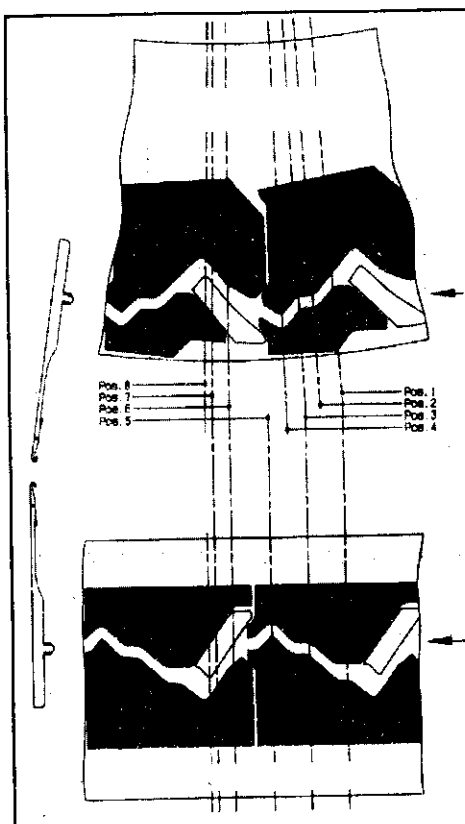
Delayed timing

When this timing is used the cylinder and dial needles are pulled in the same position. The knocking-over position is attained at the same point by the cylinder and dial needles. Synchronized timing can be used on all machines and for all rib and interlock knitted structures except:

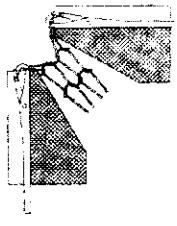
- Those with laid-in yarns
- Simultaneous tucking at cylinder and dial needles
- Rib and interlock based pile fabrics.

Structures knitted using synchronized timing will be loose and consist of uneven stitches.

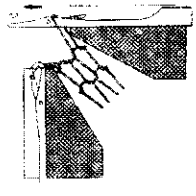
The following figures illustrate the phases of stitch or loop formation on a rib circular knitting machine working with synchronized timing.



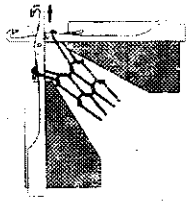
Cylinder and dial cams of a rib circular knitting machine in synchronous timing of cylinder and dial cams, seen from outside (perspective)
Pos. 1 Rest position
Pos. 2 Tucking position of dial needle
Pos. 3 Tucking position
Pos. 4 Clearing position of dial needle
Pos. 5 Clearing position
Pos. 6 Yarn presenting position
Pos. 7 Cast-on position
Pos. 8 Knock-over position



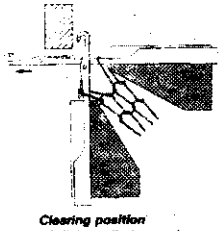
Rest position in synchronous timing, Pos. 1



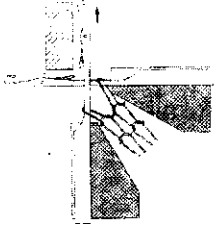
Tucking position of dial needle in synchronous timing, Pos. 2



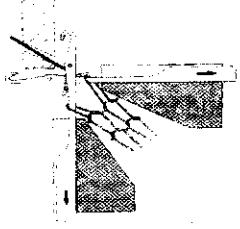
Tucking position in synchronous timing, Pos. 3



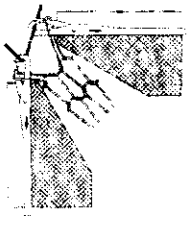
Clearing position of dial needle in synchronous timing, Pos. 4



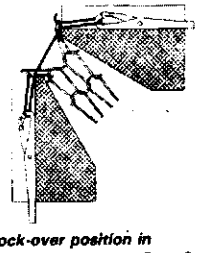
Clearing position in synchronous timing, Pos. 5



Yarn presenting position in synchronous timing, Pos. 6



Cast-on position in synchronous timing, Pos. 7



Knock-over position in synchronous timing, Pos. 8

Delayed timing:

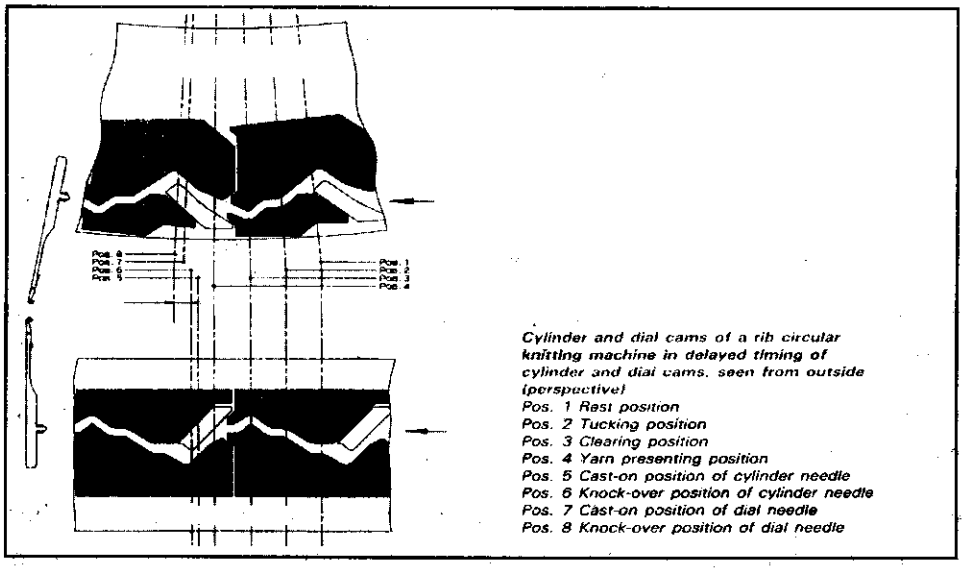
The dial needles knock-over their knitted loops later than the corresponding cylinder needles. With delayed timing the dial knock-over occurs after about four cylinder needles have drawn loops and are rising slightly to relieve the strain. The dial loops are thus composed of the extended loops drawn over the dial needle stems during cylinder knock-over, plus a little yarn robbed from the cylinder loops. The dial loops are thus larger than the cylinder loops and the fabric is tighter and has better rigidity, it is also heavier and wider and less strain is produced on the yarn. So the advantages of using delayed timing as follows:

- Tight structure
- Evenly formed stitches
- Good rigidity
- Heavier and wider fabric
- Less strain on the yarn during the stitch formation
- Longer dial stitches compared to cylinder stitches.

The knocking-over depth of the cylinder needle must be k times the knocking-over depth of the dial needle, where k = 1.2 .....1.5.

Rib jacquard or broad ribs cannot be produced in delayed timing because there will not always be cylinder needles knitting either side of the dial needles from which to draw yarn. Although the dial knock-over is delayed, it is actually achieved by advancing the timing of the cylinder knock-over.

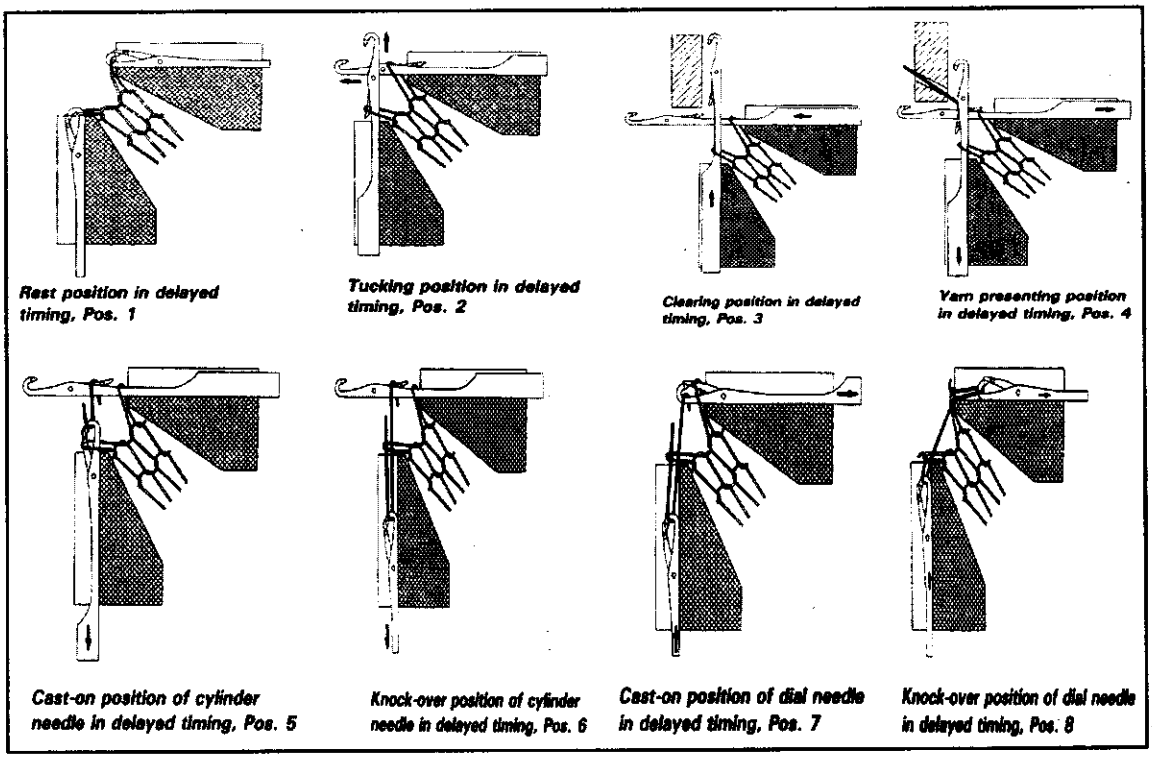
When this timing is set, the dial needles knock over their loops later than the cylinder needles lying opposite to them. Based on the synchronous timing, the dial camplate is moved in the direction of rotation of the machine over a distance equaling about five to six needle pitches.



Cylinder and dial cams of a rib circular knitting machine in delayed timing of cylinder and dial cams, seen from outside (perspective)
Pos. 1 Rest position
Pos. 2 Tucking position
Pos. 3 Clearing position
Pos. 4 Yarn presenting position
Pos. 5 Cast-on position of cylinder needle
Pos. 6 Knock-over position of cylinder needle
Pos. 7 Cast-on position of dial needle
Pos. 8 Knock-over position of dial needle

The bove figure shows a cylinder and a dial cam set for delayed timing. The knock-over point of the dial needles, position 8, is shifted in the direction of rotation of the machine over the distance corresponding to the delayed timing, in relation to the knock over point of the cylinder needles, position 6. On a circular knitting machine set for delayed timing only such fabric types can be produced, where all the cylinder needles work in each feeder. If fabrics are produced using only every second cylinder needle, knitting can be carried out in an intermediate position. For this purpose the knock-over point of the dial needles is shifted over just two or three needle pitches with regard to the knock-over point of the cylinder needles. As a rule, knitting with delayed timing results in fabrics with a more even loop appearance as compared to synchronous timing.

The following figures show the various stitch formation phases of a rib circular knitting machine with delayed timing. They differ to some extent as compared to synchronous timing.



Stitch or loop formation of Rib circular knitting machine with delayed timing

Position – 1: The rest position for the cylinder and dial needles. The heads of both these needles are in the area of the corresponding knock-over edges of the cylinder and the dial.

Position – 2: The dial and cylinder needles move more or less simultaneously into their tucking positions, as can be seen in the above figure, position 2.

Position – 3: After the latches of the dial and cylinder needles have been opened in the tucking position, the yarn feeder comes into action in circumferential direction; its task here is to

prevent a premature closing of the latches. The cylinder and dial needles attain their clearing positions, above figure, position 3, roughly at the same time.

Position – 4: The cylinder and dial needles are pulled back again and they move into their yarn presenting positions. The newly presented yarn is laid in the open needle hooks of both the needles, above figure, position 4.

Position – 5: Since the dial cams have been shifted in the direction of rotation of the machine the cylinder needles are pulled earlier than the dial needles. The cylinder needle loop closes the latch and lies on the closed head of the cylinder needle. The dial needle is approximately in its yarn presenting position, above figure, position 5. The yarn feeder stops prior to the cast-on position, so that the cylinder needle latch can be closed.

Position – 6: The cylinder needle is pulled further until it reaches its lowest point in the clearing position, as shown in the above figure, position 6. The dial needle is still roughly in its yarn presenting position. The newly presented yarn is pulled through the cylinder needle loop to form a new loop. The old loop is knocked over as a cylinder stitch. The length of this new cylinder loop determines the length of the cylinder and dial stitches to be formed later, since the dial needle can obtain yarn only from the neighbouring cylinder loops during knock-over. Therefore the drawing-in depth of the cylinder needle is set somewhat longer in delayed timing as compared to synchronous timing.

Position – 7: The dial needle is now pulled back and it moves into the cast-on position, above figure position 7; the loop lies on the closed latch of the dial needle. From its knock-over position the cylinder needle now begins to move upwards in the direction of its rest position.

Position – 8: In this position, the dial needle attains its knock-over position, while the cylinder needle is still approaching its rest position. Here the drawing-in depth of the dial needle must be sufficiently measured so that the dial needle can form a loop out of the yarn lengths of the cylinder loops, drawn in earlier by the neighbouring cylinder needles in their knock-over positions, position 6. A closer examination reveals that, while being pulled back, the dial needle draws in more yarn from the cylinder loop placed contrary to the direction of machine rotation, as compared to the other neighbouring cylinder loop, since the latter has already given up a part of its yarn reserve to the previously formed dial loop.

Due to the delayed knock-over of the dial needle one obtains more uniform stitch lengths, since the given yarn length, determined by the drawing-in depth of the cylinder needle, is evenly distributed over several stitches. This results in a more even appearance of the fabric. After the knock-over position the dial needle is guided into its rest position.

Advanced timing:

This is reverse of delayed timing in that the cylinder loops rob from the dial producing tighter dial loops, advancement can only be about one needle, this type of timing is sometimes used in the production of figured ripple double jersey fabrics where selected cylinder needles can rob from the all knitting dial needles.

Interlock Circular Knitting Machine:

Main features of Interlock machine:

Interlock is produced mainly on special cylinder and dial circular machines and on some double-system Vee-bed flat machines. An interlock machine must fulfill the following requirements:

- Interlock gating, the needles in two beds must be exactly opposite to each other so only one of the two can knit at any feeder.
- Two separate cam systems in each bed, each controlling half the needles in an alternate sequence, one cam system controls knitting at one feeder and the other at the next feeder.
- The needles are set out alternately, one controlled from one cam system the next from the other, diagonal and not opposite needles in each bed knit together.

The conventional interlock machine has needles of two different lengths, long needles knit in one cam-track and short needles knit in a track nearer to the needle heads. Long needle cams are arranged for knitting at the first feeder and short needle cams at the second feeder. The needles are set-out alternately in each bed with long needles opposite to short needles. At the first feeder long needles in cylinder and dial knit, and at the second feeder short needles knit together, needles not knitting at a feeder follow a run-through track. On modern interlock machines the needles are of the same length.

The knitting action or Stitch formation or Loop formation of Circular Interlock Machine:

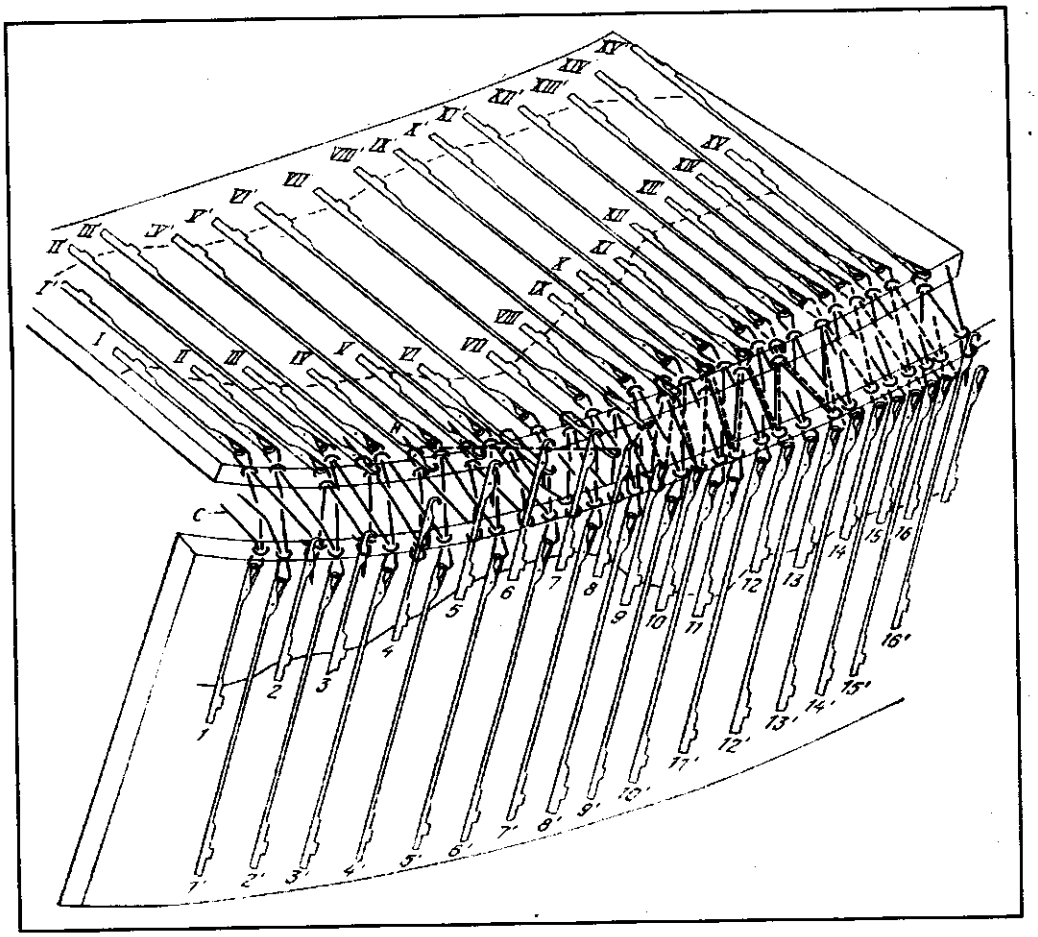
A very popular variant of a circular two needle-bed machine is the interlock machine. In the interlock machines, the consecutive loop-forming process is effected with distribution. In this case, the needles of both beds (systems) operate consecutively and then after a certain delay on the passive needle bed (dial). The active needle bed is that which receives the yarn for forming loops from the yarn carrier.

The following figure illustrates the loop forming process in the interlock machine where short cylinder needles are designated with 1,2,3, and so on; the long cylinder needles are designated with 1',2',3' and so on; short dial needles with I,II,III and so on; long dial needles with I',II',III' and so on; old loops with C and the new thread with N.

Upon reaching its extreme top position for clearing, the cylinder needle 7 starts moving down, as it must receive the yarn which is being laid. In the course of this operation, the loops of the cylinder and the dial needles shift from the needle latches onto their stems.

The dial needle VII, which has effected clearing, retreats backwards just enough to bring the old loop which it carries under its hook. The needle 8 receives a new loop, while the needle VII remains at dwell. The needle 9 is shown in the moment when pressing is effected and needle 10 during the operations of joining, casting-off and at the beginning of loop forming. The new loop formed of oncoming yarn lies on the stem of the dial needles X and XI. At the same time of

loop forming on the interlock machines, the sinker loops of new loops are disposed on the dial needles X and XI, rather than on the knock-over teeth.



The needle XI effects landing over and the needles 12 and 13 lift, and as a result, the loops formed by these needles are released. The needles XII and XIII thus acquire the possibility of forming new loops by robbing the yarn from the released loops. So, for instance, the needle XII starts forming a new loop by reducing the new loop of the needle 12. The needle 13 and 14 continue their upward motion. While the needles XIII, XIV from their loops, the needles 15 and XV have already formed new loops. A full loop course on the interlock machine is formed by two knitting feeders.

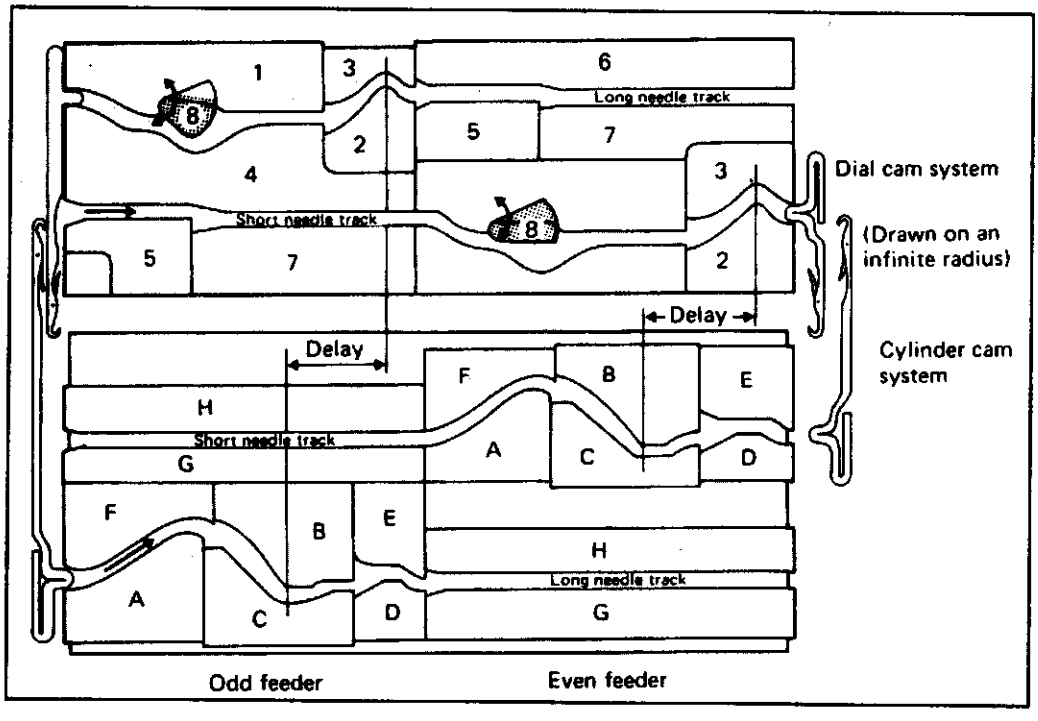
Interlock Cam System:

The cam system consists of cylinder needle cam system and dial needle cam system. The following figure shows the necessary cylinder and dial needle camming to produce one course of ordinary interlock fabric which is actually the work of two knitting feeders. In this example the dial has a swing tuck cam which will produce tucking if swung out of the cam-track and knitting if in action.

Cylinder cam system: The cylinder needle cam system consists of the followings,

- A, is a clearing cam which lifts the needle to clear the old loops.
- B and C, are the stitch and guard cams respectively and are vertically adjustable for varying stitch length.
- D, is a upthrow cam, to raise cylinder needle whilst dial needle knocks over.
- E and F, are the guard cams, to complete the track.
- G and H, provide the track for the idling needles.

Dial cam system: The dial needle cam system consists of the followings,



- 1, is a raising cam to the tuck position only.
- 2 and 3, are the adjustable dial knock-over cams.
- 4, is a guard cam to complete the track.
- 5, is an auxiliary knock-over cam to prevent the dial needle re-entering old loop.
- 6 and 7, provide the track for the idling needles.
- 8, is a swing type clearing cam, which may occupy the knitting position as shown at feeder 1 or the tuck position as shown at feeder 2.

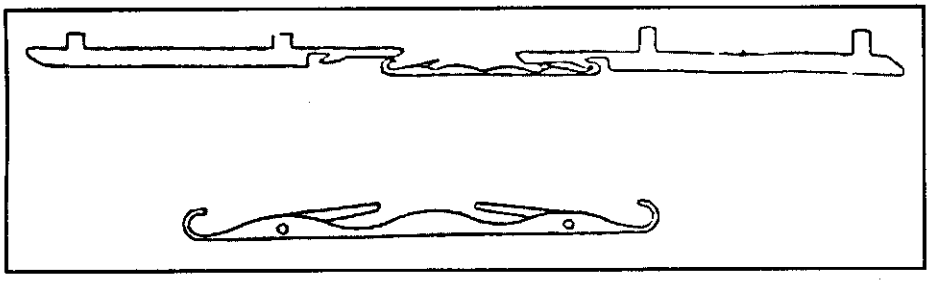
Interlock thus requires eight cam systems or locks in order to produce one complete course, two cam systems for each feeder in each needle bed. Basic cylinder and dial machines and flat-machines having this arrangement are often referred to as eight-lock machines.

Links-Links or Purl Knitting Machine

Stitch formation or loop formation on a purl knitting machine:

Links is the German word for left and it indicates that there are left or reverse loops visible on each side of the fabric. In a similar manner, the German term for rib is rechts-rechts (right-right).

The following figures show the main loop-forming elements are two headed latch needles and needle sliders.



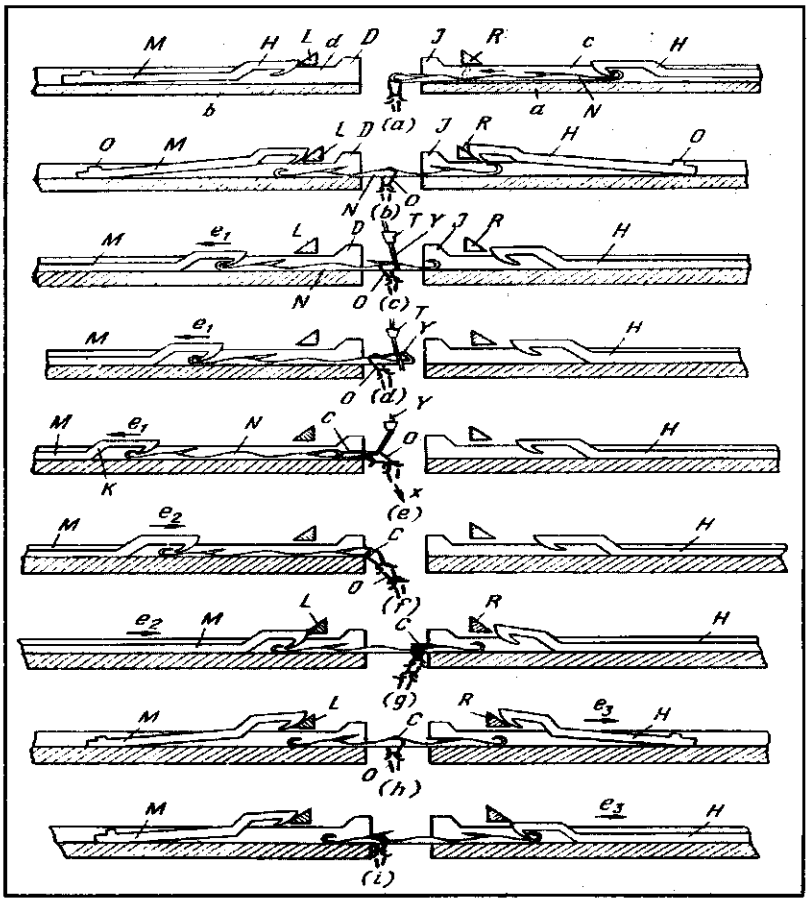
Double headed latch needle and Slider

In flat links-links machines, the double headed latch needles are arranged in slots formed either by grinding or by inserting tricks c and d in the following figure (a) into special slots of the needle beds a and b. The needles may pass from the slot of one needle bed into the slot of the other, as these slots are disposed one opposite the other. The ribs of the partitions c and d have teeth D and J which form a knock-over bar.

Two sliders M and N correspond to each needle. The slider M can engage the needle's left head, while the slider N can engage the right head of the needle, and displace it in a longitudinal direction. The figure (a) shows that the slider N is engaged with the needle's right head. On the movement of the needle from right to left, the needle latch opens and the loop is transferred to the middle of the needle, as shown in the figure (b).

On the forward movement of the sliders, their heads raise the bosses L and R and both sliders disengage with the needle. The slider which is first to begin its backward motion lowers and engages the needle head. As shown in the figure (c), the slider M, upon engagement with the needle's left head, moves the needle in the direction of the arrow e_1, while the slider N remains free.

The yarn Y is laid on the right head of the needle. At the time of yarn laying onto the needle, the same conditions must be satisfied as when knitting in single-bar machines, i.e. the yarn must get under the needle hook at yarn drawing and must not be intersected by the needle latch at the moment of pressing. On the movement of the needle along the arrow e_1 in the figure (d), the old loop O is retained by the knock-over teeth and closes the needle latch. The following figures (c) and (d) illustrate the operations of yarn laying, underlapping, or drawing and pressing on the needle's right head.



The operations of landing, joining, casting-off and loop formation are carried out by the further motion of the needle along the arrow e_1 in the above figure (e). After a new loop c is formed the slider M starts moving from left to right in the direction of the arrow e_2, displacing the needle in the same direction. The hook of the slider M then disengages from the needle's left hook in the above figures (f),(g),(h), and simultaneously clearing the loop c in respect to the needle's right head takes place in figure (h). On further displacement of the slider N in the direction of the arrow e_3, it engages the needles right head in figure (i). In this case, the new loop will be formed by the needle's left head, and it will cast off its old loop to the left side of its wale.

Thus, when the loop-forming process is effected by the left heads of the needles, the loops are cast off to the left side, while when the loop-forming process is effected by the right heads – the loops are cast off to the right side, owing to which a purl stitch is obtained.

To avoid breakage of needles at their transfer from one needle bed to the other, the machines are provided with latch openers which is not shown in the above figure.

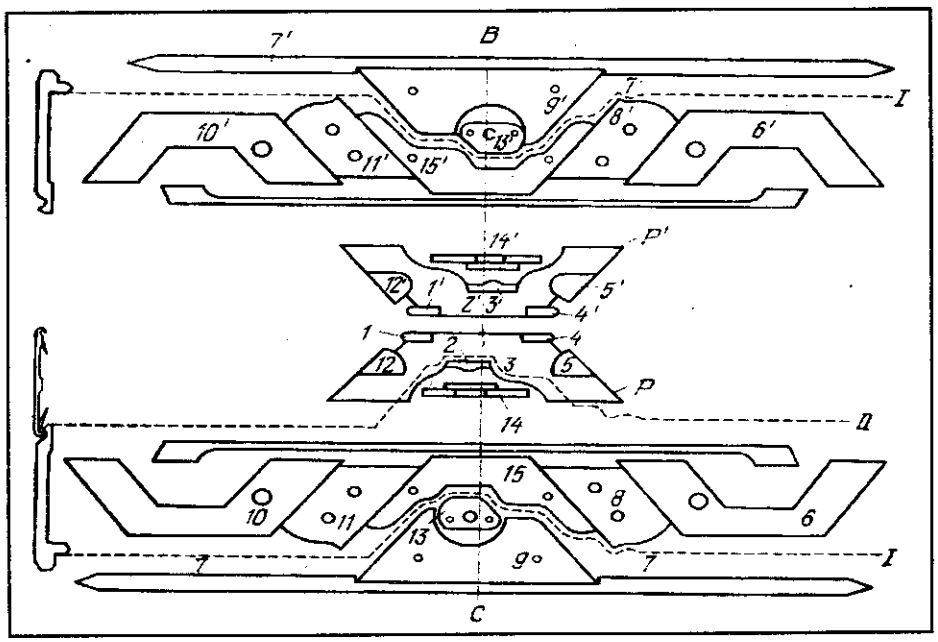
If, after the formation of a course of loops in one needle bed, the following course of loops is formed on the other needle bed, a reverse jersey is obtained with a repeat of $R_H = 2$ (R_H = height of the repeat). If two courses of loops are formed on the same needle bed, and the next

two other courses on the other needle bed, then a reverse stitch is obtained in which two face courses alternate with two reverse courses. The repeat of this knit will be $R_H = 4$.

Links-Links Cam System:

The cam systems of a flat links-links machine are illustrated in the following figure. They consist of the following cams: the pointers 7 and 7′ by means of which the sliders are directed to the big central cams 9 and 9′; the top or clearing movable central cams 13 and 13′ serving to effect clearing and needle transfer from one needle bed to the other; the guide cams 6,6′ and 10,10′ bringing the sliders in operation position; the stationary top central cams 15 and 15′, limiting the upward movement of the sliders and lowering them after the lift; the switch cams 8, 11 and 8′, 11′ and the bridges P and P′.

The bridge has the following parts: cams for raising the sliders 2 and 2′; the lowering cams 14 and 14′, which press the sliders at the moment of their engagement with the needles; the latch openers 1, 1′ and 4, 4′; the big bosses 3 and 3′, impeding the needle's independent lifting at the moment of their engagement and disengagement with the sliders; the small bosses 5, 12 and 5′, 12′, supporting the needles at the moment when the latch openers come in action.



The heads of sliders in both needle beds lift at different moments: the receiving sliders are the first to rise and the first to lower. Correspondingly the sections of the bridge 2, 2′ and 14, 14′ as well as the clearing cams (central cams) 13, 13′ are somewhat displaced in relation to each other.

As the knitting carriage moves from left to right, the back slider rises sooner than the front one to engage the needles. This is the receiving slider and the needles pass from the front needle bed to the back one. The needle transfer from the back needle bed to the front one takes place during the movement of the knitting carriage from right to left.

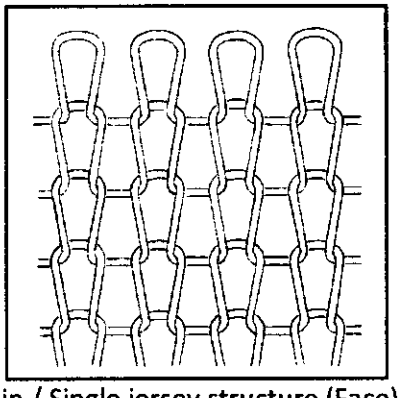
BASIC WEFT KNITTED STRUCTURES

All weft knitted structures are classified into four basic groups according to the arrangement of loops in their courses and wales. Four primary structures plain, rib, purl and interlock are the base structures from which all weft knitted fabrics are derived. The main properties of these structures are described in this area.

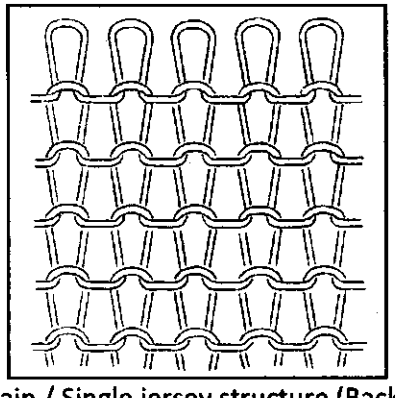
The plain knit structures or plain fabric:

The simplest and most basic structure is the "plain knit" which is also called "single knit". Plain is a knit structure family, which is produced by the needles of only one set of needle with all the loops intermeshed in the same direction. Although the plain knit family encompasses a great number of structures all produced on a single needle bed, its general characteristics are described as follows:

a. **Appearance:** The fabric is unbalanced, because each side of the fabric exhibits a different appearance. Within each side, the loops on all courses and wales are identical. Each side of the fabric is made of a single type of loop i.e. either face or back (reverse). The top and bottom of each loop occurs on the fabric back and the centre (legs) of the loop appears on the fabric face. So the face of the fabric is smooth and shows the side limbs of the loops as a series of interlocking "V"s. The reverse is rough and looks like columns of interlacing semicircles.



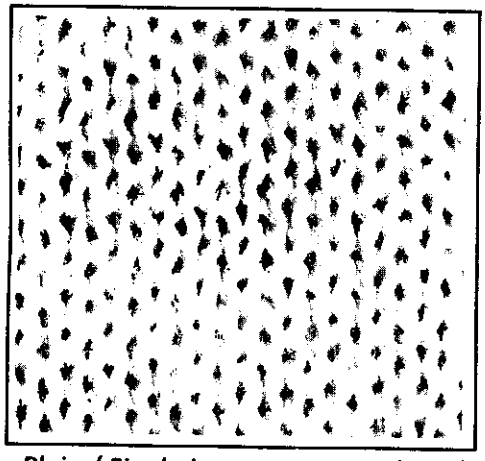
Plain / Single jersey structure (Face)



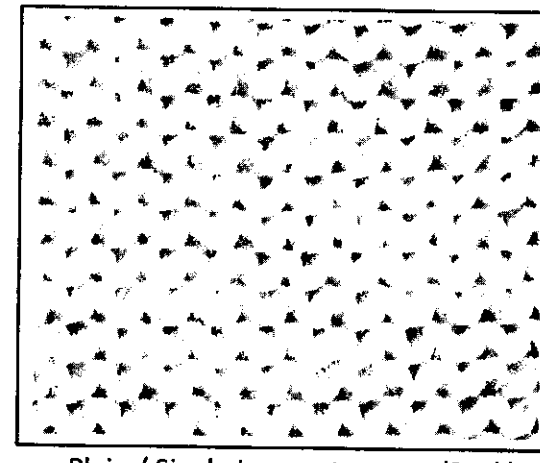
Plain / Single jersey structure (Back)

b. **Extensibility:** The fabric is stretchable although not always elastic. Usually, the fabric can be stretched much more in the width then in the length. The fabric is extensible in a course wise direction and in a wale wise direction. However, the degree of extensibility is different when pulled top to bottom from when pulled

side to side. The course wise extension is approximately twice that of the wale wise extension due to the degree of constraint imposed on each loop by its intermeshing. The loop pulled vertically extends by half its length ½ l, while the loop pulled horizontally extends by its whole length, l. The degree of recovery from stretch is not a property of the construction but depends on the nature of the raw material and yarn construction. It normally has a potential recovery of 40% in width after stretching.



Plain / Single jersey structure (Face)



Plain / Single jersey structure (Back)

c. **Edge curling:** This fabric curls at the edge when the fabric after cut in relax state. It has a tendency to curl towards the back at the sides and towards the front at the top and bottom. The difference in construction between the two faces causes stress in the structure so that the fabric tends to curl. The loop arms (face) exert a length wise stress that curls the top and bottom edges of the fabric towards the face. The needle and sinker loops which are on a horizontal plain, pull the sides of the fabric and curl them towards the reverse side of the fabric. Pressing or other heat / water processes are used to minimize or eliminate such curling which is caused by the directionality of the loop formation.

d. **Unroving:** The plain knit structure can be easily unravelled from the edge which was knitted last. This selvedge is the top edge when the fabric is held upright, as produced on the knitting machine. In contrast to other knit families, the plain knit construction is symmetrical and can also be unravelled from the edge knitted first. This edge is at the bottom when the fabric is held upright. So the plain fabric can be unroved (unravelled) from either end. The ability of the structure to unravel from both edges is demonstrated in figure (Raz. 52). Note that this ability is limited to the most basic structures of the plain family when no special loop types are incorporated.

e. **Laddering:** If a stitch is dropped during the knitting or at a later stage, a chain reaction may occur in which the following loops in the same wale will drop in

succession and a "ladder" will form. It is a fault but we consider it as properties. We mending (repair) it by manually with single needle. Since the fabric is symmetrical it might ladder vertically towards the bottom or the top. It must be appreciated that the tendency of the structure to curl, unravel and ladder is greater if the fabric is slack. The unraveling and laddering tendencies are also more severe when the fabric is made of smooth yarns.

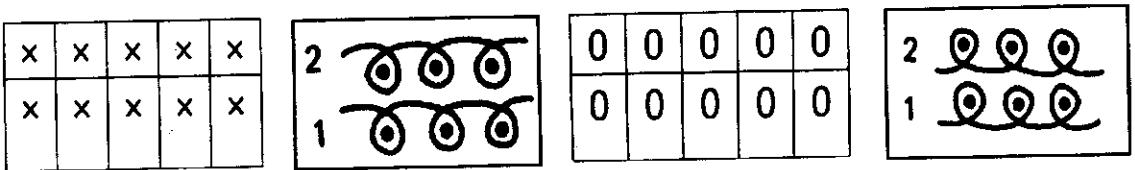
This structure has the maximum covering power. Plain fabric is the commonest weft knitted fabric and is produced by widely different sorts of knitting machinery in all forms from circular fabric piece goods to fully-fashioned panels. It is the base structure of ladies hosiery, fully-fashioned knitwear and single jersey fabric.

End uses of plain knit structures:

Plain knit structures are used for basic T-shirt, under garments, men's vest, ladies hosiery, fully-fashioned knitwear etc.
End use depends on some factors such as material used; yarn types and yarn count / linear density; machine gauge; fabric thickness and weight; types of finishing etc.

Notation of plain knit structure:

The following figure shows the symbols of one popular method used in many countries around the world. In this system an "x" symbol represents a face loop and an "o" is used to represent a reverse loop.



Face loop Reverse or back loop

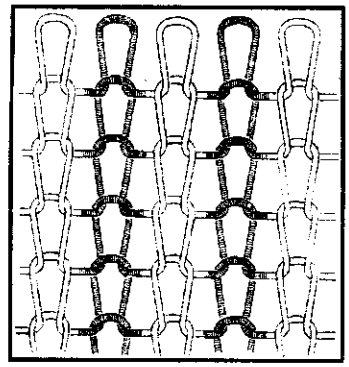
The Rib Structure or Rib Fabric:

Rib, also called "Double-knit" is the second family of knit structures. Rib requires two sets of needles operating inbetween each other so that wales of face stitches and wales of back stitches are knitted on each side of the fabric. Rib fabrics are knitted on machines with two sets of needles. These needles are arranged in such a way as to allow them to intermesh when raised, and this needle arrangement is called rib gaiting. Flat machines with two sets of needles arranged in this way are usually called "V" beds because from the side they look like an inverted "V". The needle beds are called the front and the back beds. Circular machines with two sets of needles have a dial and cylinder. The cylinder needles are arranged vertically round the machine and are the equivalent of the flat machine's front bed. The dial needles are arranged horizontally inside the cylinder and are the equivalent of the flat machine's back bed.

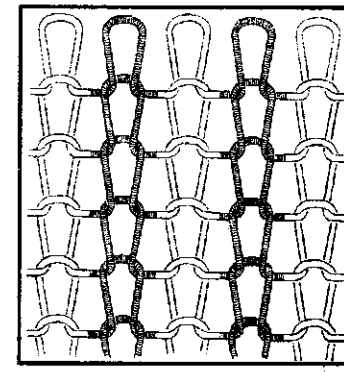
Many types of rib structures can be produced according to the arrangement of active needles in the front and back needle beds. The simplest rib structure is the 1×1 rib. To knit this structure, all the needles in both needle beds are active. The arrangement of the needles, each positioned in between two from the opposite bed and a sequential movement, ensure that the loops are produced alternately, one towards the front and one towards the back. When every third needle is inactive and is positioned between two active needles on the opposite bed the 2×2 rib fabric is formed.

The general characteristics of the rib structure family are as follows:

a. **Appearance:** Same appearance in both sides of the rib fabric. Both sides of the fabric will show face loops since the fabric is produced on the needles of both needle beds. Taken off the needles, the fabric contracts immediately in a widthwise direction. The rear or back loops which can normally seen between the front wales when the fabric is extended, will be hidden. The fabric looks as if it is made only of face loops on both sides, hence such names as right / right, Double face or Double knit. Each wale in the fabric is uniform i.e. made of a single type of loop, either face or reverse. On each side of the fabric there are face and reverse wales. The arrangement is alternate in 1×1 rib and different in various other rib structures. The fabric usually being symmetrical on both sides, is not subjected to unbalanced stresses.



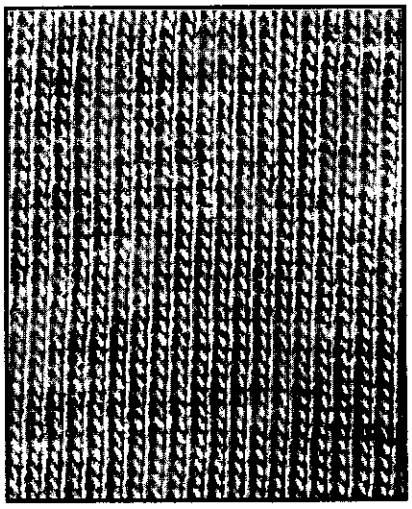
1×1 Rib structure (Face side)



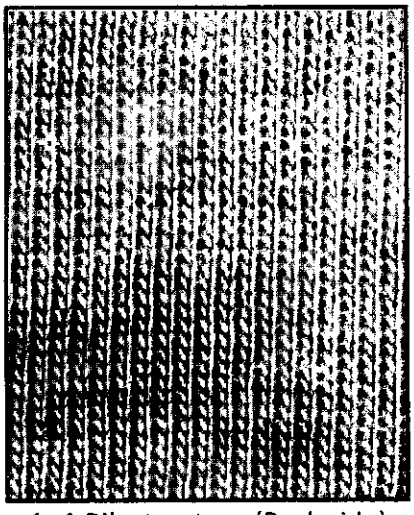
1×1 Rib structure (Back side)

b. **Extensibility:** The 1×1 rib is an elastic structure with good widthways recovery after it has been stretched because the face loop wales move over and in front of the reverse loop wales. The rib fabric is very elastic and springy in the width direction due to the tendency of the yarn to straighten and resume its previous shape. This special property of the rib structure in the width direction is frequently used to form the elastic bands in garments. In a similar way to plain knits, rib structures are stretchable rather then elastic in the length direction. The amount of possible stretch, however, is quite limited. Extensions of up to 120% can be obtained along the course, with normal constructions. Along the wale, rib fabric behaves very much like plain fabric, with very limited extensibility.

Other constructions of rib are possible and are widely used, such as two wales of face loops alternating with two wales of back loops to form 2×2 rib. On the same basis there are 3×3, 2×1, 3×2 rib etc. As the number of wales in each rib increases, the elasticity decreases because the number of changeovers from back to front diminishes. Over 3×3 rib the fabric more and more behaves like plain fabric, even curling in favour of the dominant rib. Such structures are known as "broad ribs".



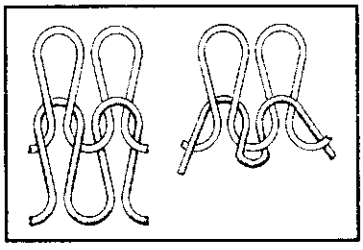
1×1 Rib structure (Face side)



1×1 Rib structure (Back side)

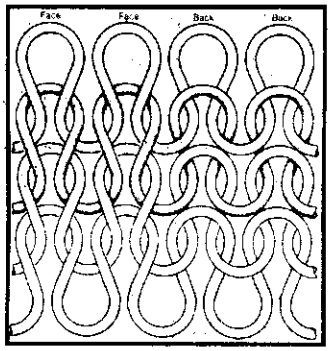
c. **Edge curling:** The fabric being in many cases symmetrical on both faces is not exposed to unbalanced stress and therefore does not curl, it lies flat, when cut.

d. **Unroving:** Rib structures can easily be unravelled from the edge knitted last i.e. the top when the fabric is held upright as produced on the knitting machine. Rib structures however, cannot be unravelled from the edge knitted first i.e. from the bottom. The arms of the connecting loops enter the loops above them from both sides. Any attempt to pull the yarn causes the connecting loops to tighten and blocks unravelling. Because ribs cannot be unroved from the end knitted first and because of their elasticity, they are particularly suited to the edge of garments such as the tops of socks, cuffs and the waist edge of garments.

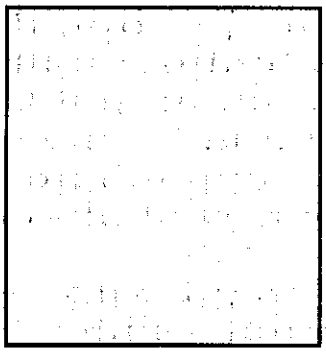


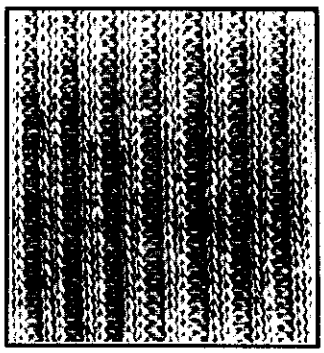
Inability of 1×1rib to unrove from the lower edge

e. **Laddering:** A dropped stitch can start a chain reaction and produced a "ladder" in the structure. The tendency of drop stitches to run is increased when the fabric is produced of smooth yarns, when the loops are large and when the fabric is stretched. In rib structures, drop stitches can only run towards the edge knitted first i.e. downwards when the fabric is held upright. The stitches cannot run in the other direction since connecting loops in rib are anchored. Such a property reinforces the argument for using ribs on the extremities of garments.



2×2 Rib structure





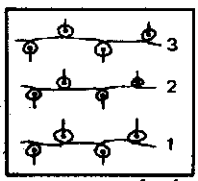
2×2 Rib structure

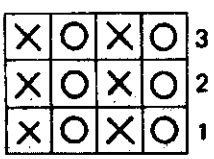
f. **Weight and thickness:** Rib structures are bulkier and heavier then plain knit structures made of a similar yarn thickness on machines of a similar gauge. The width of a 1×1 rib fabric is approximately half the width of a plain stitch fabric when knitted with the same length of yarn in the loop and the same number of loops in a course. On the other hand, thickness, weight and extensibility of the rib structure are approximately twice that of the corresponding plain fabric. After removing from the machine a 1×1 rib fabric shrinks in width so that the front loops cover the back ones. This phenomenon is accompainied by a thickness increase to approximately twice that of a plain knit fabric.

End uses of rib structures:

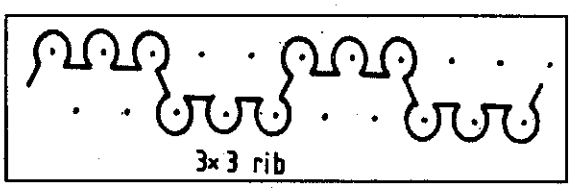
Wide range of uses, waist bands, cuffs and collars are typical applications, together with whole garments of a fitting nature. Rib fabrics are used where portions of garments are expected to cling to the shape of the human form and yet be capable of stretching when required. Cotton rib knitted fabric, bottom of the sweater, skirt belt, various types of fancy borders, under wears, sweaters etc.

Notation of Rib structures:





1×1 rib structure



3×3 rib structure

The Purl Knit Structures or Purl Fabrics:

The third family of knit structures is the purl knit. As with rib structures, it requires the participation of both needle beds for the production of the loops. The German name Links / Links, which can be translated as Left / Left or Reverse / Reverse, is widely used even in English speaking countries.

Purl fabrics are knitted on machines with special equipment (one set of needles), which are double-ended latch needles and special devices of drive them, allowing loops to be intermeshed in two directions. Purl fabrics are characterized by the fact that they have face and reverse loops in the same wale. This type of structure can only be achieved on purl machines or by rib loop transfer. Rib machines will knit purl structures if loop transfer between the beds is possible. Loops on the front bed can be transferred to needles on the back bed and vice versa to produce face and reverse loops in the same wale.

On a purl machine, the tricks (the slots in which the needles are located) of the two needle beds are directly opposite and in the same plane. This allows the double-ended needles to be transferred across from one needle bed to the other, enabling fabrics to be made that have face and reverse loops in the same wale.

There are two types of purl machine – Flat purls, the needle beds of these machines are set on the same plane instead of being in an inverted "V" formation and circular purls, which have two superimposed cylinder one above the other so that the needles move in a vertical direction, both types of machines are capable of producing garment length or other article sequences.

The knitting procedure of the flat purl knitting machine, called a "Links / Links" machine is described below:

As can be observed, there is one set of needles for both needle beds and the procedure is as follows:

I. The needle is positioned in the front needle bed in which it has just formed a face loop.
II. The needle slides through the loop toward the rear needle bed.
III. A reverse loop is produced by the other needle head through the previous face loop within the same wale.
IV. The needle slides through the loop toward the front needle bed.

The popularity of the purl flat knitting machine has been reduced during the last few years, as the sophisticated "V" bed flat knitting machines developed. However, a large number of purl flat knitting machines can still be found on production lines around the world.

To produce a purl knit structure on a "V" bed flat knitting machine, a loop transfer ability is required. The simplest 1×1 purl structure is produced according to the following procedure:

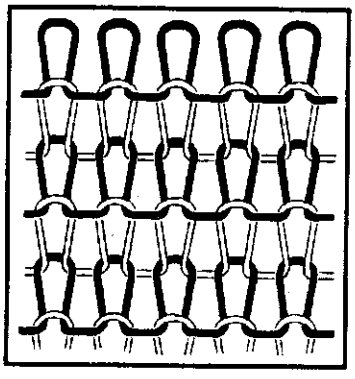
I. A course is knitted on the front needle bed while the rear bed remains idle.
II. All the loops are mechanically taken from the needles of the front needle bed and transferred to the empty needles of the rear bed.
III. A course of reverse loops is now knitted by the needles of the rear bed through the transferred loops.
IV. All the loops are now transferred from the rear needles to the front needles, which in the next cycle knit through them.

Not all loops have to be transferred after the completion of each course. The 2×2 purl structure is produced when two courses are knitted on each needle bed before the transfer operation.

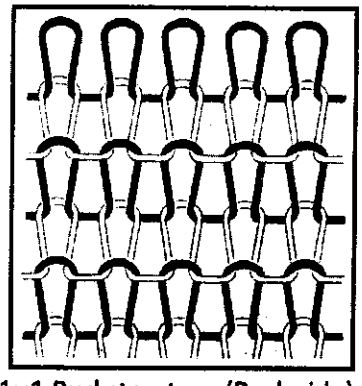
When the knitting machine is sophisticated enough to handle both loop transfer and needle selection, the variety of possible purl structures is unlimited.

Although the purl knit family includes many different structures, the general characteristics can be summarized as follows:

a. **Appearance:** Each wale can be made up of a combination of face and reverse loops. Each course can be made up of a combination of face and reverse loops. Basic purl knit structures such as 1×1 or 2×1, contract in the length direction. The face loops are covered so the needle and connection arches typical of reverse loops show on both sides. The popular German term "Links / Links", meaning "Left / Left" or "Reverse / Reverse", is based on this fabric appearance.



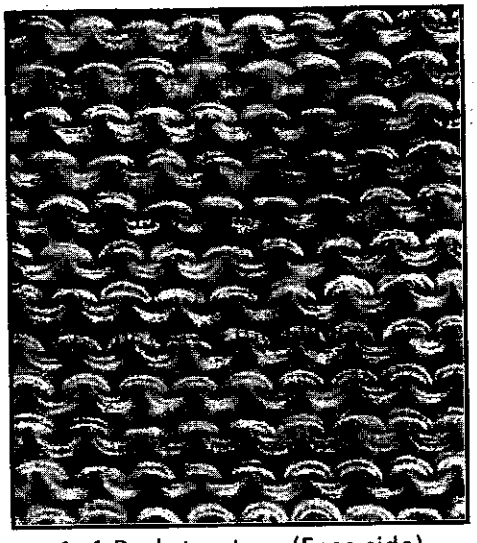
1×1 Purl structure (Face side)



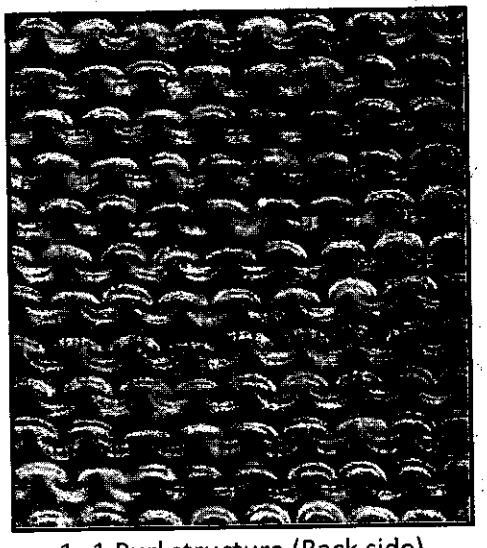
1×1 Purl structure (Back side)

b. **Extensibility:** Fabric made of the above basic purl structures have, due to contraction, a horizontal rib effect which makes them elastic in the length direction. This is an advantage, especially when compared with the very limited lengthwise extensibility of plain or rib structures. The fabric is stretchable in the

width as with all loop-based structures. Due to the contracting tendency of the structure in length, the fabric is elastic in this direction which is unusual for other knit structure families. This flexibility in length and width makes the purl knit ideal for baby wear where elongation and expansion are required due to the fast growing rate of infants and to simplify the dressing process.



1×1 Purl structure (Face side)



1×1 Purl structure (Back side)

c. **Edge curling:** The fabric is usually balanced and does not tend to curl. This however depends on the arrangement of the loops on the face and reverse side of the fabric. An unbalanced arrangement can result in a certain amount of curling.

d. **Unroving:** Purl knit structures can easily be unraveled from the edge knitted last i.e. the top edge of the fabric when held upright, as produced on the knitting machine. Basic 1×1, 2×1 and other purl structures in which each course is made of only one type of loop, behave like plain knits when unravelling is concerned. They can be unravelled from both ends.

e. **Laddering:** A dropped stitch can easily start a chain reaction and produce a "Ladder" in the fabric. As in all knit structures, the dropped stitch can run downwards when the fabric is held upright. Basic structures like 1×1, 2×2 etc. behave as plain knits where laddering is concerned and stitches can run in them either upwards or downwards.

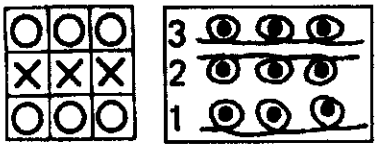
f. **Weight and thickness:** The fabric is very bulky and soft to the touch. Purl knits are usually bulkier then plain knits produced from the same yarn thickness and on the same machine gauge. It has excellent thermal insulation properties.

As with rib fabrics there are other combinations of simple purls, such as 2×2, 3×3 etc. These are uncommon, however, and not particularly useful. Unlike the rib fabric, however, the classification "purl" covers any fabric with face and back loops in the same wale. This covers a vast range of fabrics with designs in back and face loops, known as "fancy purls". Another term used, particularly in the USA is "links-links".

End uses:

Purl fabrics are widely used for baby wear children's clothing, sweater, knitwear, thick and heavy outerwear, under garments etc.

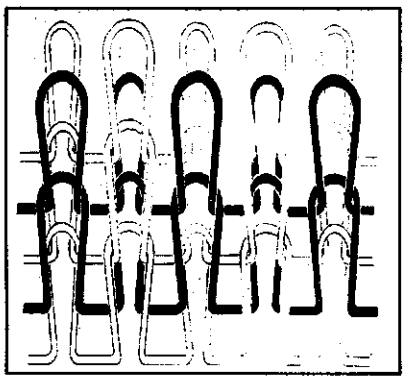
Notation of 1×1 purl knit structure:

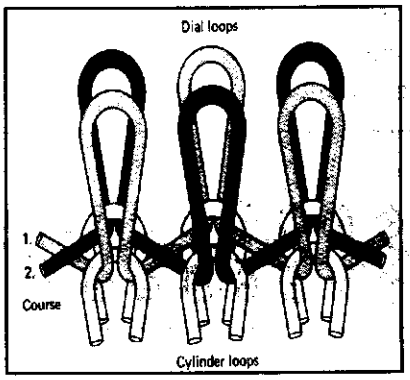


The Interlock Structures or Interlock Fabrics:

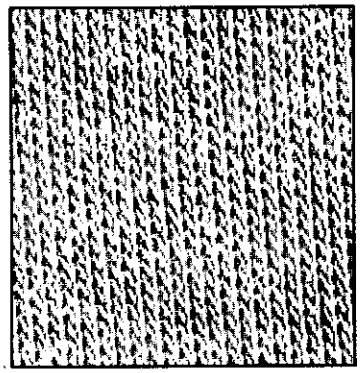
Interlock is another 1×1 rib variant structure which is produced on specially designed machines. These machines possess two sets of needles (short and long needles) in both cylinder and dial and at least two feeders. For normal interlock, the needles in both cylinder and dial are arranged to be alternately long and short, and at the odd feeders the long needles are selected to knit and at the even feeders, the short needles are selected to knit. At each feeder a 1×1 rib structures knitted at adjacent feeders interlace each other and form a double 1×1 rib fabric. So interlock fabric is produced by two 1×1 rib structure interlace to each other.

Interlock has the technical face of plain fabric on both sides, but its smooth surface cannot be stretched out to reveal the reverse meshed loop wales because the wales on each side are exactly opposite to each other and are locked together.

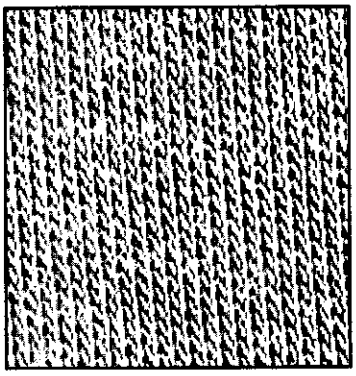




1×1 Interlock structure



1×1 Interlock structure (Face side)

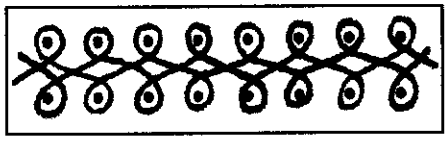


1×1 Interlock structure (Back side)

Basic interlock is a balanced, smooth, stable structure that lies flat without curl. Like 1×1 rib, it will not unrove from the end knitted first, but it is thicker, heavier and narrower than rib of equivalent gauge, and requires a finer, better, more expensive yarn. It also possesses good recovery properties.

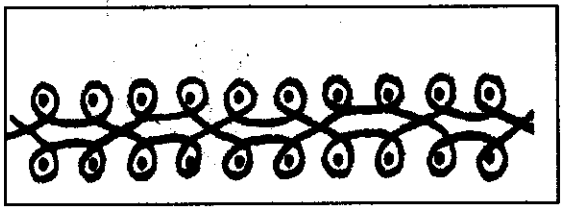
When two different-coloured yarns are used, horizontal stripes are produced if the same colour is knitted at two consecutive feeders, and vertical stripes if odd feeders knit one colour and even feeders knit the other colour. The number of interlock pattern rows per inch is often double the machine gauge in needles per inch.

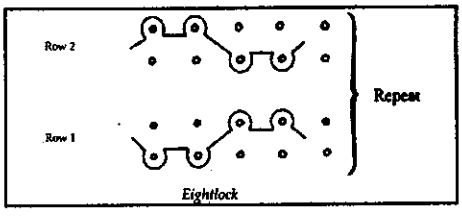
Notation of Interlock structures:



1×1 Interlock structure

Eightlock is a double-faced interlock based fabric that usually repeats over four wales. It is a 2×2 version of interlock that may be produced using an arrangement of two long and two short needles, provided all the tricks are fully cut through to accommodate them and knock-over bits are fitted to the verges to assist with loop formation on adjacent needles in the same bed.

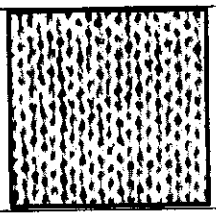
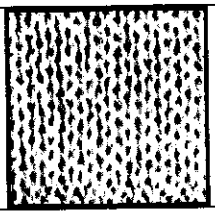
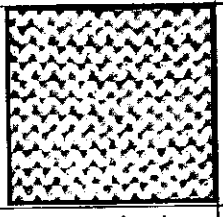
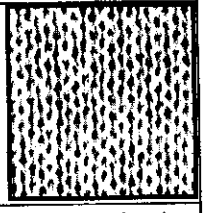




It was first produced on double-system Vee – bed flat machines having needles with two butt positions, each having its own cam system. This involved a total of eight locks, four for each needle bed, making one complete row per traverse. Set-outs for 4×4 and 3×3 can also be produced.

It is a well-balanced, uniform structure with a softer, fuller handle, greater widthwise relaxation, and more elasticity than interlock fabric. Simple geometric designs with a four wale wide repeat composed of every two loops of identical colour, can be achieved with careful arrangement of yarns.

Comparison between basic structures of weft knitted fabric:

Structure / Property	Plain	1x1 Rib	1x1 Purl	1x1 Interlock
Practical view				
Appearance	Different on face and back; V-shapes on face, arcs on back	Same on both sides, like face of plain.	Same on both sides, like back of plain.	Same on both sides, like face of plain.
Extensibility **Lengthwise** **Widthwise** **Area**	 Moderate (10– 20%) High (30 – 50%) Moderate- high	 Moderate Very high (50-100%) High	 Very high High Very high	 Moderate Moderate Moderate
Thickness and Warmth	Thicker and warmer than plain woven made from same yarn	Much thicker and warmer than plain woven	Very much thicker and warmer than plain woven	Very much thicker and warmer than plain woven
Unroving	Either end	Only from end knitted last	Either end	Only from end knitted last
Curling	Tendency to curl	No tendency to curl	No tendency to curl	No tendency to curl
End-uses	Ladies' stockings, fine cardigans, men's and ladies' shirts, dresses, base fabric for coating.	Socks, cuffs, waistbands, collars, men's outerwear, knitwear, underwear.	Children's clothing, knitwear, thick and heavy outerwear.	Underwear, shirts, suits, trouser suits, sportswear, dresses.

Identification of Single jersey and Double jersey fabric:

Weft knitted fabrics may be approximately divided into single or double jersey (double-knit) according to whether they were knitted with one or two sets of needles.

Single jersey fabrics have the following features –

- All face loops are in one side and all back loops are in other side.
- Both sides are should be different appearance.

Double jersey fabrics have the following features –

- Both sides of the fabric contain only face loops (basic rib and interlock fabrics) or only back loops (basic purl fabric) or combination of face and back loops.
- Both sides are same appearance for basic and balanced structure, but different on other structures.

BASIC LOOP OR STITCH TYPES

As mentioned in the previous chapter, the basic structure families were introduced as being constructed of only one type of knitted loop. In reality however, most knitted structures contain, in addition to the standard knit loops. The standard loop is a flexible formation, can easily change its shape under small loads and is responsible for the stretchable characteristics of the fabric.

A knitted loop stitch is produced when at each yarn feed, a needle receives a new loop and knocks-over the old loop which is held from the previous knitting cycle, so that the old loop now becomes a needle loop of normal configuration.

Other types of stitch may be produced on each of the four needle arrangement base structures by varying the timing of the intermeshing sequence of the old and new loops. These stitches may be deliberately selected as part of the design of the weft and warp knitted structure or they may be produced accidentally by a malfunction of the knitting action so that they occur as fabric faults.

When these stitches are deliberately selected, a preponderance of knitted loop stitches is necessary within the structure in order to maintain its requisite physical properties. Apart from the knitted loop stitch, the two most commonly-produced stitches are the float or miss stitch and the tuck stitch. Each is produced with a 'held loop' and shows its own particular loop most clearly on the reverse side of the stitch as the limbs of the held loop cover it from view on the face.

To simplify explanations, all knit structure families were described as being made only of basic loops. In reality however, other loop types exist which, together with the simple one, combine to enhance the patterning potential and the variety of knitted garments.

The held loop:

A held loop is an old knit loop which the needle has retained and not released and knocked-over at the next yarn feed. A held loop can only be retained by a needle for a limited number of knitting cycles before it is cast-off and a new loop drawn through, otherwise the tension on the yarn in the loop becomes excessive even though there is a tendency to rob extra yarn from adjacent loops in the same course.

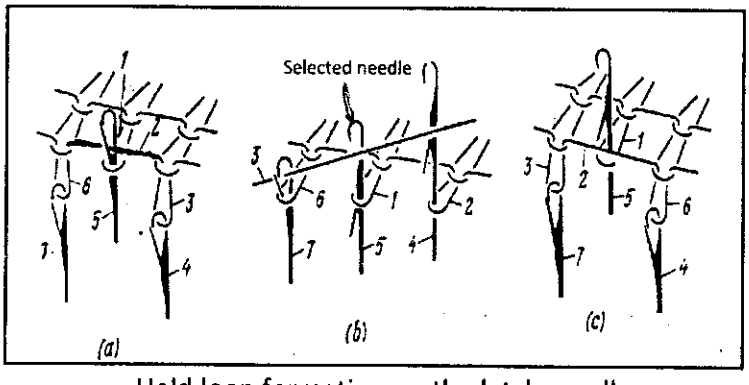
The limbs of the held loop are often elongated as they extend from its base intermeshing in one course to where its head is finally intermeshed a number of courses higher in the structure, alongside it in adjacent wales there may be normally-knitted loops at each course. So the size of the held loop is bigger than the normal knit loop and held loop is produced at the same time when tuck and miss loop will be produced.

Held loops are obtained by changing or obviating some operations from the usual cycle of loop formation.

On knitting machines equipped with latch needles three methods are used in order to obtain the held loops

a. Tucking on the latch – without cast-off operation in loop forming cycle
b. Tucking in the hook – without clearing operation in loop forming cycle.
c. With switching a needle out of action for a loop forming cycle.

a. When tuck or held stitch formation is performed without cast-off (figure – a), joining, casting-off and sinking are excluded from the loop formation cycle. In this case, the needles 4 and 7 knit the loops 3 and 6, while the needle 5 performs all the operations up to joining, and stops. Then a new yarn 2 is fed in its hook and this will be the tuck loop. The old loop 1 remains on the closed latch and this will be the held loop.



Held loop formation on the latch needles

After the needle 5 is lifted for clearing, in the following loop formation cycle it receives a new yarn and knits a loop from it, casting-off upon it the old held loop 1 and the tuck loop 2.

b. When tuck stitch formation is performed without clearing operation (figure - b) the selected needle is lifted for incomplete clearing. After clearing on needles 4 and 7 has been performed, theses needles are fed with the yarn 3 from which they knit normal loops. At the same time the selected needle is lifted just enough for the old loop1 to open its latch but the loop 1 remains on the opened latch. Having been fed with the yarn 3 the needle 5 does not knit a loop, as there will be no pressing, landing and

further operations; the held loop 1 and the tuck loop from yarn 3 are in the hook of needle 5. In this method control of held loop length is possible, as the operation of sinking is performed by the needle holding the loop 1.

c. Held loop formation by switching a selected needle out of action can be performed by two methods. One of them is based on simple leaving the needle idle in lowest position for one (or two, three) loop formation cycle; The other method consists in leaving the needle in its top most position for the rest of loop formation cycle in question (figure – c). In this cycle, the needles 4 and 7 knit the loops 3 and 6 from the fed yarn, performing all necessary operations. In the next cycle the needle resting in its top most position forms a new loop.

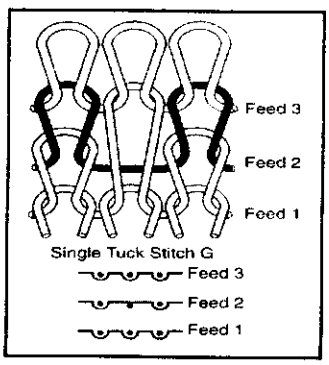
   In both cases, the yarn of which loops 3 and 6 are made, remains in form of a long floating link between loops 3 and 6; the long link (a float) is laid on the held loop 1. The process of producing held loops is described with the term "missing".

The Float Stitch or Loop:

The float stitch which is also called a 'miss' or 'welt' stitch is a variation of the basic loop structure. It is created in the fabric when a needle is inactive. The previous loop is held within the hook, the yarn fed from the yarn carrier fails to reach the needle and so skips over it.

A float stitch is composed of a held loop, one or more float loops and knitted loops. It is produced when a needle holding its old loops fails to receive the new yarn which passes as a float loop, to the back of the needle and to the reverse side of the resultant stitch, joining together the two nearest needle loops knitted from it. The float stitch shows the missed yarn floating freely on the reverse side of the held loop which is the technical back of single jersey structures, but is the inside of rib and interlock structures.

The following figure shows the effect created on the face of the fabric by a knitting sequence called "missing". As the schematic illustration shows, the main effect is created by two elements i.e. an enlarged knitted loop and a straight element of yarn.



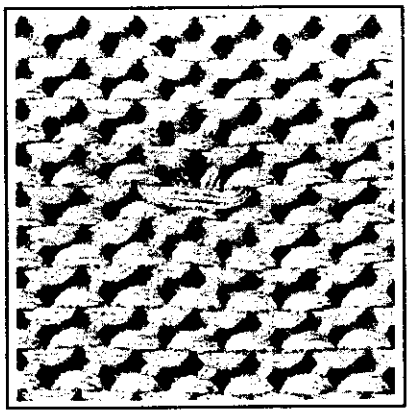
Face side of Single Miss or Float Stitch

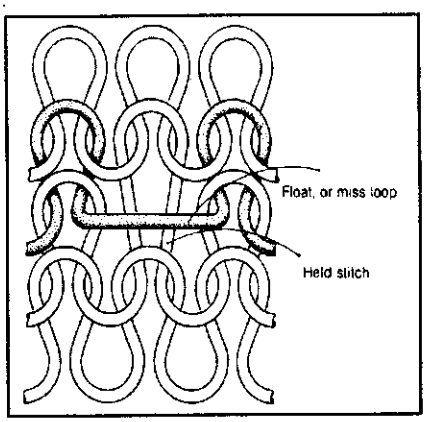
As suggested by its name, the miss stitch effect is created when one of the knitted loops is missed during the production sequence. The deformed loop is the result of a needle which has not participated in one sequence of loop formation. It has retained its loop longer then the rest of the needles.

A following macro photograph, shows the actual configuration of the miss stitch. The deformed, stretched loop, tends to rob some yarn from its adjacent loops and so reduces them in size.

In some cases, the excessive pull on the yarn in the stretched loop may pull the yarn from loops which are even farther away from the miss stitch.

The effect of the miss stitch looks different from the reverse side of the structure, as illustrated in the following figure. On this side the straight segment of yarn is visible on the surface.



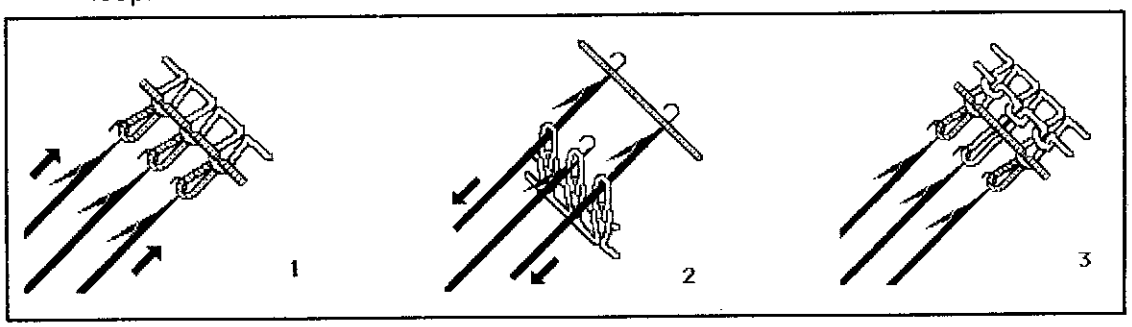


Back side of Single Miss or Float Stitch

The loop formation of a float stitch:

The following series of diagrams show the forming procedure of a miss or float stitch.

1. Only two of the needles ascend to clearing position and clear the latches. The needle in the centre fails to ascend and remains in the lower position while holding onto its loop.

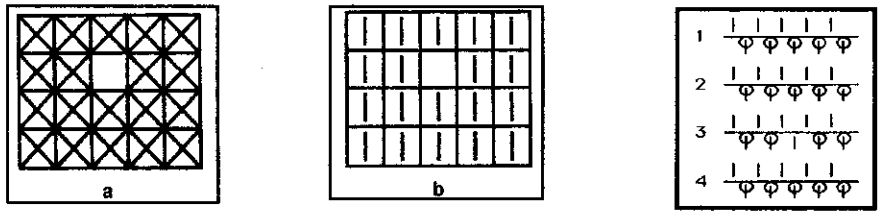


2. The yarn carrier travels across the machine feeding new yarn into the hooks of the active needles.

3. Active needles descend to knockover and form new loops. The needle in the centre creates the "miss" effect by retaining its loop.
   The connecting yarn between the newly formed loops simply passes behind it. The elongated loop formation is called a "held" loop.

The notation of the float stitch:

The inactive needle and the unformed loop are shown in notation systems by empty spaces. When the fabric is illustrated in squares, the appropriate square is left blank as illustrated in the following figure. The notation in this figure is of the structure presented in the above figure. These structures are produced on a knitting machine with one needle bed only. The two common notation systems in squares are shown as used in the English speaking countries (a) and in Germany (b).



When the needle notation system is used, the yarn is simply drawn as skipping the inactive needles, much the same as in actual practice. The illustration in the above figure (right) is of the same structure as in the previous above figure. It is drawn to demonstrate the miss stitch effect, as produced on a Vee-bed flat knitting machine with two needle beds.

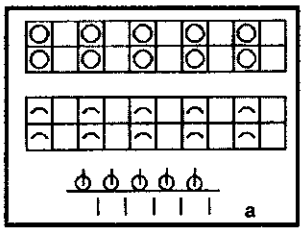
While the notation in squares represents the structure in a pictorial mode, the needle notation system represents the knitting sequence, course by course, as produced by the machine.

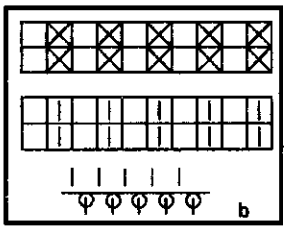
The properties and uses of the float or miss stitch:

The practice of missing certain needles during the knitting procedure is widely used in the flat knitting trade. The various uses and the loop properties exploited are:

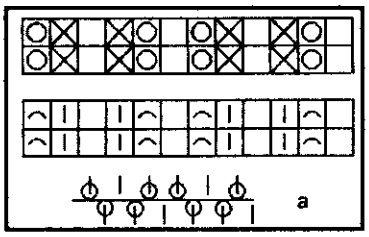
- Knitting plain knits. When the raising cams of one needle bed are completely withdrawn to miss all the needles, the machine knits with the other needle bed only. It produces a plain knit structure, as illustrated in all notation system in the following figure.The missing procedure can be carried out on the front needle bed so the rear needle bed is active (a) or on the rear needle bed leaving the front active (b). The

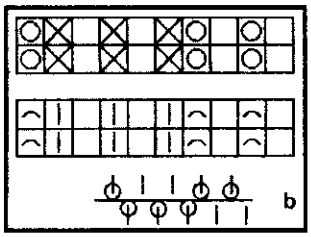
blank squares in the English and German systems are the inactive (missing) needles of the inactive needle beds.





- Knitting a variety of rib structures. Besides the 1×1 rib, all other rib structures require some of the needles to miss. The 2×2 (in German 2:1) in the following figure (a) is the most popular rib structure for garments elasticated welts. As can be observed from the illustration, in each needle bed two needles are active and one misses. In another rib structure shown in the figure (b), the combination of active and missing needles is different.





Note that in notation in squares, the 2×2 rib is not marked with two face loops and two reverse loops. Instead, it is marked as produced on the machine i.e. the inactive missing needles appear as blank squares.

- Improvement of the fabric's widthwise stability. A missed loop, creates a short connection between two adjacent wales and eliminates the accordion effect of the rib. Straight segments of yarn formed in the fabric, ensure that the stretchability of the structure is reduced. The result is a much more stable construction.

- Decrease of fabric width. Short connections between the wales, as shown in the previous paragraph, affect the fabric width. A large number of miss stitches in a course reduces the fabric width considerably.

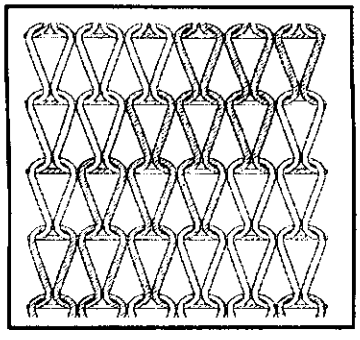
- The production of jacquard structures. The main use of miss stitches, in a selected fashion, is for the creation of jacquard fabrics.

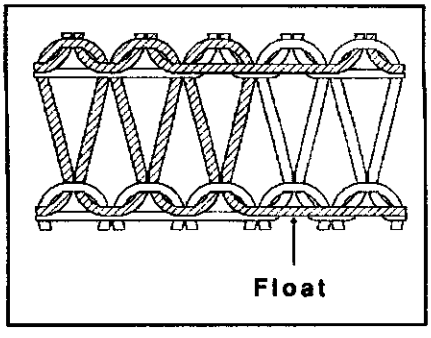
  Almost two hundred years ago, Joseph Marie Jacquard, the son of a weaving master from Lyon, France, invented the patterning mechanism equipped with punched cards, that made his name immortal. Today, every elaborately coloured patterned effect in knitting and in weaving, bear his name. The original invention and perforated cards have long since been replaced.

In flat knitting, the jacquard effect is created when each course is produced of several coloured yarns according to a predetermined design. In practice, the machine knits each course in a sequence of operations as follows:

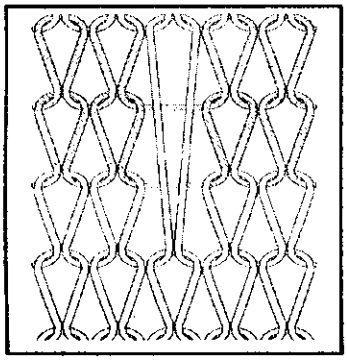
a. One yarn knits on selected needles while other needles miss.
b. The second yarn then knits on other selected needles which were missed during the previous operation.
c. The operation continues until all the needles in the course have been knitted with one of the yarns.
d. The following courses are knitted in the same way according to the design.

A segment of a two colour jacquard design is illustrated in the following figure showing that each of the yarns misses where the other knits. The long segments of yarn created by the yarn misses are call "floats". They are present on the reverse side of the fabric and can in some cases cause snagging problems when the garment is worn.

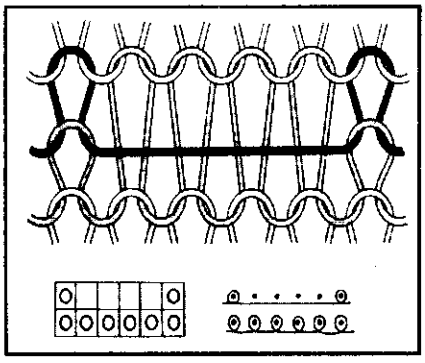




- The use of the structural deformation. The structural deformation resulting from a missing sequence can be used as a patterning effect on the fabric. The miss stitches have to be arranged according to a predetermined design to create such a pattern.
To increase the size and boldness of the deformation, the missing sequence can be repeated as shown in the following figure. The same needle is missed for two consecutive courses, the held loop is stretched even more and the deformation is greater.



Floating for two consecutive courses



Floating across four adjacent plain needles

The repeated missed sequence is limited by the properties of the yarn forming the held loop. The load is placed on this yarn and the number of misses possible depends on its tensile properties.

- Marking of garments. The different appearance of the missed loop can be used for the marking of cutting lines. Arm holes or a "V" neck lines can be defined the on garments, during the knitting process.
  On longer production lines, garments can be code marked in a hidden place to allow machine recognition and trouble shooting during later production processes.

The Tuck Loop or Stitch:

The tuck stitches are the knitted structures in which certain loops are intermeshed with elements of two kinds: tuck loop and held loops. Tuck stitches can be weft and warp knitted, and are produced on machines equipped with any known types of needles.

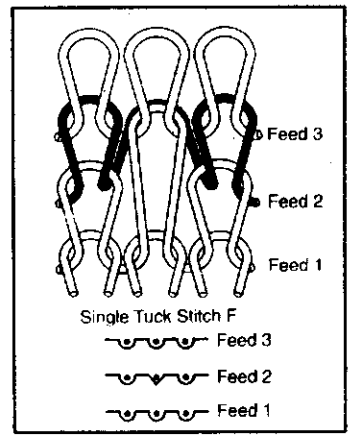
A tuck stitch is composed of a held loop, one or more tuck loops, and knitted loops. It is produced when a needle holding its loop also receives the new loop which becomes a tuck loop because it is not intermeshed through the old loop, but is tucked in behind it on the reverse side of the stitch.

Its side limbs are therefore not restricted at their feet by the head of an old loop so that they can open outwards towards the two adjoining needle loops formed in the same course. The tuck loop thus assumes an inverted 'V' or 'U' – shaped configuration. Tuck stitch structures show a faint diagonal line effect on their surface.

In analysis, a tuck stitch is identified by the fact that its head is released as a hump shape immediately the needle loop above it is withdrawn, whereas a knitted loop would require to be separately withdrawn and a miss stitch would always be floating freely on the technical back.

The following figure shows a stitch created by a knitting sequence called "Tucking". The effect is created by an enlarged knitted loop with a segment of yarn tucked behind it. A comparison with figure of the miss stitch, reveals a similarity to the float stitch construction. The stretched loop appears in both miss stitch and tuck stitches.

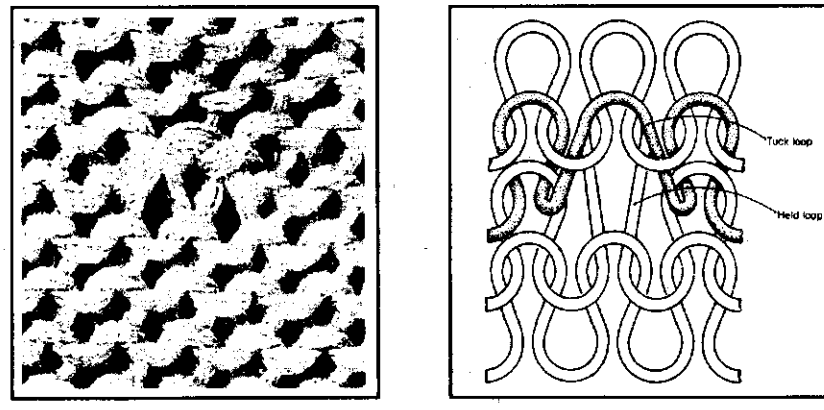
The tuck stitch is formed, as suggested by its name, when the yarn is tucked into the structure by the needle, instead of being formed into a loop. The stretched deformed loop originated as a normal knitted loop which was held by the tucking needle while the other needles knitted an additional course.



Face side of Single Tuck Stitch

A following macro photograph shows the actual yarn configuration of the tuck stitch effect. As with the miss stitch, the deformed stretched loop, robs some yarn from the adjacent loops thus reducing them in size.

An important features of the tuck stitch is that the tucked yarn is placed behind the stretched face loop, as shown again in the above figure, drawn from the reverse side. This is important when a yarn should not appear on the fabric face, as further explained in next tropics.



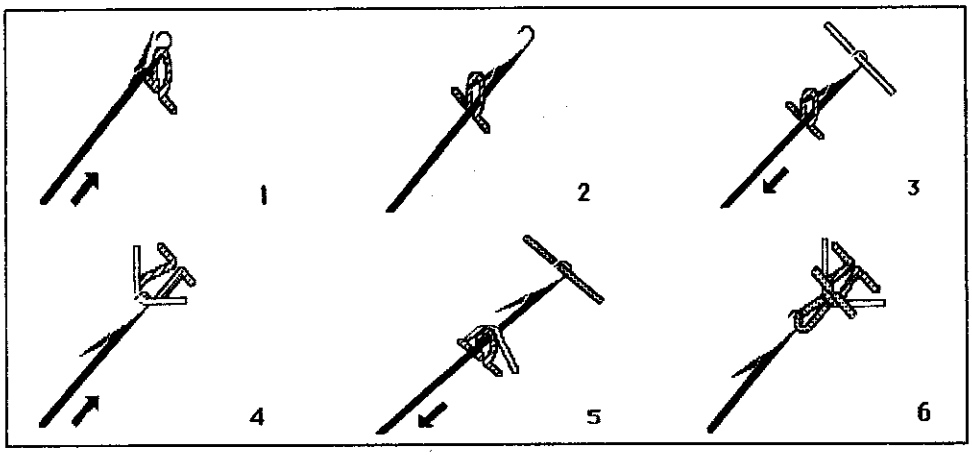
Back side of Single Tuck Stitch

The Tuck stitch formation:

In the series of following diagrams, the forming procedure of a tuck stitch is shown. The different steps in the sequence are:

1. The previously formed loop is in the hook of the needle which now starts to ascend.

2. The needle's ascent is stopped short of clearing position with the loop still placed on the needles latch.

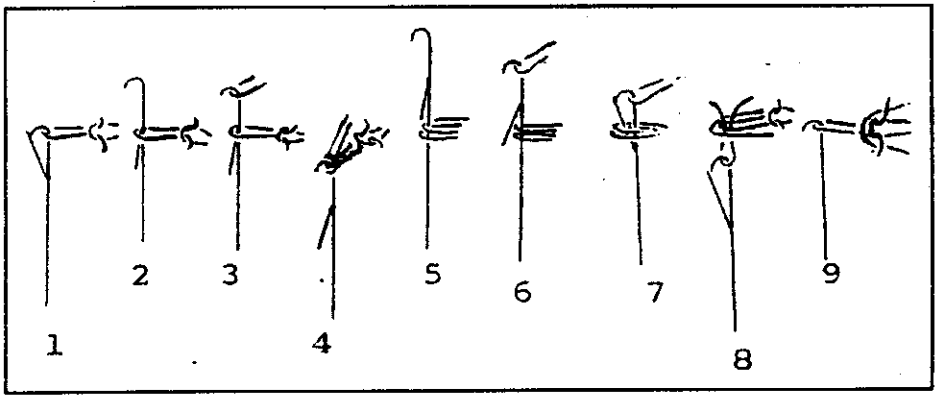


3. A new yarn is fed into the descending needle. Since the new yarn is not pulled through the previous loop, it does not acquire a loop shape. Instead, it is simply placed in the hooks enclosure together with the previous loop. The adjacent needles have formed new loops during this sequence, so the previous loop held by the tucking needle is now stretched and deformed.

4. The needle now ascends to clearing position and both previous loop and tucked yarn drop under the latch.

5. The descending needle is fed with a yarn. The previous loop together with the tucked yarn slide under the latch, close it and slide over the hook.

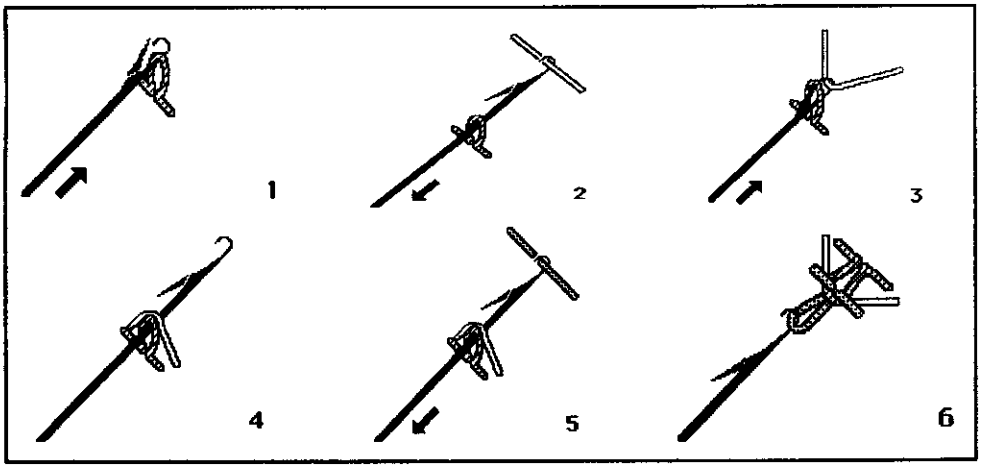
6. The new yarn is pulled into knockover position and forms a new loop. Note that the tucked yarn is hooked between the two knitted loops.



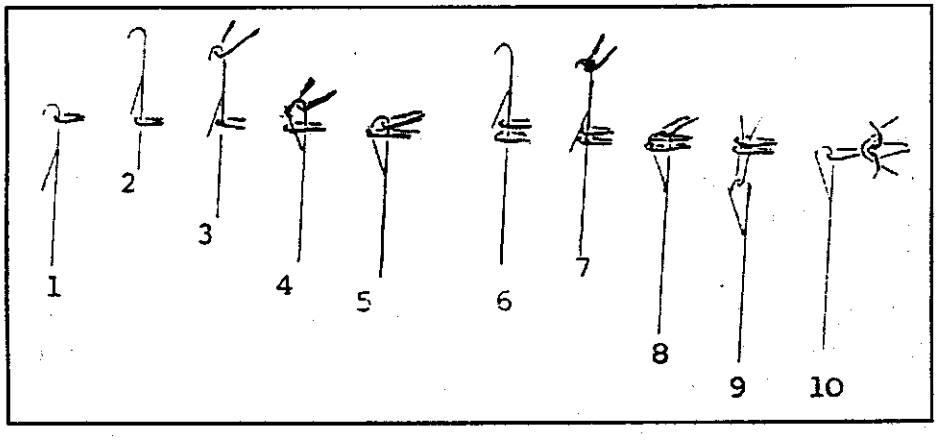
Tucking in the hook (without clearing operation)

"Tucking in the hook", described above, is the modern way of tuck stitch formation. There is another way for forming a tuck stitch, as described in the following series of diagrams. This sequence, called "Tucking on the latch", is described as follows:

1. The previous loop is held within the needle's hook which now ascends to clearing position.
2. At clearing position, the previous loop is dropped under the latch. A new yarn is fed into the hook of the needle, which now starts to descend.
3. The descent is stopped short of knockover position with the previous loop still on the outside of the latch. The new yarn has not been pulled into the previous loop and has not acquired a loop shape.
4. The needle ascends again to clearing position. Both the previous loop and the yarn within the hook drop under the latch. A new yarn is now fed into the descending needle.



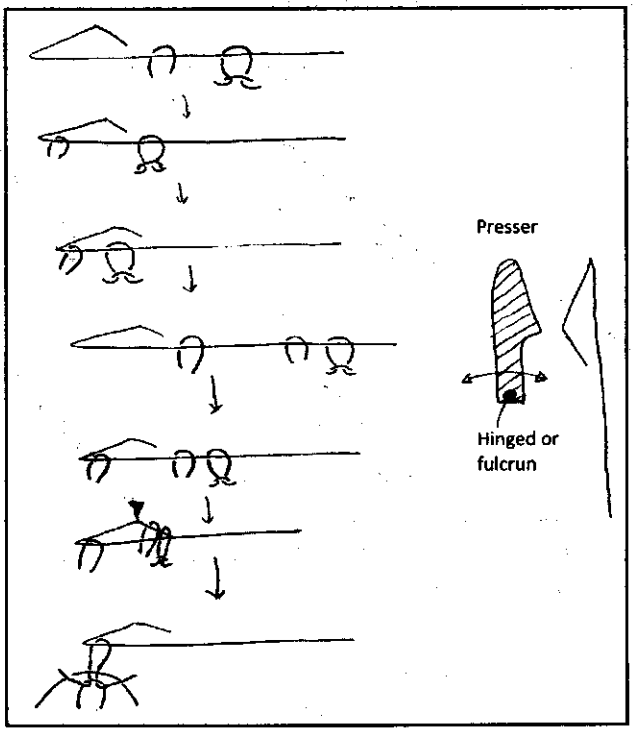
5. The previous loop and yarn slide under the latch, close it and slide outside of the hook. The newly fed yarn is in the hook's enclosure.
6. The needle is pulled into knockover position while forming a new loop through the previous one. The yarn fed into the hook during the previous cycle assumes a tuck formation identical to the one described above.



Tucking on the latch (without cast off operation)

The sequence of tuck forming "on the latch" by restricting the movement to knockover, is not as reliable as the "tucking in the hook". Loops may accidentally slip off the latch during the shortened descent and a normal loop may form instead of a tuck stitch. The method is used in older machines which are restricted by their raising cams arrangements.

For obtaining a tuck stitch on spring-bearded needles, the most widely used method consists in obviating the operation of pressing. Selected needles are not pressed during loop formation, and under the not pressed needle hook both the newly fed yarn and the old loop are slid. The not pressed needle does not perform the operation of old loop casting-off.



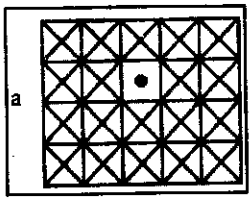
Tuck loop and held loop on the spring bearded needles

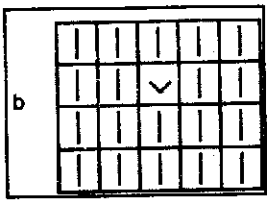
For manufacturing the tuck stitches, knitting machines with spring-bearded needles require special pressers. In some knitting machines with spring-bearded needles special pattern pressers are used. The needles have their individual pressers which can be switched in for pressing or switched off for tucking. The best example of such machines are the Cotton Patent machines; their pressers are made of a series of segments individually driven for knitting or tucking.

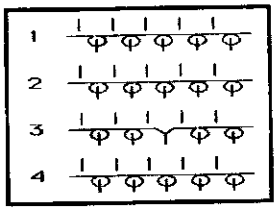
In warp- knitting machines with spring-bearded needles moving in unison (tricot machines), so called "cut pressers" are employed which are made of a steel or plastic bar with cut-outs at the pressing edge. The cut-outs can be covered in order to control the process of tucking. Compound needles form tuck or held stitches either without sinking or without pressing.

The notation of the tuck stitch:

A tuck stitch can be simulated in the various notation systems as shown in the following figure. In one notation system in squares (a), the tuck stitch is symbolized by a large dot regardless of the needle bed in which it is formed. If a dot is marked in a wale of a front needle, then it is produced by such a needle.







The German standard notation system in squares (b), uses a 'V' and an inverted 'V' shape to symbolize the tuck stitches. A 'V' marks a front tuck and a 'Λ' marks a rear tuck.

When the needle notation system is used, the yarn is marked as fed into the needle but without forming a loop. The above right figure is the notation of the tuck effect drawn in the previous figure.

The Properties and Use of the Tuck Stitch:

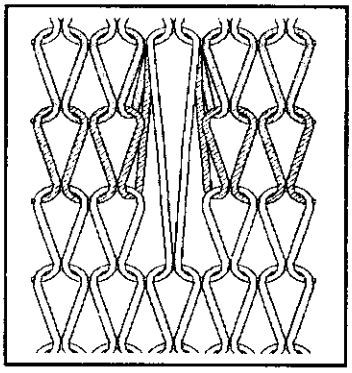
Tuck stitches are widely used in the production of Vee-bed flat knitted garments as well as in the production of cut and sew knit wear from circular knitting machine. They are used for the following reasons:

a. Fabric patterning. The different appearance of the tuck stitch, in comparison with the regular standard loop background, can be used for patterning. The stretched elongated held loop relaxes on leaving the knitting zone, forming a small buckle on the face of the fabric. When tuck stitches are arranged on the garment according to a plan, a design is formed. This however requires a needle selection system on the knitting machine.

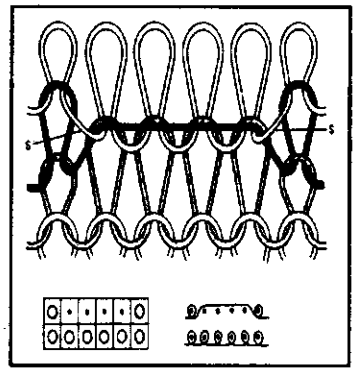
   To increase the effect, a needle can tuck for consecutive knitting sequences. The illustration in the following figure shows the arrangement of the yarn after two consecutive tucking operations. The held loop is further stretched and the needle has gathered three yarns within the hook before clearing. Consecutive tucking operations and the shrinking forces applied by the held loop, can create large knobs on the fabric plain.

   The number of consecutive tucking operations is restricted by the tensile strength of the yarns in the held loop. It is also limited by the size of the needle's hook in relation to the collective thickness of the yarn ends. While in older machine types four

consecutive tucks have been possible, modern equipment can produce up to eight or even ten such consecutive sequences.



Tucking for two consecutive courses



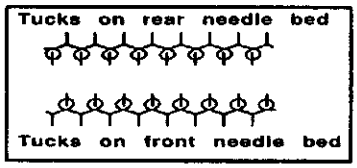
Tucking over four adjacent plain needles

Each side of the head of a tuck loop is held by a sinker loop from the course above. When tucking occurs across two or more adjacent needles, the head of the tuck loop will float freely across between these two sinker loops, after which a sloping side limb will occur. Dependent upon structural fineness, tucking over six adjacent needles is usually the maximum unit before snagging becomes a problem.

b. Increasing fabric weight and thickness. The tuck yarn is added to the standard loop without a knitting sequence and no new loop is produced. A large number of tuck stitches can thus add to the weight and thickness of the fabric.

Such a structure is the "cardigan", illustrated in the following notation figure. While the front needle bed knits, the needles of the back bed tuck. In the following sequence, the procedure is reversed. In this way, one course is produced every two knitting cycles and the fabric advances only one course spacing while containing two yarn ends.

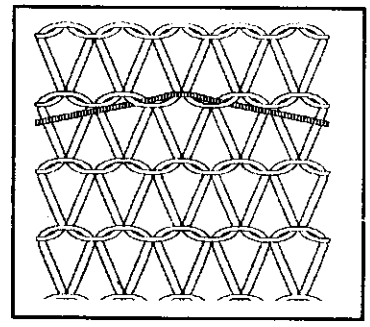
The cardigan fabric is therefore very heavy, bulky, insulating and is suitable for heavy outerwear garments.



c. Increasing fabric width. The principle described above also shows why fabric width increases as a result of a large number of tucks. This increase is caused by the presence of more yarn in the structure, and the restrictive forces applied by the tuck courses to the tendency of the rib to contract.

d. Insertion of problematic yarns. Not all yarns are able to be formed into the shape of a loop due to their mechanical properties. With tucking procedures, such yarns can

inserted into the fabric with only a minimum of bending stresses shows in the following figure. Note that while the central needle tucks, the rest of the needles miss. The fabric does not advance and the loop of the tucking needle is not stretched.



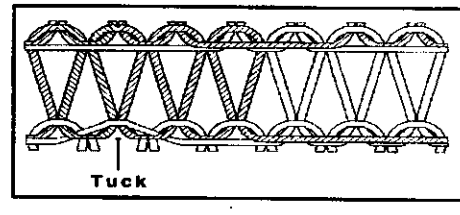
Every knitting machine is restricted by the thickness of the yarn which can be processed and turned into a fabric. Contrary to popular belief, the thickness of the yarn is not limited by the size of the hook.

It is limited by the size of the trick in the needle bed, into which it is pulled in the knockover position. Tucked yarns need not pulled into knockover position, as described before. Yarns which are much too thick for regular knitting can thus be inserted in the fabric by tucking.

e. Shortening of jacquard floats. As described in previous part, long floats can be formed on the reverse side of the fabric as a result of a jacquard patterning sequence. These floats can easily be pulled by such objects as a ring or a wrist watch, resulting in loop distortion on the fabric face and damage to the garment. To reduce the size of such floats, lessening the danger of snagging, tucks can be introduced along the float. In this respect, the tuck construction has two advantages:

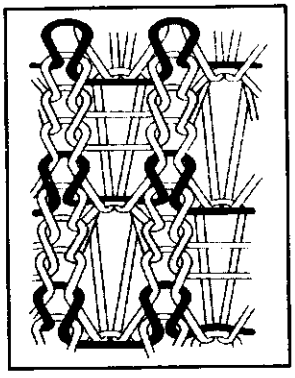
- No loop is formed so no yarn in wasted.
- The tucked yarn is placed behind the face loop and does not interfere with the design.

The reverse side of a jacquard structure with long floats is illustrated in the following figure with a tuck stitch introduced into one float to show its advantages.



f. Garment marking. The different appearance of the tuck stitch, in comparison with the standard loop background, can be used to mark cutting lines in the garment

during the knitting process. Furthermore, the knitting machine can code mark the garment in an obscure place to allow machine identification for quality control during later production stages.



Successive tucks and floats on the same rib needle

The Drop or Press-off Stitch:

Dropped stitches are usually associated with knitting failures. They can however be employed to pattern a fabric, if used according to a controlled procedure.

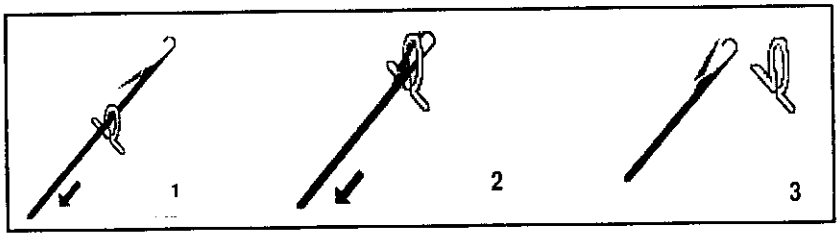
The formation of a Dropped stitch:

The following figures show the procedure by which a stitch is dropped. The stages are:

1. The needle ascends to knitting position in which the loop within the hook clears the latch.

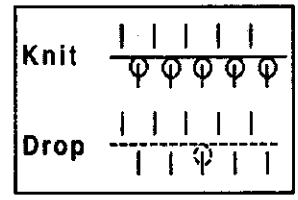
2. No yarn is fed to the needle which then descends. The loop slides under the latch, closes it and slides over the needle's hook.

3. The needle is pulled into knockover position and the loop drops from it.



The notation of the dropped stitch:

A dropped stitch has no special notation symbol and is shown simply as a knitting needle. Sometimes however, the yarn simulated in the needle notation system is drawn as a broken line to suggest that contrary to normal procedure no yarn is being fed.



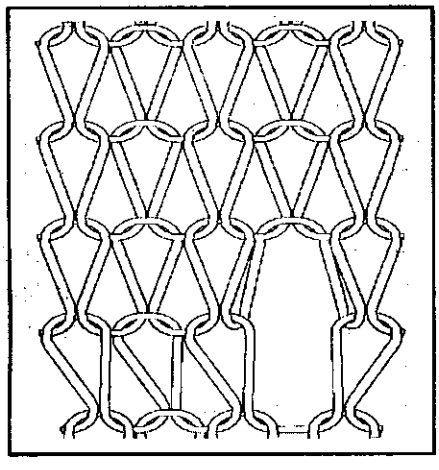
The Properties and Uses of the Dropped Stitches:

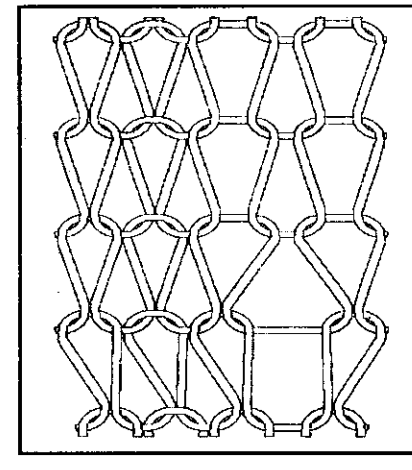
A drop stitch fault will result if a needle releases its old loop without receiving a new one, sometimes this technique is used to achieve a press-off on all needles in a set between garment length sequences. A drop stitch or press-off stitch is used very occasionally in flat knitting to cause certain loops in a plain structure to be much larger than the rest.

Knitting takes place on only one bed of needles and selected needles in the other bed pick-up loops which are immediately pressed-off by not receiving a new yarn. The yarn from the pressed-off loops flows into the adjacent loops in the other bed making them larger, giving the impression of a much coarser gauge.

Drop stitch wales are sometimes used to provide a guide for the cutting operation. A secure structure is only produced when a needle retains its old loop if it does not receive a new loop.

Previous chapters have shown that a dropped stitch creates a "Ladder" in the fabric by creating a chain reaction in the wale. To control the procedure and to be able to stop the ladder at a specified point, a special wale needs to be formed.





The patterning procedure with dropped stitches starts with a new wale being introduced into the fabric by a needle which previously was inactive. Several knitting sequences later, the same needle is programmed to drop its stitch. The chain reaction which develops, runs down the wale and stops at its root. The loops adjacent to the ladder increase in size, as shown in the above figure.

DESIGNS OF WEFT KNITTED FABRICS

As mentioned in the previous chapter there are only four knit structure families, the combination of which makes all the knitted fabrics and garments produced in weft knitting. To simplify explanations, all the basic weft knit structure families were described as being made only of basic knit loops. In reality however, other loop types exist which, together with the simple one, combine to enhance the patterning potential and the variety of knitted fabrics and garments.

All the knit structures excluding the basic structures are made of a combination of the three loop structures described previous chapter i.e. the standard knit loop, the missed and the tucked stitch. When tuck or miss loop or both tuck and miss loop are combined with the standard knit loop in case of plain or single jersey structure then it is called derivatives of single jersey structures. Similarly there is lot of rib based structures i.e. called derivatives of rib structure, interlock based structure i.e. called derivatives of interlock structure and purl based structure i.e. called derivatives of purl structure.

Decoration or ornamentation of plain knit or single jersey fabrics:

A single jersey fabric is ornamented without deviating from the true principles of plain structure as follows:

- The yarn vary in colour, raw material, types of construction and in thickness. As the fabric consists of yarn and yarn is made up of fibres or filaments the ornamentation can start from the fibre, filament stages. Fibre dyeing, yarn dyeing, fabric dyeing are some of the means by which attractive colours can be provided to fibres, yarns, filaments or fabrics to enhance the beauty of the fabric.

- Threads of different colours are combined in stripe form. If different dyed or contrasting colours are used at different feeds by supplying packages of coloured yarn on a multi-feed machine of a single jersey structure, a variety of horizontal stripes can be obtained on the surface of the knitted fabric. For casual T-shirt garments such horizontal coloured stripes are commonly used.

- By using fancy yarns. Instead of simple regular single yarn, fancy yarn such as slub, knop, mélange, loop, crepe yarn etc. can be carefully knitted in the fabric to give some interesting results.

- By using different twisted yarns (such as hard twisted yarn is produced crepon effect). In staple fibre yarns, twist is given to a group of fibres in S or Z direction to form the yarn. If some courses are knitted with S-twist followed by some courses of Z-twist then a zig-zag path of wale lines is created on the fabric surface.
- In plated single-jersey knit fabric the characteristics of one yarn are visible on the surface composed of the face loop stitches whilst the characteristics of the other yarn are visible on the reverse surface composed of the back stitches. Sometimes back side is considered as face side, if coloured or fancy yarn pattern appears attractive from the reverse side. It is common practice for sweater.
- By using extremely fine gauge for finer yarn or coarse gauge (sweater) for coarser yarn.
- For children garments two or four colour bright prints of animals, birds, boys, girls or some letters or funny messages are printed which attract the customers. For knit goods transfer printing is popular, although block printing is used.

Single Jersey Derivatives:

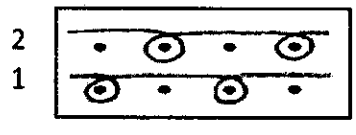
The structural modifications are used to a very great extent in designing plain-knit structures by modifying the order of knitting. The plain knit structures can be modified with the following alternatives.

- Knit loop and miss loop
- Knit loop and tuck loop
- Knit Loop, miss loop and tuck loop.

The following figure illustrates the notations of some simple tuck and float stitch single jersey fabrics.

1. **Cross Miss Design:**

   Cross miss is a miss-knit single jersey structure. So one set of needle is used to produce this structure. The repeat of the structure completes on two courses. Knitting sequence for a repeat as follows:

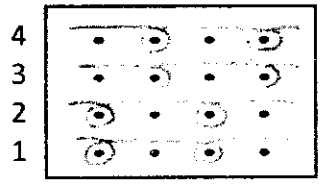


   - First course: Knit on all odd number needles and miss on all even number needles.

- Second course: Miss on all odd number needles and knit on all even number needles.

2. Birds Eye or Double Cross Miss Design:

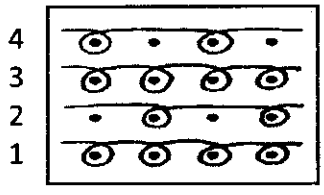
Birds eye is a knit-miss single jersey structure. So one set of needle is used to produce this structure. The repeat of the structure completes on four courses. Knitting sequence for a repeat as follows:



- First course: Knit on all odd number needles and miss on all even number needles.
- Second course: Knit on all odd number needles and miss on all even number needles. Similar as first course.
- Third course: Miss on all odd number needles and knit on all even number needles.
- Fourth course: Miss on all odd number needles and knit on all even number needles. Similar as third course.

3. Weft Locknit Design:

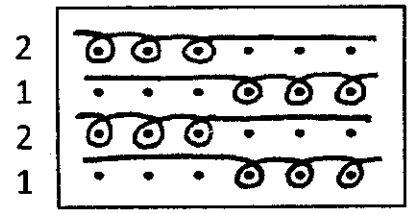
Weft locknit is a knit-miss single jersey structure. So one set of needle is used to produce this structure. The repeat of the structure completes on four courses. Knitting sequence for a repeat as follows:



- First course: Knit on all needles.
- Second course: Miss on all odd number needles and knit on all even number needles.
- Third course: Similar as first course knit on all needles.
- Fourth course: Knit on all odd number needles and miss on all even number needles.

4. Mock Rib Design:

Mock rib is a knit-miss single jersey structure. So one set of needle is used to produce this structure. The repeat of the structure completes on two courses. Knitting sequence for a repeat as follows:



- First course: Miss on first three needles and knit on second or next three needles.
- Second course: It is just opposite of the first course i.e. knit on first three needles and miss on second three needles.

5. Single Cross Tuck Design:

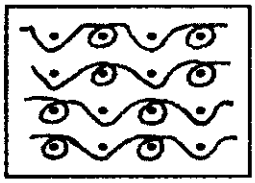
Single cross tuck is a knit-tuck single jersey structure. So one set of needle is used to produce this structure. The repeat of the structure completes on two courses. Knitting sequence for a repeat as follows:

- First course: Knit on all odd number needles and tuck on all even number needles.
- Second course: It is opposite of the first course i.e. tuck on all odd number needles and knit on all even number needles.

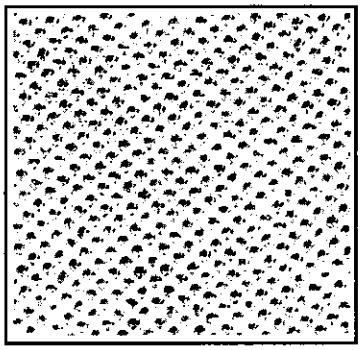
6. Double Cross Tuck or Polo Pique Design:

Polo pique is a knit-tuck single jersey structure. So one set of needle is used to produce this structure. It is a very popular structure to produce cut and sew knit wear. The prominency of the design appears on the back side of the fabric. The repeat of the structure completes on four courses. Knitting sequence for a repeat as follows:

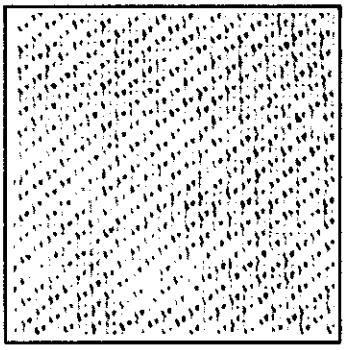
- First course: Knit on all odd number needles and tuck on all even number needles.
- Second course: Knit on all odd number needles and tuck on all even number needles, which is similar as the first course.
- Third course: Tuck on all odd number needles and knit on all even number needles.



Notation diagram

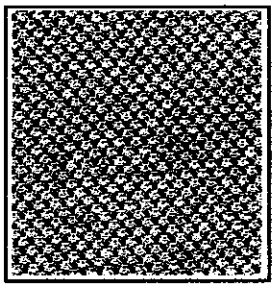


Back side

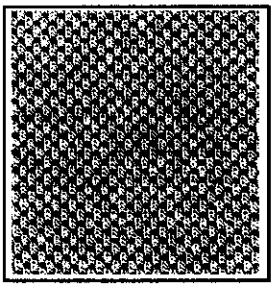


Face side

- Fourth course: Tuck on all odd number needles and knit on all even number needles, which is similar as the previous third course.

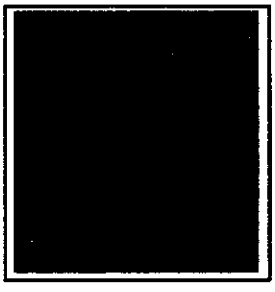


Back side

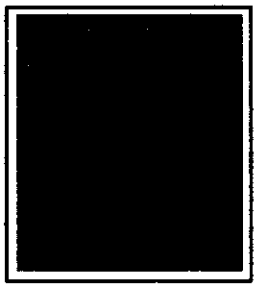


Face side

Pique Lacoste

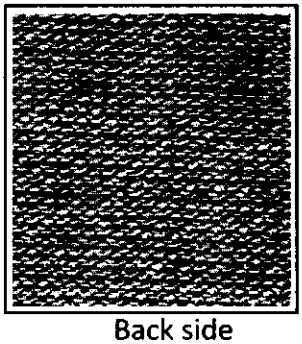


Back side

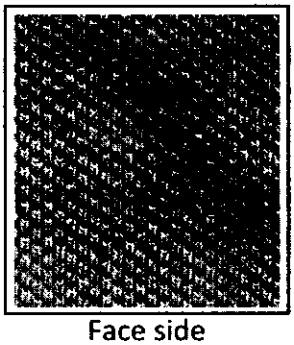


Face side

Heavy or jumbo Pique



Back side



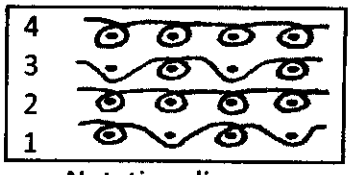
Face side

Lycra pique fabric

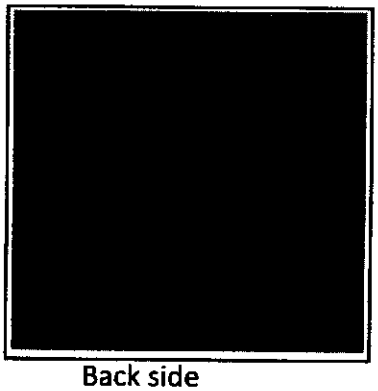
7. Single Lacoste or Fred Perry Design:

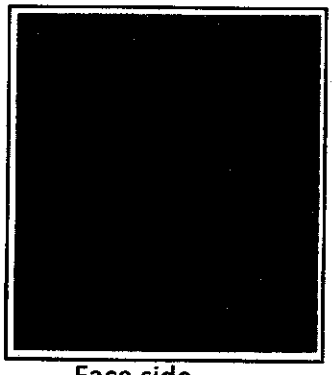
Single lacoste is a knit-tuck single jersey structure. So one set of needle is used to produce this structure. It is also a very popular structure to produce cut and sew knit wear. The prominency of the design appears on the back side of the fabric. The repeat of the structure completes on four courses. Knitting sequence for a repeat as follows:

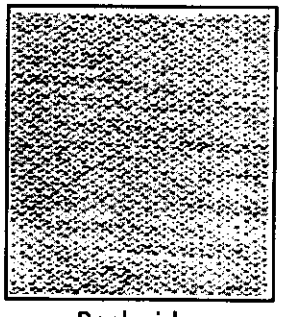
- First course: Knit on all odd number needles and tuck on all even number needles.
- Second course: Knit on all needles.
- Third course: Tuck on all odd number needles and knit on all even number needles, which is opposite of the first course.
- Fourth course: Similar as second course knit on all needles.

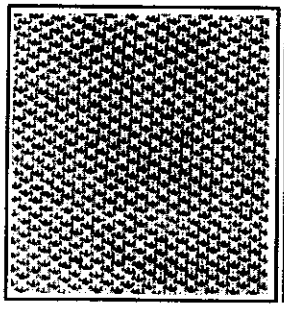


Notation diagram

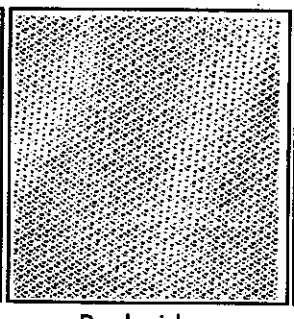

Back side

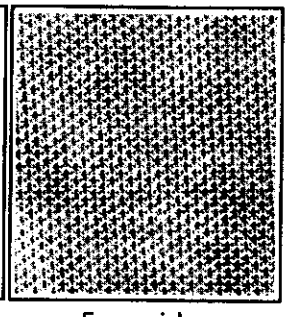

Face side


Back side


Face side

Single Lacoste


Back side

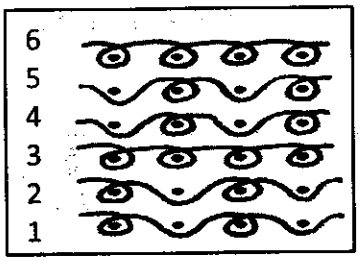

Face side

100% polyester (filament) single lacoste

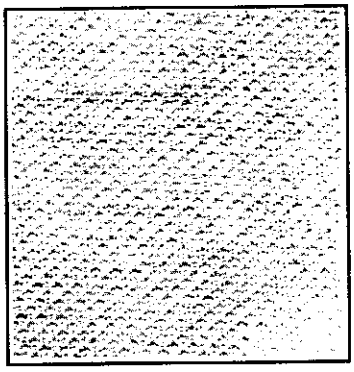
8. Double Lacoste Design:

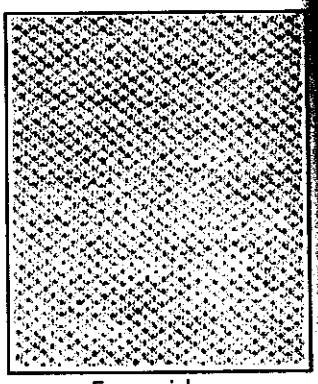
Double lacoste is a tuck-knit single jersey structure. So one set of needle is used to produce this structure. It is also a very popular structure to produce cut and sew knit wear. The prominency of this design near to the single lacoste fabric. The repeat of the structure completes on six courses. Knitting sequence for a repeat as follows:

- First course: Knit on all odd number needles and tuck on all even number needles.
- Second course: Same as first course i.e. Knit on all odd number needles and tuck on all even number needles.
- Third course: Knit on all needles.
- Fourth course: Tuck on all odd number needles and knit on all even number needles, which is opposite of the first course.

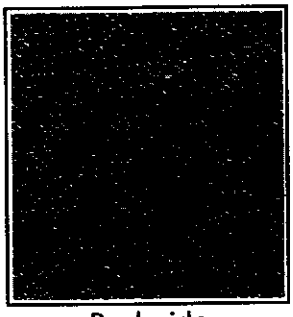


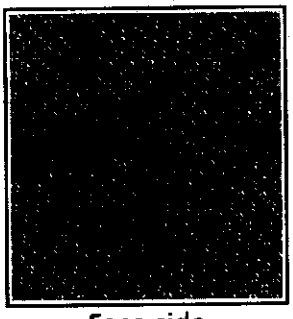
Notation diagram

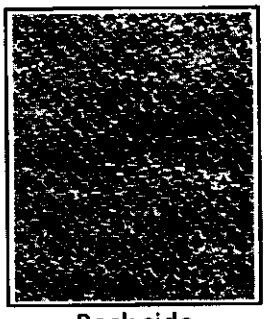

Back side

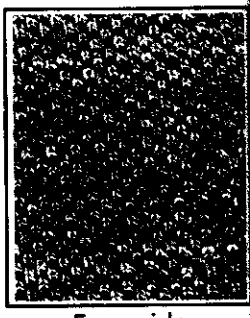

Face side

- Fifth course: Same as fourth course i.e. Tuck on all odd number needles and knit on all even number needles.
- Sixth course: Similar as third course knit on all needles.


Back side


Face side

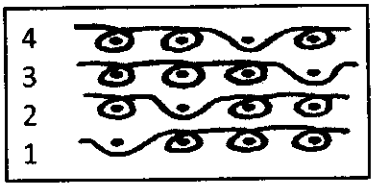

Back side


Face side

Double Lacoste fabric

9. Simple Crepe Design:

It may be tuck-knit or miss knit single jersey structure. So one set of needle is used to produce this structure. The repeat of the structure completes on four courses. Knitting sequence for a repeat as follows:

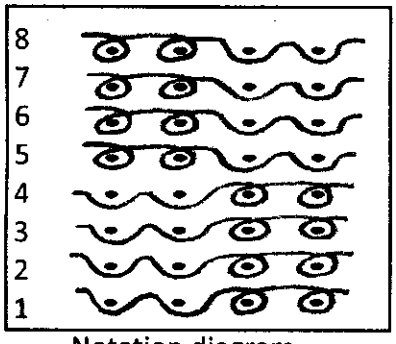


- First course: Tuck on first needle and knit on all rest of the needles.
- Second course: Tuck on second needle and knit on all rest of the needles.
- Third course: Tuck on fourth needle and knit on all rest of the needles.
- Fourth course: Tuck on third needle and knit on all rest of the needles.

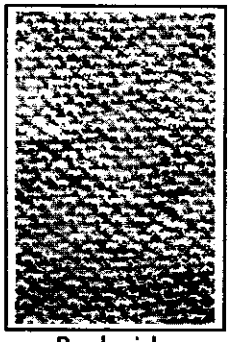
10. Cellular Blister or Popcorn Design:

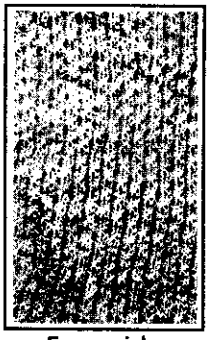
It is a tuck-knit single jersey structure. So one set of needle is used to produce this structure. The prominency of the design appears on the back side of the fabric. The repeat of the structure completes on eight courses. Knitting sequence for a repeat as follows:

- First course: Tuck on first two needles and knit on second or next two needles.
- Second course: Similar as first course.
- Third course: Similar as first course.



Notation diagram

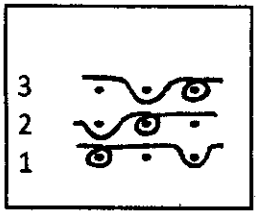

Back side

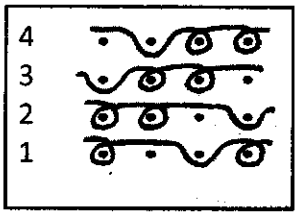

Face side

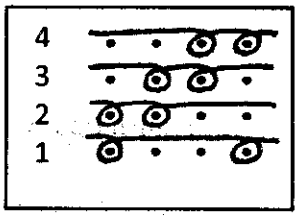
- Fourth course: Similar as first course i.e. Tuck on first two needles and knit on next two needles.
- Fifth course: Knit on first two needles and tuck on second or next two needles.
- Sixth course: Similar as fifth course.
- Seventh course: Similar as fifth course.
- Eighth course: Similar as fifth course i.e. Knit on first two needles and tuck on second two needles.

11. Twill Effects:

It may be tuck-knit or miss-knit or knit-tuck-miss single jersey structure. So one set of needle is used to produce this structure. The prominency of the design appears on the back side of the fabric. The main features of this structure is that the diagonal line (twill line) appears on the fabric surface like as woven twill fabric. The repeat of the structure completes on several courses. The following figures show the knitting sequence for a repeat:





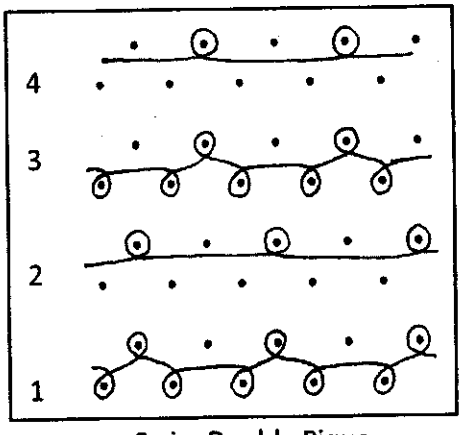


Double Jersey Derivatives based on Rib Structure:

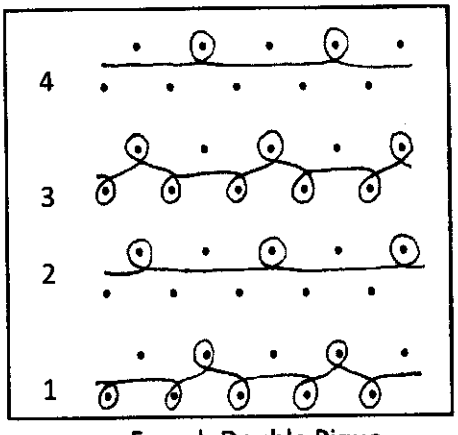
A generic name applied to a range of knitted fabrics made on a rib or interlock basis, the construction of which is often designed to reduce the natural extensibility of the structure. The term is generally confined to fabrics knitted on machines of E10 gauge or finer and it may be classified as either non-jacquard or jacquard double jersey.

1. **Double Piqué:**

Double piqué is a double jersey fabric made on a rib basis, using a selection of knitted loops and floats. The two most important sequences are known as Swiss double piqué and French double piqué respectively, and the knitting sequences for each are shown in the following figure. Double piqué is also known as wevenit, rodier, and overnit.



Swiss Double Pique



French Double Pique

a) **Swiss Double Pique**: Knitting sequence for a repeat as follows –

- First course: Cylinder needles – all are produce knit loop.
  Dial needles – odd number needles produce knit loop and even number needle produce miss loop.
- Second course: Cylinder needles – all are produce miss loop.
  Dial needles – same as first course.
- Third course: Cylinder needles – same as first course.
  Dial needles – odd number needles produce miss loop and even number needle produce knit loop.
- Fourth course: Cylinder needles – all are produce miss loop.
  Dial needles – same as third course.

b) **French Double Pique**: Knitting sequence for a repeat as follows –

- First course: Cylinder needles – all are produce knit loop

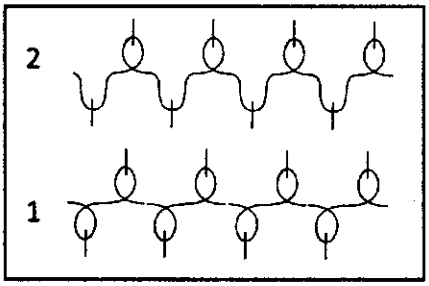
Dial needles – odd number needles produce miss loop and even number needle produce knit loop.

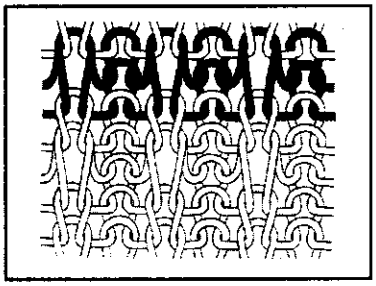
- Second course: Cylinder needles – all are produce miss loop.
  Dial needles – odd number needles produce knit loop and even number needle produce miss loop.
- Third course: Cylinder needles – same as first course.
  Dial needles – same as second course.
- Fourth course: Cylinder needles – all are produce miss loop.
  Dial needles – same as first course.

2. Half Cardigan Rib or Royal Rib:

It is a rib based structure in which a great number of tuck stitches are added to make the fabric heavy, wide and soft. From the below notation diagram it is clear that two knitting sequences are required to produce one repeat of this type of fabric.

A special effect is produced when one half of the cardigan repeat is substituted for a regular 1 × 1 rib structure. The new fabric is called a "Half Cardigan" and is produced according to the knitting notation system illustrated in the following figure. One side of the fabric, in this case the reverse side, is produced with tuck stitches and therefore looks like a "Cardigan". The loops of the other side acquire a very rounded and attractive shape which is very typical for this structure.





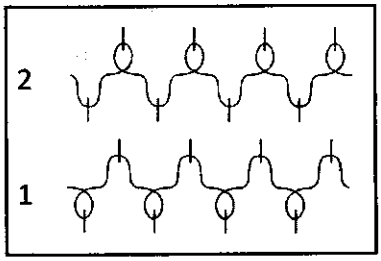
The Knitting sequence for a repeat as follows –

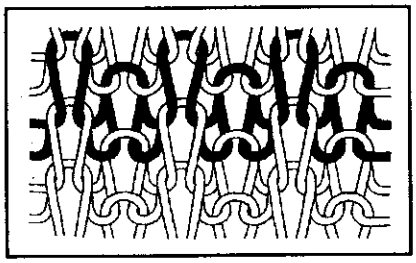
- First course: regular 1×1 rib structure.
- Second course: tuck loop formed by the all needles of one bed and knit loop formed by the all needles of other bed.

3 Full Cardigan Rib or Polka Rib:

It is another variation of the 1×1 rib structure. In this case, even more tuck stitches are introduced which makes the fabric wider, heavier, bulkier and less flexible then the half cardigan or the usual 1×1 rib. Contrary to the previous example the full cardigan is symmetric on both sides. From the below notation diagram it is clear that

two yarns are inserted into the fabric in order to complete one full course i.e. loops on the one needle bed and loops on the other needle bed.





The two courses which make the "Cardigan" repeat are illustrated in the above needle notation system. The Knitting sequence for a repeat as follows –

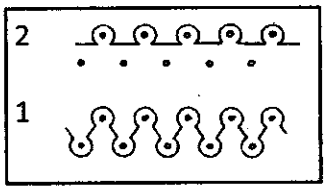
- First course: tuck loop formed by the all needles of back bed and knit loop formed by the all needles of front bed.
- Second course: tuck loop formed by the all needles of front bed and knit loop formed by the all needles of back bed.

Because of the large number of tuck stitches, both Cardigan and Half Cardigan are very bulky, in comparison with other knit structures. They are sometimes very fashionable and are used for heavy outerwear such as sweater.

4. Half Milano Rib:

A weft-knitted rib-based fabric, consisting of one row of 1×1 rib and one row of plain knitting made on either set of needles. The appearance and characteristics of the fabric are related to the ratio of the course lengths of first (1) and second (2). The Knitting sequence for a repeat as follows –

- First course: regular 1×1 rib structure.
- Second course: plain structure, all needle of one bed is active and all needles of other bed is inactive.

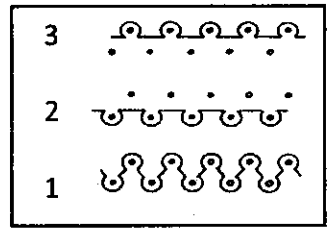


5. Milano Rib:

A weft-knitted rib-based fabric. Each complete repeat of the structure consist of three components knitted in the sequences shown to give one row of 1×1 rib and one row of plain tubular knitting, the two component parts of tubular knitting usually being similar. The appearance and characteristics of the fabrics are related to the

ratio of the course lengths of two rows. The Knitting sequence for a repeat as follows-

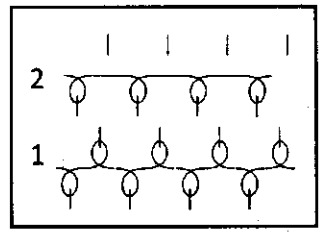
- First course: regular 1×1 rib structure.
- Second course: plain structure, all needle of one bed is active and all needles of other bed is inactive.
- Third course: reverse of second course.



6. Roma Rib:

A weft-knitted rib-based structure. Each complete repeat of the structure consist of two components knitted in the sequences shown to give one row of 1×1 rib and one row of plain knitting. The Knitting sequence for a repeat as follows –

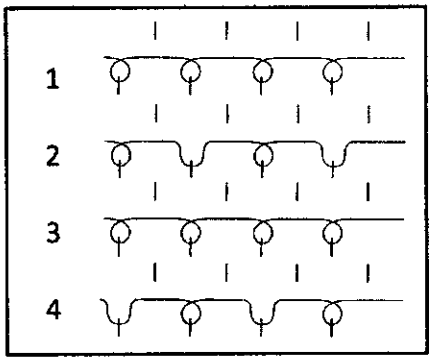
- First course: regular 1×1 rib structure.
- Second course: plain structure, all needle of front bed is active and all needles of back bed is inactive.

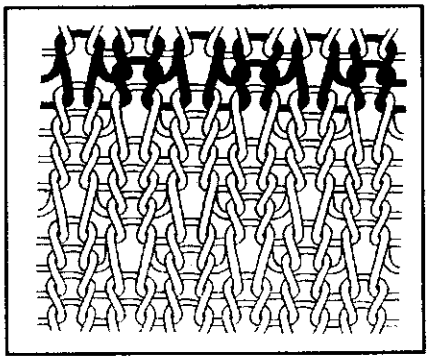


7. Lacoste Piqué:

Basically it is a derivatives of single jersey structure. This lacoste piqué is produced by using a selection of knitted loops and tuck loops. It can be produced on rib based machine, but it should be remember that for the production of this fabric one bed is active and other bed is inactive. In the following figure the front bed is active and back bed is inactive. The Knitting sequence for a repeat as follows –

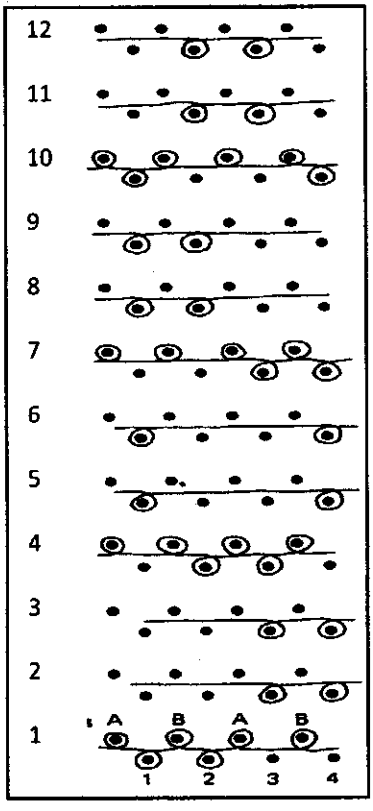
- First course: all needles of front bed makes knit loop.
- Second course: odd number needles of front bed makes knit loops and even number needles of same bed makes tuck loops.
- Third course: same as first course.
- Fourth course: odd number needles of front bed makes tuck loops and even number needles of same bed makes knit loops.



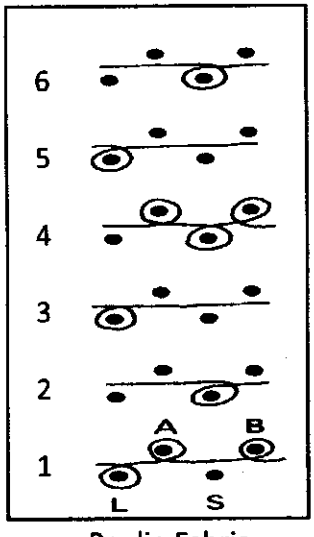


8. Gaberdine or 2 × 2 Twill Fabric:

Gabardine is a simple 2×2 twill double-blister fabric which is useful for fine-gauge men's leisurewear. It has a four needle width repeat, with the dial needles all knitting the backing at every third (ground) feed. The following left figure shows a gabardine fabric.



Gaberdine or 2 × 2 Twill Fabric



Poplin Fabric

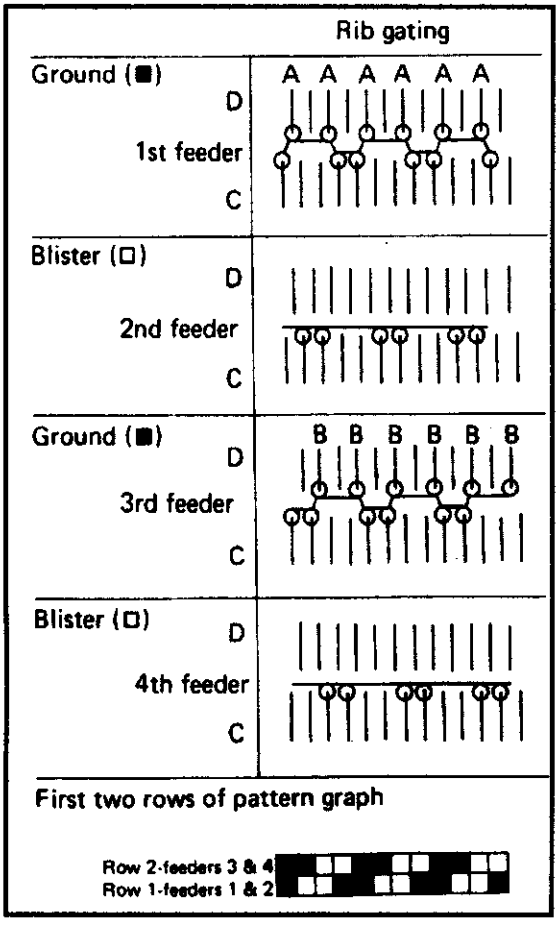
9. Poplin Fabric:

Poplin is a flatter structure. It is used for the same purpose of gabardine fabric. It is type of single blister with a two needle width repeat. The above right figure shows the notation diagram of a poplin fabric.

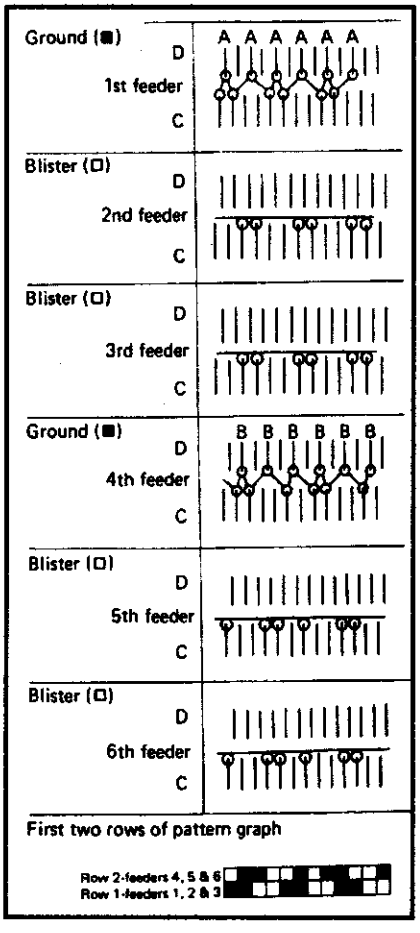
10. **Blister fabric:**

A three-dimensional relief effect fabric generally made on a rib basis. There are two types of blister fabric, such as single blister and double blister fabric.

- Single blister: It is sometimes termed three-miss blister because each dial needle misses three feeders after knitting. It has one blister feeder course between each ground feeder course.
- Double blister: It has two blister feeder courses between each ground feeder course. This produces a more pronounced blister relief, with twice as many courses of blister loops to ground loops. It is heavier and has a slower rate of production than single blister. It is sometimes termed five-miss blister. Blister loops at two successive feeders may not necessarily occur on the same needles. They may be in one or more colours with a self-colour or a one or two-colour ground. All blister structures show only the ground loops on the back.



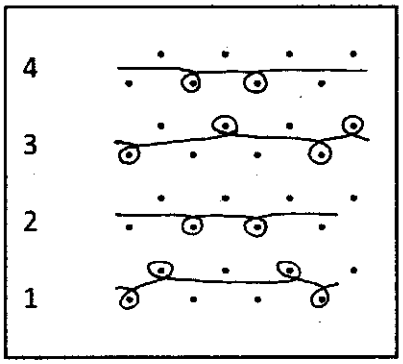
Single blister fabric



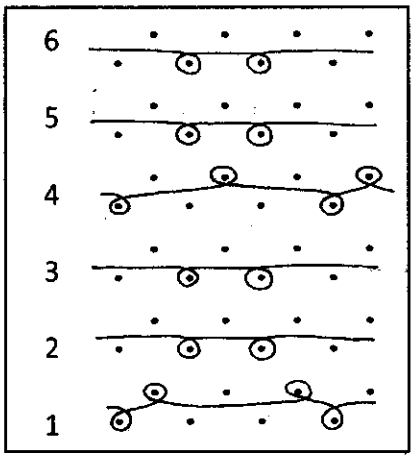
Double blister fabric

11. Relief Fabric:

A patterned rib-based fabric, the surface of which exhibits a characteristics relief or blister effect in which the number of loops in the relief portion is greater than in the surrounding area on the effect side and on the reverse side. The relief area may be of a different colour from the main ground and the ground may also be patterned. Two main types of structure are recognized: single relief or three-miss blister and double relief or five-miss blister. The latter has a greater preponderance of loops on the face of the fabric in the relief areas than the former. Also known as blister fabric or cloqué fabric.



Single Relief Fabric



Double Relief fabric

Non-Jacquard Double Jersey Structures or Derivatives of Interlock Structure:

It produced mainly on the modified interlock machine. Various modifications to the basic interlock machine have been necessary in order to produce the new structures. Originally only alternate tricks were fully cut through to accommodate long needles so that mock eight-lock was achieved by knitting normal interlock with every third dial needle removed, now all tricks may be cut through and inserts placed in tricks under short needles.

Most interlock variation structures have six or eight feeder repeat sequences as only alternate needles in one bed are in action in a course.

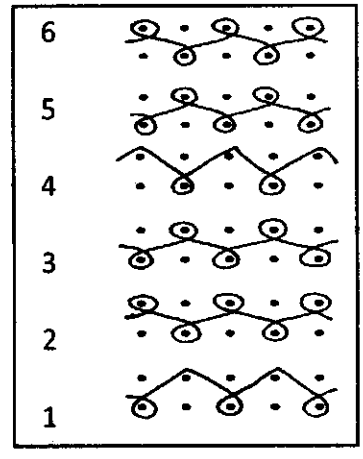
1. Single Pique or Cross Tuck Interlock Structure:

It was one of the first to be produced, by placing tuck cams in the dial at every third feeder. The tuck stitches throw the fabric out approximately 15% wider than normal interlock to a satisfactory finished width of over 60", they break up the surface uniformity and help to mask feeder stripiness but they also increase fabric weight.

Single pique is a tuck-knit interlock structure. So interlock needle gating system is used to produce this structure. Long and short needles in dial and cylinder, long

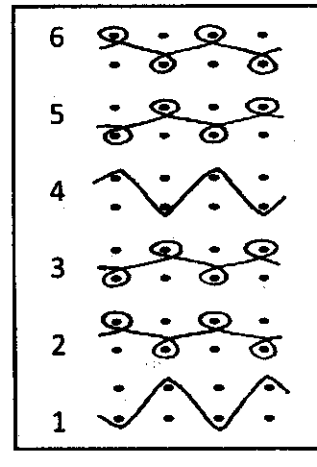
needles facing short needles and vice-versa. The repeat of the structure completes on six feeders. Knitting sequence for a repeat as follows:

- First feeder: Knit on all short cylinder needles and tuck on all short dial needles.
- Second feeder: Knit on all long cylinder and dial needles.
- Third feeder: Knit on all short cylinder and dial needles.
- Fourth feeder: Knit on all long cylinder needles and tuck on all long dial needles.
- Fifth feeder: Knit on all short cylinder and dial needles.
- Sixth feeder: Knit on all long cylinder and dial needles.



2. Texi Pique Structure:

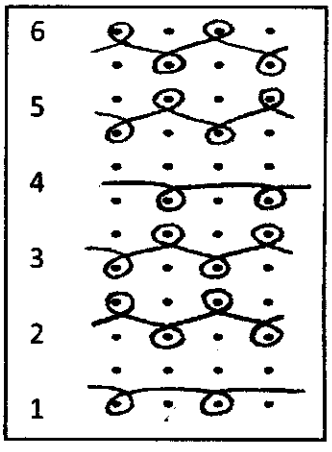
It is wider and bulkier and shows the same pique effect on both sides of the fabric. Texi pique is a tuck-knit interlock structure. So interlock needle gating system is used to produce this structure. Long and short needles in dial and cylinder, long needles facing short needles and vice-versa. The repeat of the structure completes on six feeders. Knitting sequence for a repeat as follows:



- First feeder: Tuck on all short cylinder needles and tuck on all short dial needles.
- Second feeder: Knit on all long cylinder and dial needles.
- Third feeder: Knit on all short cylinder and dial needles.
- Fourth feeder: Tuck on all long cylinder needles and tuck on all long dial needles.
- Fifth feeder: Knit on all short cylinder and dial needles.
- Sixth feeder: Knit on all long cylinder and dial needles.

3. Cross Miss Structure:

It is the knit miss equivalent of single pique but it is narrower and lighter in weight. Cross miss is a miss-knit interlock structure. So interlock needle gating system is used to produce this structure. Long and short needles in dial and cylinder, long needles facing short needles and vice-versa. The repeat of the structure completes on six feeders. Knitting sequence for a repeat as follows:

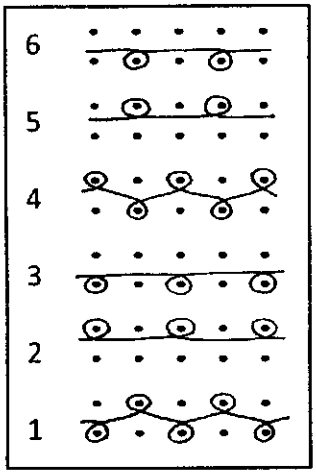


- First feeder: Knit on all short cylinder needles only and all dial needles remain idle.
- Second feeder: Knit on all long cylinder and dial needles.
- Third feeder: Knit on all short cylinder and dial needles.
- Fourth feeder: Knit on all long cylinder needles only and all dial needles remain idle.
- Fifth feeder: Knit on all short cylinder and dial needles.
- Sixth feeder: Knit on all long cylinder and dial needles.

4. Piquette Structure:

It is a reversible knit miss structure with a light cord effect. Piquette is also a miss-knit interlock structure. So interlock needle gating system is used to produce this structure. Long and short needles in dial and cylinder, long needles facing short

needles and vice-versa. The repeat of the structure completes on six feeders. Knitting sequence for a repeat as follows:

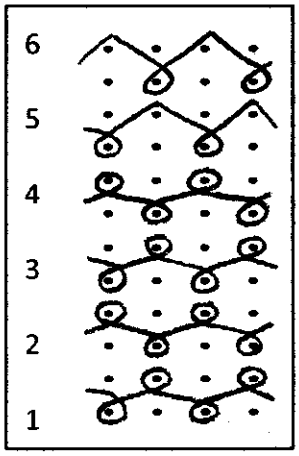


- First feeder: Knit on all short cylinder and dial needles.
- Second feeder: Knit on all long dial needles only and all cylinder needles remain idle.
- Third feeder: Knit on all short cylinder needles only and all dial needles remain idle.
- Fourth feeder: Knit on all long cylinder and dial needles.
- Fifth feeder: Knit on all short dial needles only and all cylinder needles remain idle.
- Sixth feeder: Knit on all long cylinder needles only and all dial needles remain idle.

5. Pin Tuck Structure:

Pin Tuck is a tuck-knit interlock structure. So interlock needle gating system is used to produce this structure. Long and short needles in dial and cylinder, long needles facing short needles and vice-versa. The repeat of the structure completes on six feeders also. Knitting sequence for a repeat as follows:

- First feeder: Knit on all short cylinder and dial needles
- Second feeder: Knit on all long cylinder and dial needles.
- Third feeder: Knit on all short cylinder and dial needles.
- Fourth feeder: Knit on all long cylinder and dial needles
- Fifth feeder: Knit on all short cylinder and tuck on all short dial needles.
- Sixth feeder: Knit on all long cylinder and tuck on all long dial needles.



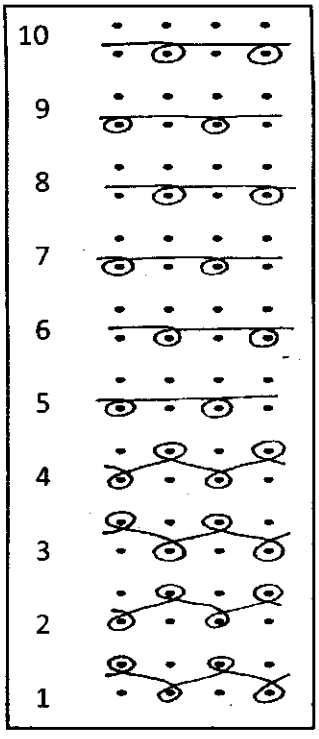
6. Bourrelet Structure:

A non jacquard double jersey fabric made on an interlock basis which is characterized by horizontal ridges on the effect side (the surface of the fabric intended to be used outermost on a garment or other construction). The knitting sequence is generally a number of courses of interlock, followed by a number of courses knitted on one set of needles only.

Bourrelet fabrics have pronounced horizontal cords at regular intervals produced by knitting excess courses on the cylinder needles, the cord courses may be in a different colour to the ground courses. There may be half, more than half, or less than half the total number of feeders knitting the cord courses. Interlock rather than rib base bourrelet is usually preferred because it provides a softer, smoother more regular surface with less elasticity but it requires two feeders per cord row.

Bourrelet is a miss-knit interlock structure. So interlock needle gating system is used to produce this structure. Long and short needles in dial and cylinder, long needles facing short needles and vice-versa. The repeat of the structure completes on ten feeders. Knitting sequence for a repeat as follows:

- First feeder: Knit on all long cylinder and dial needles.
- Second feeder: Knit on all short cylinder and dial needles.
- Third feeder: Knit on all long cylinder and dial needles.
- Fourth feeder: Knit on all short cylinder and dial needles.
- Fifth feeder: Knit on all short cylinder needles only and all dial needles remain idle.
- Sixth feeder: Knit on all long cylinder needles only and all dial needles remain idle.
- Seventh feeder: Knit on all short cylinder needles only and all dial needles remain idle.
- Eighth feeder: Knit on all long cylinder needles only and all dial needles remain idle.

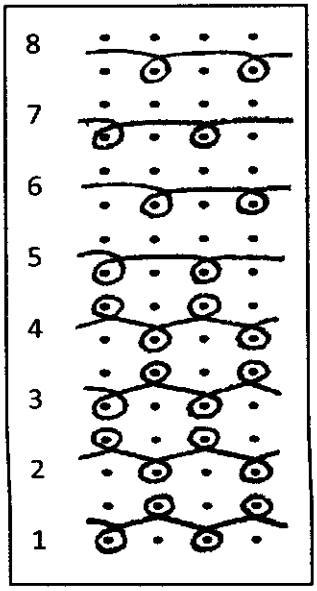


- Ninth feeder: Knit on all short cylinder needles only and all dial needles remain idle.
- Tenth feeder: Knit on all long cylinder needles only and all dial needles remain idle.

7. Jersey Cord Structure:

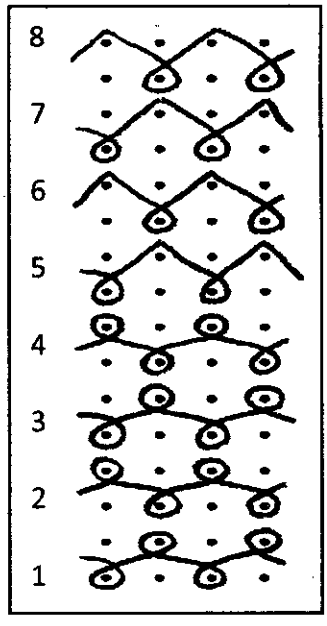
Jersey cord is an example of a Miss bourrelet. So it is a miss-knit interlock structure. Interlock needle gating system is used to produce this structure. Long and short needles in dial and cylinder, long needles facing short needles and vice-versa. The repeat of the structure completes on eight feeders. Knitting sequence for a repeat as follows:

- First feeder: Knit on all short cylinder and dial needles.
- Second feeder: Knit on all long cylinder and dial needles.
- Third feeder: Knit on all short cylinder and dial needles.
- Fourth feeder: Knit on all long cylinder and dial needles.
- Fifth feeder: Knit on all short cylinder needles only and all dial needles remain idle.
- Sixth feeder: Knit on all long cylinder needles only and all dial needles remain idle.
- Seventh feeder: Knit on all short cylinder needles only and all dial needles remain idle.
- Eighth feeder: Knit on all long cylinder needles only and all dial needles remain idle.



8. Super Roma Structure:

Super roma is an example of a tuck bourrelet, this one sometimes termed horizontal ripple fabrics, tend to be heavier and to have a less pronounced cord than the jersey cord, which are termed 'Ottomans' in the USA. It is a tuck-knit interlock structure. Interlock needle gating system is used to produce this structure. Long and short needles in dial and cylinder, long needles facing short needles and vice-versa. The repeat of the structure completes on eight feeders. Knitting sequence for a repeat as follows:



- First feeder: Knit on all short cylinder and dial needles.
- Second feeder: Knit on all long cylinder and dial needles.

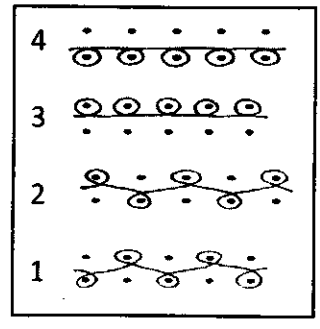
- Third feeder: Knit on all short cylinder and dial needles.
- Fourth feeder: Knit on all long cylinder and dial needles.
- Fifth feeder: Knit on all short cylinder needles and tuck on all short dial needles.
- Sixth feeder: Knit on all long cylinder needles and tuck on all long dial needles.
- Seventh feeder: Knit on all short cylinder needles and tuck on all short dial needles.
- Eighth feeder: Knit on all long cylinder needles and tuck on all long dial needles.

9. Punto di-Roma Structure:

It has replaced double pique as the most popular non-jacquard double jersey fabric, it belongs to a group of structures which are reversible and have a tubular sequence of dial only and cylinder only knit. It has an acceptable weight and finishes with a width of about 70 inches.

It is a interlock bsaed structure. Interlock needle gating system is used to produce this structure. Long and short needles in dial and cylinder, long needles facing short needles and vice-versa. The repeat of the structure completes on four feeders. Knitting sequence for a repeat as follows:

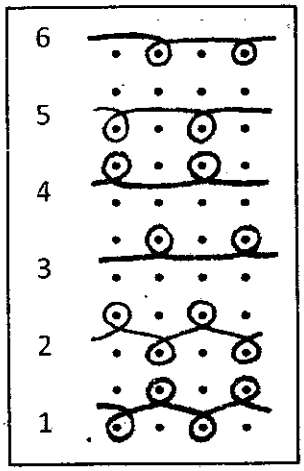
- First feeder: Knit on all short cylinder and dial needles.
- Second feeder: Knit on all long cylinder and dial needles.
- Third feeder: Knit on all both long and short dial needles and all cylinder needles remain idle.
- Fourth feeder: Knit on all both short and long cylinder needles and all dial needles remain idle.



10. Cortina Structure:

Cortina is the six feeder version of punto diroma, produced on interlock camming with run-through cams where missing is required. So it is a missknit interlock structure. Interlock needle gating system is used to produce this structure. Long and short needles in dial and cylinder, long needles facing short needles and vice-versa

The repeat of the structure completes on six feeders. Knitting sequence for a repeat as follows:

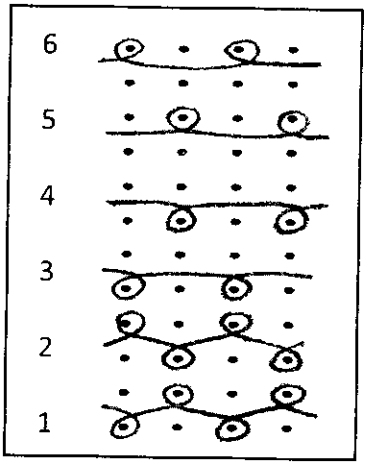


- First feeder: Knit on all short cylinder and dial needles.
- Second feeder: Knit on all long cylinder and dial needles.
- Third feeder: Knit on all short dial needles only and all cylinder needles remain idle.
- Fourth feeder: Knit on all long dial needles only and all cylinder needles remain idle.
- Fifth feeder: Knit on all short cylinder needles only and all dial needles remain idle.
- Sixth feeder: Knit on all long cylinder needles only and all dial needles remain idle.

11. Six course Punto di-Roma Structure:

It is a miss-knit interlock structure. So interlock needle gating system is used to produce this structure. Long and short needles in dial and cylinder, long needles facing short needles and vice-versa. The repeat of the structure completes on six feeders. Knitting sequence for a repeat as follows:

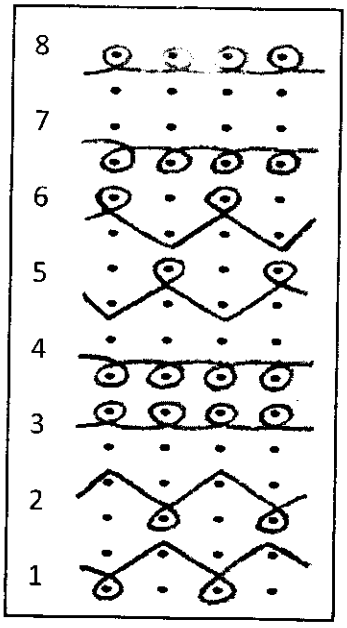
- First feeder: Knit on all short cylinder and dial needles.
- Second feeder: Knit on all long cylinder and dial needles.
- Third feeder: Knit on all short cylinder needles only and all dial needles remain idle.
- Fourth feeder: Knit on all long cylinder needles only and all dial needles remain idle.
- Fifth feeder: Knit on all short dial needles only and all cylinder needles remain idle.
- Sixth feeder: Knit on all long dial needles only and all cylinder needles remain idle.



12. Evermonte Structure:

It has a row of tuck stitches on one side after each tubular course which produces a slight ripple effect. It is a tuck-knit interlock structure. Interlock needle gating system is used to produce this structure. Long and short needles in dial and cylinder, long needles facing short needles and vice-versa. The repeat of the structure completes on eight feeders. Knitting sequence for a repeat as follows:

- First feeder: Knit on all short cylinder needles and tuck on all short dial needles.
- Second feeder: Knit on all long cylinder needles and tuck on all long dial needles.
- Third feeder: Knit on all both long and short dial needles and all cylinder needles remain idle.



- Fourth feeder: Knit on all both short and long cylinder needles and all dial needles remain idle.
- Fifth feeder: Tuck on all short cylinder needles and knit on all short dial needles.
- Sixth feeder: Tuck on all long cylinder needles and knit on all long dial needles.
- Seventh feeder: Knit on all both short and long cylinder needles and all dial needles remain idle.
- Eighth feeder: Knit on all both long and short dial needles and all cylinder needles remain idle.

Weft knitted Jacquard Design:

Weft knitted jacquard designs are built up from face loops in selected colours on a base fabric of either single jersey, 1×1 rib, or links-links (purl). The face loop needles are individually selected, usually each only once per pattern row, to rise and take one yarn from a sequence of different coloured yarn feeds on a knit or miss basis.

In two-colour jacquard, certain needles will be selected to knit colour A from the first feed and, at the next feed, there will be a negative selection with the remaining needles being selected to knit colour B. The face loops of two feed courses thus combine to produce one complete row of face pattern loops.

In three-colour jacquard, each needle will be selected to knit once and miss twice at a sequence of feeds, so that three feeder courses will produce one design row. The greater the number of colours in a design row, the lower the rate of productivity in design rows per machine revolution or traverse, assuming striping is not employed.

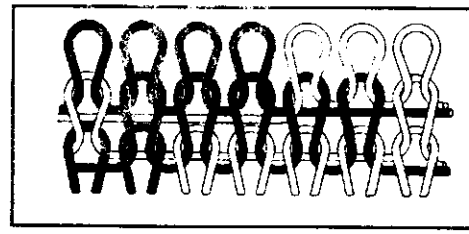
If striping is employed with jacquard selection, different colours can be selected at different design rows so that there are more colours in the total design than in one design row. For example, a four-feed machine with four-colour striping at each feed could knit four colours per design row but have a total of sixteen colours in the design depth.

Single Jersey Jacquard design:

A patterned single-jersey weft knitted fabric, usually made from two or more yarns of differing colour or texture to give a construction that consists essentially of knitted and float loops, but may incorporate tuck loops. The surface pattern is derived from the chosen arrangement of the yarns and of the knitted and float loops.

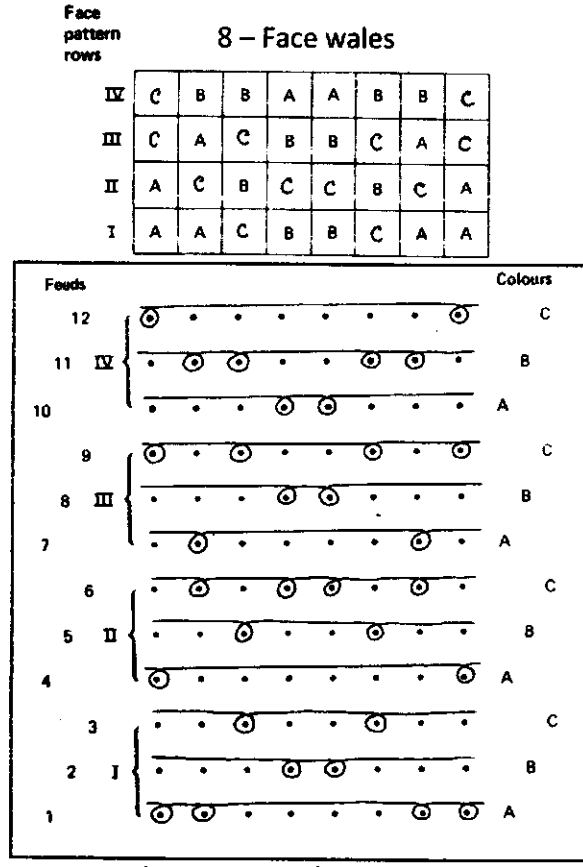
The inclusion of tuck loops into the construction eliminates long lengths of floating threads from the back of the fabric.

Single-jersey tuck jacquard – A patterned single-jersey weft knitted fabric usually made from two or more yarns differing in colour or texture in construction that consists of knitted and tuck loops. The surface pattern is derived from a chosen arrangement of the yarn and of the knitted and tuck loops.



The floats of single-jersey jacquard to some extent reduce the lateral extensibility of the garments and when continuous filament yarns are used in gauges of E 18 (npi) or less, the floats on the technical back can create problems of snagging. Single-cylinder sock machines may knit 1×1 float stitch jacquard, odd needles being selected for knit and miss whilst even needles knit at every feed, thus reducing the coloured yarn floats on the technical back to a single wale. The clarity of the coloured pattern area is only slightly impaired.

The following squared diagram illustrates part of a three-colour jacquard design, each face stitch being represented by a square. Using the running thread notation, provide a representation of the design for single-jersey knit / miss jacquard.

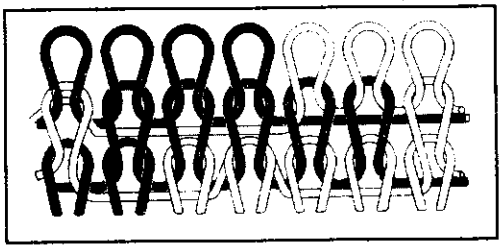


Single-jersey knit / miss jacquard

Accordion Fabric:

It is a single-jersey jacquard fabric. A weft knitted plain-based fabric, showing a figured design in two or more colours, that is produced by knitting and missing, and in which tuck loops are introduced to eliminate long lengths of floating thread at the back.

In accordion fabrics, the long floats are held in place on the technical back by tuck stitches. They were originally developed using knit and miss pattern wheel selection, needles required to tuck (if not selected to knit) were provided with an extra butt in line with a tuck cam placed immediately after the pattern wheel selection.

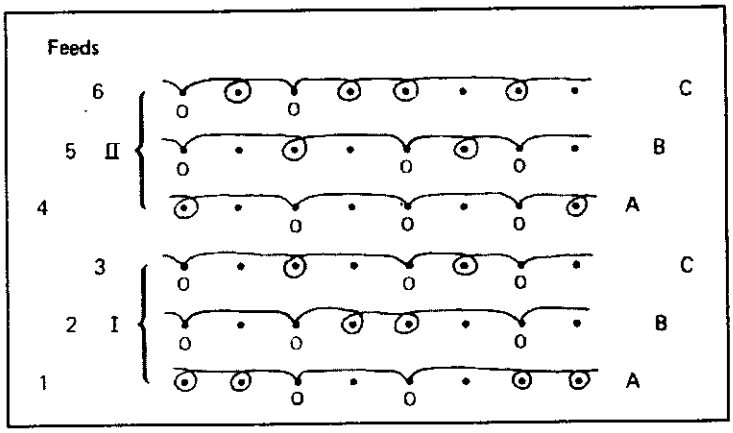


There are three types of accordion fabrics, such as – straight accordion fabric, alternate accordion fabric and selected accordion fabrics.

Straight accordion fabric:

In straight accordion fabrics, every odd needle was of this type, so every odd needle tucked when not selected to knit. The following figure shows a repeat of the representation of two pattern rows for the straight accordion fabrics.

II	A	C	B	C	C	B	C	A
I	A	A	C	B	B	C	A	A



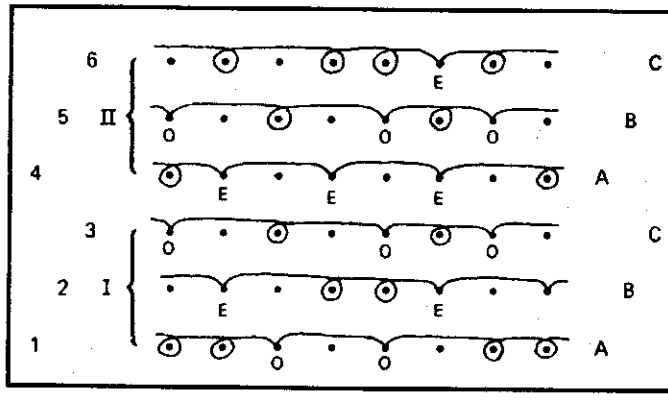
O = odd needles

Straight accordion fabric (Tucking on non-knitting odd needles)

Alternate accordion fabric:

Alternative accordion provides a better distribution of tuck stitches, odd needles had a tuck butt position in line with cams placed at odd feeders and even needles had another butt position for cams at even feeders. With both these types of accordion, tuck stitches can occur close together causing distortion of face loops and allowing unselected colours to 'grin' (a defect in a compound structure e.g. a double cloth in which one fabric can be seen through or 'grinning through' the other, as a result of bad cover. The term can be applied to compound woven and knitted structures including pile fabrics) through between adjacent wales onto the face. The following figure shows a repeat of the representation of two pattern rows for the alternate accordion fabrics.

II	A	C	B	C	C	B	C	A
I	A	A	C	B	B	C	A	A



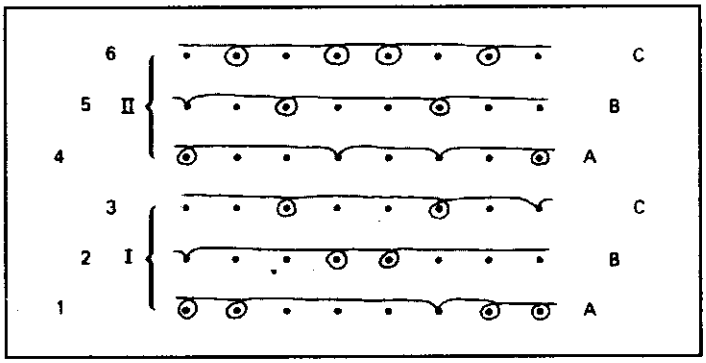
O = odd needles and E = even needles
Alternate accordion fabric

(Tucking on odd needles at odd feeders and even needles at even feeders when non knitting)

Selected accordion fabric:

The selective accordion fabric is the third type of accordion. It is most widely used but it requires a three-step pattern wheel or other selection device which can select the tuck loops so that they are carefully distributed to create the minimum of stitch distortion on the face of the design. The following figure shows a repeat of the representation of two pattern rows for the selected accordion fabrics.

II	A	C	B	C	C	B	C	A
I	A	A	C	B	B	C	A	A



Selected accordion fabric
(Tucking only on carefully selected non-knitting needles)

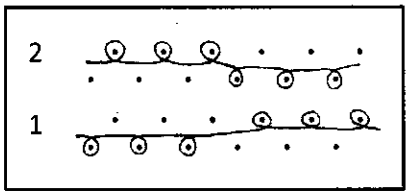
Double Jersey Jacquard Design:

It produced on the rib jacquard machine. Rib jacquard is a patterned rib-based fabric the surface of which is essentially flat and exhibits a figure or design in differing colour or texture. The patterned surface is derived from the chosen arrangement of yarns, and of knitted and miss or float loops. The back of the fabric may be either plain, striped, birdseye or ladder backing.

Rib jacquard designs are achieved by cylinder needle selection. The dial needles knit the backing and eliminate floats that occur when cylinder needles only are selected to miss. Tuck stitches are therefore unnecessary. On circular knitting machines, the selection is on the cylinder needles only and the dial needles knit the backing loops, whereas on flat knitting machines both beds may have selection facilities.

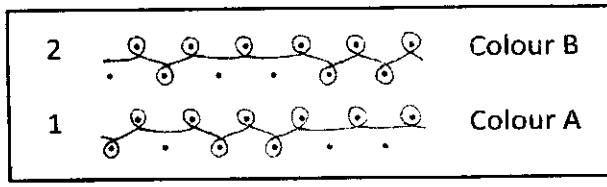
1. **Reverse Jacquard fabric:**

   A rib-based fabric in which the design on the effect side is reversed on the other side by alternation of the two component threads between the two sides.



2. Striped Backing for a Two Colour Rib Jacquard Fabric:

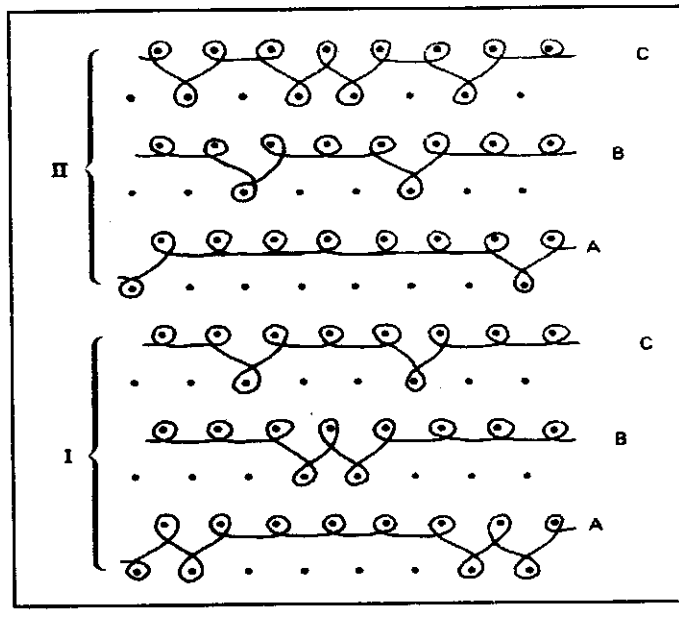
The reverse side of a rib jacquard fabric characterized by successive courses of horizontal stripes of each of the yarns used to form the pattern. The effect is obtained by knitting on all the needles in the set opposite to that used to form the pattern.



3. Three colour rib jacquard with Striped backing:

With horizontally striped backing, all dial needles will knit at every feeder thus producing an unbalanced structure with more backing rows of stitches than pattern rows. In the case of three-colour jacquard, there will be three times as many backing rows as face pattern rows. This type of backing ensures that the maximum yarn floats are only across one needle space and there is thus little loss of lateral extensibility – a prerequisite for garment length and hosiery knitting. The following figure shows a representation of two pattern rows as rib jacquard with horizontally-striped backing.

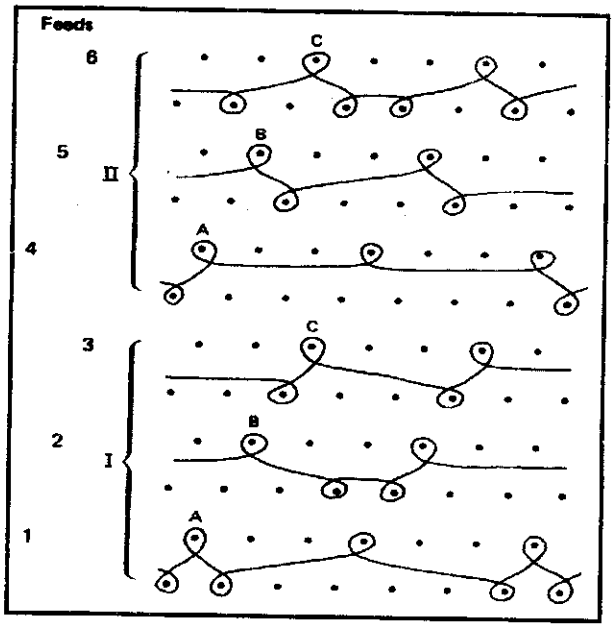
II	A	C	B	C	C	B	C	A
I	A	A	C	B	B	C	A	A



Rib jacquard with horizontally striped backing

The following figure shows a representation of two pattern rows as rib jacquard with horizontally-striped backing.

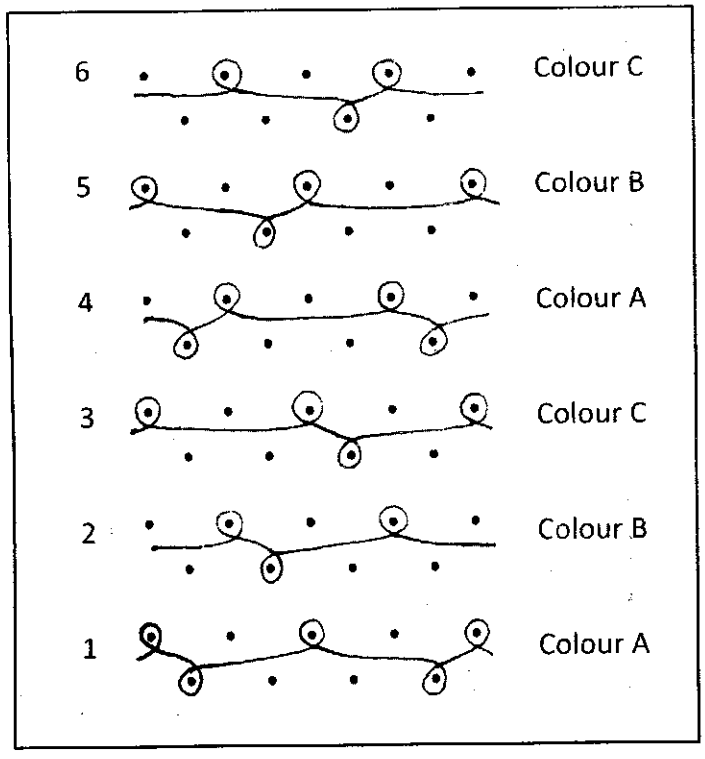
II	A	C	B	C	C	B	C	A
I	A	A	C	B	B	C	A	A

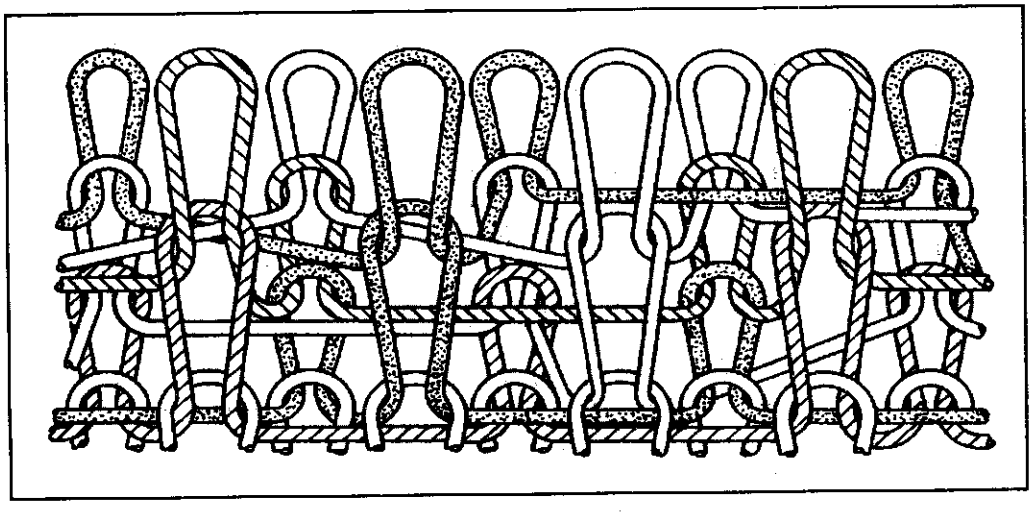


Rib jacquard with vertically striped backing

4. Birdseye Backing for a Three Colour Rib Jacquard Fabric:

The reverse side of a rib jacquard fabric characterized by courses in which knitted and float loops of one colour alternate with knitted and float loops of another, within and between successive courses. For double jersey fabrics, birds eye or twill backing is preferred as this is a more stable structure which is better balanced and has a pleasing, scrambled-colour appearance on the backing side. It is achieved by knitting the backing on alternate needles only and arranging for each colour to be knitted by odd backing needles at one feed and even needles at the next. The optimum number of colours is usually three.

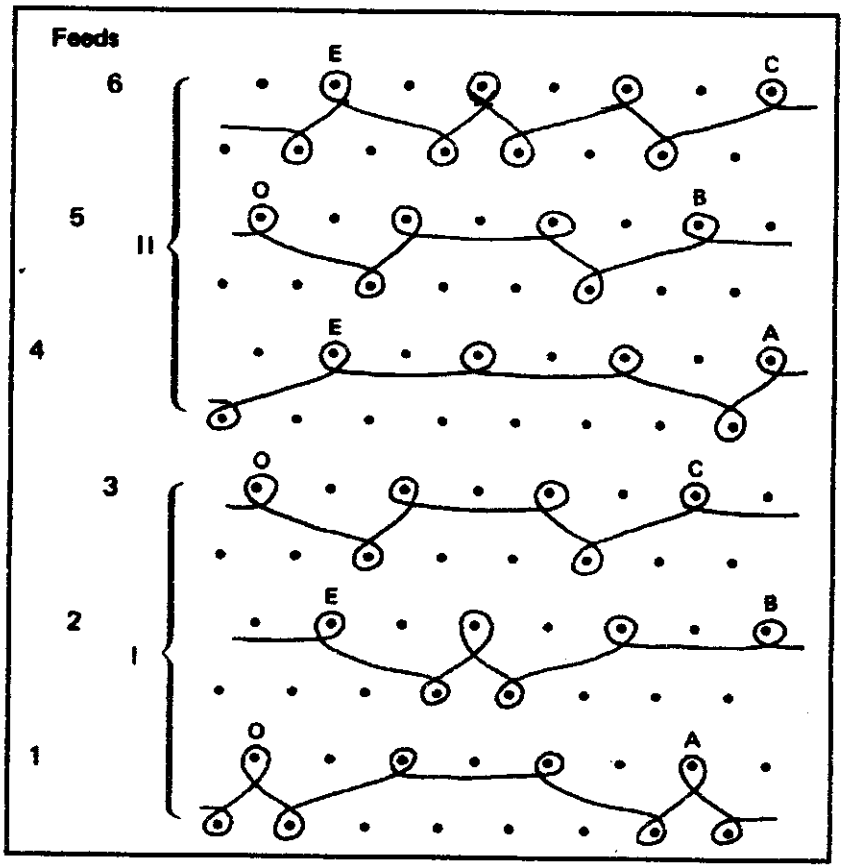




Birdseye backing for a three colour rib jacquard fabric

The following figure shows a representation of two pattern rows as rib jacquard with birds eye backing.

II	A	C	B	C	C	B	C	A
I	A	A	C	B	B	C	A	A



O = odd dial (backing needles) and E = even dial (backing needles)
Rib jacquard with birds eye backing

SWEATER KNITTING
(Fully Fashioned Knitwear)

In traditional garment production, rectangular flat knitted panels are cut to the required shapes, which are then sewn together. When a panel has to be cut according to a marker, the amount of waste is considerable and profits are reduced.

Fully fashioning is the process whereby portions of a garment are shaped at the selvedges by progressively increasing or decreasing the number of loops in the width of the fabric. Such narrowing and widening produces the shape of a piece of garment that would otherwise be generated by cutting. Sweater is a typical fully fashion knitwear.

The advantages of the fashioning process are:

- A considerable decrease in waste in the subsequent production stages. When the raw materials used in the knitting operation are expensive like Lambswool, Angora or Cashmere, the process is more attractive. There is little or no cutting waste.
- A reduction of some of the production stations such as marking, grading and cutting. The labour cost in each country define the importance of this point. In areas where higher wages are paid the process become more attractive.
- The quality of a fashioned garment edge is much better then a cut edge. The edges of the garment pieces are sealed and not liable to fraying, so can be joined by simple non-bulky seams. With the correct making-up equipment, this method produces a higher class garment.
- The shape of the panel is more accurate when produced during the knitting operation rather then being cut later.

The disadvantages of the fashioning process are:

- A reduced machine productivity due to the need to transfer loops from one needle bed to the other.
- The final shape of the garment has to be designed before the knitting procedure can be started. This is too complicated for many knitters who are not prepared to be involved in these operations.
- A somewhat higher level of designing skills has to be exercised. The fashioning procedure has to be added to the regular patterning of the fabric.
- The making-up operation of a fashioned garment requires a different type of sewing machine to achieve a higher quality product.

Fully fashioned garments are usually associated with knitted outerwear of a particular classical type and with a particular type of machinery: the 'straight bar' or 'Cotton's Patent' knitting machine.

However, knitted underwear is made on a fully fashioned basis, although the quantity is now very small compared to that made in the 19th century.

Men's heavy rib sweaters are also fully fashioned on hand flat knitting machines, as are fine gauge ladies suits and dresses.

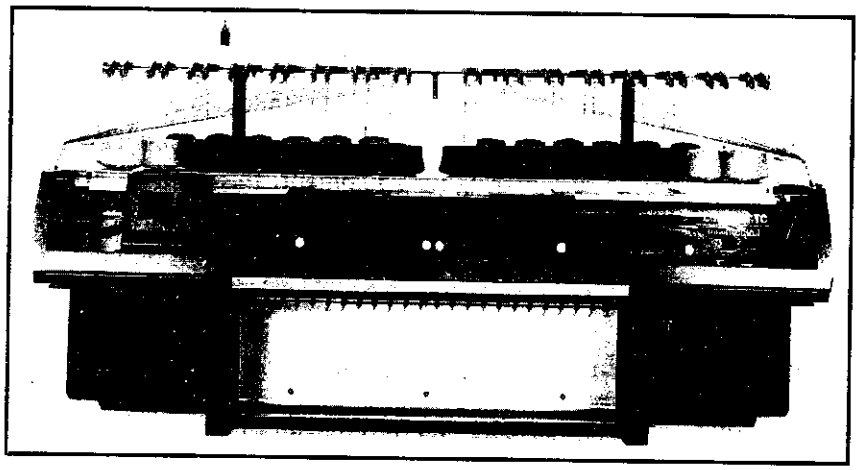
Increasingly the fashioning capabilities of modern electronically controlled V-bed flat machines are being used for making fully fashioned garments with scope for embellishment using a wide range of patternings. Such a use, with savings of material and making up costs, will increasingly feature as a development of the stitch shaped industry.

This chapter mainly discuss with the sweater knitting technology. The Vee-bed flat knitting machine is widely used to produce sweater part.

The features of a Vee-bed flat knitting i.e. sweater knitting machine:

The main features of a Vee – bed flat knitting machine are listed below:

- Numerically these are the most important industrial knitting machines.
- The needles, mounted in beds opposed in an inverted "V" formation, are operated by cams in a reciprocating carriage.



Automatic Vee-bed flat knitting machine

- The hand flat machine is still widely used but most modern machines are powered. Machines are built with 1.5 to 20 needles per inch in widths from a few inches to 76 inch.
- Many are employed to produce collars and rib trimmings for garments made on other machines, but because of the almost unlimited patterning scope available with jacquard flat machines considerable numbers are used for the production of patterned fabrics and garment lengths. Automatic narrowing has been common on these machines for some time and models are now being offered with full fashioning capability.
- Their main disadvantage is low productivity compared with other types.

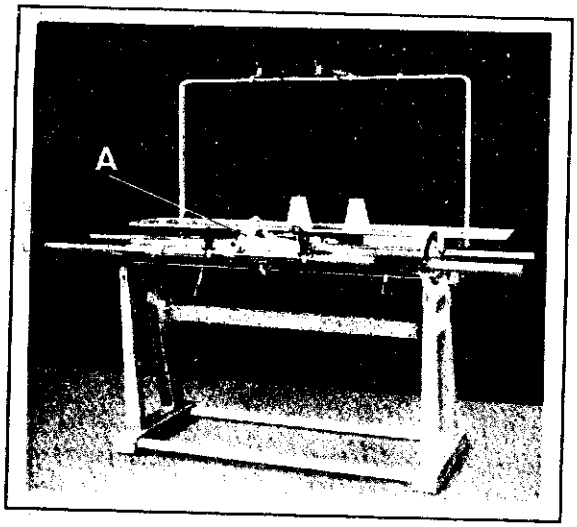
- Most have a single knitting head or section but versions with 2 to 6 sections arranged side by side are produced.
- Arrangement of 2 sections back to back allows knitting to take place in one direction using 15 or more carriages that traverse over the front section and return over the back one: the resulting machine is thus a hybrid circular-flat machine.

The Manual Sweater knitting machine:

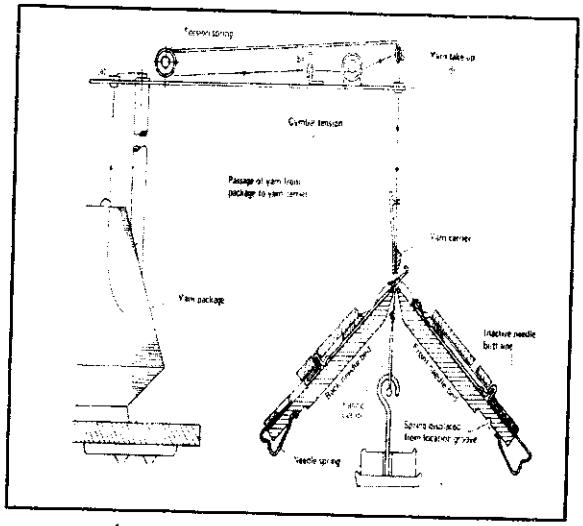
The manual sweater knitting machine consists of the following parts:

The frame:

The manual sweater knitting (flat knitting) machine is made up by a frame carring the base; this structure supports all the needle beds and motions necessary for the knitting process. In the rear side of the machine there is a spool rack for storing the yarn spools.



Manual sweater knitting machine



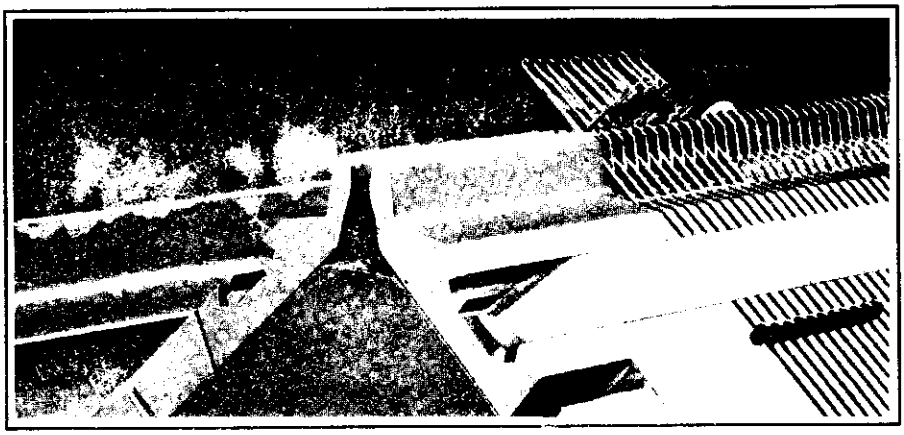
Yarn passage from package to yarn carrier

The yarn unwound from the spool is picked up by the feeding system: a tensioner, which adjusts the feeding tension and a thread guide, driven by the machine carriage, which provides the needle with yarn at the proper time.

The tensioner is made up by a spring-load flexible arm, that lowers when the yarn tension increases, to feed a bigger quantity of yarn, and lifts up when the tension decreases.

The needle bed:

The following figures show the needle bed and the motions of a manual sweater knitting machine. The needles accommodated inside the grooves of the needle bed can be either in a knitting or in a non-knitting position and are moved by special springs, which is shown in the above yarn passage figure. Placed between the grooves in the upper part of the needle bed, the knock-over jacks (the most part of the trick wall) act as supports for the yarn fed during the stitch formation.

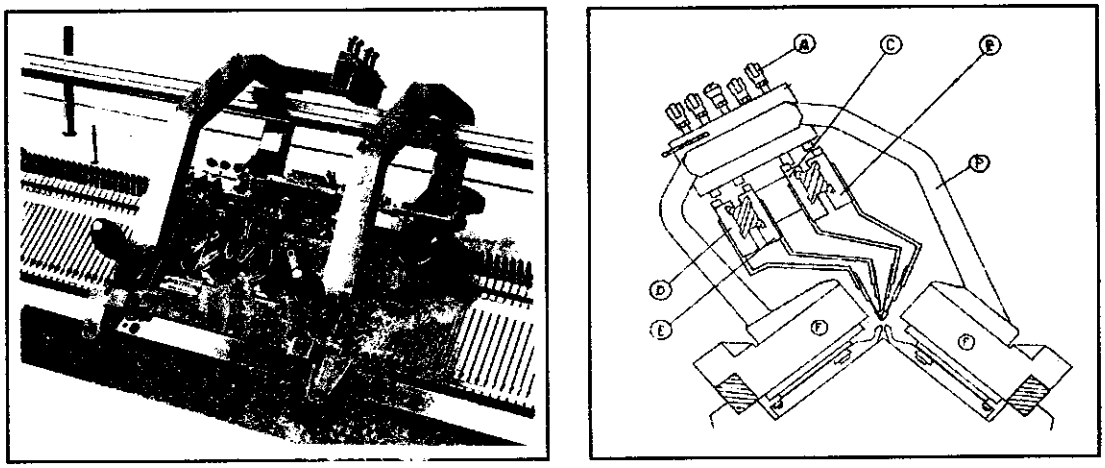


The needle bed

A spring securing bar and a needle securing bar are also attached to the needle bed to keep needles and springs in a correct sliding position.

The carriage:

The following figure shows the schematic diagram of the carriage of manual sweater knitting machine. It is made up of two metal plates linked by a stiff bridge (P); the plates work individually and simultaneously on the front and the rear needle beds.



Needle bed and carriage of a manual sweater knitting machine

The carriage carries out a double function and can be used:

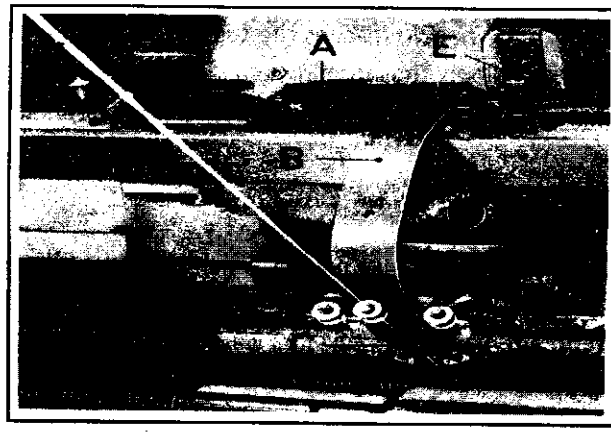
- To select the needles and make them raise or lower to form the stitch;
- To select and drive the thread guides which feed the needles.

The plates include cam locks (F) bearing the drive and control systems of the needles, i.e. the cams. When the carriage moves right-wards or left-wards, the thread guides (B), (C), (D), (E) are locked

individually by the corresponding pistons (A) on the upper part of the bridge, that are manually driven.

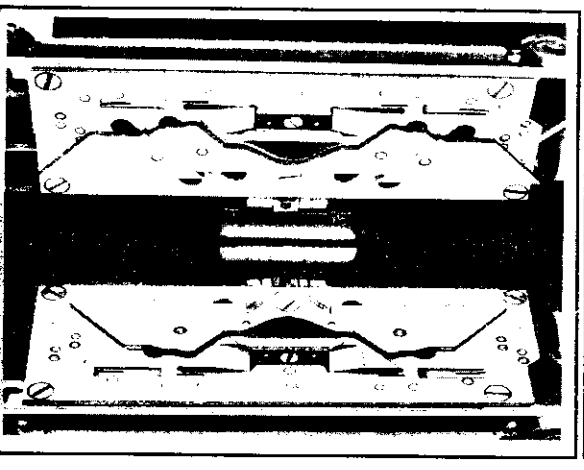
Brushes are also mounted on the carriage to ensure a smooth needle latch opening and grant a correct feeding of the yarn, which is shown in the following figure. As with all yarn carriers, the yarn carrier represented below is composed of the following elements:

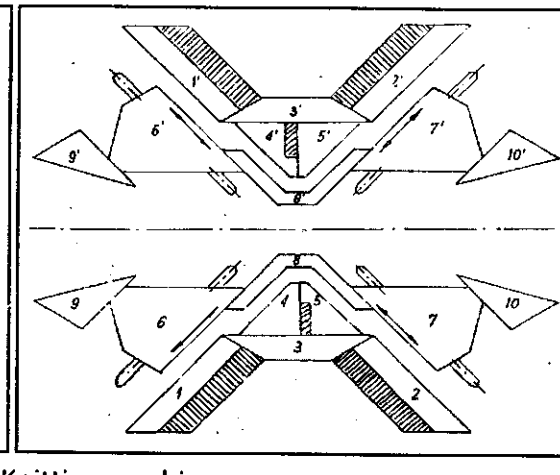
- A – is the block which guides the yarn carrier on its guiding bar;
- B – is the support;
- C – is the feeder holder, fixed with a hinge to enable the yarn carriers to pass one another and
- D – is the feeder.



The Cam-locks:

The cam-locks are a cam system which gives the necessary working information to the individual needles; they include a fixed part, working as support, and movable cams, which can be divided into raising cams and lowering or knock-over cams. The raising cam includes a tucking cam and a looping cam.





Camboxes of a Sweater Knitting machine

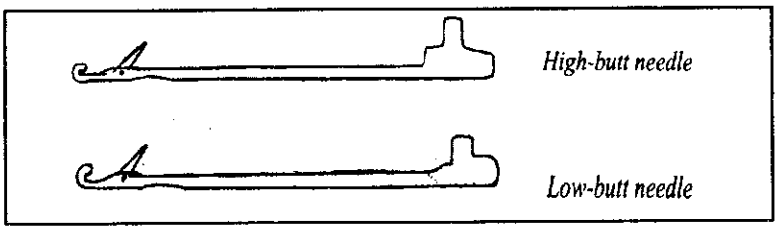
The fixed or movable cams form a symmetrical channel where the needle butt slides; the needle moves downward and upward in the groove to form the stitch. The different parts of the cams are chamfered; their profiles are curvilinear to make the needle move smoothly.

The angle of inclination of the cams ranges between 40^0 and 50^0; these values grant an optimum running of the needle and avoid high pressures between metal parts during the motion and excessive tensions on the yarn during the downward stroke of the needle. The carriage allows three different work ways according to the needle stroke and to the positions of the raising cam:

- Knit stitch – when the needle carries out a complete stroke, reaching the maximum height on the looping plane.
- Tuck stitch – when the needle reaches the tucking plane and receives a new yarn while still holding its former loop, thus forming two loops in the one needle hook.
- Miss or float stitch – when the needle is not knitting and remains out of the knock-over plane.

High-butt and Low-butt needles:

The latch needle can have two different butt heights which make it a high-but needle or a low-butt needle. The assembly of high-butt needles and low-butt needles on the knitting machine allows different selection and different manufacturing work ways, according to the positions of the tucking and looping cams.



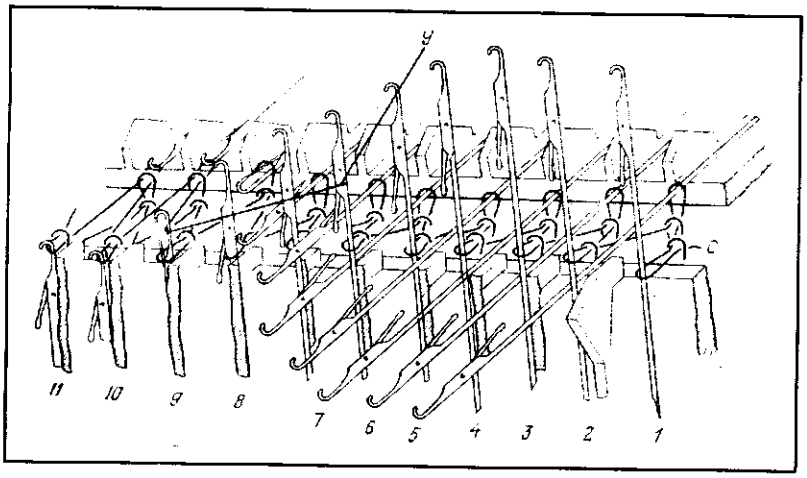
The knitting action or Loop-forming process on Sweater knitting machine:

The loop forming process in a sweater (two bed flat) knitting machine is illustrated in the following figure. It comprises the following operations:

- Clearing (on the needles 1 to 3)
- Yarn laying (on the needle 8)
- Yarn drawing
- Pressing
- Landing (on the needle 9)
- Joining (not shown in the drawing)
- Casting-off
- Loop forming (on the needle 10) and
- Drawing off (on the needle 11)

At the time of clearing, the needles move over a distance sufficient to make the old loop pass from the latch onto the stem. When this occurs, the old loops are retained from lifting together with the needles by the action of the force that draws-off the knitted fabric.

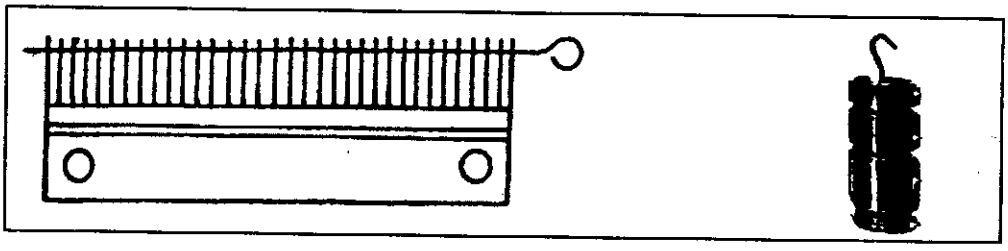
As the needles move down, they grasp the new yarn in consecutive order. To obtain casting of old loops C in the following figure on the new yarn, it is necessary that the needles be sufficiently lowered in relation to the knocking-over plane. The amount of needle lowering in relation to the knocking-over plane (sinking depth) determines the size of formed knitting loops.



All the movements necessary to accomplish the loop-forming process are imparted to the needles by the cams as they exercise their action on the needle butts.

Fabric Take-down:

Knitted fabrics require a special system to take them down while they are formed on the knitting machine. On manual flat knitting machines, after the first stroke of the carriage, a steel reed is fitted into the course; the reed is hooked using a steel wire, which is shown in the following figure.



Fabric take-down reed or Set-up comb Weight holder

Once the manufacturing cycle comes to an end the steel wire is removed and the reed released. The machine and the reed must have the same gauge; the holes in the lower part of the reed accommodate the weight-holder hooks to increase the tension on the fabric according to the specific needs.

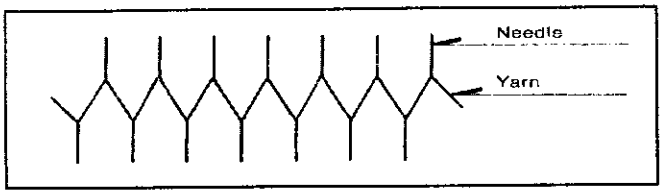
Production of different Fabrics on Sweater knitting machine:

The descriptions which follow, relative to different types of classic fabrics, embrace the basic knowledge of every knitter. These descriptions are often illustrated by photos taken on a hand machine, as this type of machine is the most suitable for describing the basics of knitting.

The set-up:

The description of the principle of the formation of a stitch, shows that the needle carries the thread or a first stitch and explains how the latch needle makes a second stitch. The study of the set-up must enable one to understand how the first thread is laid in the hooks of the needles.

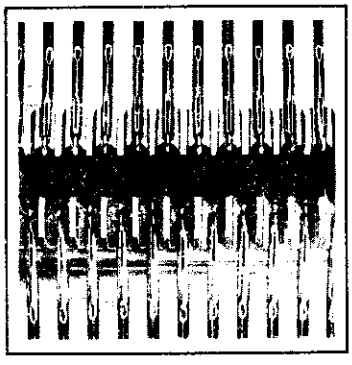
The start made by a set-up. The yarn is fed to the needles by the yarn carrier, passes from one needle to the other, i.e. from front to back then from back to front. This is the first row of the welt – a single row of yarn – and can be represented graphically as follows:



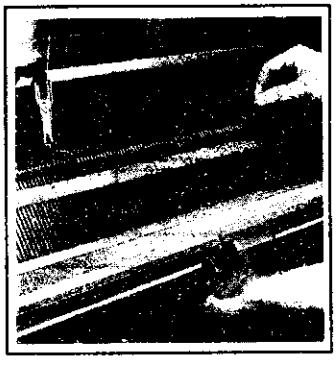
To put this first row in the hooks of the needles, it suffices to put the raising cams front and back into action, to adjust the lowering cams on an average position and to pass the carriage entraining the yarn carrier. Check the opening of the latches of all the needles.

The following steps are carried out for the set-up; those are shown in the figure below:

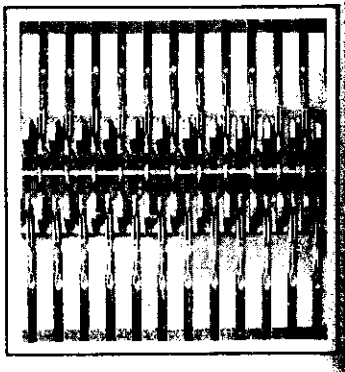
- Step – 1: The first row of the welt. The yarn passes alternately on the front and back.
- Step – 2: Over the set-up row from below and between the needle-beds the set-up comb is introduced and then through the eyelets of the set-up comb, the wire.
- Step – 3: The comb is thus suspended on the set-up row.



Step – 1



Step – 2



Step – 3

The set-up row is generally followed by a welt – often composed of two or several rows of tubular knitting. The set-up and the circular rows constitute the welt. Each knitted article, unless it is cut,

commences by a welt. But the utilization of automatic flat machines impedes the use of a set-up comb because the various articles knitted follow one another without stopping the machine. In this case, they are separated one from the other, by a draw-thread or by partial press-off.

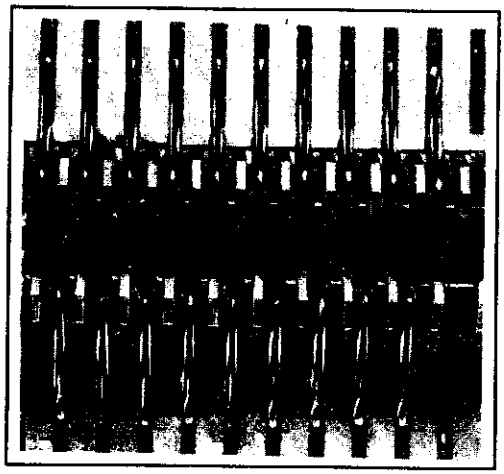
So that the first row of the welt is correctly executed, it is important that the yarn, in passing from one needle to the other, passes also from front to back and back to front. In effect, if this is not so, the first row is imperfect.

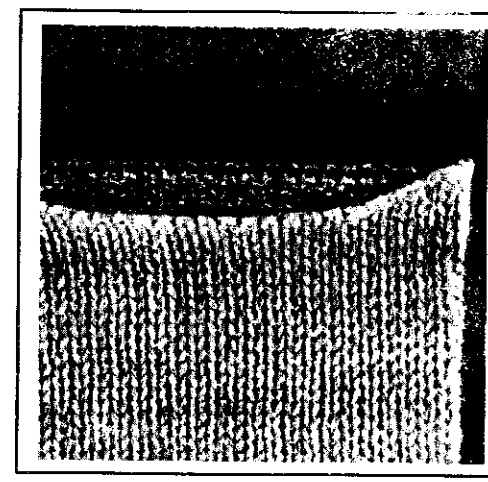
Tubular fabric:

This is also called circular knitting. It can be made on circular machines with one needle-bed or on flat machines with two needle-beds. In this latter case the tubular fabric knits a flat tube which takes its circular form after knitting. The following description gives tubular knitting made on flat machines with two needle-beds. The flat machines have, in regard to circular machines for instance, the important advantage of being able to produce tubular fabric of any diameter, due to the simple fact that one puts into action the needles on any width.

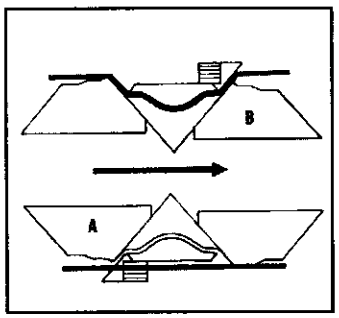
It can be interesting, in certain cases, - especially for trimmings – to not connect the selvedges of the fabric of the front to that of the back, thus producing tubular fabric open at one or both sides. To do this, knit two rows on the back needle-bed, then two rows on the front needle-bed, and so on. Now the liason will only be effected at one side, at the right or the left, depending on whether the start has been done from the right or the left. To obtain circular knitting open both sides, one must naturally use two yarn carriers, one on the back knitting always with the needles of the back needle-bed and the other on the front feeding the front needles. In this manner the thread of each yarn carrier feeds always the needles of the same needle-bed and the two pieces of fabric are not joined to one another. The ordinary welt of an article is knitted generally with 2, 4, or 6 rows of tubular knitting, which ensures a sound edge. In effect, tubular fabric is not very elastic.

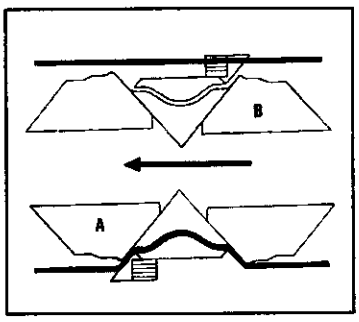
The tubular fabric is composed of the joining up of two pieces of knitting on one needle-bed, one piece made on the front needle-bed and the other on the back needle-bed. They are connected one to the other by a common thread which passes from one needle-bed to the other at the two selvedges. This liason is not visible in the fabric, the gap between the needle-beds is designed so that the interstitch at the selvedges is equal to the other inter-stitches.

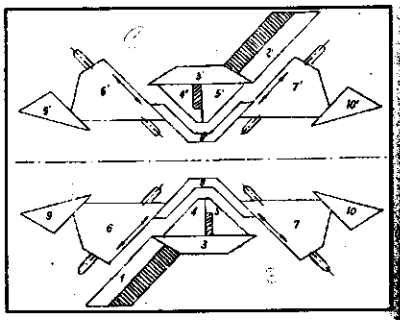




The following figures illustrate the cam plates of a hand sweater knitting machine arranged for the production of tubular fabric. Two raising cams, one at the front, one at the back, are out of action. Thus when the carriage travels from left to right, the back needles only will form a stitch. On the other hand, when the carriage goes from right to left, only the front needles form a stitch. In this manner, the lowering cams A and B are always inactive. They must therefore be fixed at a higher position than the other two so as to avoid any tension on the stitches. In the following right corner figure of cam-boxes the clearing or raising cam 1' and 2 set for tubular fabric.



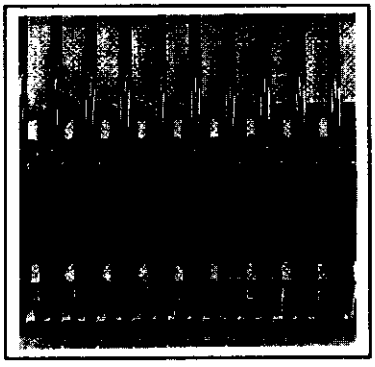


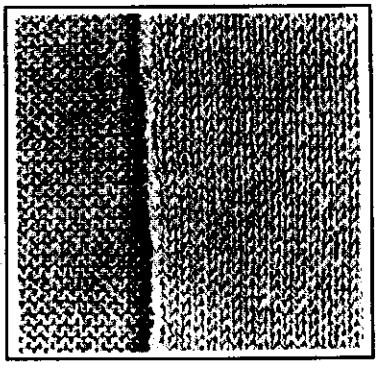


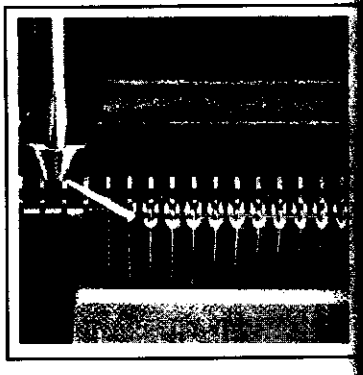
Single bed fabric:

This is also called jersey fabric in spite of the term often being used to describe all sorts of other fabrics in different textures, generally in fine stitches, but where the sole common point is the single colour. As in the case of tubular fabric, the quality of the single bed fabric depends principally on the shape and polish of the jacks of the needle-bed, as well as the accurate setting of the lowering cams. These must be set at exactly the same height, i.e. on the same division. Irregular setting of the lowering cams causes the rows to be short and long. The fabric, in consequence, shows horizontal stripes.

Single bed fabric, which is shown in the following figure, is the expression employed for knitting on one needle-bed only, generally on the back. Its characteristics are the same as those for tubular knitting: light, little elasticity, and stitches formed very uniformly.







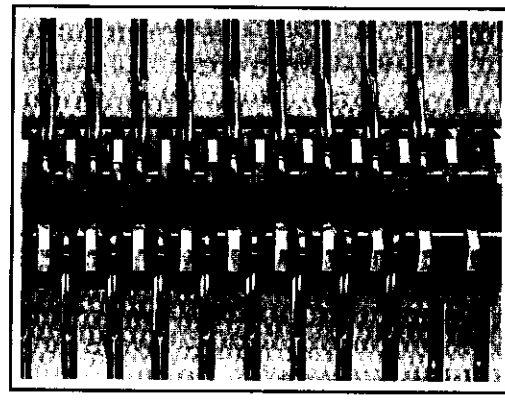
A fabric on one needle-bed is almost always preceded by a piece of rib fabric made on two needle-beds with an ordinary welt. To pass to the single bed fabric, all the stitches of one needle-bed must

be transferred by a hook to the needles of the other needle-bed. Generally from front to back. Various procedures of the transfer of stitches are described in the following section. It is however possible to commence knitting on one needle-bed without a rib welt. In this case, a set-up comb is placed between the needle-beds, as high as possible, in such a manner that the eyelets rest against the jacks of the needle-bed which will produce the knitting. In knitting the first row of the single bed fabric, the needles pass between the eyelets of the set-up comb, and the yarn taken is trapped. The above right corner figure shows the set-up comb, with its wire, can be used to commence single bed fabric without a welt.

Rib fabrics:

1×1 rib:

Contrary to circular fabric or fabric on one needle-bed, all rib fabrics are made simultaneously on the two needle-beds. Thus the yarn passing from one needle to the other passes equally from front to back and back to front, as for the set-up row. It is owing to machines fitted with two needle-beds and to rib fabrics thus produced.



1×1 rib has the same appearance on both sides. It is a very elastic fabric in its width. Its elasticity not only depends on the texture of the fabric, but is also influenced by the stitch length and the type of yarn. 1×1 rib is characterized by the fact that all the needles of both needle-beds are in action. All the raising cams will therefore be in work and all the lowering cams must be set exactly on the same division.

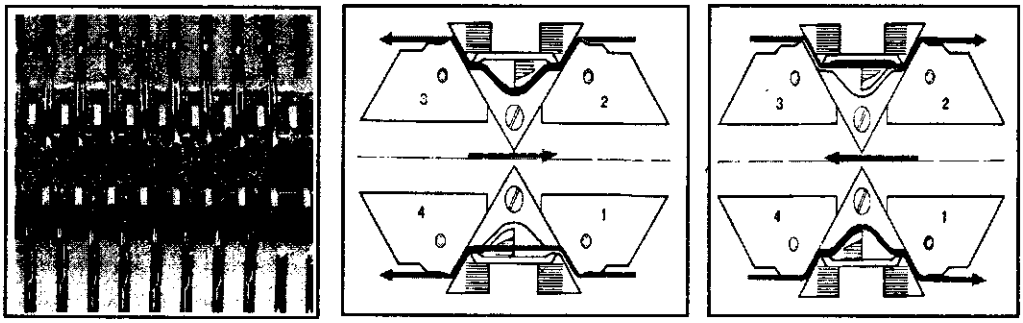
Cardigan Stitch or Full Cardigan Stitch:

Cardigan stitch is a fabric of tucks. The tuck renders the stitch doubled. That is why tuck fabrics are often described by the terms "double stitch fabric" or "multi-stitch fabric" when the tuck is repeated. There are two ways of making a tuck, such as – tucking in the hook and tucking on the latch.

The general appearance of cardigan stitch is similar to that of 1×1 rib. The two sides are identical. However, the columns of stitches are wider apart. On the other hand, cardigan stitch can be recognized by the tucks, which between the column of the stitches, show small loops. Cardigan stitch fabric is thicker, heavier, than 1×1 rib.

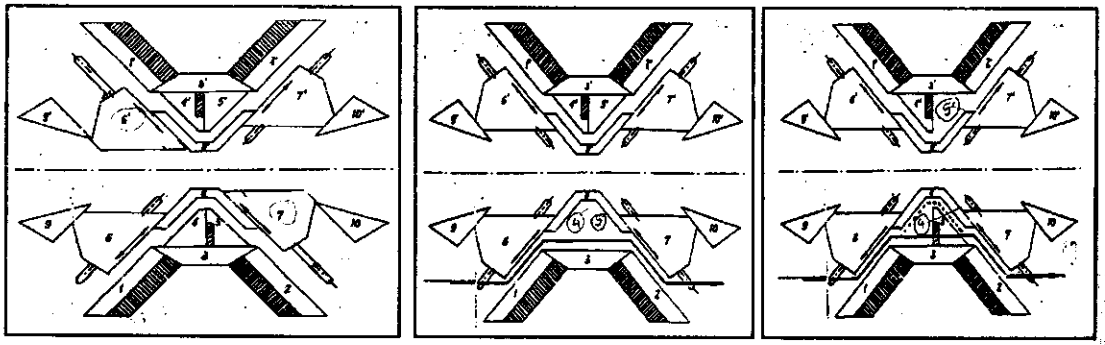
The following left figure shows the row of cardigan stitch. The tuck is on the back. The descriptions which follow, concerning tuck stitches (cardigan stitch, half cardigan, nopps, repeated tucks) relate

to cardigan cam plates. The cardigan stitch is knitted on all the needles. The stitches tucked are produced on the back and front needle-beds alike. The drawings of the following figures represent the cam plates of hand sweater knitting machines and the raising cams are set for the production of cardigan stitch.



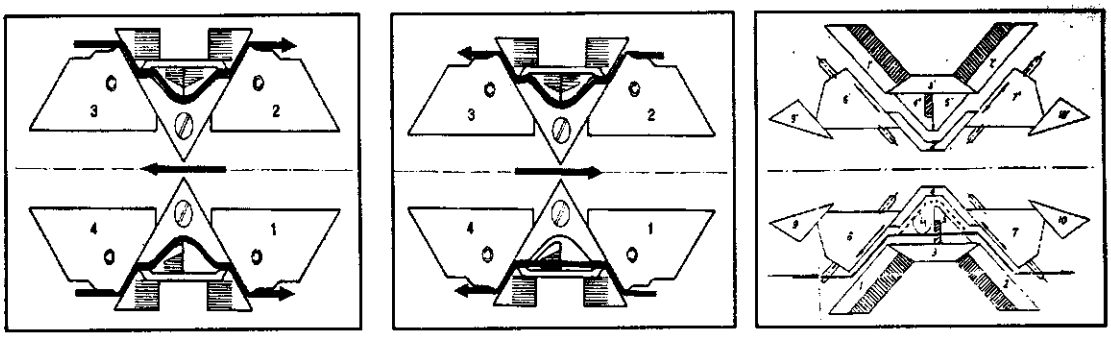
In cardigan stitch the lowering cams can all be set on the same division. However, to ensure a normal appearance to the fabric, the tuck must be generally and as much as possible, shorter than the stitch. The lowering cams Nos.2 and 4 in the above figure will thus be set to about the 'flush jack' position, whereas the lowering cams Nos. 1 and 3 occupy a normal position of formation. The above middle figure shows the carriage passes from left to right – the back needles form a stitch and the front needles form a tuck. The above right figure shows the carriage passing from right to left – the back needles make a tuck, whereas the front needles, previously tucked, form a double stitch.

The following figures show the camboxes of the manual sweater knitting machine. In the left corner figure, the stitch cams 6' and 7 set for tucking. In the middle figure, the cam setting for continuous tucking in one needle bed. In the right corner figure, the cam setting for full cardigan stitch.



Half Cardigan Stitch:

This fabric results from a combination of 1×1 rib and cardigan. It is obtained by alternating a row of 1×1 rib with a row of cardigan stitch. Thus, one set of needles forms individual stitches at each row whereas the other forms double stitches. The cams of the cam plate represented at the below are set for the production of half cardigan stitch.



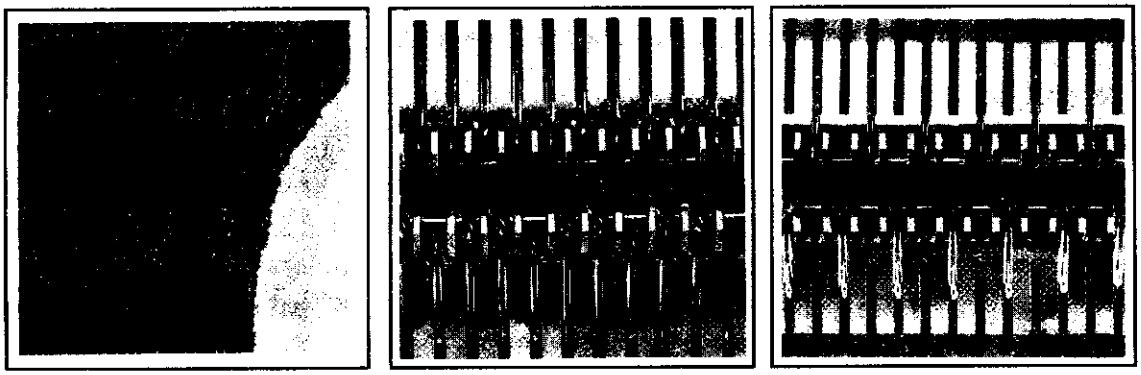
When the carriage travels from right to left, the front and back needles make a complete ascension and form a single stitch. This is the 1×1 rib row. When the carriage travels from left to right, the back needles make a second single stitch, whereas those of the front make a tuck. This is the cardigan row. The lowering cam No. 4 – which determines the length of the tuck – will be placed a little higher than the other one.

The right side of the fabric with the single stitches. It presents this characteristic that the stitches of one row predominate whereas those of the following row are almost invisible. The predominating stitches are relatively large compared with those of the preceding row. They give the fabric a certain appearance of pearl stitch, which sometimes the fabric is called.

Needle drop design:

The expression "rib fabrics" denotes fabrics in rib (executed on two needle-beds) by means of needle-beds with needles out of action, or idle. The most common of these – rib 2/3 and rib 1/2 - are mainly used for the bottom border of a pullover, a jacket, or for the cuff of a sleeve, that is for all the parts of an article which must be close fitting. As its name indicates, the 2/3 rib is knitted with a needle field comprising 2 needles in 3 in action. In other words, one needle in 3 is out of action. In the same way, in 1/2 rib, 1 needle in 2 is in action.

The following left and middle figures show the 2 in 3 rib (2/3). The 2/3 rib is very commonly known as 2×2 rib, which is a classic example of a rib fabric. On each needle-bed 2 needles in 3 are in action. The inactive needle is situated in the centre of the needles in action on the opposing needle-bed.

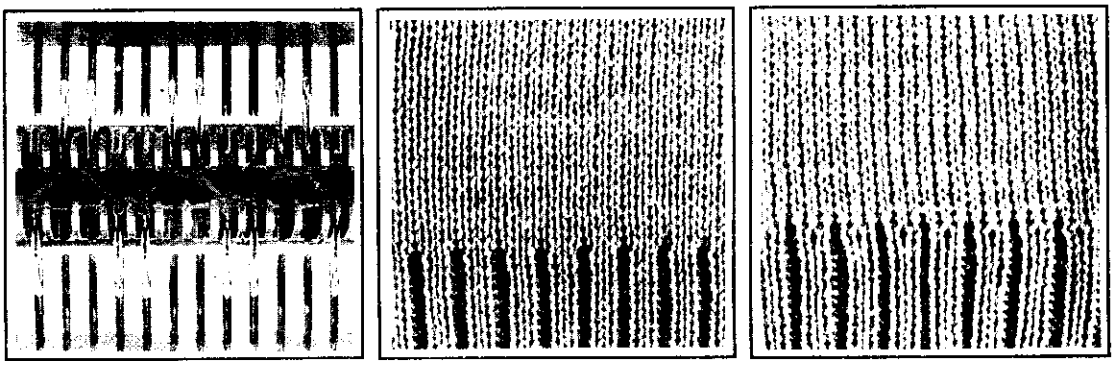


Rib fabrics can naturally be in single stitches or tuck stitches, in just the same way as rib on all the needles. Thus, the 2/3 rib can be 2/3 cardigan or 2/3 half cardigan. Ribs are generally very elastic in their width, especially when in single stitches. This elasticity is the result of the spaces made by the inactive needles which thus give space to the closing up of the ribs.

The inactive needle can be:

- A low butt, or short. The rib will be knitted on the high butt needles or the long needles only. Most knitting machines are equipped with these two sorts of needles.
- Out of action. This solution is used for machines without jacquard and fitted with needles having a single height of butt. In this case, the inactive needle is pushed downwards to the base of the needle-bed. Its butt occupies a position which is below the bottom raising cams.

The 1/2 rib is composed of a needle in action alternating with a needle out of action. The 2/4 rib is composed of 2 needles in action alternating with 2 needles out of action. These two kinds of rib are also very popular. Their elasticity is even greater than with 2/3 rib. The above right corner figure show the rib 1 in 2 (1/2) and the below left corner figure show the rib 2 in 4 (2/4).

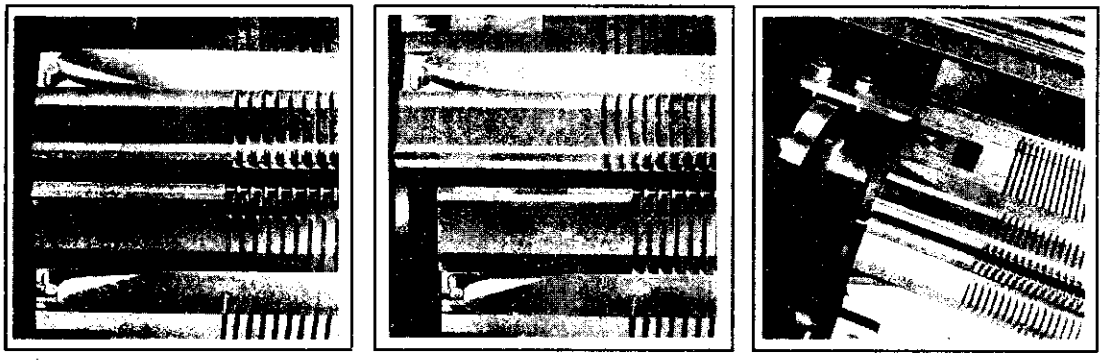


To pass form a rib to 1×1 rib, it is necessary between the two to make 2 rows of tubular fabric on all the needles. If not, unsightly holes will appear between the rib and the 1×1 rib on all the needles.

Rib 2/3 followed by 1×1 rib with, between the two, 2 rows of tubular fabric on all the needles, which is shown in the above middle figure. The same sample without the two tubular rows shows small holes between the 2/3 rib and the 1×1 rib, which is shown in the above right corner figure.

Needle-bed Racking:

During the process of loop formation, the needle-beds are stationary and the tricks of one are set between the tricks of the other. This is the knitting position, and the needles of both beds are able to knit simultaneously. One of the needle beds can be driven sideways a short distance to change the relative positioning of the needles. In this respect, the needle-beds of flat knitting machines are not stationary. All flat knitting machines are provided with a needle-bed racking system which is used for shifting one bed in relation to the other by means of a special cam placed on the machine's side, whilst at the same time maintaining the needle-bed gap.



Racking can occur in both directions. This racking movement is measured by needle spaces, i.e. the bed can be moved number of needles. The needle-bed can also take different positions: racking over half needle or full needle.

The above left corner figure shows the normal position of the needle-beds. The first slot at the left is of the front needle-bed. At the right, the last slot is of the back needle-bed. The back needle-bed is displaced three slots, which is shown in the above middle figure. One says that it has been racked three needles.

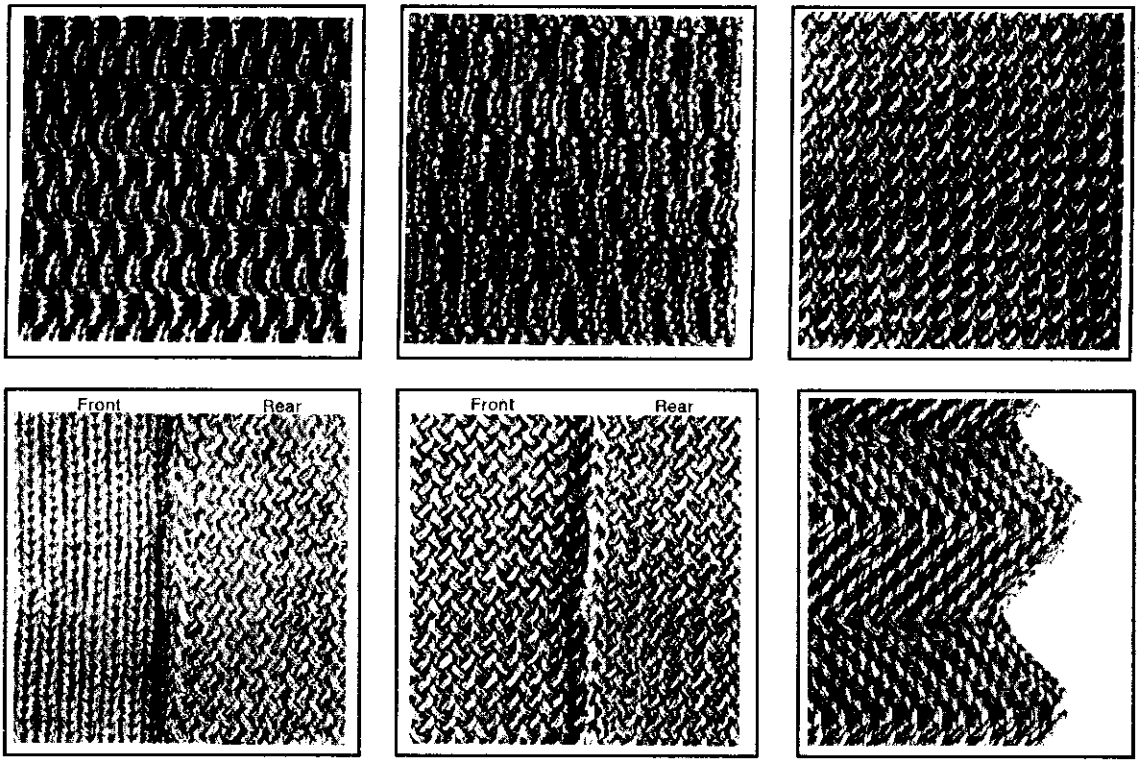
The displacement of the needle-bed is generally provoked by the rotation of the racking wheel, shaped in steps each of which corresponds to the gauge of the machine. This rotation can be controlled by hand or automatically. In each case, the angular displacement of the wheel must be limited in a very precise manner to ensure that the crossing of the needles in ascension is maintained.

The racking is carried out for either of the following reasons:

- To position the tricks almost in alignment. This is needed to allow needles of one needle bed to penetrate the transfer springs of the needles at the opposite bed and facilitate loop transfer. Loop transfer and transfer position are described in the following section.
- One of the needle beds can be moved a few needles to one side and still be positioned in a knitting arrangement. The needles of one bed are between the needles of the other. This is carried out to assist the transportation of transferred loops to a new location or to distort the regular vertical arrangements of the wales.

Note that the racking of the needle beds can take place only when all the needles are in the resting position. This time is between the completion of one machine knitting cycle and before the commencement of the next. Any attempt to rack the needle bed while some of the needles are in the clearing position and the needles are intermeshed, will result in mechanical damage.

The racking motion allows the creation of inclined patterns (right-hand or left-hand) on the knit fabric. The following figures show the fabrics produced by the racking system.



Stitch or Loop Transfer in weft knitting:

A loop that is displaced after being formed so that it combines with an adjacent loop, or so that it appears in a different wale, is said to have been transferred.

The transfer of a full or part of a needle loop or sinker loop onto an adjacent needle, either in the same bed or in an opposing bed is called stitch or loop transfer. The stitch formed by this loop transfer is called loop transfer stitches.

Objects of loop transfer:

The object of loop transfer is to achieve shaping, produce a design, or change the stitch structure. Transferring is used to generate holes in the fabric to form lace-like effects. Transferring can be used to produce structural effects by inclining wales of both plain and rib fabrics. This is also used to produce cables by exchanging two or more groups of wales with one another. In addition, loop transfer is used in ladies' stockings, when producing the double-thickness, plain fabric, in-turned welt. It also used in running-on and doubling rib loop fabric onto the needles of a straight bar frame to form the rib border of a garment part. Loop transfer is used when running the loops of two separate fabrics onto the points of a linking machine for linking these fabrics together.

Loop transferring process:

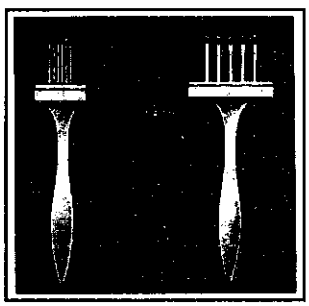
Loop transfer by hand-controlled points is a tedious and skilled operation, but automatic loop transfer requires a specific arrangement of specially shaped needles and / or transfer points. The

following description relates firstly to manual transfer, then to automatic transfer on the sweater knitting machine

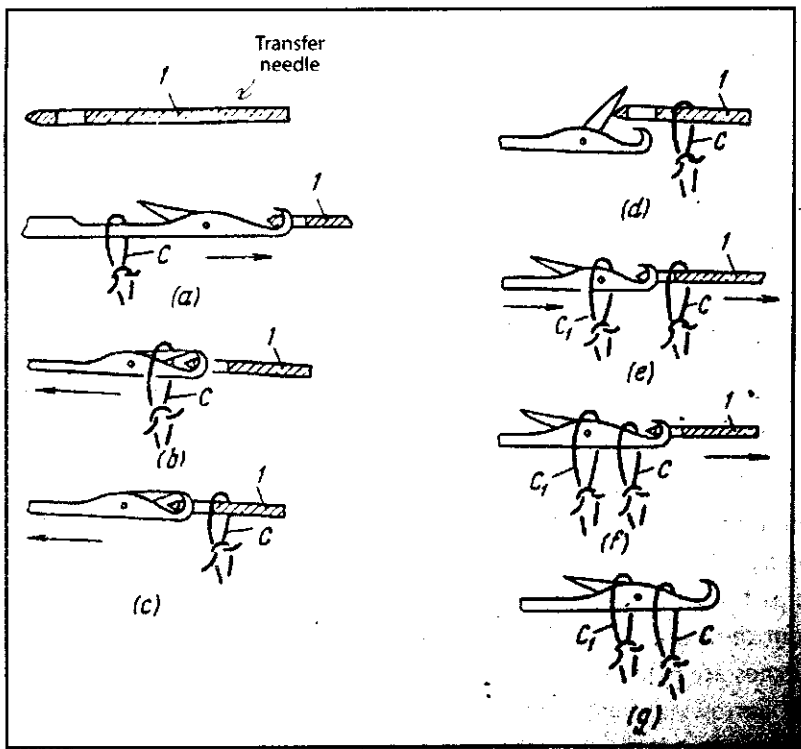
Manual loop transfer or Transfer by hand:

The transfer by hand is executed by means of a narrowing handle or transfer needle of which the size of the point varies according to the machine gauge. To transfer a stitch of one needle to a neighbouring needle by means of the narrowing handle is shown in the following figure and comprises the following steps:

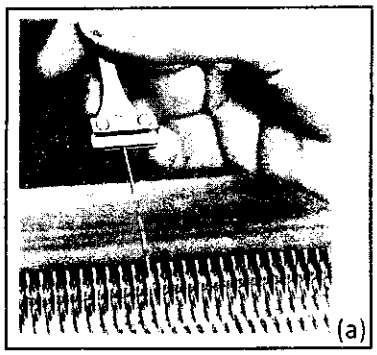
- Fitting the transfer needle 1 on the hook of the knitting needle to be put out of action, and pulling this needle out of the needle bed in order to cast-off the loop C from the needle latch onto the needle stem (a);
- Transferring the loop from the knitting needle onto the transfer needle by pushing the knitting needle into the needle bed (b & c);
- Removing the transfer needle with the loop to be transferred, from the knitting needle and fitting the transfer needle on the hook of the knitting needle which is to receive the transferred loop (d& e);
- Displacing the transferred loop from the transfer needle onto the knitting needle in such way that both loops (the old loop C1 and the transferred loop C) remain in the knitting needle hook (f) on the open latch.

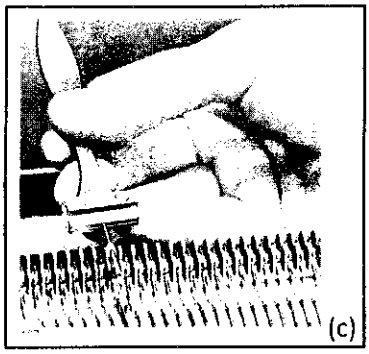


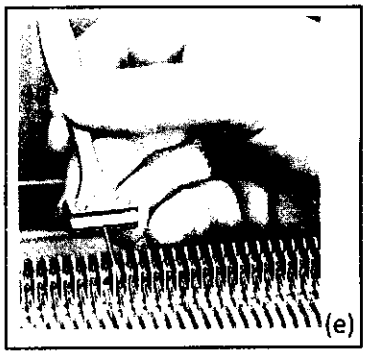
Narrowing handle
or
Transfer needle



Schematic diagram of Manual loop transferring pro

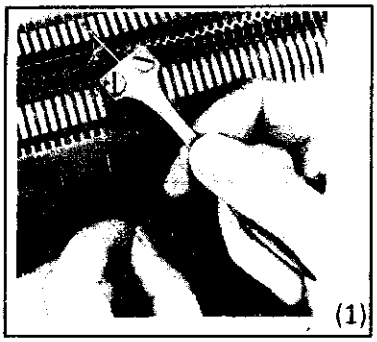

(a)

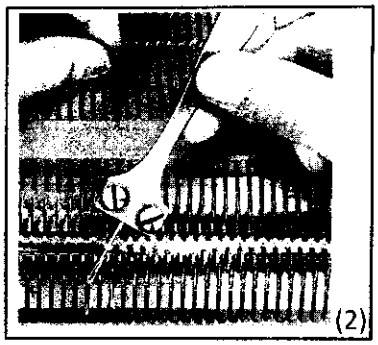

(c)

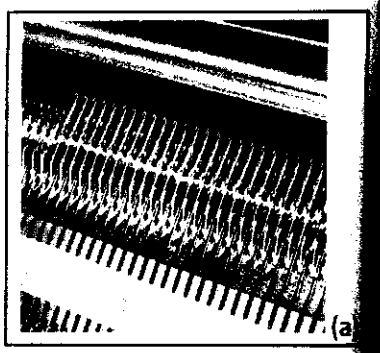

(e)

The above three photos are also show the steps of manual stitch transferring process by means of narrowing handle those are explained above.

Transfer of a back stitch to the front is shown in the following photo (1). The left hand manoeuvres the butt of the front needle and pushes it into the stitch held by the narrowing point. Similarly the following photo (2) shows the transfer of a front stitch to the back. The left hand manoeuvres the butt of the back needle and pushes it into the stitch held by the narrowing point.

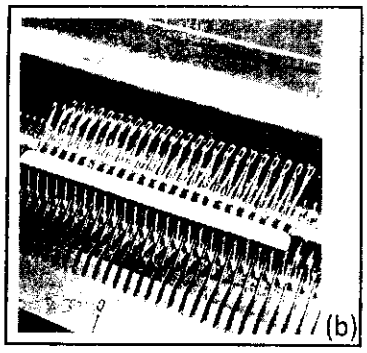

(1)

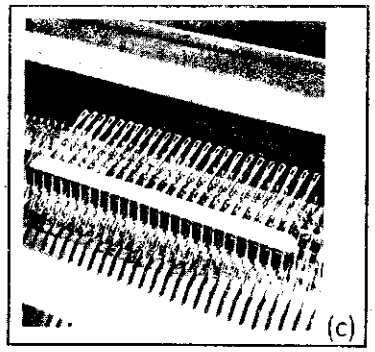

(2)

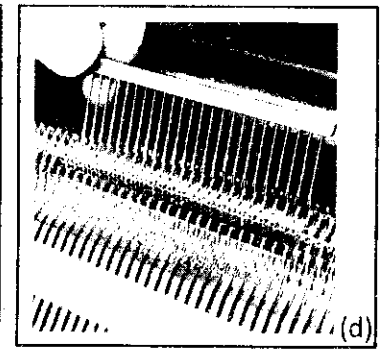

(a)

Before operating with the narrowing handle, all the latches that are to be transferred or to receive a stitch must be opened. The knitting on one needle-bed is normally always preceded by a rib fabric. To pass to single bed, all the needles of one needle-bed must be transferred to the needles of the other needle-bed. This operation can be done with a single needle narrowing handle or, more rapidly, by means of a transfer comb, a sort of bar equipped with several narrowing points appropriate to the gauge. The descriptions and illustrations of the above right corner figure (a) to below right corner figure (d) show how to transfer all the stitches from the front to the back. If possible, this transfer must be preceded by a last row of stitches a little slacker on the front.

Open the latches of all the back needles. On the front, lift up the needles to be transferred. Lower the front needle-bed, which is shown in the above figure (a). Rack one of the needle-beds 2 needles so as to open the stitches to be transferred, then in these stitches, introduce the transfer comb from the front, which is shown in the below left corner figure (b). Lower the front needles. The stitches are held by the transfer comb, which is shown in the below middle figure (c). Then connect the narrowing points to the back needles and, in turning these over, slide the stitches into the hooks, which is shown in the following right corner figure (d).

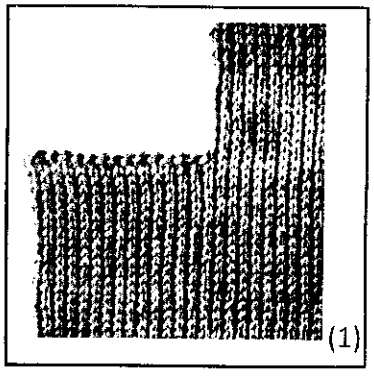

(b)

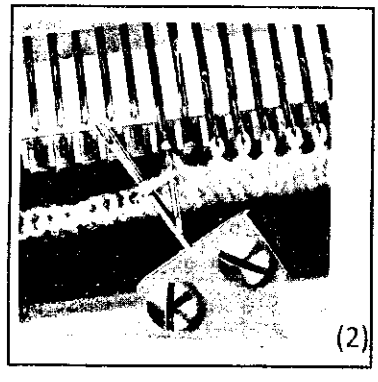

(c)

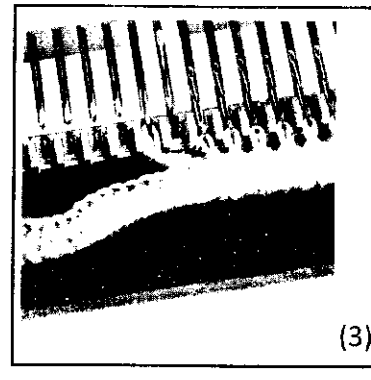

(d)

Chain Stitch: when partial, it is executed during the knitting. It is also done by transfer of stitches with the narrowing point, as indicated by the following figures (1) to figure (4).

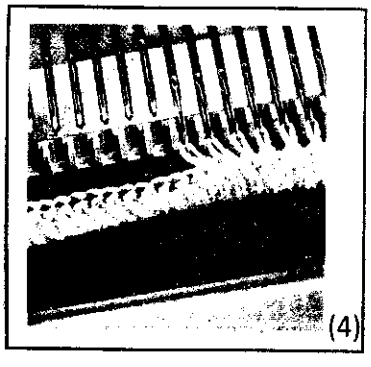
- Figure – 1: Over the section where the chain stitch will be made, transfer the stitches from the front to the back needles. On the front, leave or put back into action all the needles. Knit one row of rib and press-off on the front the loops thus formed.
- Figure – 2: Take the last but one stitch with the narrowing handle and transfer it on to the selvedge needle. Push this up until the end of the latch is between two stitches.
- Figure – 3: Lower the selvedge needle and draw out the narrowing point. The transfer stitch is passed through the selvedge stitch.

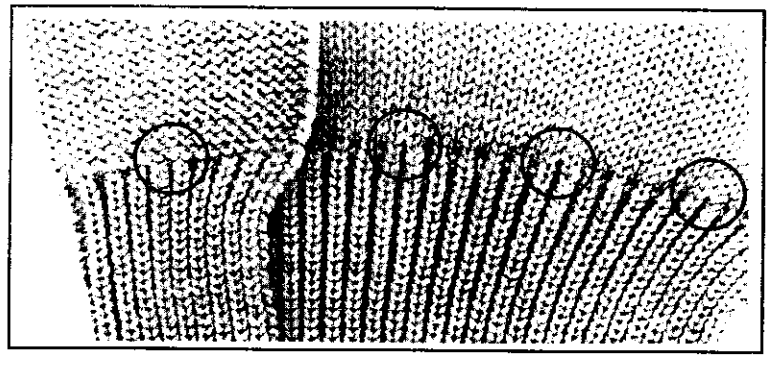

(1)


(2)


(3)

- Figure – 4: With the narrowing handle, put this new stitch on to the needle which has become empty and re-commence the operation with the neighbouring stitch.


(4)



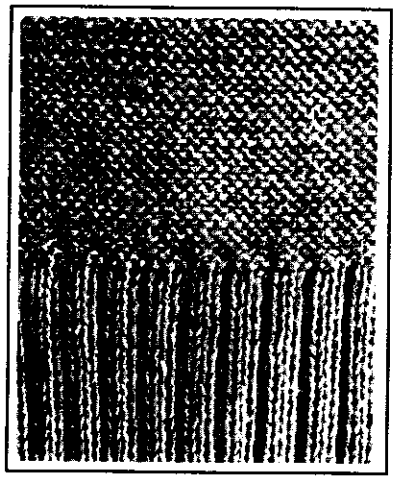
The chain stitch prevents the stitches from running. At the end of an article, it is often done off the machine by means of a latch needle which does the work of the narrowing point. However, in the Knitwear i.e. Sweater Industry, linking machines avoid the need for a chain stitch and also stop the stitches from running.

The doubling operation for ribs of fully-fashioned articles: Certain types of frames used in knitwear automatically produce articles entirely shaped (fully-fashioned) in plain jersey stitch fabric. But they cannot knit the ribs at the same time, as they have only one row of needles. The users of such frames must use flat knitting machines with two needle-beds to produce the ribs which are then transferred to the needles of the frame by means of a special transfer bar.

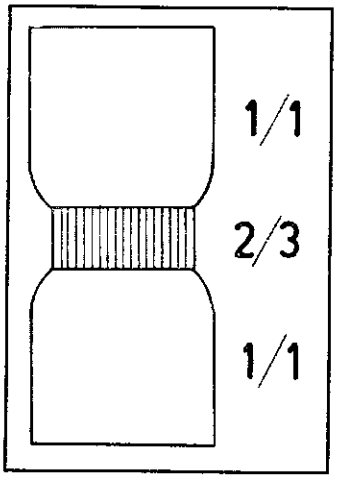
Furthermore, experience has shown that, to meet the making up needs, the ribs must have a greater number of stitches than for the article itself. In consequence, at the end of the ribs, the number of stitches is reduced. This operation, called doubling can be executed by hand, when the rib is picked on, or automatically on a stitch transfer machine, incorporating the possibility of transferring the stitches of the low butt needles only. In the previous right figure, the illustration shows a border knitted in 1×1 rib transferred to plain fabric after doubling. In effect, certain stitches (encircled) have been doubled by stitch transfer. It is in this way that the number of stitches of the rib is adjusted to those of the article knitted in plain.

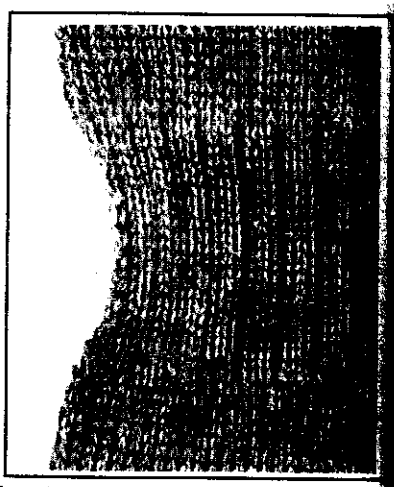
Although it is slightly visible, the doubled stitch does not unfavourably affect the appearance of the fabric. The change between the rib and the plain is quite natural, there being no join that is so obvious with fabrics with sewn-on welts. Finally, the automatic doubling is more rapid and more uniform than doubling made by hand.

The following figures show the execution of a few classic samples with stitch transfer. 2/3 i.e. 2×2 rib border and following reverse jersey structure is shown in the following left corner figure. The finished shape of the 1×1 rib to 2/3 (2×2) rib to 1×1 rib fabric sample can be represented as shown at the following middle figure. Knitted in fine gauges, it is used for the manufacture of vests (underwear). The following right corner figure shows the close-up view of this fabric.



2/3 rib and plain back



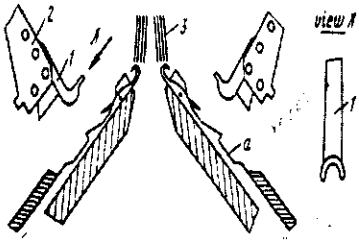


1×1 rib – 2/3 rib – 1×1 rib

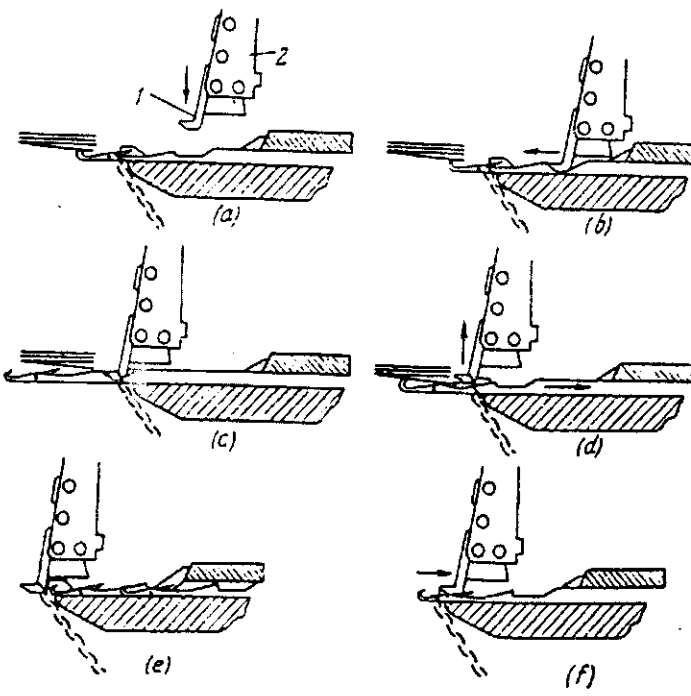
Automatic loop transfer:

The process of automatic loop transfers on V-bed knitting machines and the working mechanism taking part in loop transfers are shown in the following figures. For loop transfer an auxiliary element must be brought in action and it is the transfer unit. The latch needle has a recess, 'a' which accommodates the transfer unit for loop transfer. The process of loop transfer is fulfilled in the following steps:

- needle selection for loop transfer (a);
- rising the needle to such a position that the loop remains on the open latch (a);
- the transfer unit 1 lowers onto the needle recess (b);
- the needle rise, coupled with the transfer unit, and the transfer unit takes over the loop (c);
- the rising transfer unit releases the needle which lowers into the needle bed (d & e);
- now, the transfer unit is shifted by one needle spacing to the needle which is to take over the loop carried by the transfer unit (e);
- new needle takes the transferred loop over (e & f).



Loop transferring device
(1-a transfer unit,
2-narrowing carriage,
3-latch openers)

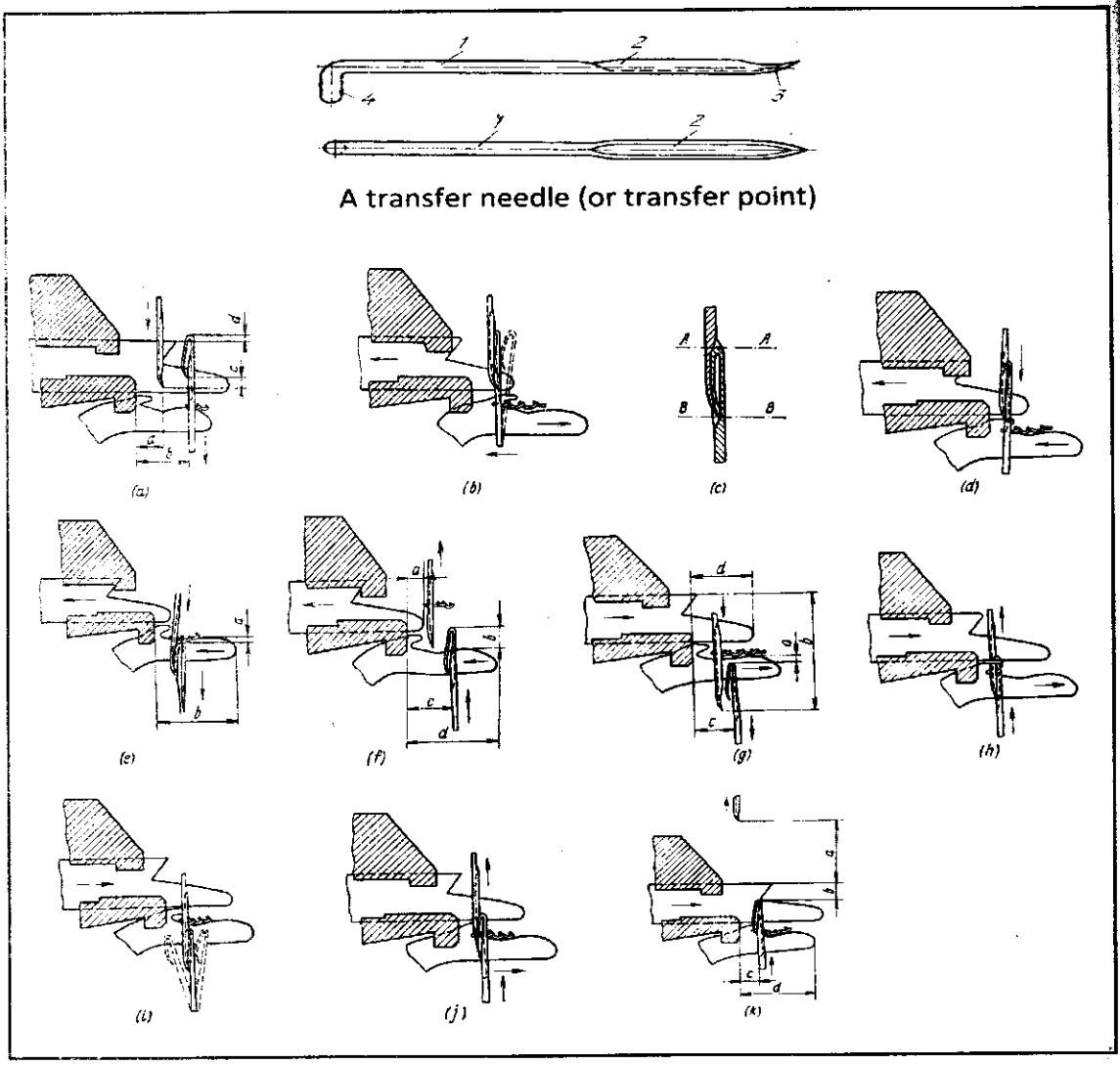


Automatic loop transferring process

Loop transfer on bearded needles:

On spring-bearded needles (e.g. Cotton Patent machines) removal and transfer of loops are performed by means of transfer needles (transfer points) which are attached to special bars. Such a transfer needle consists of a stem 1, a groove 2, a tip 3 and a butt 4. In the transfer needle groove

the hook of the spring-bearded needle is hiding during pressing by loop transfer. The tip of th transfer needle enters in the groove of the knitting needles pressed.



A transfer needle (or transfer point)

Loop transfer on a cotton's patent machine

a) Transfer needle positioned in front of a knitting needle, b)&c) Needle pressing, d)&e) Loop removal, f)&g) Separation of needles; transfer needle rack, h) Clearing, i) Needle pressing, j) Loop transfer onto a knitting needle, k) Second separation of needles, l) Transfer needle retreat.

The loop transfer is performed in the following ten steps:

1. positioning the transfer needle in front of the selected spring-bearded needle;
2. pressing the spring-bearded needle in the groove of the transfer needle;
3. loop removal from the spring-bearded needle onto the transfer needle;
4. separation of needles;

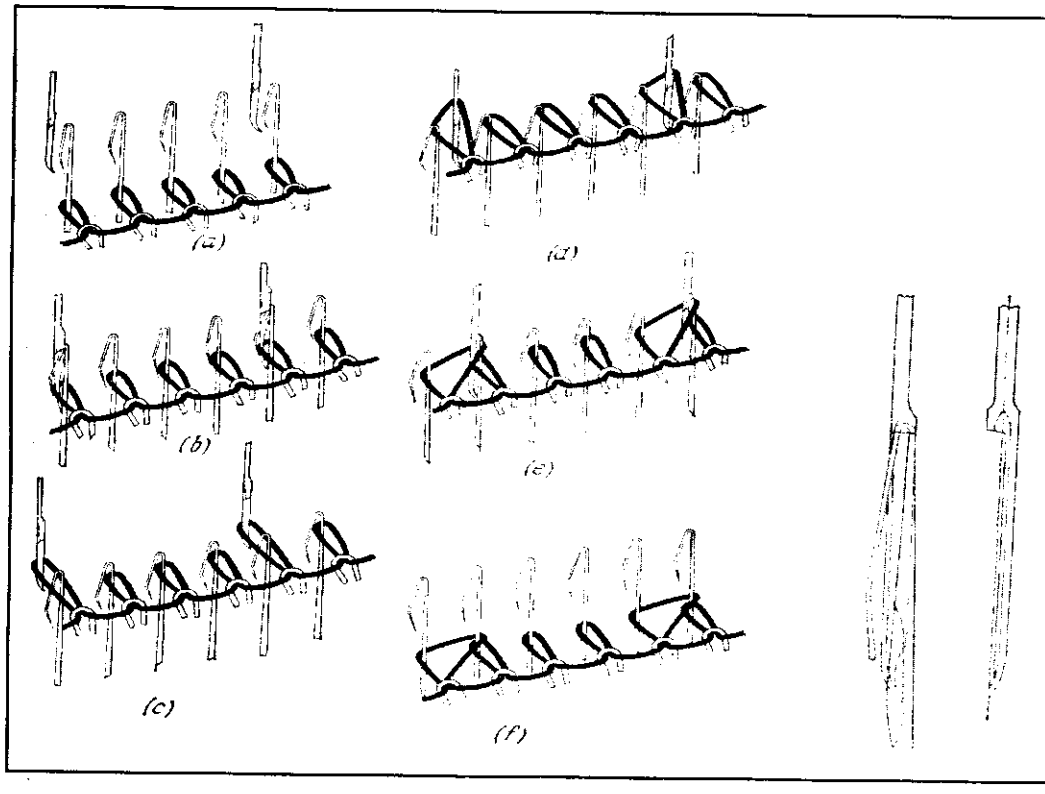
5. transfer needle rack;
6. clearing;
7. pressing;
8. loop removal from the transfer needle onto spring-bearded needle;
9. separation of needles;
10. transfer needle out of action.

Fabric narrowing and widening are performed with identical interaction of loop forming elements and transfer needles.

Half loop transfer or Partly loop transfer:

For obtaining the lace effects (lace holes) by loop transfer without loop removal from the spring-bearded needles, points or transfer needles with a cut-out are used. The loop transfer in this case comprises the same operations, but at the first pressing the needle hook is not pressed by the point as shown in the figure. As a result, the loop transfer process is effected without loop removal by the points.

The sequence of operations at the transfer of a half-loop is illustrated in the following figure (a – f).



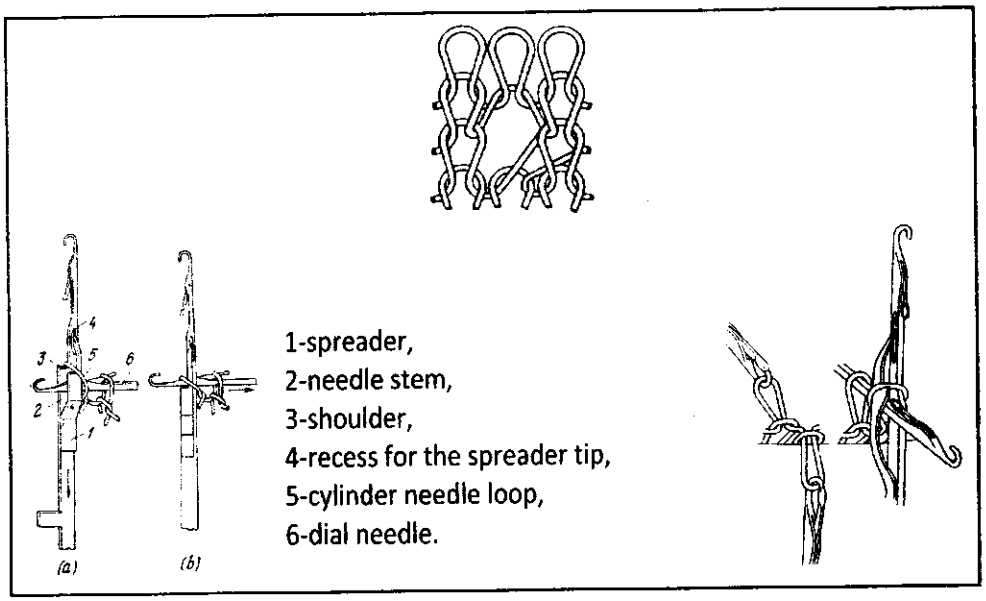
Sequence of operations in half-loop transfer

The above right figure shows the position of the needle and transfer point with cut-out at first pressing.

Loop transfer on knitting machines with latch needles:

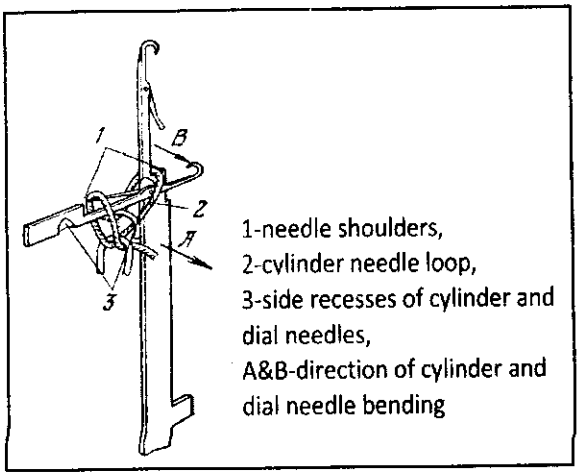
The process of loop transfer on circular knitting machines with latch needles is carried out by using needles of various special design. Most largely used in practice are two methods of loop transfer from one needle bed of the knitting machine to another.

The first method makes use of latch needles with a spreader. Between the spreader and the needle stem there is a clearance.

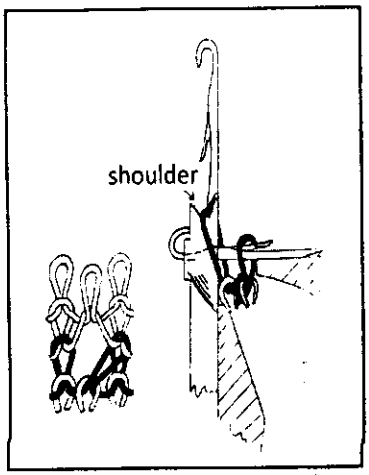


Loop transfer using latch needles with spreader

The second method involves latch needles with side recesses and shoulders. The needle shoulde stretches the loop brought to the level of the head of the loop receiving needle in opposite needl bed, thus preparing the loop to piercing by the receiving needle.



Loop transfer at needle bending



Loop transfer in 1×1 rib

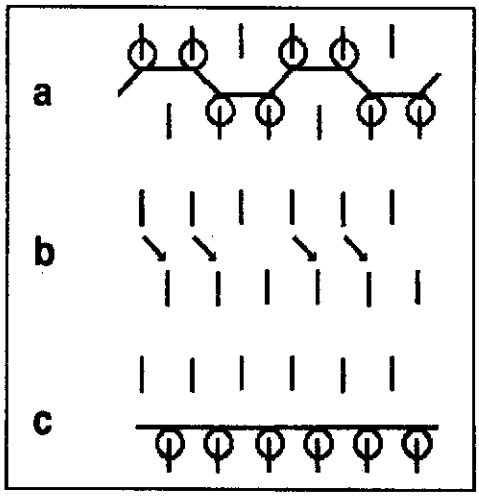
The sequence of loop transfer operations is as follows:

- Needle selection for loop transfer
- Bending the loop transferring needles towards their receiving counterparts with recesses, in the other needle bed – in circular knitting machines, or – in V-bed knitting machines – racking one of the needle beds for 0.5 needle spacing
- Bringing the loops on selected needles to the level of needles in the opposite needle bed
- Putting the transferred loops on the hooks of receiving needles
- Casting-off the loops from the needles transferring the loops onto the heads of receiving needles
- Opening the latches of needles which have cast-off their loops
- Bringing the needles into their initial position.

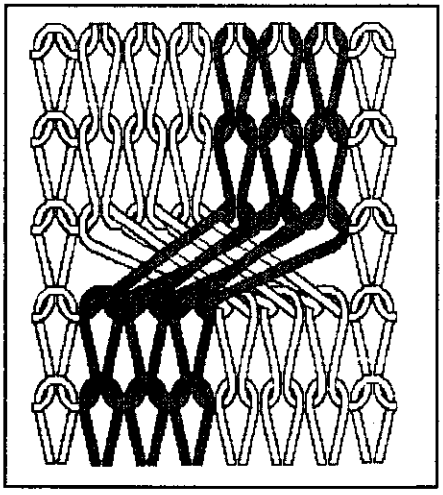
The properties and use of the Transferred Stitch:

Loop transfer is widely used in flat knitting for various reasons, some of which are described below:

1. **Changing from rib to plain:** Often, garments are produced with a rib welt, which provides elastic properties, and then continues as a plain construction to reduce thickness and weight. In these cases, all the loops participating in the production of the rib welt are transferred to one needle bed. The plain knit structure continues to knit on this single bed.
2. **Knitting purl knits**: To knit purl knit structures containing face and back loops within the same wales, loops should be transferred between front and rear needles.
3. **Patterning:** Transferred loops are widely used in fabric patterning. Wale distortion is one example, in which certain wales are moved from needle to needle which then continue to knit through them. The vertical lines of the wales are thus distorted. The most common example of this pattern procedure is the "Cable" illustrated in the following figure. Some wales are highlighted to clarify the effect.



Changing from rib to plain



Cable Design

4. **Shaping:** Sophisticated knitting machines are able to shape the garment rather than to produce only rectangular panels. Panel shaping requires needle selection and transferring ability, in which loops are transferred inward at the edges, to facilitate narrowing. Since the loops are transferred from one needle bed to the other, which is then racked to allow the return procedure, the efficiency and productivity of the machine is reduced. The profitability of the process should be considered by weighing together the raw material costs and the reduction in cutting operations, against the knitting efficiency and productivity.

Types of Transfer Stitches:

There are four main types of transfer stitches:

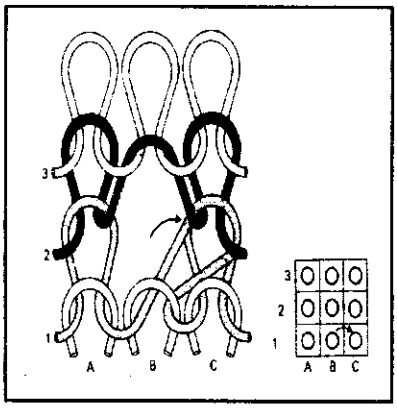
1. Plain needle loop transfer stitches – It is produced by transference of a loop from one needle to another in the same bed.
2. Fancy lacing stitches – It is produced by modification of the plain loop stitch.
3. Rib loop transfer stitches – It is produced by transferring a loop from one needle bed to the other.
4. Sinker loop transfer stitches.

Openwork weft knitted fabrics:

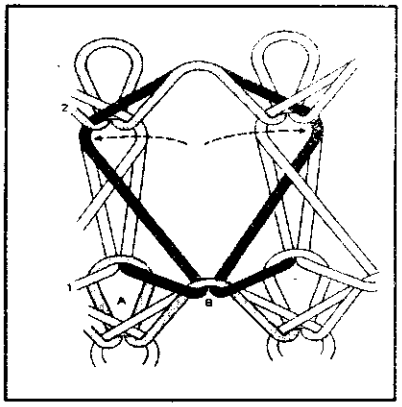
The stitch variant is obtained by transfer of needle loops on the neighbouring needles or by transfer of sinker loops on one or two needles of the wales to which the transferred sinker loop belongs.

This variant stitches obtained by needle loop transfer are often called lace stitches whilst sinker loop transfer produces the pelerine stitches. These stitches can be obtained in a plain stitch or a rib stitch knitted fabric. The lace stitches and pelerine stitches are employed to obtain openwork design effects or to impart new properties to the knitted fabrics.

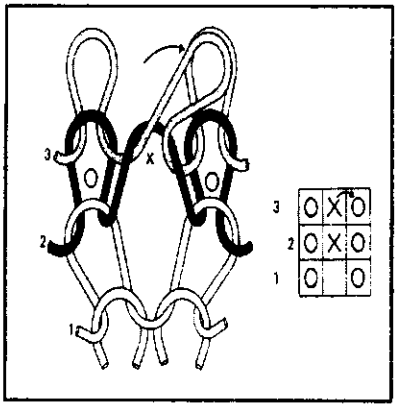
- **Lace stitches:**
  In designs the plain loop transfer stitches is termed a lace stitch whereas in selvedge shaping it is termed fashioning. Lace stitches can be produced on weft knitting machines with spring bearded needles and latch needles. For obtaining a lace effect, the loops can be transferred into neighbouring wales either by removing the loops of needles on which they have been formed or without removing them from those needles.
- **Pelerine stitches (sinker loop transfer stitches):**
  The sinker loops can also be transferred onto both needles producing the loop wales that transferred sinker loop belongs to. Pelerine stitches can also be obtained in plain stitch and rib stitch knitted fabrics. The structure of a fabric with pelerine stitches obtained by transfer of sinker loops onto a single needle or onto two needles. Pelerine stitches can also be obtained by transfer of two, three or four sinker loops lying one above another in two, three or four consecutive loop courses.



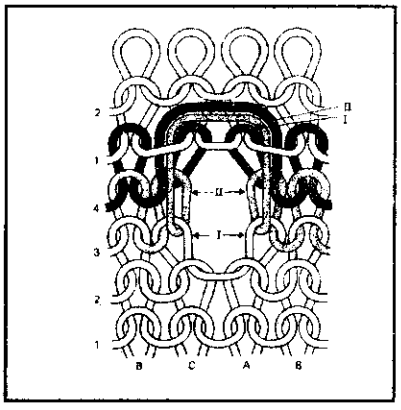
Lace Stitch (Plain loop transfer stitch)



Fancy lacing stitch



Rib loop transfer stitch



Pelerine Stitch (Sinker loop transfer stitch)

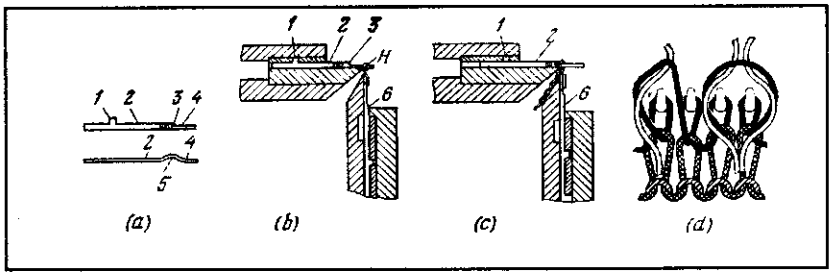
Process of producing the pelerine stitches:

One of the needle beds – the dial or the cylinder is equipped with latch needles; the other needle bed is equipped with transfer jacks with butts, nibs, shoulders and bends. Transfer jacks in pairs are used, with right-hand bend and left-hand bend. One jack is used in case of sinker loop transfer on one needle (left or right respectively), or two jacks are used for sinker loop transfer on two needles (left and right).

Process of knitting the pelerine stitches:

The process of knitting pelerine (nipp) stitches is carried out in the following sequence:

- selection of sinkers(transfer jack) for loop transfer;
- advancing the transfer jack nibs to the line of knock – over plane of the needles in opposite needle bed (fig. b);
- grasping the sinker loop 'H' by transfer jack nib, and bringing the sinker loop to the level of needle hooks in opposite needle bed (fig. c);
- transfer the sinker loop 'H' on the needles of the opposite needle bed (fig. d); these needles are partly protruding from their grooves;



knitting process of the pelerine stitches

- retreat of the jacks to their initial positions; the sinker loop is laid on the open latches of the protruding needles of the opposite needle bed;
- bringing the needles with sinker loop to their initial positions.

Transfer of sinker loops can be performed in one, two, three or four consecutive loop courses, on the same needles.

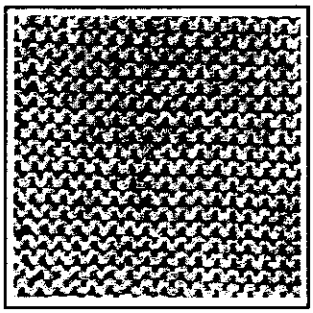
Fancy lacing stitches:

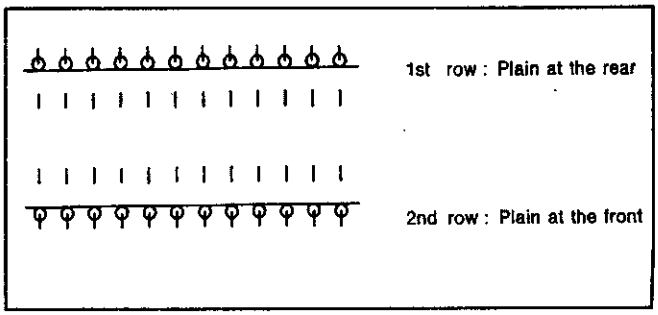
The bearded needle sinkerwheel machine produced the largest range of fancy lacing stitches. Some are unique to it and have the term 'a jour' in their description, which implies a sequence of samples. *A jour C* or *knupf* – also termed *filet lace, weft knitted net* and *knotted stitch* – square apertures in an all-over effect that is popular for men's athletic underwear. On an E16 fine gauge machine, 1/18's cotton or 2/70 denier nylon might be used. A course of long loops is knitted and the two side limbs of every second needle loop 'B' are spread sideways onto the needle loops 'A'. The second is knitted with a short stitch length and tucking occurs on needles 'B' to make the aperture wider.

Another stitch, known as *a jour B*, has a twisted transferred loop, produced by deflecting the beard of the receiving needle across into the eye of the delivering needle so that, as the loop is pressed-off from the delivering needle, it twists over. The effect is achieved by using toothed lacing wheels with the upper wheel's teeth coupling two beards together; these teeth are arranged according to pattern requirements.

Purl stitch fabric:

The following sample illustrates the purely basic fabric of purl stitch machines. It comprises rows of

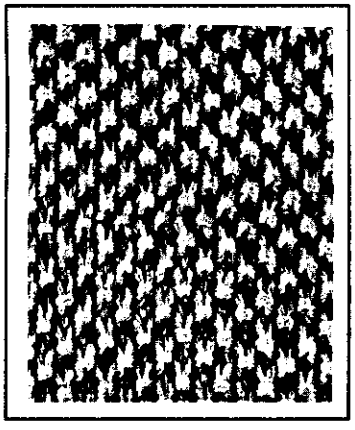


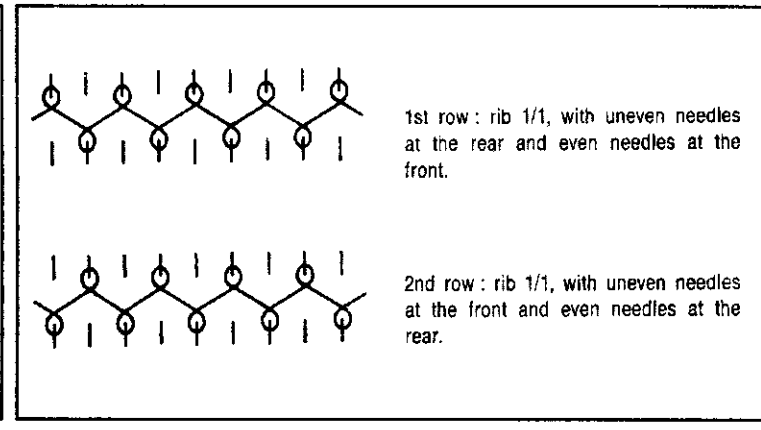


stitches, knitted alternately, back and front on all the needles. Thus, after each row of stitches, all the needles pass to the opposite needle-bed to knit the next row of stitches. Both sides of the fabric are obviously identical.

Moss stitch:

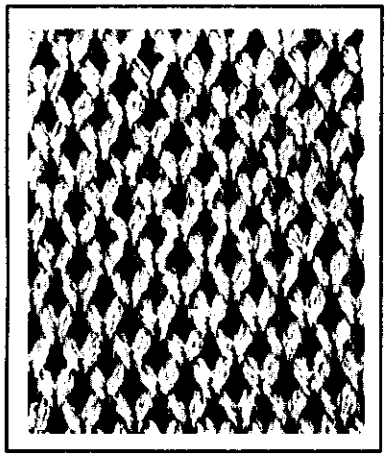
The stitch formation chart of moss stitch is illustrated in below. In this case uneven needle means odd number needle. In each row, all the needles pass from front to back or back to front, depending on whether they are even or odd (uneven). Moss stitch fabric is identical front and back. It is particularly used for knitting articles of a layette.

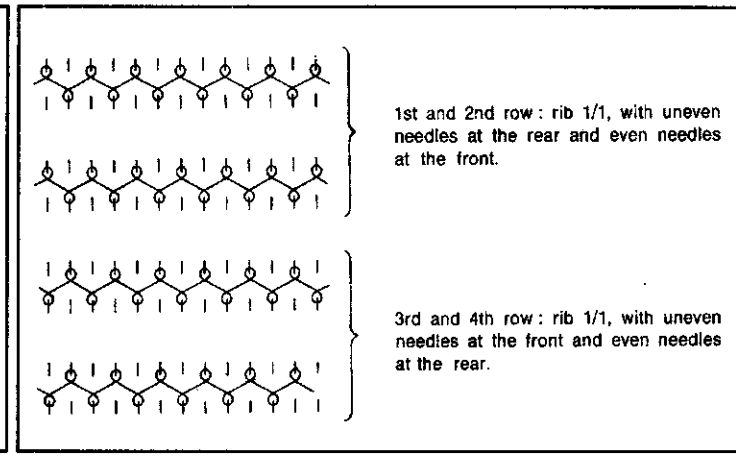




Double moss stitch:

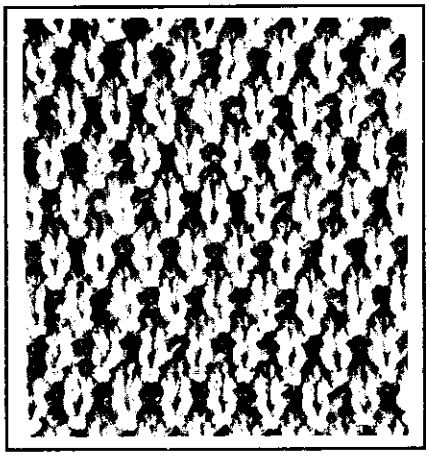
This fabric is a variation of the preceding sample. The stitch formation chart is illustrated in below.

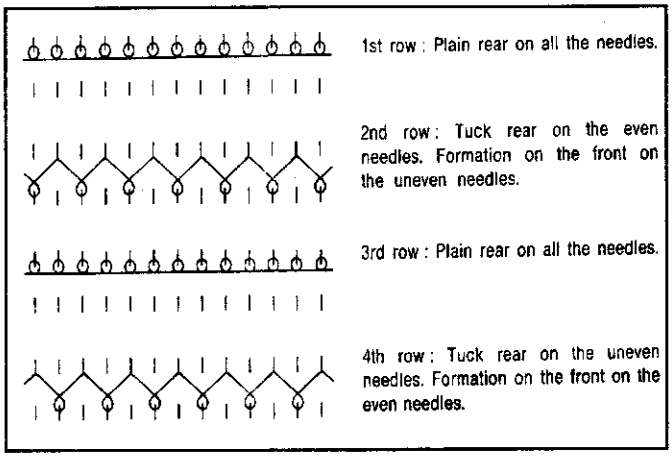




Tucked moss stitch:

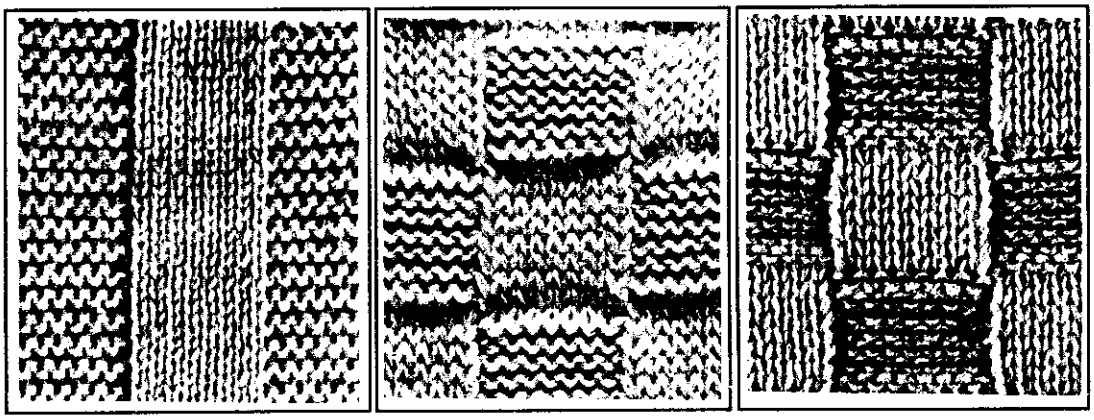
This fabric is also a variation of the preceding sample. The stitch formation chart is illustrated in below.





Plain and Purl Stitch:

As indicated before, purl stitch machines generally permit the execution of the majority of basic fabrics, in plain or in rib, with single or tucked stitches. In addition, as the needles can pass from one needle-bed to the other, purl stitch fabrics increase the variety of the sampling of these machines. The samples below, in purl stitch and plain, illustrate one of these sampling possibilities. The following three samples composed of plain and purl stitches have been knitted on a hand machine.



Links-links knit:

Links-links knits are based on the concept of superimposition, on the same column of plain stitches and purl stitches. These structured stitches were originally made on special machines featuring grooved flat and coinciding needle beds, equipped with special double-hook needles. Today, thanks to easier stitch transfer options, these structured stitches can be made quickly and safely on standard flat knitting machines.

The characteristic appearance of links-links designs consists in presenting alternated areas of purl stitches and plain stitches, often arranged so as to create a design motif. A classic example of links-links structured stitches is that shown in the (above middle figure) illustration, that is, the chequered design.

Plaited fabrics on purl stitch machines:

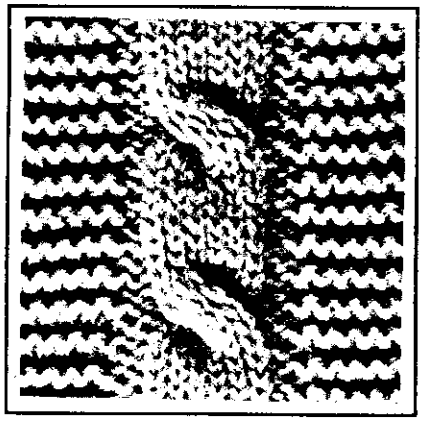
Plaiting is often utilized on purl stitch machines. This follows the same principle as plaiting. In rib fabrics, the plaited yarn does not appear. It remains contained at the interior of the fabric. On the other hand, in plain on one needle-bed, the plaited yarn appears on one side, i.e. at the front. One can thus obtain plain fabrics in different colours, depending on whether they are seen at the back or the front.

Fabrics in purl stitch are eminently suitable for this possibility, because they are composed, in principle, of a succession of rows knitted in plain, either at the front or the back. The plaiting enables therefore these plain rows to be in two colours. The two samples at the above (middle and right figures) are of identical texture, but the right one is plaited.

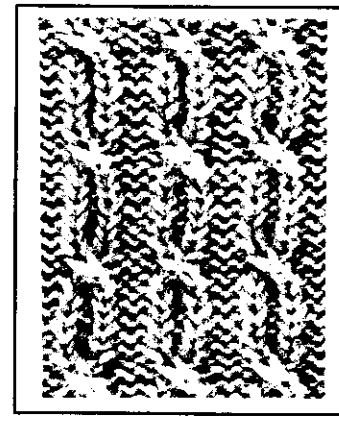
Cable design:

Other classic knitting structures that can be made thanks to stitch transfer are cables. In cable designs the vertical wales cross each other, have always been very popular in the sweater knitting trade. The basic concept consists in producing a series of plain stitch columns on a purl stitch base. After a number of rows, some of the stitches, corresponding to half the stitch columns in question, are transferred on the other stitch columns, while the stitches of the latter are transferred to the previous stitch columns. The stitches are thus crossed over and produce the classic cable effect.

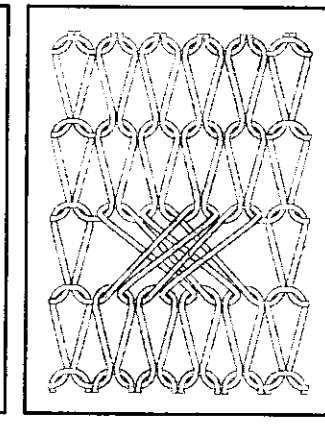
The cables can be of various sizes. A large number of variations exist, from "two needle cable" in which two wales cross each other, to "twelve needles cable" where six needles switch places with another group of six to form a very wide design effect. The principle of wale crossing is illustrated in a simplified loop configuration diagram (below right corner figure) in which a "four needles cable" is drawn. The most common and classic cable design is the "six needles cable" which is shown in the following left corner figure. This size of cable is popular because although the effect is clear it is still in proportion with a garment. The only limit to this size is determined by the displacement achievable by the machine all in one go.



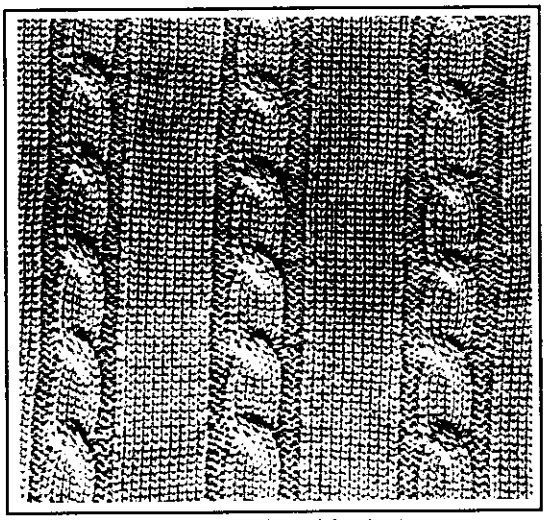
Six needle cable design



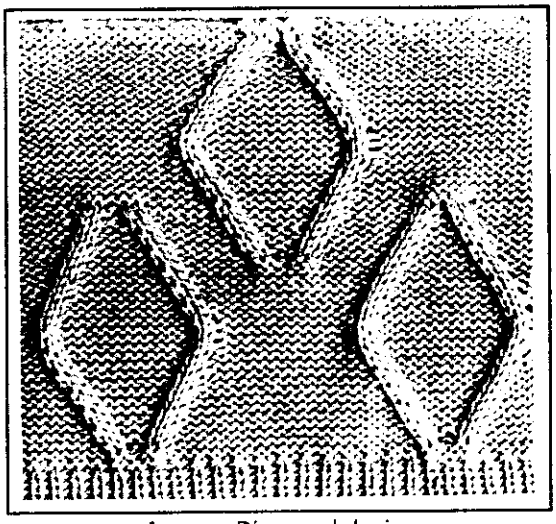
Two needle cable design



Four needle cable design



Six needle cable design



Aran or Diamond design

Aran or Diamond design:

Another very common knitting structure made according to the same concept as the cable is the aran. The procedures used are similar to those of the cable. The only difference is that the arms determined by the moving stitch columns are diverging rather than converging as is the case of the cable.

An example of diamond effect made using the aran technique is shown in the above right illustration, though naturally, the branches of the various arms of the cables and arans can be much more imaginative and complex.

The Welt:

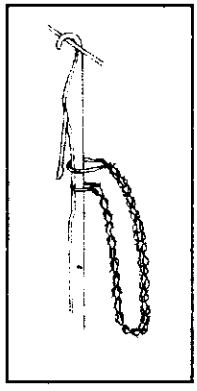
A welt is an attractive and secure edge of a knitted article that helps to prevent laddering or unroving of a structure. It is formed either during the knitting sequence (usually at the start, and parallel to the courses) or as a later seaming operation during making – up. Seamed welts, which are made after the knitting process, may occur in any position in the fabric.

Types of welt:

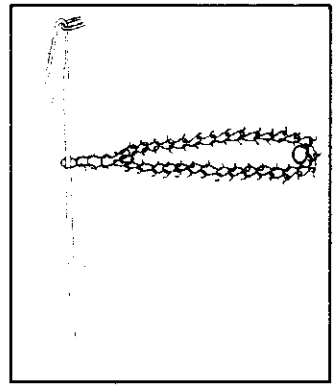
There are the different following types of welt:

- **The inturned welt:** A welt consisting of a double fold of plain fabric made on a circular stocking machine. Sinker loops from one of the first few courses are retained while the welt fabric is knitted and are later intermeshed with alternate needle loops of a subsequent course. The inturned welt is used particularly for manufacturing ladies' hose and sports socks on circular machines and some knitwear on cottons patent machines. Jacks or hooks collect the sinker loops of the third course or the set – up course and hold them, drawing the fabric away until sufficient has been knitted for the double – thickness welt.

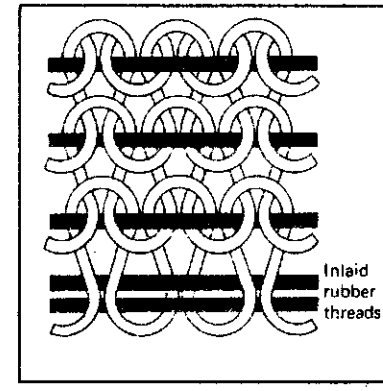
- **The turned welt:** A welt that consists of a double fold of plain fabric and is made on a straight – bar knitting machine. All or alternate sinker loops of the first course are retained while the welt fabric is knitted and later intermeshed with the needle loops of a subsequent course.
- **Reverse welt:** A roll welt in which the plain courses are intermeshed towards the reverse side of the fabric. This welt is used particularly for stockings with turnover tops.



Turned welt on latch needle



Turned welt on bearded needle



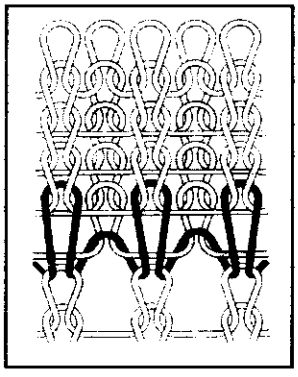
Accordion welt top

- **Accordion welt top:** An accordion top, welt and mock rib, can be produced on single–cylinder half-hose and sock machines, and on other machines using a single set of needles in a tubular arrangement. Elastomeric yarn is laid-in to odd needles only for a few courses so that when the first plain course is knitted by the textile yarn, the straight contracted elastomeric yarn lies through its sinker loops, forming a neat roll edge. The elastomeric yarn is then usually inlaid on a two-tuck two-miss or a one-and-one basis at each course or alternate courses for a number of courses. As the elastomeric yarn relaxes, it causes alternate wales to be displaced into a mock rib configuration. Sometimes, the second course of textile yarn is knitted only on alternate needles.
- **Rib welt:** Most fully-fashioned and stitch-shaped underwear and outerwear garments, half-hose, and socks have ribbed borders containing a welt sequence that is produced by causing the sets of needles to act independently of each other after the 1×1 rib set-up course. When the rib border is to be knitted in 2×2 rib, the needle bed is either shogged to form a skeleton 1×1 rib needle arrangement or it is knitted on a normal 1×1 rib needle set-out followed by rib loop transfer to achieve 2×2 rib for the border.

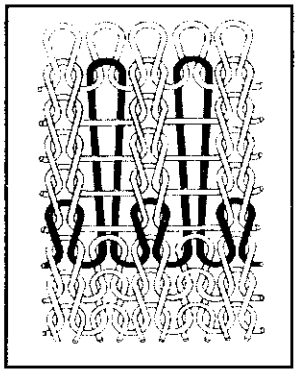
  Three types of welt are possible when needles are arranged in 1×1 rib set-out. These are:
  1. The Tubular or French welt
  2. The Roll or English welt
  3. The Racked welt

1. The Tubular or French Welt: A welt made on a rib basis, in which the number of courses with loops intermeshed in one direction is equal to the number of courses with loop

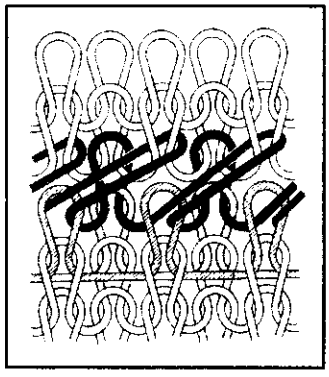
intermeshed in the other direction. In making such a welt on a 1×1 rib, the first and last courses are knitted on both sets of needles and the intermediate courses consist of an equal number of plain courses on each set of needles. The tubular welt is the most popular welt because it is a balanced structure that is reversible, lies flat, can be extended to any depth and is elastic. Its only disadvantage is that it can become baggy during washing and wear unless knitted tightly. Apart from old cottons patent Rib Frames, most garment-length knitting machines can knit this welt. The split welt is actually a tubular welt knitted at the end of the garment sequence instead of at the beginning. It is used as an open tube for a collar or stolling, to fit over the cut edge of a garment to which it is then linked by a through stitch.



Tubular welt



Roll welt



Racked welt

2. **The Roll or English Welt:**

A welt made on a rib basis, in which all the courses of loops except the first and last are intermeshed in the same direction towards the face side of the fabric. In making such a welt on 1×1 rib, the first and last courses are knitted on both sets of needles and the intermediate courses are knitted on only one set of needles. The roll welt is produced by knitting approximately four courses on one set of needles only whilst continuing to hold the setting-up course of loops on the other set of needles. It is bulkier and less elastic than the tubular welt and has the disadvantage of long held loops. This welt is knitted particularly on half-hose and links-links garment-length circular machines. A reverse roll welt is knitted for sleeves with turn-back cuffs and for turn-over top socks. To obtain this welt, the opposite set of needles (the bottom set of needles on half-hose machines) are caused to hold their loops so that the roll of the welt appears on the other side of the structure, but it is on the face when the fabric is folded over.

3. **The Racked Welt:**

The racked welt is neat and inconspicuous, rather like the set-up course of hand knitting in appearance, and is favoured for collars and other trimmings. It is not as elastic as the other two welts and is normally only knitted on V-bed flat knitting machines. It is produced by racking the needle bed by one needle space after the set-up course and retaining this arrangement.

Garment panel separation:

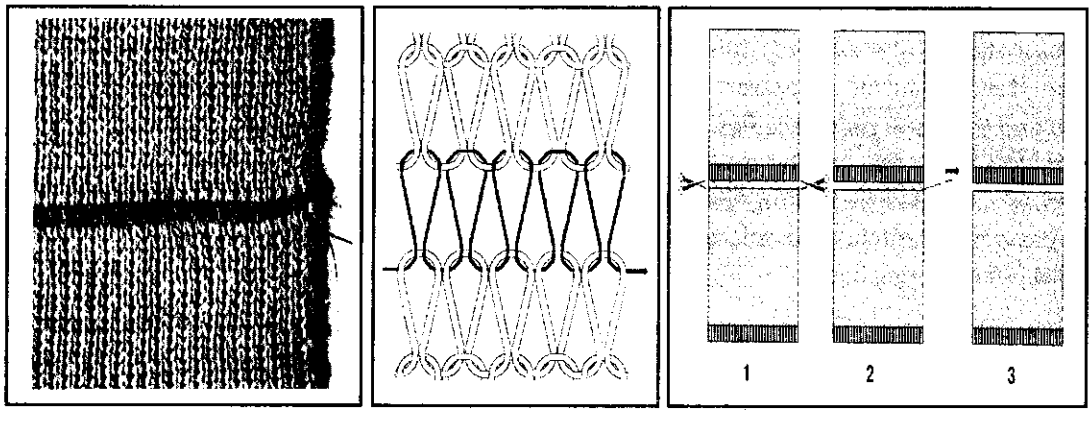
Knitted articles are often produced separately on single-cylinder machines, Cottons Patent machines and some flat machines. Others are knitted in continuous string formation on many flat and circular rib and purl machines because fabric tensioning is dependent on a continuous length of fabric between the needles and the take-down rollers. Also, there would be a danger of latches not being open at the start of a new garment sequence. If the string of garments is separated by cutting, there is a danger of either the welt being damaged or of unwanted yarn not being removed. For these reasons, some form of separation course is usually provided, normally in the form of a draw thread course, preceding the first course of the new garment.

Although the "hand flat" or manual sweater knitting machine can be re-threaded before the production of each panel, a continuous production is also possible. A special yarn can be knitted at the end of each panel so the following panel can use it instead of the comb.

In products which are later finished through a wet process, a dissolving thread can be inserted between panels. Separation is achieved without the need for an additional working stage. When no wet process is planned or the panels are to be separated at another stage, the dissolving yarn technique cannot be used. For these panel types, there is two principal methods of separating fabrics – separation by a draw-thread and separation by press-off – are dealt with below.

Separation by draw-thread:

The draw thread is usually a smooth strong yarn that may be knitted as a slack, plain tubular course to facilitate easy removal. It appears between the end of the piece and the commencement of the next piece, at the end of the protecting rows. The tubular draw thread course does not unrove accidentally during wet processing. The draw-thread must be followed by the set-up of the next piece (set-up and welt). To separate the two pieces, the thread must be cut and drawn out. To facilitate this latter operation, the draw-thread must be knitted at a slack tension. The draw-thread is particularly convenient for fabrics where the needle arrangement is the same at the end of one piece and the beginning of the next. For example, to separate articles commencing and finishing in 1×1 rib, to separate ribs knitted in 2/3 rib, etc.



The separating process is schematically shown in above, in the following stages:

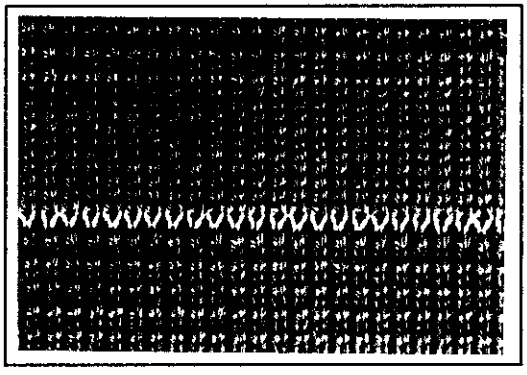
- The draw thread, knitted according to the special routine, is cut at the selvedges.
- It is easily pulled out through one selvedge.
- The panels are separated.

The separating sequence differs according to the knitting structure at the end of the completed panel and the rib construction of the next. Only some common procedures are shown in the below.

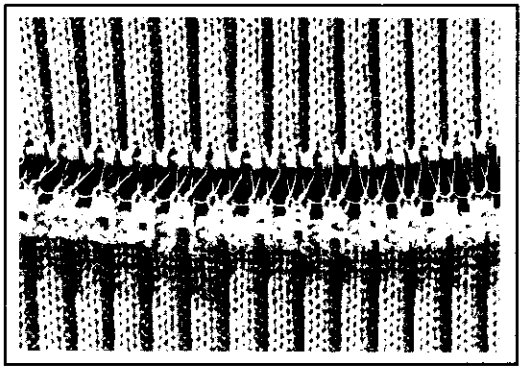
A separating draw thread is shown in the following left corner figure. It is inserted between a panel finishing in a 1×1 construction and a panel starting with a 1×1 rib. The sequence is based on the principle of knitting the draw thread in a plain construction. It is easier to pull out later. To change from 1×1 rib to a plain construction, two different methods can be used:

- All loops can be transferred to one needle bed.
- One needle-bed can be activated to press its loops off.

The manual machine is not always equipped to transfer loops automatically and manual transferring is time consuming. It is natural that the press-off technique is preferred. A press-off sequence should be well controlled and prepared to avoid laddering which is usually associated with dropped stitches.



A draw thread from 1×1 to 1×1



A draw thread from 2×2 to 2×2

Separation by press-off:

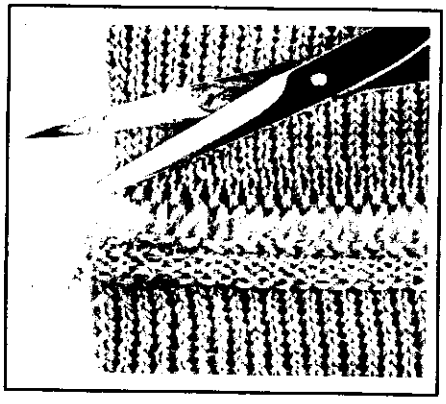
Another method is the press-off draw thread construction, which, although more expensive in time and yarn, tends to be more popular. The course preceding the start of the new garment is knitted in 1×1 rib and then one set of needles presses-off its loops, leaving a single plain course of extra long draw thread loops that can be quickly and easily removed. Prior to the press-off course, locking courses are produced by knitting three or more additional courses, only on the set of needles that are to press-off. These help to reduce tension in the structure after pressing-off and thus reduce the possibility of laddering back.

The draw-thread monopolises a yarn carrier which could be of greater advantage for something else. On the other hand, it cannot be used for separating two fabrics when some of the needles are eliminated. For example between 1×1 rib and 2/3 rib. In these cases, the pieces must be separated by press-off.

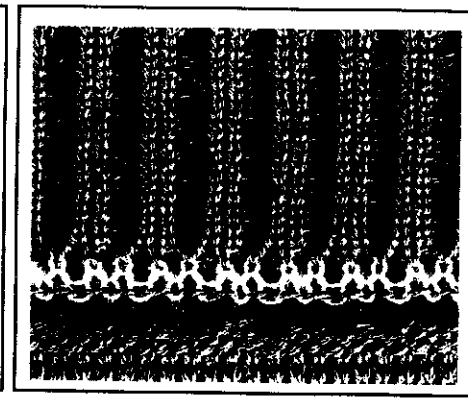
The separation by press-off consists of pressing off all or part of the stitches of one needle-bed. To avoid the stitches running to the bottom of the preceding piece, the press-off is always preceded by a few rows of single bed fabric.

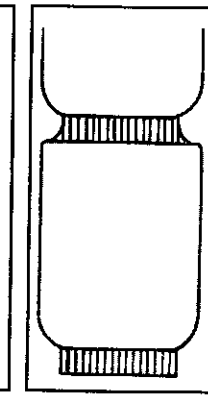
To separate the two pieces, one must cut, then draw out the thread of the slack row. This can be made with a smooth and strong thread (mercerized cotton, nylon, etc.) to facilitate the separation of the pieces.

The separation by press-off enables the needle arrangement to be modified between the end of one piece and the commencement of the following piece. Change from 1×1 rib to 2/3 rib by press-off of all the needles. This is the most common change, used for all machines without stitch transfer or jacquard. This method is ideal between two fabrics during which certain needles must be eliminated. From 1×1 rib to 2/3 rib or 1/2 rib etc.



Two articles in 1×1 rib are separated by press-off





A draw thread from 1×1 to 2×2

A popular alternative to a draw-thread, employed on half-hose and sock machines, is to knit a number of courses in a soluble yarn such as alginate. The socks are separated by cutting, and the remaining courses of yarn are dissolved away during finishing to leave a neat edge to the welt.

Most garment-length machines using two needle beds have a butt arrangement of two long, one short for each bed, enabling 2×2 rib knitting after pressing off the loops of a 1×1 rib set-out and recommencement of knitting on only long butts on each bed in turn.

Shaping during knitting:

In addition to facilities for garment-length sequence knitting, weft knitting provides unique opportunities for width-wise shaping during knitting, with the sequence being initiated and co-ordinated from the same central control mechanism.

There are three methods of width shaping as follows:

- varying the number of needles in action in the knitting width,
- changing the knitting construction, and
- altering the stitch length.

Shape formation (Fashioning):

Shaping by fully fashioning involves the movement of a small number of loops at the selvedge of th fabric. Such movement reduces or increases the total number of loops being knitted. The term used in the industry for such movements are narrowing and widening, and collectively fashioning.

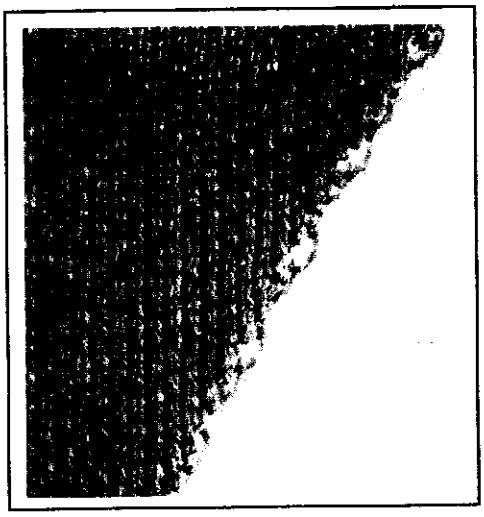
To alter the shape of the panel, the courses are widened by increasing the number of knittin needles or narrowed by eliminating needles at the selvedges. The two operations require differen knitting procedures.

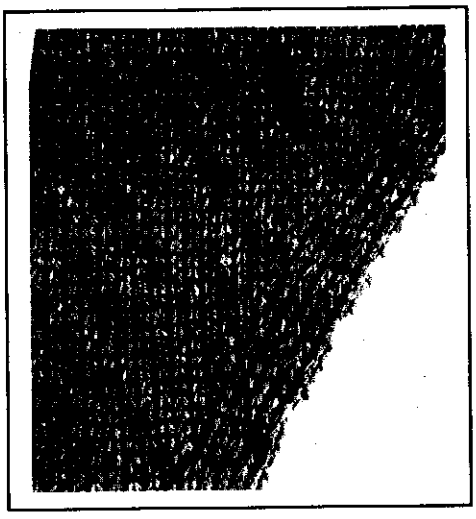
The Widenings:

Widening is the process of increasing the width of the knitted fabric produced, by increasing th number of working needles.

To widen the width of a knitted piece, gradually needles are added – thus stitches – at th selvedges. Generally, widening is done needle by needle. Special cases involve two needles at onc being put into action. The angle at the widened selvedge depends on the frequency of th widenings in relation to the rows of knitting. Thus, widenings of one needle every two rows c stitches is more rapid than widenings of one needle every four rows.

To increase the width of the piece knitted by a stitch, it is sufficient to add a needle in action at th selvedge. The widening of a rib fabric requires, naturally, 2 supplementary needles, one at the fron the other at the back, which is shown in the following left figure.

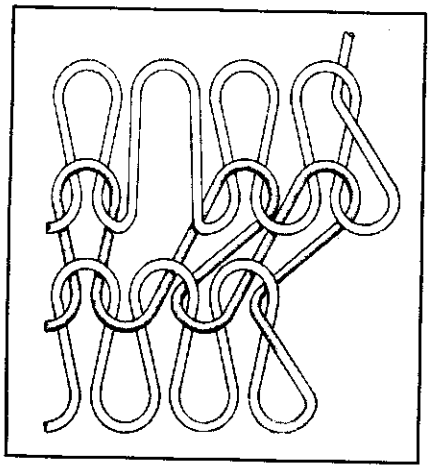




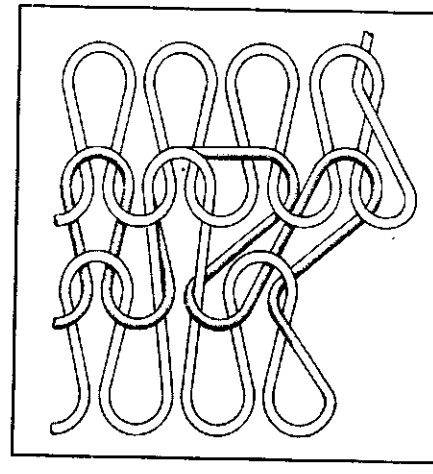
In order to improve the appearance of the selvedges, the widening, on a hand machine, can b done by a narrowing handle. This involves firstly putting a needle into action front and back. The take the stitch or stitches of the selvedge on a narrowing handle with one or more points, move t handle a needle towards the exterior of the fabric and hook on the stitches to the selvedge needl To avoid the formation of small holes, hook up the last but one stitch that has been formed on the empty needle, by means of the narrowing point or work hook. The above right figure show t

sample in 1×1 rib, has been widened as per the method explained now, by means of a 6-point narrowing handle. The widening done in this way takes much longer, but give a more regular appearance to the selvedges.

In widening, the movement outwards creates a space adjacent to the innermost needle of the group, where a new wale may start. The empty space, followed by the tuck loop formed at the next knitted course, leaves a hole in the fabric. It is usual in commercial practice to fill this hole by moving a previously knitted loop to commence the new wale. Such holes restrict the widenings to single needle only.



A single widening



A single widening with filling in

On flat knitting machines (e.g. V-bed knitting machine) widening can be performed in two ways:

- by putting in action the border needles (one needle on either side, in a loop cpurse) and respectively extending the working range of the yarn carrier;
- by transferring the border loops on the needles just put in action (one needle from either side in a loop course) and extending the working range of the yarn carrier (for one or two needles just put in action, on either side, in a loop course).

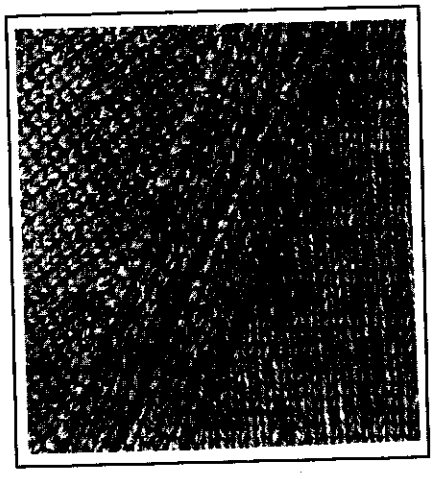
Another way of widening is performed as follows:

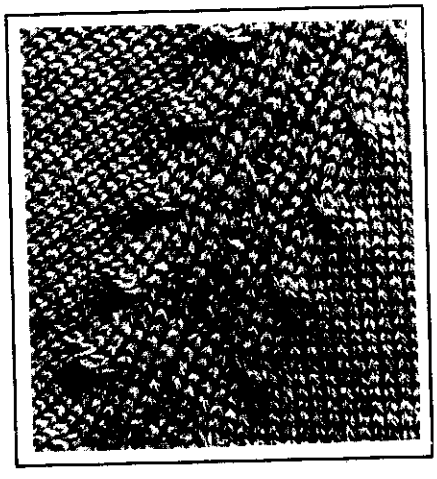
1. Only one selvedge of the panel can be widened with each stroke of the carriage.
2. When a special twin carriage machine is used, two courses are knitted in each carriage stroke.
3. No transfer operations are required for widening and the course is increased simply by adding new active needles to the panel.
4. The newly activated needles are introduced on the side from which the carriage starts its traverse. When the carriage travels from right to left, needles can be introduced at the right selvedge. In this way, the new loops are secured in the needle's hook.
5. To complete one cycle of widening on both sides of the panel, the carriage has to travel once in each direction thus knitting four courses.

The Narrowings:

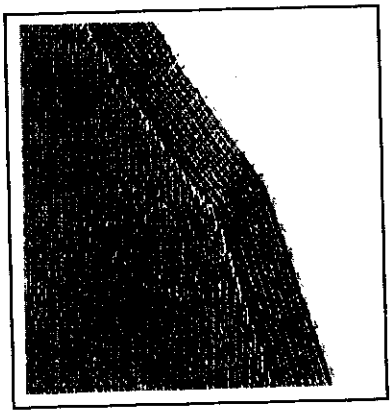
This is the reverse of what takes place in widening i.e. narrowing is the process of lessening the width of knitted fabric produced, by decreasing the number of working knitting needles.

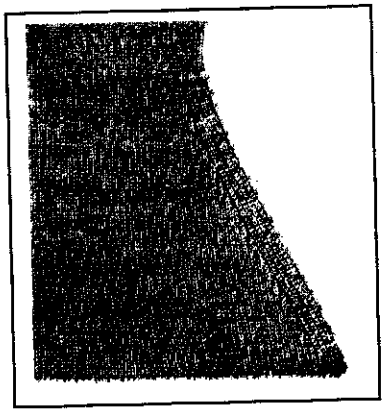
Narrowings by hand are executed by stitch transfer with a narrowing handle. To avoid doubling the last stitch of the selvedge, a narrowing handle with several narrowing points is used. The narrowing handle with several points is used in the same manner as a narrowing handle with one point. The narrowing handle takes as many stitches as there are points, and transfers these one needle towards the centre of the piece. The extreme selvedge needle loses its stitch and can be put out of action. The stitch doubled by the narrowing is towards the interior of the piece. The use of a narrowing handle with several points gives the article a highly finished appearance. The selvedge stitches remain parallel. This appearance characterizes narrowed articles, which is shown in the following left figure. The following right figure shows the single bed knitting, in 12 gauge, narrowed by means of a 6-point narrowing handle of 3 stitches at once.



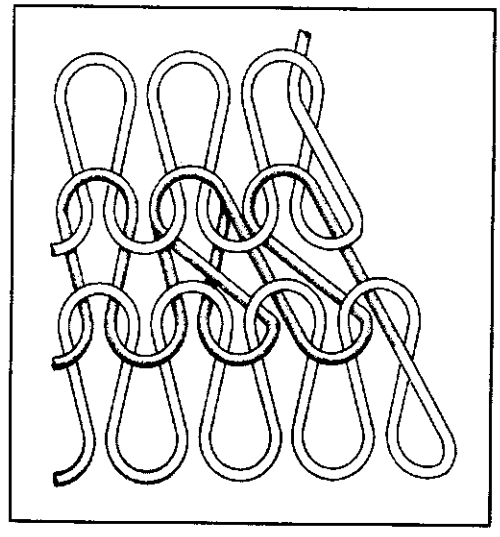


The following left figure shows the 1×1 rib in 12 gauge narrowed on a typical automatic machine, first in double system (1 transfer every 4 rows of stitches), and then in single system (1 transfer every 2 rows of stitches). The following right figure shows the side of collar knitted in 1×1 rib in 12 gauge and narrowed on the same automatic machine.





When narrowing, the innermost loop of the group being moved combines with the loop adjacent to it. The figure represents two loops being moved by one loop space, thus losing one loop at the edge. It is possible on plain fabric to move the edge loops more than one needle space, losing more than one loop at the edge. In the fully fashioned industry these are known as 'needle narrowings' e.g. two needle narrowings where the outer group are moved in two needles. Such multi-loop narrowings produce small puckers where the loops combine. The number of loops in the group being moved varies from three to seven.



A Single Needle Narrowing

With finer fabrics tending to involve more loops than coarser fabrics.

On flat knitting machines (e.g. V-bed knitting machine) narrowing can be performed in two ways:

- by putting out of action the bordering needles and casting off their loops; at the same time the working range of the yarn carrier should respectively be decreased;
- by transferring the loops of the needles to be put out of action, on the neighbouring needles, in order to prevent unraveling of the loops; the working range of the yarn carrier should respectively be decreased.

Another way of narrowing is performed as follows:

1. To decrease the size of the course and the width of the panel, needles have to be deactivated at the selvedges. The loops held by these needles cannot be pressed-off (ladders can be formed). Instead, these loops have to be transferred inwards to active needles.
2. Loops cannot be transferred from needle to needle on the same bed. The operation involves the transfer of loops to the opposite bed; racking and then transferring them back to adjacent needles. The procedure is further complicated by the need to transfer in opposite directions at each selvedge.

3. Narrowing of both selvedges can be performed after each stroke of the carriage regardless of its direction. If the panel is symmetrical, identical operations are performed for each selvedge.

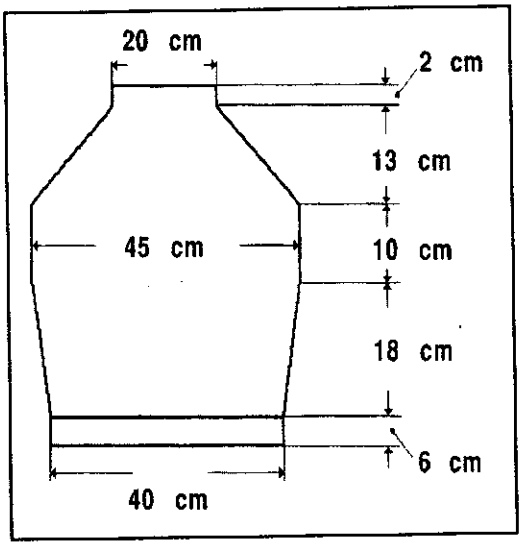
Fashioning is not restricted to plain fabric only; rib fabrics are increasingly the subjects of fully fashioning. Particularly suitable for shaping in this way are the cardigan fabrics containing tuck loops and broad ribs.

Shaping Calculation or Fashioning Frequencies Calculation:

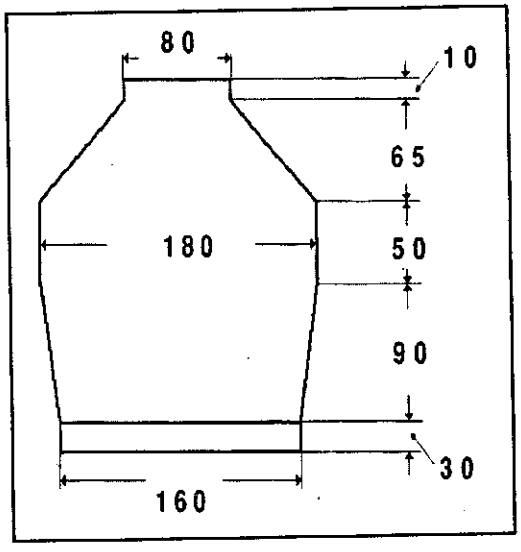
Example no.1:

The measurements for the complete panel are required to calculate the widening / narrowing procedure. The following figure shows the measurements of a front panel as designed for the garment. These measurements are to be used as an example for the planning of the fashioning operation.

- The panel measurements have to be translated into wales and courses.
- This is carried out according to the course and wale quality of the fabric to be knitted by the knitting machine.



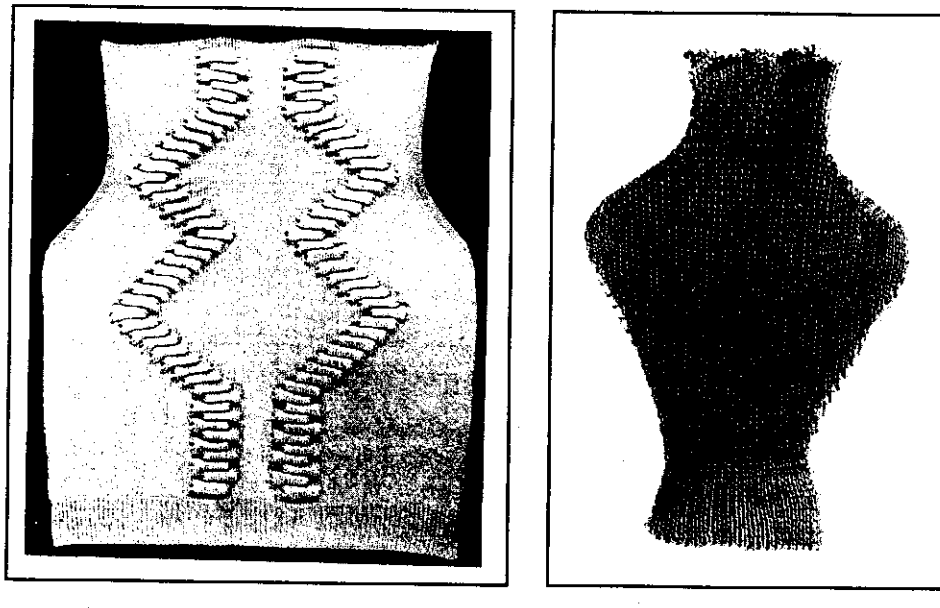
Measurements of a garment panel



Panel measurements converted into wales & courses

- For this example, the fabric quality is 4 wales per centimeter and 5 courses per centimeter (plain knit on 6 gauge). The converted measurements are presented in the figure also.
- When the garment is produced, the elastic border is knitted first. It can be adapted from the standard programmes in the data bank. As the first fashioning process, the knitting width has to be widened from 160 wales to 180 wales. 20 widening operations are required (180 – 160 = 20), or 10 operations on each selvedge of the panel.

- The widening has to be completed during the knitting of 90 courses. If these available courses are divided by the number of widening operations, the result is 9. One extra needle has to be included in the knitting operation every 9 courses, on the right and on the left.
- After the widening operation, the panel is knitted on the same number of needles for 10 centimeters or 50 courses.
- The narrowing procedure follows and the number of active needles have to be reduced from 180 to 80. The narrowing takes place on both sides of the panel in a single routine. Traditionally, two needles on each side are eliminated each time so the width is reduced by four wales. The number of operations is $\frac{180-80}{4} = 25$.
- Narrowing should be completed within 65 courses. These available courses are divided by the number of narrowing operations. 25 operations are required so 15 operations are carried out after every 3 courses and 10 operations after every 2 courses.
- After the narrowing operations, the panel is knitted on the same number of needles for 2 centimeters or 10 courses.



Fully fashioned panel

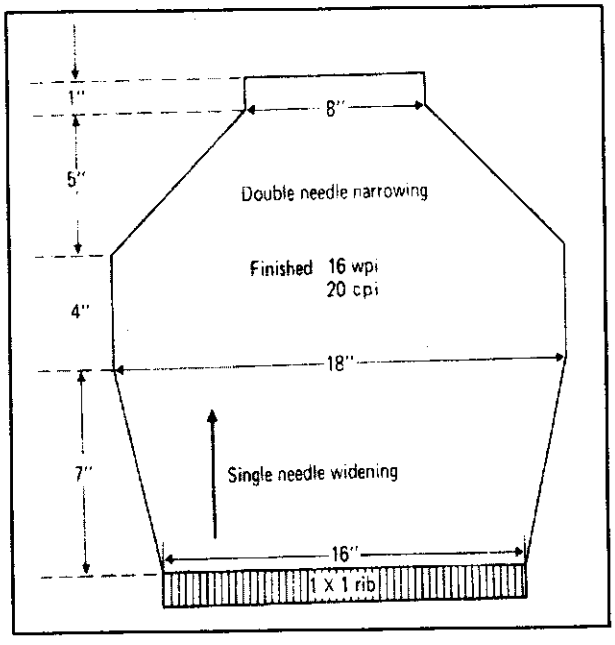
A fully-fashioned panel, produced on a modern flat knitting machine, is shown in the above figure. In addition to the fashioning techniques, the panel is designed with protruding elements.

Example no.2:

Using the details shown in the figure below as an example, the following sequence is necessary in order to calculate the required fashioning frequencies from the dimensions of a garment part:

- Convert the length dimensions in each section to total number of courses by multiplying the length measurement by the courses per inch. Thus, 7 × 20 = 140; 4 × 20 = 80; 5 × 20 = 100 courses.

- Convert the width dimensions at the start of each section to total numbers of needles by multiplying the width measurement by the wales per inch. Thus, 16 × 16 = 256; 18 × 16 = 288; 8 × 16 = 128 needles.
- Calculate the total number of needles increased or decreased from one section to another by taking one total from the next.
- Divide the totals obtained by 2 in order to obtain the increase or decrease of needles at one selvedge. Thus, 288 – 256 = an increase of 32 needles. 32 ÷ 2 = 16 single needle widenings; 288 – 128 = 160; 160 ÷ 2 = 80 needles, 80 ÷ 2 = 40 double needle narrowings.



Measurements of a garment panel

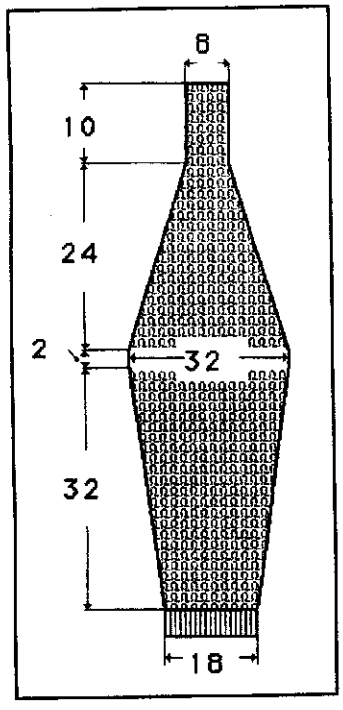
- There are 16 single-needle widenings occurring during the knitting of 140 courses; assuming the first fashioning occurs in the first course, there will be 16 – 1 = 15 fashionings in 140 – 1 = 139 courses; 139 ÷ 15 = 9 with a remainder of 4. Thus 4 fashionings must occur at 10 course intervals and the remaining 11 at 9 course intervals.
- Forty double-needle narrowings occur during 100 courses, again assuming the first fashioning occurs in the first course; 99 ÷ 39 = 2 with a remainder of 21. Thus 21 fashionings occur at 3 course intervals and the remaining 18 fashionings occur at 2 course intervals.

Example no.3:

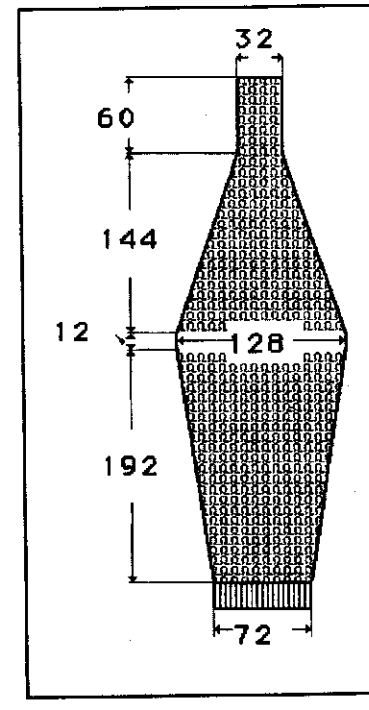
To calculate and plan the widening / narrowing operations, the measurements for the complete panel are required. In the following figure the measurements of a sleeve are presented, in centimeters, to be used as an example.

- The next stage is to translate the panel measurements into wales and courses, according to the quality of the fabric that is knitted by the machine with the required yarn.

- Assuming for this example that the fabric quality is 4 wales per centimeter and 6 courses per centimeter, the converted measurements are calculated and presented in the following second figure.
- After the knitting of the elastic border, the first fashioning process is required and the knitting width has to be widened from 72 wales to 128 over the period of 192 courses. 128 – 72 = 56 single widening operations are required or 56 ÷ 2 = 28 on each side of the panel.



Measurements of a garment panel



Panel measurements converted into wales & courses

- If the available 192 courses are divided by the four courses required for each widening operation, the result is 48 cycles out of which only 28 are required. The twenty unnecessary cycles are spread among the required 28 so that the procedure is as follows:
  - 20 widening routines after each 8 courses (each two sequences).
  - 8 widening routines after each 4 courses (each sequence)
- After the widening operation, the sleeve is knitted at the same width for two centimeters or 12 courses.
- The narrowing procedure follows and the number of active needles have to be reduced from 128 to 32 over 144 courses.
- The narrowing takes place on both sides of the panel and is carried out in a single routine. Usually two needles on each side are eliminated so that each time the width is reduced by four wales.
- The required number of operations is $\frac{128-32}{4}=24$.

- When the available 144 courses are divided by the shortest sequence between narrowing operations (2 courses or one carriage stroke) the result is 144 ÷ 2 = 72.
- Since only 24 operations are required, each can take place after 3 sequences (72 ÷24) = 3 or:
- 24 narrowing operations each after 6 courses (three carriage strokes).
- To complete the sleeve, the same width is kept for an additional 10 centimeters or 60 courses.

Linking operation:

A method of joining together the edges of a piece of fabric or fabrics by a single or double chain-stitch on a linking machine, in which one or more of the pieces of fabric is run on to the points on a loop-to-point basis and is therefore stitched through adjacent needle loops. Where none of the pieces of fabric are run on to the points on a loop-to-point basis, this is referred to as random linking. The joining together of two edges, usually knitted selvedges is also called cup seaming. The edges to be joined are positively fed to a sewing point by two cup-like wheels. Cup seamers have been used almost exclusively for the assembly of fully fashioned knitwear.

Linking machine, straight or circular, provided with grooved points spaced to receive loops, which are then joined together by chain-stitch.

Linking machine:

Linking machines have a common basic construction that consists of a circular "dial" containing grooved points that face radially outwards, which is shown in the following figure. It is on to these points that the fabric is placed. The diameter of the dial varies according to the particular make of the machine, and the spacing of the points varies between different gauges of the machine. The gauge is still specified in imperial measure as points per inch of circumference. For knitwear gauges are available from 3.5 points/inch to 24 points/inch.

The points remain static except in the sense that the dial revolves relative to the looping mechanism. The looping mechanism consists of two moving parts: the needle and the looper. These are carried in a supporting arm mounted internally on the dial plate, so that the looping elements are presented in the vicinity of the points. Two variations of the machine exist, one where the needle enters the work from the inside of the dial, and the other where the needle enters the work from outside the dial and the looper works on the inside.

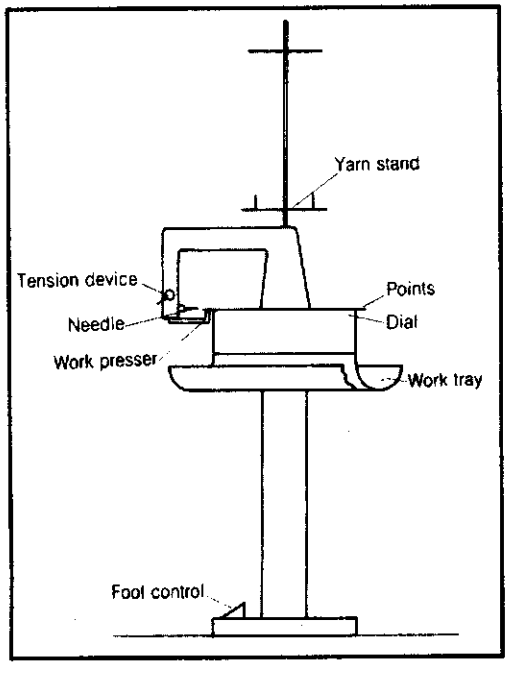
Principle of stitch formation:

To complicate matters, two forms of needle exist: an eyed needle similar to those found on other seaming machines and a hooked needle similar to that used for hand crochet work.

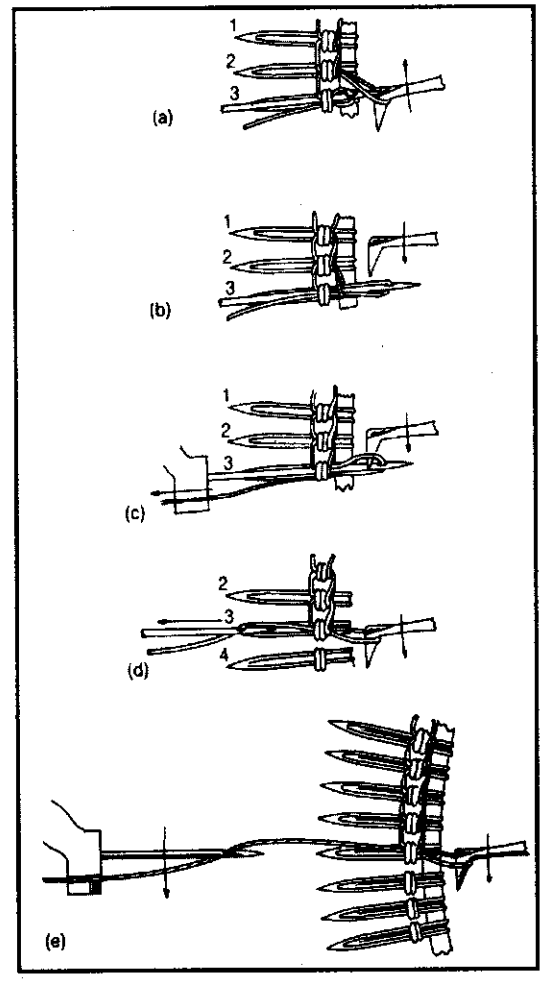
Principle of stitch forming action on linking machine equipped with eyed needle:

Eyed needle; the needle is usually mounted so that it enters the work from the outside, sliding along the groove of a particular point. In doing so it carries the thread with it. Once through the fabric it

enters the previously formed loop held by the looper, which is shown in the following figure-a. The looper withdraws leaving the previously formed loop on the needle, which is shown in the following figure-b. As the needle starts to withdraw, the thread is trapped at the base of the needle, causing the loop formed on the looper side of the fabric to bell out, which is shown in the following figure-c. The looper now enters this loop and holds it while the needle withdraws, which is shown in the following figure-d. The dial now advances one point space and the whole cycle begins again, which is shown in the following figure-e. The chain is formed on the side of the fabric facing the inside of the dial, i.e. on the looper side.



General view of a linking machine



Stitch forming action of a conventional needle linking machine forming single chain stitch

Principle of stitch forming action on linking machine equipped with hooked needle:

Hooked needle; the crochet hook is usually mounted on the inside of the dial and enters the work along the groove in the point, as described before, but in the opposite direction. The thread is presented to the needle by a yarn carrier. This is a tube on Complett machines, and a small ring on

Mathbirk machinery. The thread enters the hook of the needle which withdraws dragging a loop through the fabric and through the previously formed loop. The needle retains the loop on its stem as the dial moves on one point and the cycle starts again.

The chaining again takes place on the inside of the dial. Both types of loop forming principles exist in reversed versions, with inside mounted conventional needles and outside mounted crochet needles. Uses and advantages are claimed for each version. For both needle types entering from outside the dial, there is a tendency for the work to be pushed back on the points, requiring less presser plate control.

Thread control is effected by two principal methods: a tension device usually of the spring loaded disc type, and a yarn take up device that controls slackness in the thread between the disc tension and the stitch forming zone. Most linkers also have fitted a yarn trapping device that acts when the needle is withdrawing on the conventional needle type. Linkers are used in the making up of knitted outerwear in operations where a loop for loop seam is required or where a seam is precisely located down a particular wale.

Examples of loop for loop seams are closing the shoulder seams of some types of fully fashioned garments or closing the toe on socks. An example of wale seaming for precision is the attaching of a pocket to the front panel of a cardigan.

By far the commonest use of linking machines is for attaching neck ribs to knitwear. The operator of the machine sits on a seat positioned so that the dial is just below eye level. The dial and the arm are free to rotate around the central support pillar, making it easier for the operator to progress the work on to the points. Sometimes two operatives run on work to the same dial, working on opposite sides of the machine. The bulk of the garment being seamed hangs down from the points, usually into an annular cup-shaped support tray. The drive to the machine is direct and not through a clutch, a foot switch turning the motor on and off. Speed of stitching is also controlled by a foot pedal.

KNITTED FABRIC FAULTS

Faults in circular knitting production can be caused in various ways and quite a few of them cannot be related to just one cause. The following explanations are expected to be helpful in trying to locate the causes of these faults easier.

Reasons of fabric faults:

- Yarn manufacturing faults
- Fabric manufacturing faults
- Fabric processing faults – dyeing, printing or finishing faults

Sources of fabric faults:

The sources of faults could be (in circular knitting machine, 80% faults comes from yarn)

- Faults in yarn and the yarn package
- Yarn feeding and yarn feed regulator
- Machine setting and pattern defects
- Machine maintenance
- Climatic conditions in the knitting plant

Fabric faults:

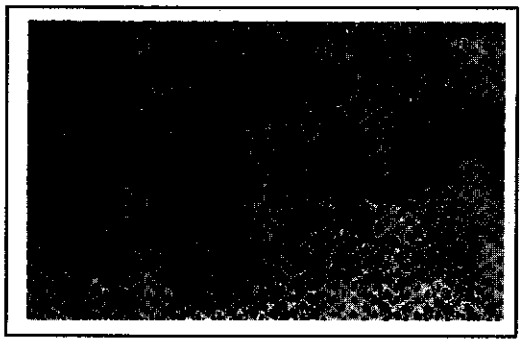
Knitted fabric faults are very different in nature and appearance and are often superimposed. The most common faults are:

- Broken ends, holes or cracks
- Drop stitch
- Cloth fall-out or pressed-off stitches
- Snagging or snags
- Tuck or double loop or stitches
- Bunching-up
- Vertical stripes
- Horizontal stripes
- Soil stripes
- Colour fly or coloured tinges
- Distorted stitches or deformed or tilted loops

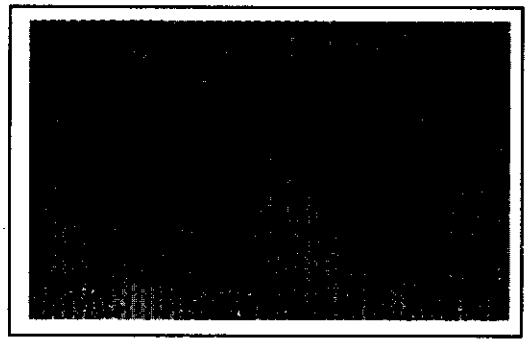
Holes:

Holes are the result of cracks or yarn breakages. During stitch formation the yarn had already broken in the region of the needle hook. Depending on the knitted structure, yarn count,

machine gauge and course density, the holes have different sizes. This size can therefore only be estimated if the comparable final appearance of a comparable fabric is known.



Hole on the front side



Hole on the back side

Possible causes:

a) Yarn parameters
   - High yarn irregularity
   - Incorrect yarn input tension setting, yarn running-in tension is too high
   - Poorly lubricated yarns
   - Weak places in yarn, which break during stitch formation
   - Knots, slubs etc.
   - Yarn is too dry.

b) If the yarn is trapped between the cheek taper and the closing latch
   -yarn damage

c) Too small stitches
   -difficulty in casting-off of the stitches

d) Relation between cylinder and dial loop not correct; yarn feeder badly set; defective knitting elements.

Drop stitches:

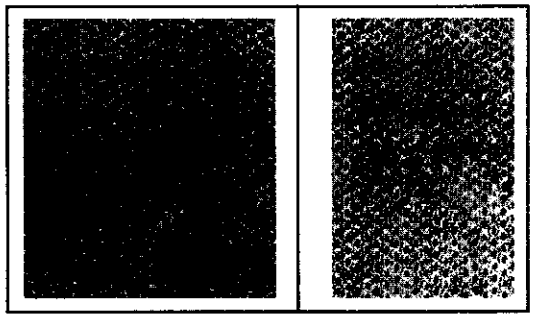
These are the result of a defective needle. They also occur when a yarn is not properly fed during stitch formation, i.e., not properly laid-in the needle hooks. These are the unlinked knitted loops.

Possible causes:

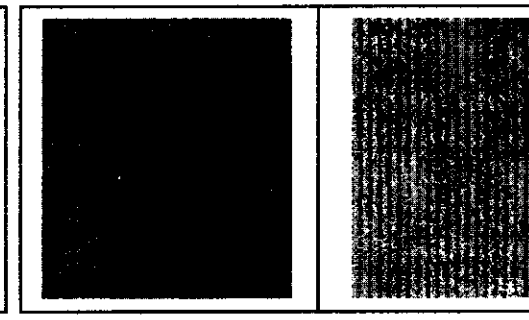
a) Inaccurate insertion of the yarn into the needle hook;
   - Closed latch – a wale of dropped stitches will be produced until the latch is opened either by the operator or due to machine vibration.

b) Broken needle hook;

c) Due to high yarn twist and low fabric take-down-tension the knitted loop could fall out of the hook;



Drop stitches on the front side

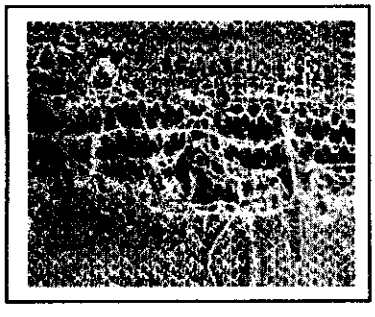


Drop stitches on the back side

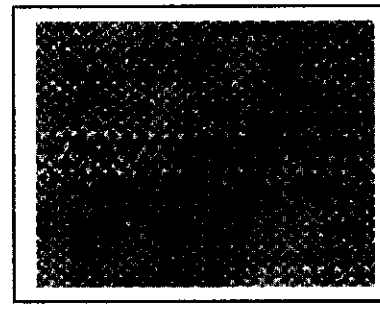
d) Improper setting of the yarn feed angle i.e. badly set yarn feeder
   - The yarn is not caught by the needle hook, Example – low yarn tension and high yarn vibrations
e) Yarn feeder wrongly threaded-in;
f) Dial loop length not properly related to cylinder loop length; the loop jumps out of the needle hook;
g) Bad take-up;
h) Very dry material;
i) Insufficient yarn tension.

Cloth fall-out or Pressed-off stitches:

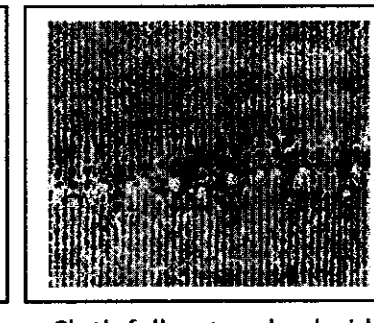
It is an area consisting of drop stitches lying side by side. They can occur either when a yarn is laid-out or when it breaks without any immediate connection. Cloth fall-out can occur after a drop stitch especially when an empty needle with closed latch runs into the yarn feeder and removes the yarn out of the hooks of the following needles.



Cloth fall-out



Cloth fall-out on front side



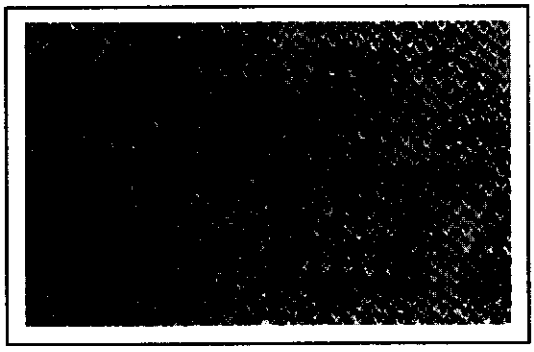
Cloth fall-out on back side

Possible causes:

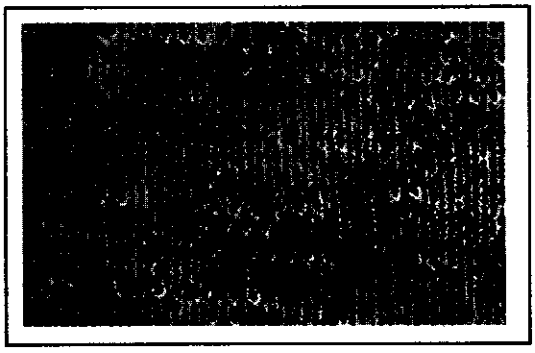
a) Yarn breaks before the yarn feeder
b) Yarn package winding faults, poor package build-up;
c) Fibre fly block the yarn guides, feeders etc.

Needle marks or Vertical stripes:

Vertical stripes can be observed as longitudinal gaps in the fabric. The space between adjacent wales is irregular and the closed appearance of the fabric is broken up in an unsightly manner. Vertical stripes and gaps in the fabric are often the result of a meager setting, i.e., the yarn count selected is too fine for the machine gauge or the stitch size (course density) is not correct. Needles are bent, damaged, do not move uniformly smooth, come from different suppliers or are differently constructed.



Vertical stripes



Tuck loops

Possible causes:

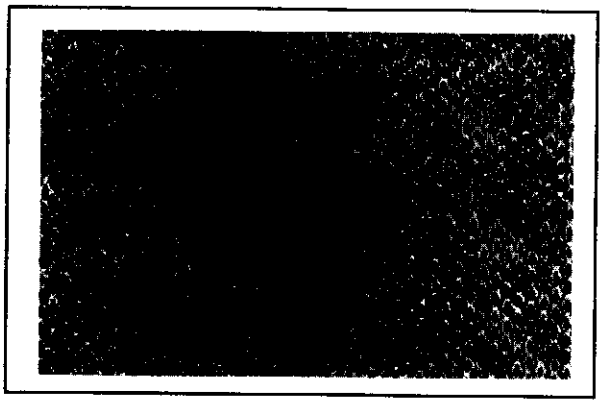
a) Twisted or bent needle hooks;
b) Stiff latches and needles;
c) Incorrect closing of the hook by the latch;
d) Heavily running needles;
e) Damaged dial and cylinder;
f) Damaged needle latch and needle hooks;
g) Damages on other knitting elements.

Horizontal Stripes:

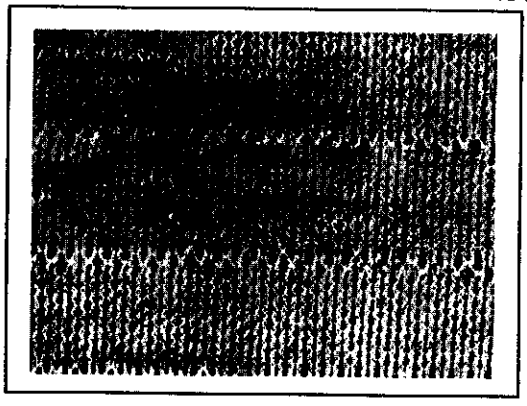
These are caused by unevenness in the courses; they traverse horizontally and repeat themselves regularly or irregularly.

Possible causes:

a) Deflector in dial cam brought into tuck position.
b) Deflector not completely switched off. Needle can still grip the yarn and forms a tuck loop.
c) Yarn feeder badly set.
d) Differences in the yarn running-in tension.
e) Couliering not constant at all feeders.
f) Jerky impulse from fabric take-up.



Horizontal Stripe on face side



Horizontal Stripe on back side

Barre'ness:

Barre'ness is the periodic lateral irregularities

- **Structural Barre'ness:**
  Possible causes:
  - Individual yarns differ with respect to count, properties or structure;
  - Different course lengths in feeders.

- **Colour Barre'ness:**
  Possible causes:
  - Knitting of yarns which differ in colour;
  - Yarns dye differently during piece dyeing.

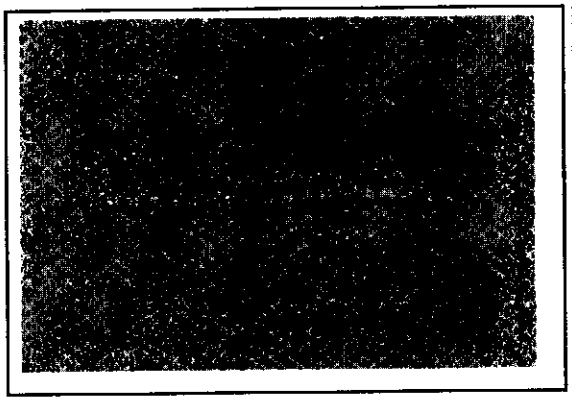
- **Shadow Barre'ness:**
  - Shadow like changes in the appearance of the fabric. Very difficult to detect and done by reflected light.

Bunching-up or Thick and Thin Places:

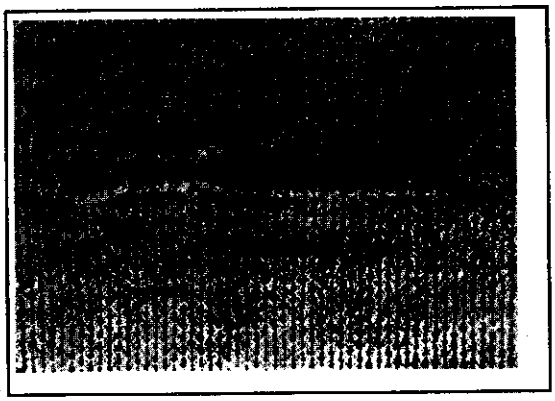
Visible knots in the fabric are referred to as bunching up. They appear as beads and turn up irregularly in the fabric. Can build up resulting in a "cloudy" appearance. More irregular the yarn, more pronounced is the "cloudy" appearance.

Possible causes:

a) Thick and thin places in the yarn;
b) Fabric take-up too weak.



Bunching-up on front side



Bunching-up on back side

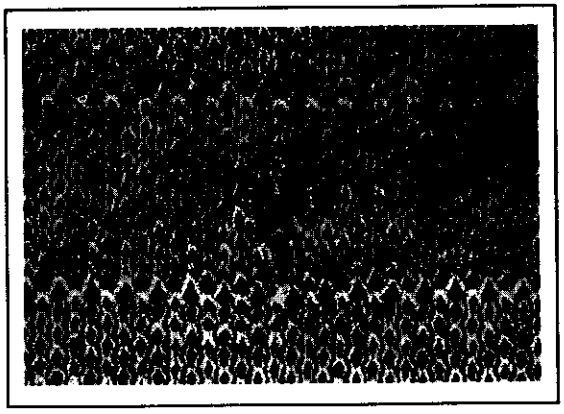
Snags:

Snags mainly occur while processing filament yarns. The tendency towards snagging can be reduced by using yarns with a coarser single filament count, lesser crimp elasticity and higher twist.

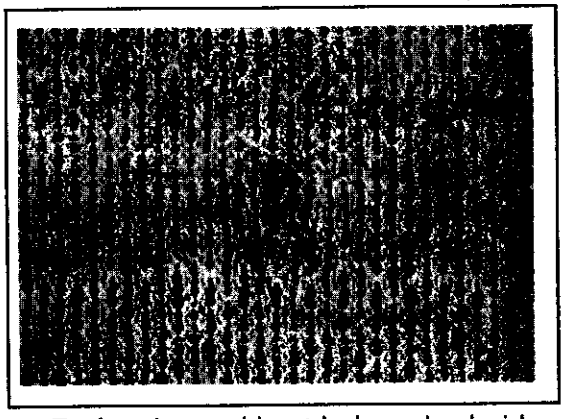
During knitting all mechanical influences, caused by rough surfaces on yarn guide elements, yarn feeders, needles, fabric take-up, etc. have to be avoided. Even after knitting some snags can appear especially during fabric setting, if its storage and further processing has not been undertaken carefully.

Tuck or Double stitches:

These occur due to badly knitted or non-knitted loops. They are unintentional tuck loops or floats, also showing up as thick places or small beads in the fabric. At first instance they may also appear as a shadow when the fabric is observed against light.



Tuck stripe and knot hole on front side



Tuck stripe and knot hole on back side

Possible causes:

a) Fabric take-up is too weak, i.e., fabric take-up is insufficient, must be readjusted, has a one sided drag on the fabric or is not continuous.
b) The dial is set too high. The dial needles do not support the fabric, which is thus pulled up.
c) The course density or couliering is not set correctly.

The loops are too tight, e.g. with interlock. These loops are not removed from the needles.

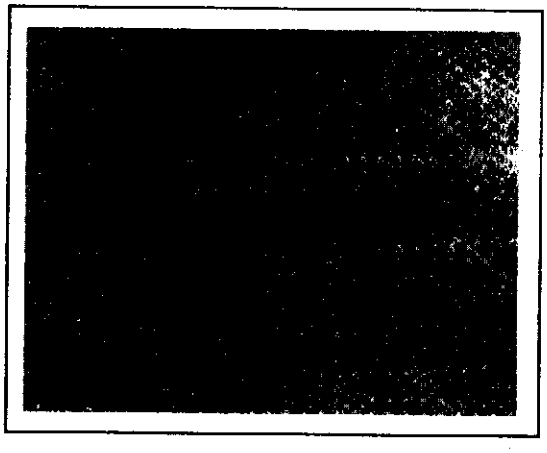
Soil stripe:

Soil stripes can appear both in the direction of wales as well as courses. Soil stripes in the direction of the wales are solely caused by the knitting machine. In most cases they are so-called needle stripes; they occur when individual needles have been replaced or when the working of mechanical or automatic oiling or greasing devices is defective.

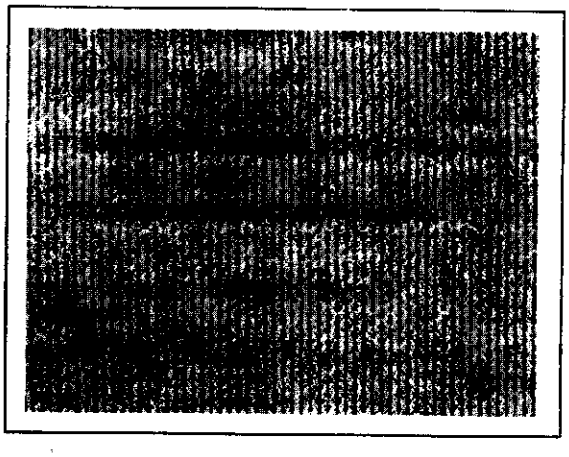
Stripes or soiled places in the direction of the courses were already present usually in the yarn, if not caused by a standing course as a result of machine stoppage.

Colour Fly:

Colour fly consists of single fibres, bunches of fibres or yarn pieces in varying colours. It additionally sticks on the yarn or is knitted into the fabric and is very difficult to remove.



Unsettled fabric appearance on front side



Unsettled fabric appearance on back side

CALCULATION RELATED TO WEFT KNITTING

The function of textile arithmetic is to record or determine all interrelationships which can be recorded in figure form. The calculations listed below will explain operations in production control and on circular knitting machines. At the same time, the calculations will serve as a basis for costing and cost accounting.

The equations for calculating the various machine parameters, such as system count and density i.e. feeding system, knitting speed and machine rpm, performance factor and efficiency level, will first of all be discussed below.

System count:

By a knitting system (functional unit), we understand on circular knitting machines a cam system or a number of cam systems with yarn feed, arranged in such a way that a course is formed on all needles in one cylinder revolution. In the case of individual needle selection or selected choice, they are the part courses equivalent to a full course.

Influencing variables on the number of functional units:

The variables influencing the number of functional units are

- Cylinder diameter
- The circular knitting machine operating principle (single-jersey, rib, purl)
- Possibilities (plain and structured knits, jacquard fabrics), and also
- Machine gauge.

System density or number of systems / inch of nominal cylinder diameter:

System density (SD) describes the number of system / inch of nominal cylinder diameter.

$$\text{System density (SD)} = \frac{\text{No. of systems}}{\text{Nominal cylinder diameter, d (inch)}}$$

Example:

If the system count is 96 and the nominal cylinder diameter is 30", then

$$\text{System density (SD)} = \frac{\text{No. of systems}}{\text{Nominal cylinder diameter, d (inch)}} = \frac{96}{30} = 3.2 \text{ systems / inch.}$$

On circular knitting machines today, system density lies between 0.4 and 4.8 systems / inch of cylinder diameter, depending on the machine model.

Knitting speed and machine rpm:

Cylinder operating speed on a circular knitting machine is also indicated as peripheral speed. By this, we understand the distance in m covered in 1 second from a point on the outer circumference of a disk. The peripheral speed is indicated in m/sec. and designated 'V'. Peripheral speed depends on

- The machine operating principle (single-jersey, rib, purl)
- The machine patterning units (jacquard or draw course unit)
- The type and construction of the circular fabric to be produced (e.g. single or double sided fabric), and
- The type and properties of the yarn to be processed (e.g. carded or combed yarn, natural or man-made fibre yarns)

The knitting speed is individually adjustable, and must be adapted to the individual influencing variables from case to case.

$$V = \frac{\pi \cdot d \cdot n}{39.37 \times 60} \text{ m/sec.}$$

Where, $\pi = 3.14$

d = cylinder diameter in inch

n = cylinder rpm

39.37 = conversion factor from inch to meter

60 = conversion factor from mins. to secs.

Example:

If the cylinder diameter is 30" and the cylinder rpm is 35 then

The knitting speed, $V = \frac{\pi \cdot d \cdot n}{39.37 \times 60} = \frac{3.14 \times 30 \times 35}{39.37 \times 60} = 1.396$ m/sec.

Circular machine knitting speeds generally lie in a range between 0.8 and 1.8 m/sec.

The above equation can be simplified to some extent if the constant dimensions like π, 39.37 and 60 are combined as one factor.

$$\text{Factor} = \frac{3.14}{39.37 \times 60} = 0.00133$$

$\therefore$ $V = 0.00133 \times d \times n$ m/sec.

For calculating machine rpm from the knitting speed, the above equation is transposed as follows:

$$\text{The machine rpm, } n = \frac{V}{0.00133 \times d}$$

Example:

If the knitting speed is 1.63 m/sec and the cylinder diameter is 26", then

$$\text{The machine rpm, } n = \frac{V}{0.00133 \times d} = \frac{1.63}{0.00133 \times 26} = 47.137 \approx 47 \text{ rpm}$$

Speed factor or performance number:

With the aid of the speed factor SF or the performance number L, circular knitting machines with different system counts and operating speeds can be compared in productivity terms. The performance number L is calculated in accordance with the above equation as follows:

$$L = S \cdot n \quad \text{courses/min.}$$

A circular knitting machine with 72 systems (no. of feeder) and an rpm of 25 per min. has therefore a performance number of

$$L = 72 \times 25 = 1800 \quad \text{courses/min.}$$

The performance number 'L' indicates therefore the theoretical number of courses/min. produced by the circular knitting machine.

$$SF = L = n \cdot S \quad \text{courses/min.}$$

$$\text{Or,} \quad n = \frac{SF}{S} \text{ per min.}$$

Example:

If the Speed factor, SF is 2520 courses/min and system count i.e. no. of feeder is 84, then

$$n = \frac{SF}{S} = \frac{2520}{84} = 30 \text{ rpm.}$$

Performance and efficiency:

Performance or efficiency plays a decisive role in producing perfect productivity calculations and cost accounting data for all machines used in warp and weft knitting. By performance, we understand actual output expressed as a % of theoretical output. Performance N_E is also expressed by the Greek letter η.

$$\text{Performance, } N_E = \frac{\text{Actual output}}{\text{Theoretical output}} \times 100 \quad \%$$

Due to various influencing variables, performance is always less than 100% or expressed as a decimal, less than 1.

Production calculation:

It has been expounded in the sections above that the output of a circular knitting machine depends on a series of different influencing variables. A wealth of machine data and data on the fabric to be produced is required for calculating production capacity.

In this respect the cylinder diameter d in inch, the gauge E, the system count S, the machine rpm n, and the efficiency level η of the circular knitting machine must be known. The following data on the fabric to be produced must also be available:

- The construction (e.g. single-jersey, rib, purl etc.)
- The course density or courses / cm, and
- The weight per unit area in gm / m^2.

Machine output:

The machine capacity or performance in running m/hr is calculated in accordance with the following equation:

Machine capacity, L =

$$\frac{\text{Speed of machine in rpm X No.of system or feeders on the machine X efficiency X 60 minutes}}{\text{No. of feeders or systems per course X courses per cm. X 100}} \text{ m / hr.}$$

Example:

Calculate the length in meters of a plain, single sided or single-jersey fabric knitted at 20 courses / cm. on a 30" diameter 22-gauge circular machine having 108 feeds. The machine operates for 8 hours at 36 rpm at 87% efficiency.

Machine capacity i.e. the total length of the fabric in metres

$$= \frac{\text{Speed of machine in rpm X No.of system or feeders on the machine X efficiency X 60 minutes}}{\text{No. of feeders or systems per course X courses per cm. X 100}}$$

$$= \frac{36 \text{ X } 108 \text{ X } 87 \text{ X } 60 \text{ X } 8}{1 \text{ X } 20 \text{ X } 100 \text{ X } 100}$$

$$= 811.82 \text{ metres}$$

Example:

Calculate the length in meters of a plain, single sided or single-jersey fabric knitted at 16 courses / cm. on a 26" diameter 28-gauge circular machine having 104 feeds. The machine operates for 8 hours at 29 rpm at 95 % efficiency.

Machine capacity i.e. the total length of the fabric in metres

$$= \frac{\text{Speed of machine in rpm X No.of system or feeders on the machine X efficiency X 60 minutes}}{\text{No. of feeders or systems per course X courses per cm. X 100}}$$

$$= \frac{29 \text{ X } 104 \text{ X } 95 \text{ X } 60 \text{ X} 8}{1 \text{ X } 16 \text{ X } 100 \text{ X} 100}$$

= 859.56 metres

Fabric width:

The fabric width (WB) in metre is calculated in accordance with the following equation:

$$\text{Fabric width, WB} = \frac{\text{Cylinder diameter in inch X } \pi \text{ X machine gauge}}{\text{Wales per cm. X 100}}$$

Example:

If the cylinder diameter is 30", machine gauge is 32 and the wales per cm. is 14, then

$$\text{The Fabric Width, WB} = \frac{30 \text{ X } 3.14 \text{ X } 32}{14 \text{ X } 100} = 2.153 \text{ metres.}$$

Production capacity:

If the production capacity P of a circular knitting machine is to be calculated in kg / hr., it can be calculated in accordance with the following equation:

$$\text{Production capacity, P} = \frac{\text{Running length in metre per hour X Fabric width in metre X Weight in GSM}}{1000} \text{ Kg/hr.}$$

Example:

If the production in running metres per hour is 63.76, fabric width is 1.76 metres and the fabric weight is 160 gm/m^2, then

$$\text{The production capacity, P} = \frac{\text{L X WB X Weight in GSM}}{1000} = \frac{63.76 \text{ X } 1.76 \text{ X } 160}{1000} = 17.95 \text{ Kg / hr.}$$

Production example:

- **Plain circular knitting machine:**

Values of circular knitting machine:	**Values of article:**
Machine diameter 30"	Structure: plain (Single-jersey)
Gauge E 28	Yarn: cotton N_m 50/1 (N_e 29.6/1)
Number of feeders 96	Course density 18 courses/cm.
Machine speed 35 rpm	Wales density 13 wales/cm.
Machine efficiency 85%	Fabric weight 125 gm/m^2

$$\text{Machine performance L in metre per hour} = \frac{n \text{ X } S \text{ X } 60 \text{ X } \eta}{\text{feeders / course X courses X cm X } 100}$$

$$= \frac{35 \text{ X } 96 \text{ X } 60 \text{ X } 0.85}{1 \text{ X } 18 \text{ X } 100} = 95.2 \text{ m/hr.}$$

Fabric width, WB in metre $= \frac{d \times \pi \times E}{WPcm \times 100} = \frac{30 \times 3.14 \times 28}{13 \times 100} = 2.03$ m

Machine performance in Kg per hour $= \frac{L \times WB \times \text{Weight in GSM}}{1000} = \frac{95.2 \times 2.03 \times 125}{1000} = 24.157$ Kg/hr.

Example:

- **Interlock circular knitting machine:**

An interlock fabric comprising, in the simplest case, two part courses. These part courses complement each other to make a full course, and therefore two systems or feeders are required for producing one course.

The following data were assumed for the interlock fabric production:

Example – 1:

Values of circular knitting machine:	**Values of article:**
Machine diameter 30"	Structure: plain interlock
Gauge E 28	Yarn: polyester dtex 76/1
Number of feeders 96	Course density 17 courses/cm.
Machine speed 31 rpm	Wales density 14 wales/cm.
Machine efficiency 85%	Fabric weight 100 gm/m^2

Machine performance L in metre per hour $= \frac{n \times S \times 60 \times \eta}{\text{feeders / course} \times \text{courses / cm} \times 100}$

$= \frac{31 \times 96 \times 60 \times 0.85}{2 \times 17 \times 100} = 44.64$ m/hr.

Fabric width, WB in metre $= \frac{d \times \pi \times E}{wpcm \times 100} = \frac{30 \times 3.14 \times 28}{14 \times 100} = 1.88$ m

Machine performance in Kg per hour $= \frac{L \times WB \times \text{Weight in GSM}}{1000} = \frac{44.64 \times 1.88 \times 100}{1000} = 8.39$ Kg/hr.

Example – 2:

Values of circular knitting machine:	**Values of article:**
Machine diameter 30"	Structure: plain interlock
Gauge E 42	Yarn: polyester filament yarn dtex 50 f 88/1
Number of feeders 108	Course density 19 courses/cm.
Machine speed 31 rpm	Wales density 23 wales/cm.
Machine efficiency 87%	Fabric weight 100 gm/m^2

Machine performance L in metre per hour $= \frac{n \times S \times 60 \times \eta}{\text{feeders / course} \times \text{courses / cm} \times 100}$

$= \frac{31 \times 108 \times 60 \times 0.87}{2 \times 19 \times 100} = 45.99$ m/hr.

Fabric width, WB in metre $= \frac{d \times \pi \times E}{WPcm \times 100} = \frac{30 \times 3.14 \times 42}{23 \times 100} = 1.72$ m

Machine performance in Kg per hour $= \frac{L \times WB \times \text{Weight in GSM}}{1000} = \frac{44.99 \times 1.72 \times 100}{1000} = 7.91$ Kg/hr.

- **Jacquard circular knitting machine:**

A two-colour jacquard fabric is to be produced, and the following machine and fabric data were assumed:

Example – 1:

Values of circular knitting machine:	**Values of article:**
Machine diameter 26"	Structure: two colour jacquard (two part courses for one course)
Gauge E 20	Yarn: cotton yarn N_m 50/1 (80%), polyester filament yarn dtex 67 f 14 (20%)
Number of feeders 60	Course density 10.5 courses/cm.
Machine speed 27 rpm	Wales density 16 wales/cm.
Machine efficiency 80%	Fabric weight 90 gm/m^2

Machine performance L in metre per hour $= \frac{n \times S \times 60 \times \eta}{\text{feeders / course} \times \text{courses / cm} \times 100}$

$= \frac{27 \times 60 \times 60 \times 0.80}{2 \times 10.5 \times 100} = 37$ m/hr.

Fabric width, WB in metre $= \frac{d \times \pi \times E}{WPcm \times 100} = \frac{26 \times 3.14 \times 20}{16 \times 100} = 1.02$ m

Machine performance in Kg per hour $= \frac{L \times WB \times \text{Weight in GSM}}{1000} = \frac{37 \times 1.02 \times 90}{1000} = 3.396$ Kg/hr.

Example – 2:

Values of circular knitting machine:	**Values of article:**
Machine diameter 30"	Structure: three colour jacquard
Gauge E 20	Yarn: polyester dtex 150/1
Number of feeders 96	Course density 12 courses/cm.
Machine speed 23 rpm	Wales density 11 wales/cm.
Machine efficiency 80%	Fabric weight 180 gm/m^2

Machine performance L in metre per hour $= \frac{n \times S \times 60 \times \eta}{\text{feeders / course} \times \text{courses / cm} \times 100}$

$= \frac{23 \times 96 \times 60 \times 0.80}{3 \times 12 \times 100} = 29.44$ m/hr.

Fabric width, WB in metre $= \frac{d \times \pi \times E}{WPcm \times 100} = \frac{30 \times 3.14 \times 20}{11 \times 100} = 1.7$ m

Machine performance in Kg per hour $= \frac{L \times WB \times \text{Weight in GSM}}{1000} = \frac{29.44 \times 1.7 \times 180}{1000} = 9$ Kg/hr.

Example:

Calculate the production of a single-jersey circular knitting machine in kg/hr from the following data:

Values of circular knitting machine:	**Values of article:**
Machine diameter 30"	Structure: plain (Single-jersey)
Gauge E 28	Yarn: cotton N_m 50/1 (N_e 29.6/1)
Number of feeders 96	Stitch length 0.25 cm
Machine speed 35 rpm	
Machine efficiency 80%	

Production in Kg/hr $= \frac{n \times S \times (\pi \times d \times E \times \text{stitch length in cm}) \times 60 \times \eta \times 0.4536}{100 \times 100 \times Ne \times 840 \times 0.9144}$

$= \frac{n \times S \times (d \times E \times \text{stithch length in cm.}) \times \eta}{Ne} \times 0.00001112598$

$= \frac{35 \times 96 \times (30 \times 28 \times 0.25) \times 80}{29.6} \times 0.00001112598$

$= 21.22$ Kg.

Example:

Calculate the length of fabric produced per shift at 75% efficiency of a knitting machine from the following particulars:

No. of feeders 48
Fabric open width 264 cm
Stitch density 15
Machine speed 20 rpm
Machine diameter 30 cm
Machine gauge E 14

Fabric width $= \frac{\text{Total no.of wales}}{\text{Wales per cm.}}$

Wales per cm. $= \frac{\text{Total no.of wales}}{\text{Fabric width}} = \frac{d \times \pi \times E}{WB} = \frac{30 \times 3.14 \times 14}{264} = 4.99 \approx 5$

Again stitch density = wales/cm × courses/cm

Courses/cm $= \frac{\text{Stitch density}}{\text{Wales / cm.}} = \frac{15}{5} = 3$

Length of fabric produced per minute $= \frac{\text{courses per minute}}{\text{courses per cm}} = \frac{n \times S}{cpcm} = \frac{20 \times 48}{3} = 320$ cm $= 3.2$m

Length of fabric produced per shift at 75% efficiency = 3.2 X 60 X 8 X 0.75 = 1152 m.

Example:

Calculate the courses / cm of a fabric producing 1152 metres per 8 hours shift in a circular knitting machine with the following particulars:

No. of feeders 48
Machine speed 20 rpm
Efficiency 75%

$$\text{Length of fabric produced per shift at 75\% efficiency} = \frac{\text{courses per minute X 60 X 8 X 0.75}}{\text{courses per cm}}$$

$$\text{Courses / cm} = \frac{20 \text{ X } 48 \text{ X } 60 \text{ X } 8 \text{ X } 0.75}{1152 \text{ X } 100} = 3$$

Weight per unit area and cover factor:

Weight per unit area of fabric is an important property that is again related to a host of other properties. The weight is determined by two factors that interact: the loop size and the yarn size. The effect of the loop size is simple to express: if the size of the yarn remains constant, then increase of loop size produces a decrease of weight per unit area. The effect is an inverse ratio.

Stitch density is the most important one in defining knitted fabric properties and is directly related to appearance, weight per unit area, thickness, drape and many other factors.

The stitch length is the absolute quantity of any knitted fabric and is directly related to the stitch density. In general terms, for any knitted fabric, as the loop size increases the loop density decreases. For simple fabrics the relationship can be expressed in a single equation:

$$S = \frac{K}{l^2}$$

Where S is the stitch density, l is the loop length and K is a constant for the particular construction. A large amount of data and research work has been carried out relating the above expression to the characteristics of plain fabric, and definite values of K have been proposed. For other constructions, while the proposition still holds the situation is more complex and further study is required.

Example:

We know that, $S = \frac{K}{l^2}$ and Let K = 20

- For a loop length of 0.4 cm, stitch density $S = \frac{20}{0.4^2} = 125$ stitches/cm^2

  Length of yarn in 1 cm^2 of fabric = 125 × 0.4 = 50 cm

- For a loop length of 0.8 cm, stitch density $S = \frac{20}{0.8^2} = 31.25$ stitches/cm^2

  Length of yarn in 1 cm^2 of fabric = 31.25 × 0.8 = 25 cm

So double the loop size means half the weight per square unit. Usually in knitted fabrics, for fabrics of a similar construction, as loop length increases so the size of yarn increases. Yarn sizes are themselves expressed not in terms of diameter but in weight per unit length.

In a knitted fabric, to maintain cover, as the length of loop doubles so the diameter of the thread must double.

Cover is a simple ratio of the area of a knitted fabric covered by yarn to the area covered by the gaps in between loops. It can be demonstrated that for a given knitted structure, if the cover ratio is maintained through a range of fabrics with different loop lengths, then those fabrics are related in characteristics of tightness / looseness and other physical properties.

This concept of cover leads to the property of 'normality' of a knitted fabric. A 'normal' fabric is one that is neither too tight and stodgy nor too loose and floppy. Lay observers given a range of fabrics of differing loop size and yarn size make surprisingly similar judgements on what 'normality' is in a knitted fabric intended for normal apparel.

There is a simple formula that can be used to express 'cover factor' or tightness factor, taking into account and abbreviating diameter of yarn, length of loop and loop density.

$$\text{Cover factor (cf)} = \frac{\sqrt{\text{Count in tex}}}{l}$$

For a particular value of cover factor we can obtain a range of fabrics having similar normality relationships. The calculation for weight/m^2 involves combining the equation for stitch density and the equation for cover factor:

Weight in gm of 1 m^2 of fabric, i.e. $\text{GSM} = \frac{\text{CPI X WPI X l(mm)}}{N_e} \times 0.9158$

$$\text{GSM} = \frac{\text{CPI X WPI X l (cm)}}{N_e} \times 9.158$$

$$\text{GSM} = \frac{\text{CPI X WPI X l (mm)}}{N_m} \times 1.55$$

$$\text{GSM} = \text{CPI} \times \text{WPI} \times \text{l(mm)} \times \text{Tex} \times 0.00155$$

$$\text{GSM} = \text{CPI} \times \text{WPI} \times \text{l(mm)} \times \text{Denier} \times 0.00017$$

In another form, $\text{GSM} = \frac{\text{Loops/cm}^2 \times \text{l (cm)} \times \text{tex}}{10}$

$$\text{As loops per cm}^2 = \frac{K}{l^2}$$

Therefore GSM $= \frac{K \times tex}{l(cm) \times 10}$

As Tex $= (cf \times l)^2$

Therefore GSM of a fabric $= \frac{K \times (cf \times l)^2}{l \times 10}$

The concept of the relaxed state for knitted fabrics is well recognized and documented. Quality control must ensure that before knitted garments are cut, the fabric is in a relaxed or near relaxed condition, i.e. that there will be little shrinkage of the fabric/garment when it is in the consumer's possession. Relaxation tests can be carried out on fabric as a routine procedure, or as spot checks on suspect deliveries. There are British Standard procedures for relaxation testing and some of the large retail/wholesale purchasers have established tests of their own. Most test procedures involve agitation in aqueous solution followed by measurement under water, and/or spinning and tumble drying. They attempt to reproduce the conditions under which the garment will be laundered during usage.

Relation between Yarn count and Machine gauge:

Selection of machine gauge depends upon yarn diameter. Yarn diameter also depends on several factors such as yarn count, fibre type, yarn twist, yarn finishing etc. General practice of yarn count and machine gauge in different industries in Bangladesh given below:

Yarn count used	Machine gauge	Yarn count used	Machine gauge
16	18	28	22
18	20	28	25
20	20	28	28
20	24	30	22
24	22	30	24
24	24	3o	28
26	20	30	34
26	22	34	28
26	24	34	28
26	28		

The above values may differ, because it is the results of a research work. There is a relation between yarn in tex and machine gauge is given by a equation,

For single-jersey, $G = \sqrt{\frac{1650}{Tex}}$ and for double-jersey, $G = \sqrt{\frac{1400}{Tex}}$, where G is measured in needles per cm.

The yarn count to be used on a circular knitting machine depends largely on the pitch, and thus on the machine gauge. For any given machine gauge it can lie within a larger range, because on the same machine different yarn counts can be used, depending on the knitted structure, the desired optics (fabric appearance) and the fabric properties.

The following tables contain practical values of the average count of yarn to be used, depending on the machine gauge and several fabric types. The values in N_e (converted from values in N_m) refer to staple fibre yarns and those in dtex are related to filament yarns.

Yarn count and machine gauge for Single-jersey

Machine gauge E Needles/inch	Yarn count Ne	dtex
5	2.5/2 - 7.0/2	660x2 - 550x2
6	3.5/2 - 9.5/2	550x2 - 400x2
7	5.0/2 - 12.0/2	470x2 - 330x2
8	7.0/2 - 14.0/2	400x2 - 280x2
9	9.5/2 - 8.5/1	330x2 - 235x2
10	10.5/2 - 10.5/1	280x2 - 200x2
12	14.0/2 - 12.0/1	235x2 - 150x2
14	8.5/1 - 14.0/1	200x2 - 235x1
15	10.5/1 - 16.5/1	150x2 - 200x1
16	12.0/1 - 19.0/1	250x1 - 167x1
18	14.0/1 - 23.5/1	200x1 - 150x1
20	18.0/1 - 26.0/1	167x1 - 122x1
22	21.5/1 - 29.5/1	150x1 - 110x1
24	23.5/1 - 35.5/1	140x1 - 100x1
26	26.5/1 - 41.5/1	122x1 - 84x1
28	29.5/1 - 47.5/1	110x1 - 76x1
30	35.5/1 - 59.0/1	100x1 - 67x1
32	41.5/1 - 71.0/1	84x1 - 55x1

Yarn count and machine gauge for Interlock

Machine gauge E Needles/inch	Yarn count Ne	dtex
5	2/14.0/2 - 2/21.5/2	800x1 - 550x1
6	2/18.0/2 - 2/23.5/2	660x1 - 470x1
7	2/21.5/2 - 14.0/2	550x1 - 400x1
8	2/23.5/2 - 18.0/2	470x1 - 330x1
9	14.0/2 - 21.5/2	400x1 - 280x1
10	16.5/2 - 12.0/1	330x1 - 235x1
12	21.5/2 - 14.0/1	280x1 - 200x1
14	12.0/1 - 16.5/1	235x1 - 167x1
15	14.0/1 - 19.0/1	220x1 - 150x1
16	16.5/1 - 21.5/1	200x1 - 133x1
18	21.5/1 - 23.5/1	167x1 - 110x1
20	23.5/1 - 29.5/1	150x1 - 100x1
22	28.5/1 - 35.5/1	133x1 - 100x1
24	33.0/1 - 41.5/1	122x1 - 90x1
26	35.5/1 - 47.5/1	110x1 - 84x1
28	41.5/1 - 53.0/1	100x1 - 76x1
30	47.5/1 - 59.0/1	90x1 - 67x1
32	53.0/1 - 71.0/1	76x1 - 50x1

Yarn count and machine gauge for Fleecy

Machine gauge E Needles/inch	Yarn count Ne	dtex
12	2.5/1 - 9.5/1	720x2 - 622x1
14	3.5/1 - 12.0/1	620x2 - 500x1
15	4.7/1 - 14.0/1	500x2 - 420x1
16	6.0/1 - 16.5/1	833x1 - 360x1
18	7.0/1 - 18.0/1	660x1 - 300x1
20	8.5/1 - 20.0/1	500x1 - 280x1
22	10.5/1 - 23.5/1	360x1 - 200x1
24	14.0/1 - 26.0/1	300x1 - 167x1
26	16.5/1 - 29.5/1	250x1 - 150x1
28	19.0/1 - 35.5/1	200x1 - 122x1
30	21.5/1 - 41.5/1	150x1 - 110x1
32	23.5/1 - 47.5/1	122x1 - 84x1

Yarn count and machine gauge for Fine Rib

Machine gauge E Needles/inch	Yarn count Ne	dtex
5	12.0/2 - 16.5/2	800x1 - 550x1
6	14.0/2 - 19.0/2	660x1 - 400x1
7	16.5/2 - 21.5/2	550x1 - 330x1
8	19.0/2 - 12.0/1	470x1 - 280x1
9	21.5/2 - 14.0/1	400x1 - 235x1
10	12.0/1 - 18.0/1	330x1 - 200x1
12	14.0/1 - 20.0/1	280x1 - 167x1
14	16.5/1 - 23.5/1	235x1 - 150x1
15	20.0/1 - 29.5/1	200x1 - 122x1
16	23.5/1 - 35.5/1	167x1 - 100x1
18	29.5/1 - 47.5/1	150x1 - 90x1
20	41.5/1 - 53.0/1	122x1 - 76x1
22	47.5/1 - 59.0/1	100x1 - 67x1
24	53.0/1 - 71.0/1	84x1 - 55x1

Relation between Yarn count and GSM:

From the research work it is try to find the following equations for the selection of yarn count to get required GSM equations vary for fabric types, fabric construction. List of equations are tabulated below:

Name of fabrics	Equations	Name of fabrics	Equations
Single-jersey	$N_e = -0.141\ GSM + 50.22$	Single-jersey	$GSM = 350.4 - 6.879\ N_e$
Pique	$N_e = -0.146\ GSM + 57.16$	Lycra single-jersey	$GSM = 354.56 - 4.9716\ N_e$
Double lacoste	$N_e = -0.167\ GSM + 64.36$	Pique	$GSM = 386.44 - 6.6737\ N_e$
1×1 Rib	$N_e = -0.123\ GSM + 54.57$	1×1 Rib	$GSM = 437.66 - 7.9731\ N_e$
Lycra 1×1 Rib	$N_e = -0.119\ GSM + 59.12$	Lycra 1×1 Rib	$GSM = 494.08 - 8.2839\ N_e$
Lycra 2×2 Rib	$N_e = -0.108\ GSM + 56.62$	Lycra 2×2 Rib	$GSM = 519.05 - 9.1216\ N_e$
Interlock	$N_e = -0.206\ GSM + 80.56$	Interlock	$GSM = 388.41 - 4.778\ N_e$

Selection of yarn count for various GSM for different fabrics:

Fabrics / GSM	Plain or Single-jersey	Pique	1×1 Rib	Lycra 1×1 Rib	Lycra 2×2 Rib	Interlock
100	36.12	47.66	42.27	47.22	45.82	59.96
120	33.3	44.32	39.81	44.84	43.66	55.84
140	30.48	40.98	37.35	42.46	41.5	51.72
160	27.66	37.64	34.89	40.08	39.34	47.6
180	24.84	34.3	32.43	37.7	37.18	43.48
200	22.02	30.96	29.97	35.32	35.02	39.36
220	19.2	27.62	27.51	32.94	32.86	35.24
240	16.38	24.28	25.05	30.56	30.7	31.12

Relation among GSM, stitch length and yarn count can be derived from the following equation:

$$GSM \propto \frac{1}{\text{Yarn count (Ne) X Stitch length}}$$, when yarn count and stitch length both are variables

$$\therefore \quad GSM = \frac{K}{\text{Yarn count (Ne) x Stitch length}}$$, where K is a constant

$$\therefore \quad \text{Yarn count } (N_e) \times \text{Stitch length} \times GSM = K$$

$$\therefore \quad \text{Stitch length} = \frac{K}{\text{Yarn count (Ne) x GSM}}$$

Constant 'K' which can be derived as follows:

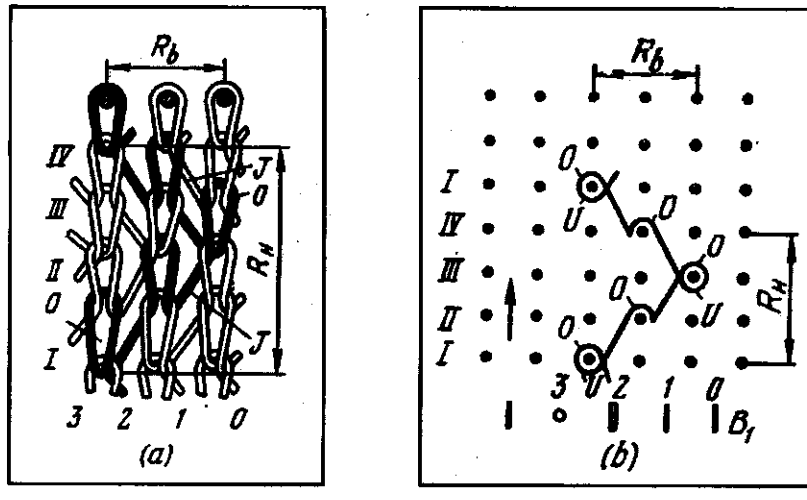
Fabrics	Constant K values
Single-jersey or Plain	12068.509
Double lacoste	14855.2
1×1 Rib	16431.497
2×1 Rib	19005.333
Interlock	24013.8

These values are get from a research work. It may be changed. For getting more accurate results it needs more data from different industry.

WARP KNITTING PRINCIPLE

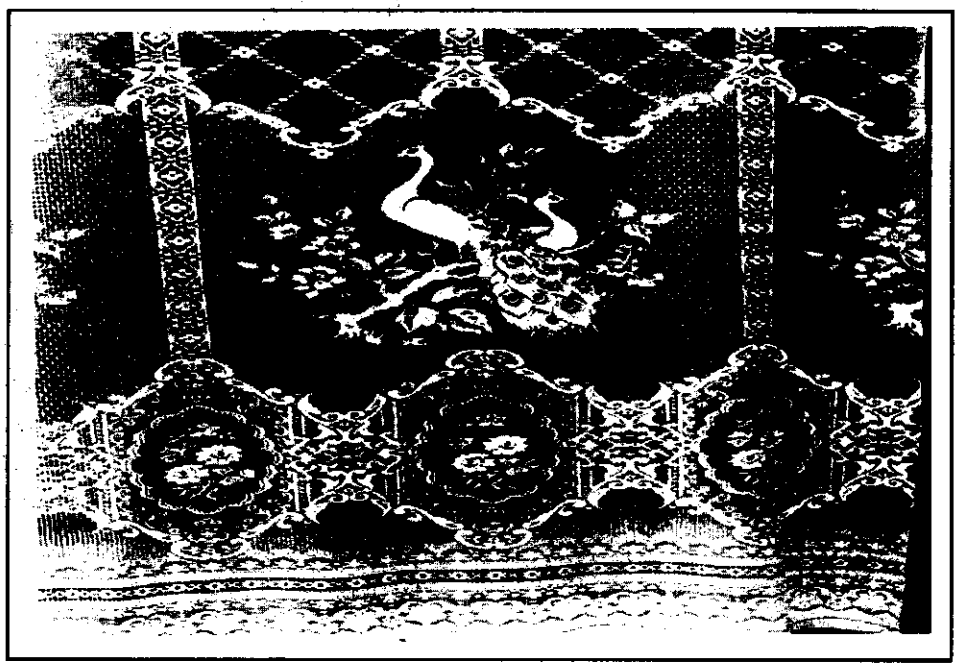
Introduction to Warp Knitted Fabrics:

Warp knitted fabric is formed from a yarn system called "the warp". All ends supplied from the same warp sheet normally have identical lapping movements because each is lapped by a guide attached to the same guide bar. The warp yarns, after forming loops in one course, pass into the following course, and, as a rule, the number of loops formed in the course is the same as the number of yarns in the warp. Due to this, loop formation in warp knitted fabric features the presence of links J connecting the loops in the adjacent courses. Depending on the method the warp yarn is layed on the needles, the loops are of the following types: Open loops (courses II and IV), closed loops (courses I and III), with one side links (courses I and III) and with two-side links (courses II and IV).



Beams supply the warp sheets in parallel form to the guide bars whose pattern control determines the timing and configuration of the lapping movements in the form of overlaps and underlaps. The needles intermesh the new overlaps through the old overlaps to form the intermeshed loop structure.

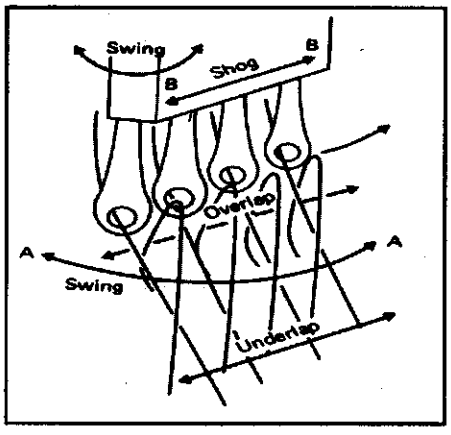
Part of the yarn, between the loops which connect the wales together, is referred to as the underlap. The two sides of the fabric are referred to as the technical face (the side on which the knitted loops are prominent) and the technical back (the side on which the underlaps are prominent).



Warp knitted curtain fabric

The Guides:

Warp guides are thin metal plates drilled with a hole in their lower end through which a warp end may be threaded if required, they are held together at their upper end in a metal lead and are spaced in it to the same gauge as the machine. The leads in turn are attached to a guide bar so that the guides hang down from it with each one occupying a position at rest midway between two adjacent needles, in this position the warp thread cannot be received by the needles and it will merely produce a straight vertical float.



The needles only receive the warp thread in their hooks if the guide bar overlaps across their hooks, or across the side remote from their hooks when the guide bar underlaps. All guides in a conventional guide bar produce an identical lapping movement at the same time and therefore have identical requirements of warp, tension and rate of feed, although the threads may differ in colour or composition from each other.

Overlap, that length of yarn in a warp knitted fabric that has been placed over the needle during loop formation.

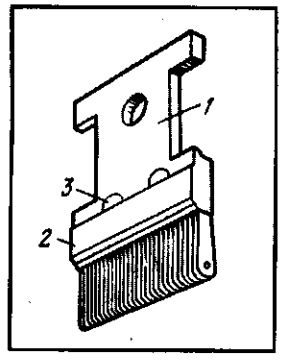
Underlap , that length of yarn in a warp knitted fabric that connects two overlaps in consecutive courses.

The Guide Bar:

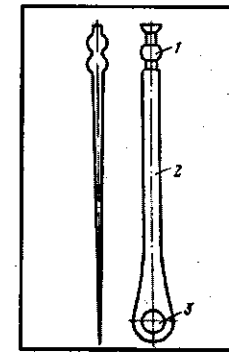
A bar running the full width of a machine and equipped with guides through which threads are passed so that the lateral motions imparted to the guide bars by the pattern control device are transmitted to the threads.

Each end of yarn from each warp is located in the knitting zone by passing through the eye of a guide. All the guides containing the yarns fed from a single warp, are connected to a guide bar, so that all of them move uniformly with it.

The individual guides are usually cast in 1 inch units – which in turn are fitted on the guide bars. The guides swing between and around the needles in order to warp the yarn around them to form a new loop. They also shog side ways to connect the wales into a fabric.



Lead with guide needles



Guide needles

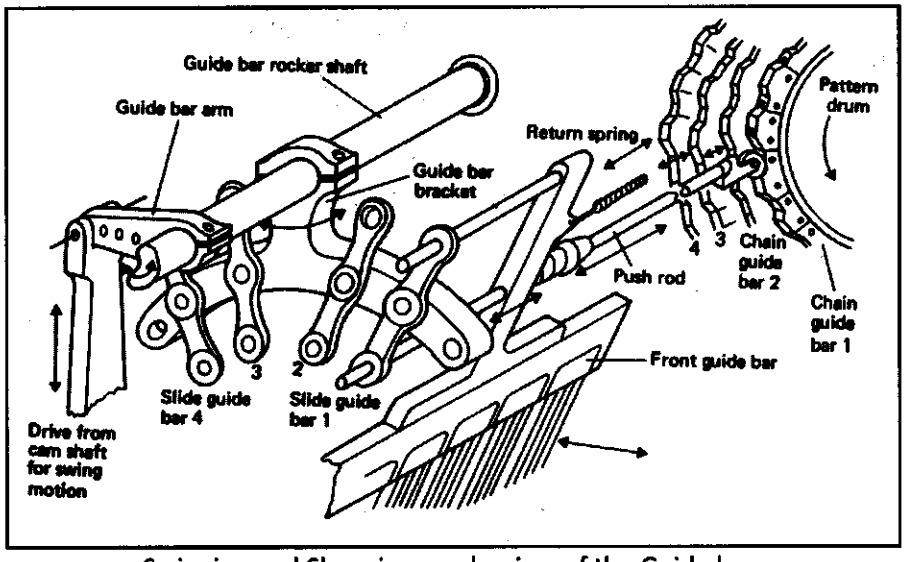
Each guide bar is normally supplied with a warp sheet from its own beam shaft to suit its requirements of threading and rate of warp feed for its particular lapping movement.

Occasionally, two partly-threaded guide bars may be supplied from the same full-threaded beam provided they make lapping movements of the same extent to each other whilst moving in opposite directions. The minimum number of guide bars and warp sheets for commercially acceptable structures is usually two.

Lapping movement of the Guide Bar:

When the needle bar is observed in plan view from above, it can be seen that the guides of a guide bar are required to execute a compound lapping movement composed of two separately derived motions. A swinging motion and a shogging movement act at right angles to each other in order for their threads to form overlap and underlap paths which are joined together around the needles.

The swinging motion is in an arc from the front of the machine to the hook side and a later return swing. It occurs between adjacent needles and is a fixed, collective and automatic action for all the guide bars as they pivot on a common rocker-shaft. It is derived in a similar manner to the needle and other element bar motions from the main cam-shaft and is adapted via levers, pivots and linkages. The two swinging movements produce the two side limbs when combined with the overlap shog. When the overlap is omitted the guides swing idly between adjacent needles and achieve no useful purpose.



Swinging and Shogging mechanism of the Guide bar

The sideways shogging movement which occurs parallel to the needle bar produces the underlaps and overlaps. The occurrence, timing, direction and extent of each shog is separately controlled for each guide bar by its pattern chain links or pattern wheel attached to a horizontal pattern shaft driven from the main cam-shaft but set at right angles to it at one end of the machine. The guide bars are shogged independently sideways parallel to each other along linear bearings which support them in the swinging frame assembly which is keyed to the guide bar rocker-shaft.

A shogging movement can occur when the guides have swung clear of the needle heads on the back or front of the machine. On the hook side it will produce an overlap and on the side remote from the hooks it will produce an underlap. The timing of the shog during the 360 degrees of the main cam-shaft revolution will thus determine whether an overlap or underlap is produced.

The Pattern Mechanism:

The shogging movement is initiated by varying the radius of the continuously-turning pattern shaft either in the form of different heights of pattern links which pass over a pattern drum attached to the shaft, or in the form of carefully-shaped solid metal circular cams, termed pattern wheels or pattern disks, attached to it.

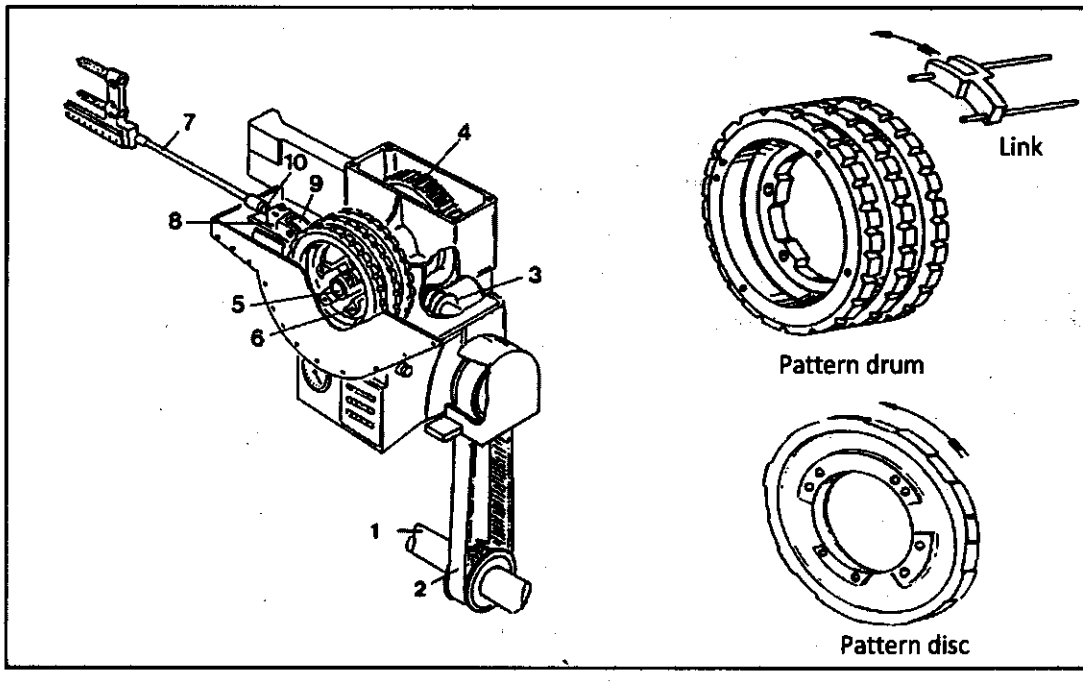
An increase in height from one link to the next produces a thrust against the end of the guide bar shogging it positively into the machine, a decrease will produce a negative shog towards the pattern shaft as the result of the action of a return spring. A constant height will produce no shog and the guide bar will continue to swing through the same needle space. The periphery of the pattern wheel or chain track is scanned by a roller which is linked by a flexible ball-jointed push-rod to the end of a guide bar, the underside of the rod near the roller is supported on a slide which moves freely on a metal surface as shogging occurs.

The drive for the pattern shaft is obtained from the main cam-shaft via bevel gears and a universal joint to a worm which derives the worm wheel of the pattern shaft. The ratio of cam-shaft speed to the pattern shaft speed is usually 16:1, therefore $\frac{1}{16}$ th of the surface of a pattern wheel would represent one course or knitting cycle.

The lateral movement of the guide bars is generated by the patterning mechanism, which is situated on the side of the machine. The patterning mechanism of a tricot machine is describe as follows.

The mechanism is driven by the main shaft (1) via a belt (2), worm (3) and a worm gear (4). The pattern drum (6) is mounted onto the shaft (5) so that it rotates in a constant ratio to the speed of the main shaft.

A chain made of links of different heights is placed on the pattern drum. While rotating, the different chain links move the roller (9) and slide (8) so that the push rod (7) moves the guide bar and displaces it laterally. The roller and push rod are held against the pattern drum by springs.



Patterning mechanism of a tricot machine

A lateral gating adjustment to the position of the guides is carried out by changing the length of the push rod using the bolt (10). The pattern drum with its pattern chain can be easily replaced by a pattern disk, precisely pre-cut for a certain design. Although the disk can only be used for one lapping sequence, it has the advantage of a very accurate, smooth and high-speed performance.

Pattern wheels provide accuracy and smooth running at high speeds but they are only economical for long production runs of the common simple repeat structures; for fancy structures, frequent changes of pattern and long pattern repeats, the shogging movements are obtained by assembling a chain of re-usable pattern links.

Chain links:

The identically **Y**-shaped chain links are similar in appearance to a tuning fork with the fork end leading. The tail of the preceding link fits into the fork of the succeeding link and the links are held together by pins which are pushed through holes in the side of the fork and tail, the pins pass through all the tracks and chains and the ends fit into grooves in the serrated flanges of the pattern drum so that as the drum turns the chain links are advanced in unison, in correct timing.

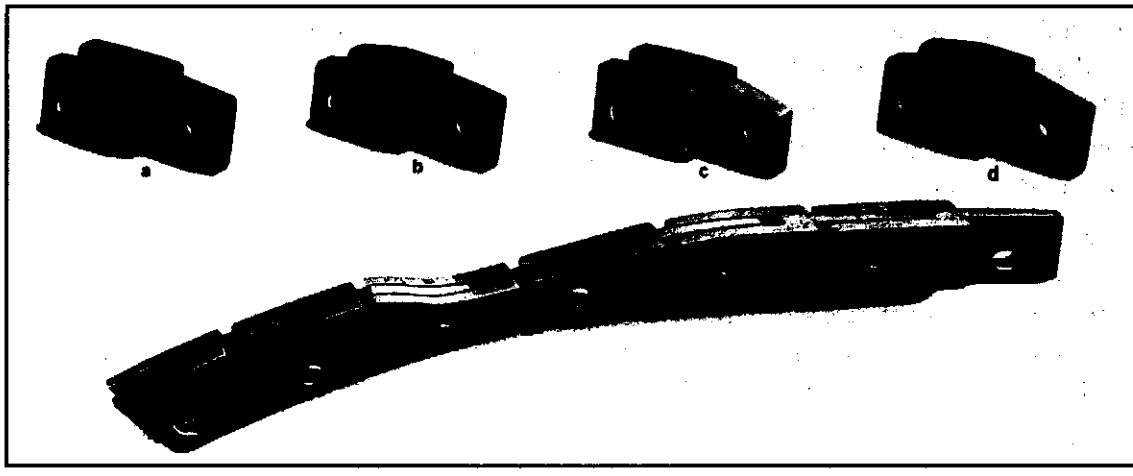
The link is slightly arched to fit the surface of the pattern drum. In order to ensure that the wider side of the link takes the greater load when pushing the guide bars, the fork side is the leading part of the link when connecting a chain. Links are made to fit a certain machine gauge. To eliminate any confusion, the gauge is stamped on to the link, together with the height of the link in needle spaces.

To ensure smooth operation, the leading and trailing edges of the links are ground to produce a slope. The angle and length of the ground edge must be very accurately set, so that the shogging movement is correctly timed.

Too steep an angle moves the guide bar before the swing to the hook side has been completed. A long angle causes the guide bar to move later when the swing-back has already started. A badly timed shogging movement might cause the yarn to be cut between needles and guides and, in extreme cases, knitting elements can be damaged.

A grinding gauge is usually supplied by the machine manufacturer and the links must only be ground according to it. Pattern links are also available with preground edges to fit different chain arrangements. These links are designated by letters indicating the ground edge.

- 'a' – is an unground link.
- 'b' – is a link on which the fork is ground.
- 'c' – indicates a ground tail.
- 'd' – means that both fork and tail are ground.



A profile of a pattern chain

With direct transmission of the shogging movement from chain links to guide bar, as described, the exact distance shogged is the difference in heights between the two successive links. This method is employed on most high speed machines and on the ground guide bars of many multi-bar Raschels.

Chain link numbering commences with '0' height and every guide bar chain sequence must contain at least one of these '0' links because when the guide bar is on this link it will be in its nearest position to the pattern mechanism, during that particular lapping movement. Tricot links are numbered 0, 1, 2, 3, 4, 5, etc., and with direct shogging, each will be successively one needle space higher than the previous link, so that on a 28 gauge tricot machine, a '2' link will be $\frac{1}{28}$th inch (0.9 mm) higher than a '1' link which will be $\frac{1}{28}$th inch higher than a '0' link. If a '1' link is placed after a '0' link, a one-needle space shog away from the pattern mechanism will be produced. If a '0' link is placed after a '3' link a three needle space shog towards the pattern mechanism will occur. If two links of the same height are placed next to each other, for example '3' followed by a '3' a shog will not be produced and the guides will remain between the same needle spaces.

It must be understood that a height of link, for example '0', does not represent a fixed position between two needle spaces, it represents the nearest position each guide in a particular guide bar approaches the pattern mechanism during that lapping movement. When a guide bar is on a '0' link, all guides in that bar will be in their '0' position but each will occupy a different space between needles across the width. Likewise, two guides from different bars may occupy the same space between two adjacent needles and yet be at different heights of links at that point.

A chain notation is a list in correct sequence of chain link numbers spaced into knitting cycles for each guide bar necessary to produce a particular structure. The difference between the first two links is normally the overlap. It must be remembered that the links are joined together in a closed loop with the starting link for each bar joined to its last link. For this reason, underlap movements towards left and right tend to balance each other.

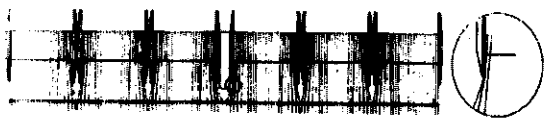
The number of links per course is fixed for each machine, a minimum of two is usually required with the overlap occurring between the second link of one course and the first link of the next. On tricot machines, a third intermediate link is often used so that the underlap is also spread between the second and third links giving it more time and coinciding more closely with the knitting cycle requirements.

Modern Tricot machines use 3 links for each knitting sequence. This is because the guides spend very little time on the hook side of the needles during the overlap; a much larger proportion of the knitting cycle is spent when they are on the front side. The 3 links per course movement distributes the time allocated for each shogging movement in a better way. One-third for overlap and two-thirds for underlap.

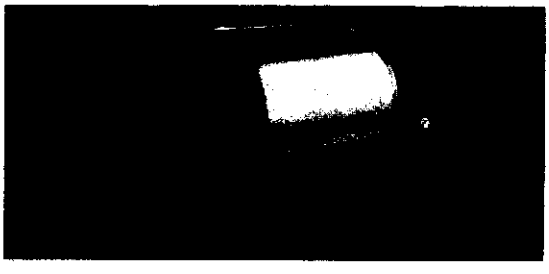
It must also be remembered that the overlap is in most cases only one needle space, while the underlap shog consists sometimes of several needle spaces. The fact that there are two links available for the underlap allows a long shogging movement to be distributed between them.

The Warp Beams:

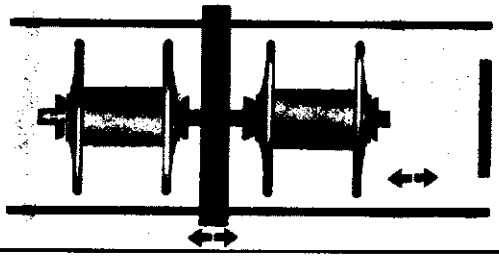
To ensure uniform conditions of warp feed and tension, the ends are supplied from flanged beams attached to shafts which turn to unwind the warp sheet in parallel formation. For convenience of handling, a number of beams may be attached to a beam shaft to achieve the full width of warp sheet, for example, a warp sheet 76 inches wide might be supplied from a full width beam, two beams each 38 inches wide, or four beams each 19 inches wide.

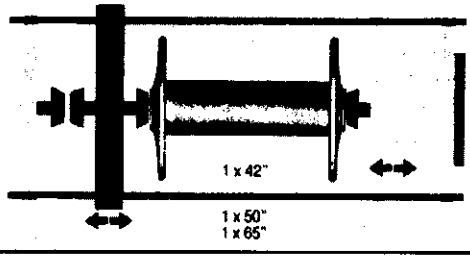


The width of the warp section has increased in order to decrease the number of flanges and the contact between flanges and yarn. Beam width can be up to 84 inches.



A modern Warping machine



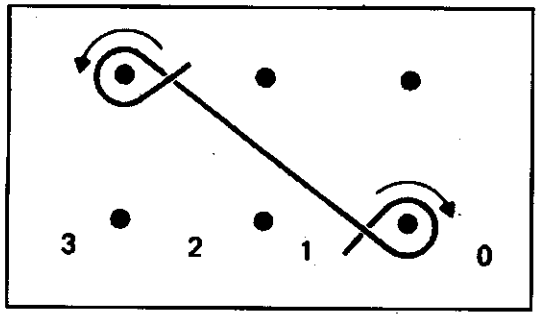


Different beam sections accommodated by a modern warping machine

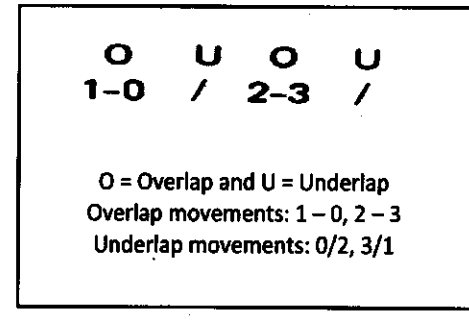
Lapping Diagrams and Chain Notations:

Lapping diagrams are drawn around horizontal rows of points which represent needles in plan view, usually assuming the pattern mechanism to be on the right. As the guides position themselves in the spaces between needles, the positions between the vertical columns of points can be given chain link numbers commencing with '0' position which is to the right of the right hand column of points.

Provided the direction and extent of the overlaps are correctly indicated in the lapping diagram and chain notation, the underlaps will always be correctly positioned as each extends from the end of one overlap to the start of the next.



Guide bar lapping movement notation



Chain notation (2 links per course)

In the lapping diagram, the first overlap will be drawn in a curve over a point from space 1 to space 0 and the second from space 2 to space 3. The lapping diagram is completed by joining the overlaps together with underlaps and the chain is notated as 1 – 0 / 2 – 3 / where ' – ' represents an overlap and '/' an underlap. Whereas the shogging movements are produced by the transition from one link to the next, the swinging motions occur whilst the push-rod roller of the guide bar is in the centre of a link so that no shog is produced.

When plotting a lapping diagram, a few basic rules must be observed:

1. When the fabric is composed of more than one guide bar, the lapping movement of each guide bar must be represented separately by one thread
2. The lapping diagrams of all bars, knitting the fabric, must be plotted from the same course, so that the relative lateral position of all is kept.
3. The numbers allocated for the spaces between the needles must always correspond to the position of the pattern mechanism. For machines with patterning mechanisms on their right side, which is more common, the spaces must be numbered from right to left, as for the above example. The spaces are numbered from left to right if the patterning mechanism is at the left of the machine.

   For multi-guide-bar machines with two patterning mechanisms, one on each side, the lapping movement of each guide bar has to be analyzed regarding the position of the patterning mechanism operating it.

4. When mounting a chain on the pattern drum, special care must be taken to ensure that the position of the chain corresponds to the movement of the knitting elements. If the chain is placed one link forwards or backwards, the guide bar shogs its underlap on the hook side of the needle, wrapping more than one needle and causing, in some cases, damage to the knitting elements.

Single-needle or Double-needle Overlaps:

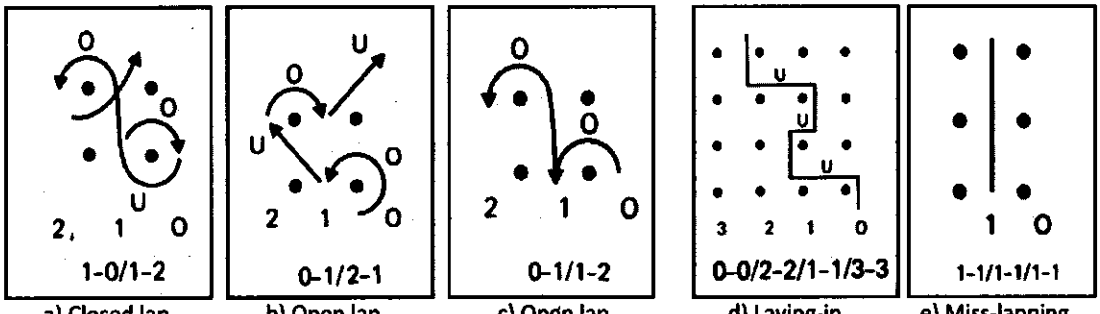
Overlap movements are normally across only one needle space as a double needle overlap would cause both the warp thread and the needles to be subjected to the severe strain of two simultaneous adjacent knock over actions, whilst different tensions on the two loops in the structure will adversely affect their appearance. The underlap between the double overlap loops has the appearance of a sinker loop. Only in a few Raschel structures is the double-needle overlap used and here the needles are less easily deflected and there are no knock over sinkers over which to draw the loops. A single full-threaded guide bar making a double-needle overlap will cause each needle to receive two overlapped threads at that course.

The greater the extent of the underlap in needle spaces, the heavier the fabric and the more horizontal the path of the thread as it crosses the structure.

Basic Overlap or Underlap Variations:

All guide bar lapping movements are composed of one or more of the following five lapping variations:

a) Closed lap – an overlap followed by an underlap in the opposite direction.
b) Open lap – an overlap followed by an underlap in the same direction.
c) Open lap – only overlaps and no underlaps.
d) Laying-in – only underlaps and no overlaps.
e) Miss-lapping – neither overlaps nor underlaps.



a) Closed lap b) Open lap c) Open lap d) Laying-in e) Miss-lapping

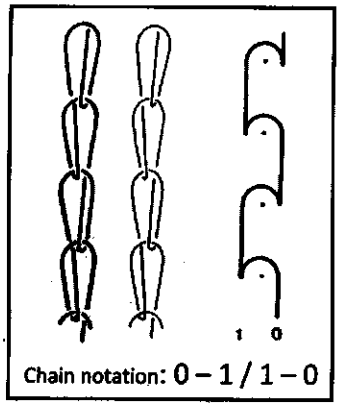
Basic Lapping Movements or Basic Stitches in Warp Knitting:

Most warp knitted fabrics are produced by a few guide bars, each one knitting a simple and basic lapping movement, which are described in the following:

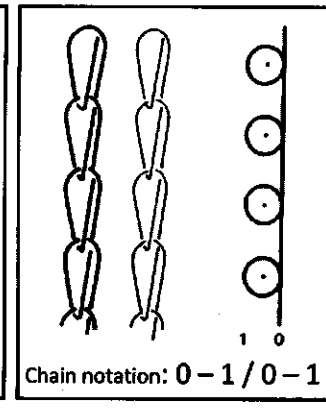
1. Pillar or Chain Stitch:

A pillar stitch which produces a vertical chain of consecutively knitted loops on the same needle from the same yarn. The chains may be connected together by other yarns or they may be entirely separate from each other.

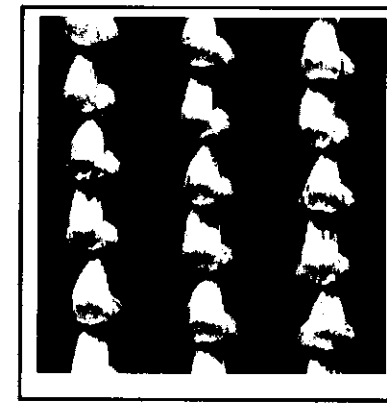
A pillar stitch is formed when a needle is being lapped continuously by the same guide. Since the guide bar does not lap the adjacent needles, there are no sideways connections and no fabric is formed. For the same reason, it is very difficult to form a chain (pillar) construction on a tricot machine, unless at least one more underlap forming guide bar is employed. With no underlap to be held in the throat of the sinker, the fabric rides up with the needles and does not clear the hooks.



Open-lap pillar stitch



Closed-lap pillar stitch



Back side of open-lap pillar stitch

With Raschel machines, however, chain constructions can very easily be produced due to the downward pull of the take-up mechanism. Different net fabrics, constructed of chain lapping movements, are produced in great quantities by the Raschel industry.

The pillar lapping movement can be open, closed or can be a combination of closed and open laps. The more common open lap chain construction is formed when the guide laps the needle alternately from the right and the left. The chain notations, as derived from figure are 0 – 1 for the first course and 1 – 0 for the next.

To produce a closed lap pillar, the guide has to lap the needle continuously in the same direction and the chain notations are 0 – 1 for all courses. A closed chain construction is less common because the guide, while rotating around the needle in the same direction, may insert an undesired false twist into the yarn.

Constructions made with a combination of closed and open laps, as well as constructions of only closed laps, are usually produced in order to achieve a certain technological aim.

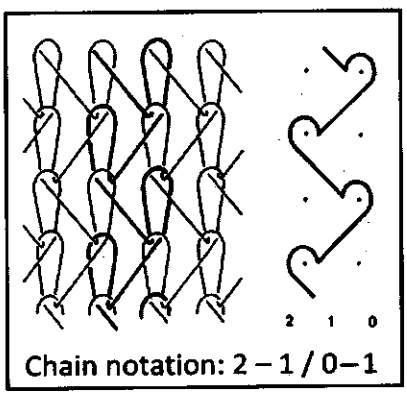
Having no sideways underlaps, the yarn consumption of a chaining guide bar is relatively very small. This, and the fact that the construction is very stable lengthwise, makes it very popular for the production of certain fabric types.

Pillar construction can easily be unraveled from the end knitted last by pulling on a free end of the yarn. Although usually a disadvantage, this characteristic is used in the production of lace edgings as a method of separating the bands after finishing.

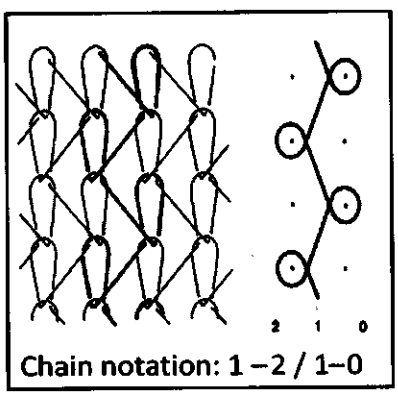
2. Tricot Stitch or 1 and 1 Lapping Movement:

Tricot stitch is a stitch formed of one warp; the tricot loops are disposed in an alternate order in two adjacent wales. This tricot may be formed of closed, open or alternate closed and open loops; the links in tricot are seen on the back.

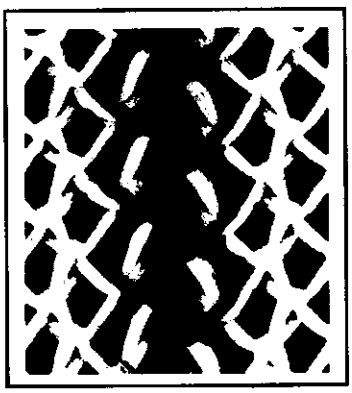
This lapping movement is formed by the guide lapping alternately two adjacent needles. It is also called a tricot lap, and the definition "1 and 1" implies an underlap of one needle space and one overlapped needle.



Open 1 and 1 lapping movement



Closed 1 and 1 lapping movement



Back side of closed 1 and 1 structure

Although a fabric is formed by this lapping movement it has as with most single-bar fabrics, a restricted commercial value. As with pillar lapping, the 1 and 1 movement can be formed open or closed. The closed 1 and 1 structure is more popular. The chain notations for the closed lap construction are 1 – 2 / 1 – 0 and for the open one: 2 – 1 / 0 – 1. For tricot machines, the chain reads 1 – 2 – 2 / 1 – 0 – 0 and 2 – 1 – 1 / 0 – 1 – 1 respectively.

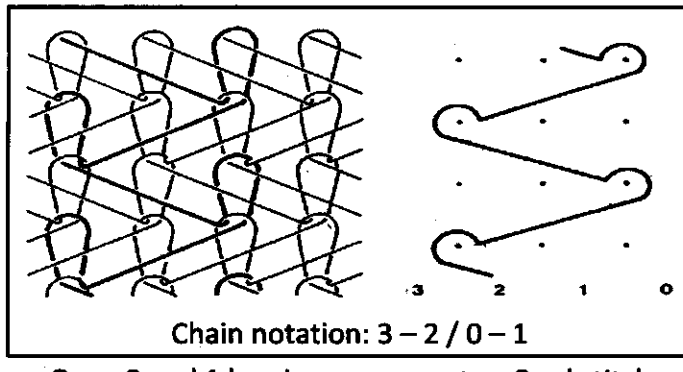
The guide bar producing a 1 and 1 lapping movement consumes more yarn than a chaining one, however, the amount is still relatively small. The construction is flexible, light and very popular in the production of two guide bar fabrics.

Tricot is a warp-knitted fabric knitted with two full sets of warp threads, each set making, a 1 and 1 lapping movement but in opposite directions. Additionally the term is

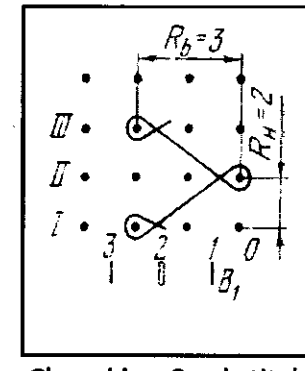
now used generically to cover all types of warp knitted fabric made on tricot warp knitting machines.

3. Cord Stitch or 2 and 1 Lapping Movement:

It differs from tricot in the length of links. It is knitted from a one warp system and the loops are formed by one yarn inturn in adjacent courses, every two wales (R_b = 3, R_H = 2). In the atlas derivatives of the cord type, the yarns from loops in every other wale in one direction over several courses, and then in the same order in the other direction. The smallest repeat of such an atlas in width is $R_{b\,min}$ = 5, and of the satin type atlas $R_{b\,min}$ = 7, and so on; $R_{h\,min}$ for an atlas of any type is equal to 4.

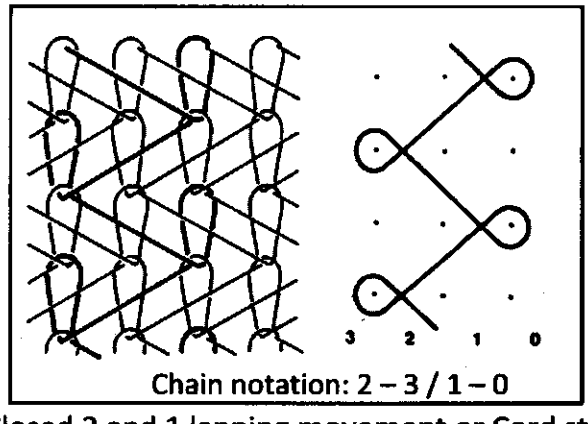


Open 2 and 1 lapping movement or Cord stitch

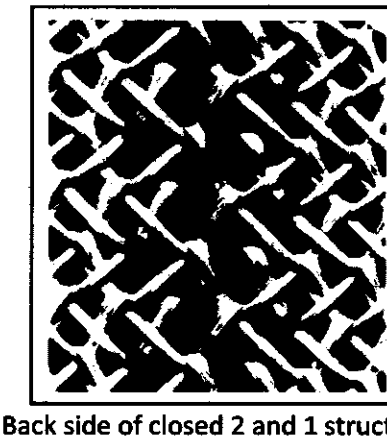


Closed lap Cord stitch

By increasing the underlap produced by the guide bar by one more needle, a 2 and 1 structure is produced. The longer shogging movement causes the yarn to lie more horizontally in the fabric, thus increasing the widthwise stability. The guide bar consumes more yarn so that the fabric is heavier and has a better covering factor.



Closed 2 and 1 lapping movement or Cord stitch



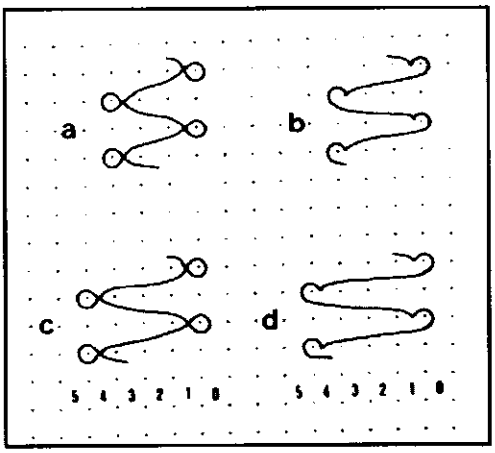
Back side of closed 2 and 1 structure

As before, the lapping movement can be open or closed, the closed one is the more popular. The chain notations for the closed lap structure are 2 – 3 / 1 – 0 and for the open one 3 – 2 / 0 – 1. For tricot knitting, the chain reads 2 – 3 – 2 / 1 – 0 – 1 and 3 – 2 – 1 / 0 – 1 – 2 respectively.

The 2 and 1 lapping movement is used in conjunction with the 1 and 1 lap for the production of the most popular tricot knitted fabric, namely Locknit.

4. Longer Reciprocating Lapping Movements:

By increasing the underlap shogging movement by one or more needle space, a 3 and 1 construction or satin stitch is formed and as with the other structures, it can be produced with closed (fig. a) or open (fig. b) lapping movement.



3-and-1 and 4-and-1 lapping movements

Back side of closed 3 and 1 structure

The chain notations for the closed lap structure are 3 – 4 / 1 – 0 and for the open one 4 – 3 / 0 – 1.

Satin stitch differs from tricot and cord in the length of links. It is also knitted from a one warp system and the loops are formed by one yarn in turn in adjacent courses, every three wales ($R_b = 4$; $R_h = 2$).

More yarn is used with the production of this lapping movement, widthwise stability is increased together with fabric weight and cover factor. With the construction of two-or more guide bar fabrics, this lapping movement is usually used for one of three purposes:

a) To increase stability
b) When produced on the front guide bar, the long underlaps floating on the technical back apply a bright and smooth appearance to the fabric.
c) When produced by the front guide bar, the long underlaps can be brushed to produce a pile effect on the fabric.

4 and 1 or longer lapping movements or velvet stitches are produced for similar purposes. Velvet stitch also can be produced with closed (fig. c) or open (fig. d) lapping movement. The chain notations for the closed lap structure are 4 - 5 / 1 - 0 and for the open one 5 - 4 / 0 - 1. The longer the underlap, the greater the weight, stability and

density of the fabric. Velvet stitch differs from tricot, cord and satin in the length of links. It has large link length compare to other. It is also knitted from one warp system and the loops are formed by one yarn in turn in adjacent courses, every four wales, (R_b = 5; R_h = 2).

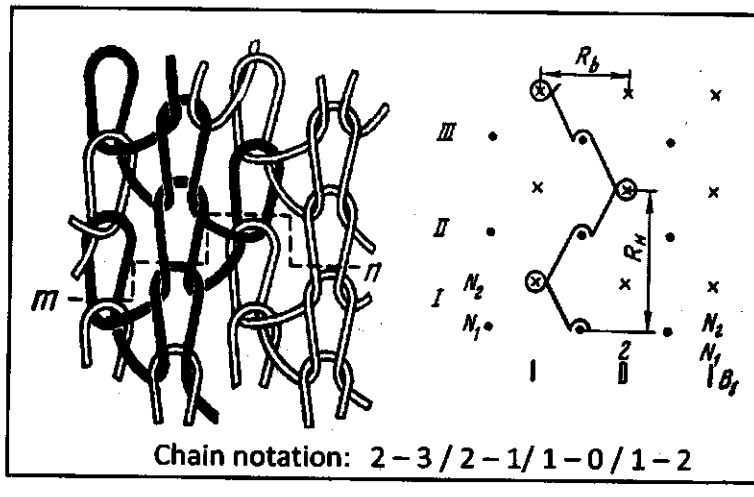
5. Atlas Stitch or Lapping Movement:

It is a stitch in which each yarn consecutively forms loops in a multitude of adjacent wales. In atlas there are loops with single-side and double-side links. The smallest stitch repeat is R_b = 3 in width, and in height R_h = 4. The graphical representation of yarn laying in this atlas is shown in figure. In high repeat multicourse atlas the links connect the adjacent wales first in one direction, and then in the reverse direction (to the initial wale).

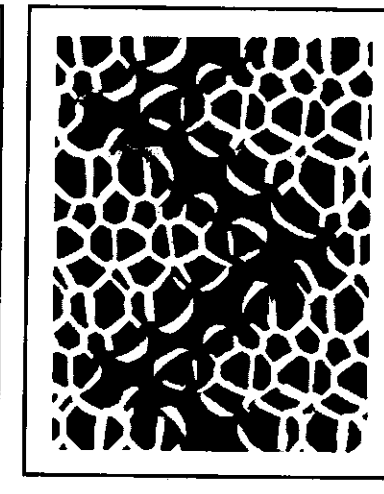
Atlas stitch normally means Tricot Atlas. There are various types of Atlas –

- Tricot Atlas – 2 course Tricot Atlas, 3 course, 5 course Tricot Atlas, etc.
- Cord type Atlas
- Satin type Atlas
- Velvet type Atlas.

The lapping movements illustrated in figure are called atlas movements. The guide moves to one side for a few knitting cycles, lapping the needles on its way. After a predetermined number of courses, the guide reverses.

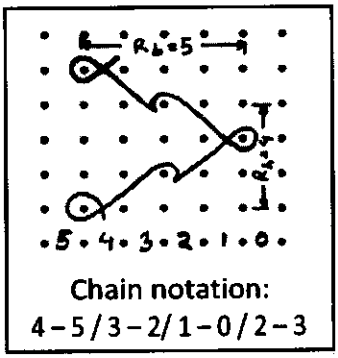


Construction of a Two course Tricot Atlas

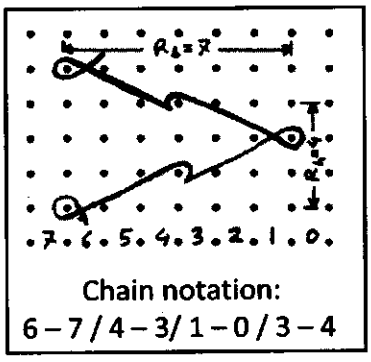


Back side of an Atlas structure

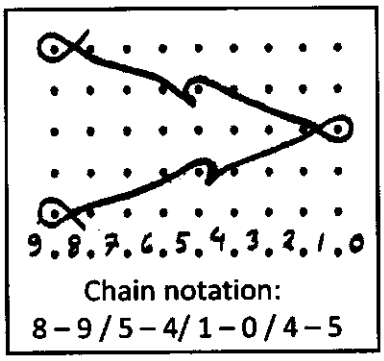
Atlas movements differ from one another by the number of courses in one repeat and by the type of lapping used (Open or closed). A typical atlas fabric (5-course tricot atlas) with a repeat of 10 courses is illustrated in figure.



Cord type Atlas



Satin type Atlas



Velvet type Atlas

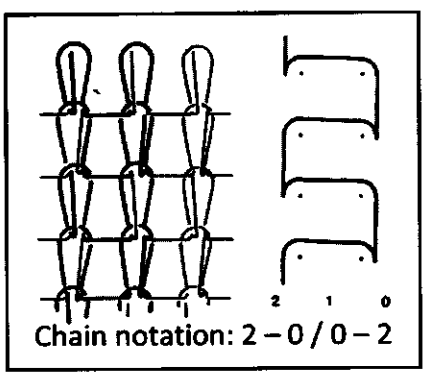
Loop inclination, which is very prominent in a single-bar fabric, will take a different shape when an atlas movement is produced. With the production of all previously described fabrics, the loops incline once to the left and once to the right, according to the alternate movement of the guide bar. With the production of atlas, however, the guide bar moves for a few courses in the same direction, so that the loops incline during those courses in the opposite direction. In this way, the loops incline to the same direction for a few courses, thus creating horizontal stripes on the face of the fabric. Those stripes of different shading can be used for patterning purposes.

Atlas lapping is often used with the guide bars threaded with coloured yarns. With two bars moving in opposition, the threading arrangement produces, due to the atlas movement, diagonal or diamond shapes.

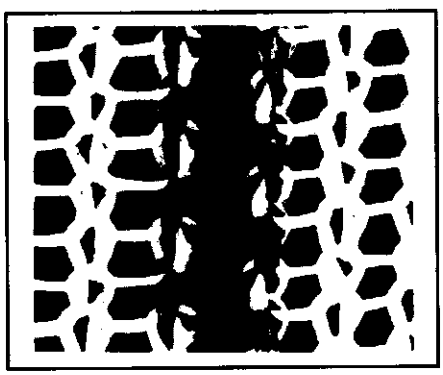
6. Two needle Overlap:

The guide can be shogged by two needle spaces on the hook side of the needle during an overlap. In this way, two needles are wrapped by each yarn and both will draw the loops simultaneously.

This lapping movement is usually produced in order to add body and stability to a single-guide-bar fabric.



Two-needle overlap construction



Back side of Two-needle overlap structure

The facts that two separate loops must be drawn from a relatively small amount of yarn and that one of the two has no access to the guide and warp cause a lot of stress to be placed on the yarns and the needles. Usually, when producing a two-bar fabric, with incorporated two needle overlap, the movement should be produced by the front guide bar. The yarns of the front guide bars float freely on the face of the fabric and, if necessary, can move more easily into the knitted loop.

Figure illustrates a construction in which chaining and two needle overlap are combined. As can be observed, each needle receives two yarns and horizontal connections between the wales are formed. The fabric has erect loops, is relatively stable and resembles the appearance of two-bar fabrics.

The chain notations for the structure in figure are 2 – 0 / 0 – 2 and for tricot machine with 3 links per course movement 2 – 0 – 0 / 0 – 2 – 2.

WARP KNITTING MACHINERY

Introduction to Warp Knitting Machinery:

In the past, it was usual to distinguish between Tricot and Raschel, by the needle used in each machine type. Tricot machines were equipped with bearded needles, while Raschel machines only used latch needles.

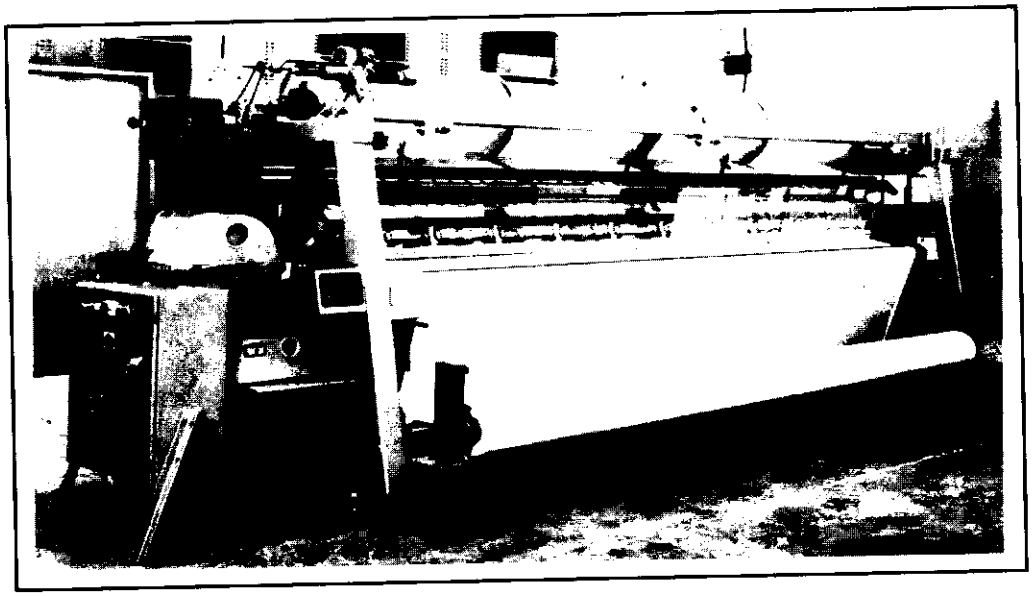
With the production of modern warp knitting machines, however, the compound needle replaced the bearded needle in Tricot and penetrated into the Raschel sector as well. The classification of machines by the needle type is, therefore, no longer possible. An accurate definition can be made by regarding the type of sinkers with which the machine is equipped and the role they play in loop formation.

The sinkers used for Tricot knitting machines control the fabric throughout the knitting cycle. The fabric is held in the throats of the sinkers while the needles rise to clear and the new loops are knocked over in-between them.

In Raschel knitting however, the fabric is controlled by a high take-up tension and the sinkers are only used to ensure that the fabric stays down when the needles rise.

It is for this reason, that the fabric produced on a Raschel machine is pulled tightly downwards from the knitting zone, at an angle of about 160^0 to the backs of the needles. On Tricot machines, high take-up tension is not necessary, and the fabric is pulled gently from the knitting zone at a right angle to the back of the needles.

Tricot warp knitting machine:



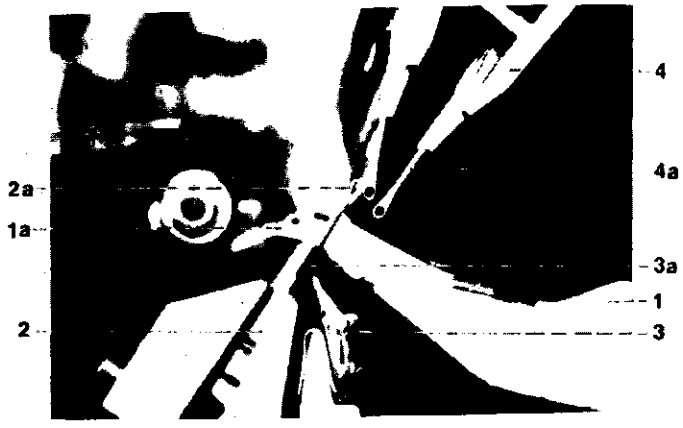
Main Features of The Tricot Warp Knitting Machine:

Tricot warp knitting machines have the following important features:

- In the past, Tricot machines mainly employed bearded needles with a presser bar.
- Tricot machines have a gauge expressed in needles per inch and chain link numbering 0, 1, 2, 3, 4, etc., generally with three links per course.
- Their sinkers, which are joined to each other at the front and back, never move clear of the needles as they combine the functions of holding-down, knocking-over and supporting the fabric loops.
- The fabric is drawn-away towards the batching roller almost at right angles to the needle bar.
- The warp beams are accommodated in an inclined arc towards the back of the machine with the top beam supplying the front guide bar and the bottom beam supplying the back guide bar.
- The warp sheets pass over the top of the guide bar rocker-shaft to their tension rails situated at the front of the machine.
- Mechanical attention to the knitting elements is carried out at the front of the machine as the beams prevent access to the back.
- As all the warp sheets are drawn over the rocker-shaft to the front of the machine it is easier to thread up the guide bars commencing with the back bar, otherwise the front warp will obscure this operation.
- The guide bars are therefore numbered from the back towards the front of the machine because of this threading sequence.
- The conventional tricot beam arrangement generally restricts the maximum number of beams and guide bars to four but this is not of major importance as the majority of tricot machines employ only two guide bars.
- The small angle of fabric take-away and the type of knitting action provides a gentle and low tension on the structure being knitted which is ideal for the high – speed production of simple fine gauge (28 – 40 npi) close knitted plain and patterned structures, especially two guide bar structures with both bars overlapping and underlapping.

Knitting Elements of the Tricot warp knitting machine:

The knitting elements are located on four different bars and produce the rows of stitches in a pre-determined, precisely coordinated and simultaneous series of movements. Every knitting element has its own corresponding movement.



Name of the Bars:

1. Sinker bar
2. Compound needle bar
3. Tongue or sliding latch bar
4. Guide bar

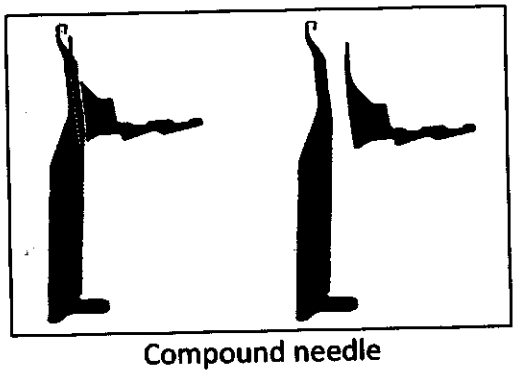
Knitting Elements:

1a. Enclosing knock-over sinkers
2a. Compound needle
3a. Tongue or sliding latch
4a. Guide

The above knitting elements of the tricot warp knitting machine are described as follows,

- **The Needle:**

Modern Tricot warp knitting machines, apart from a small number, are constructed with compound needles. The bearded needle, which until recently dominated the field of tricot knitting, can still be found running efficiently and reliably in thousands of machines around the world. Its knitting action is, however, nonharmonic, and so imposed many limitations on the machine builders.



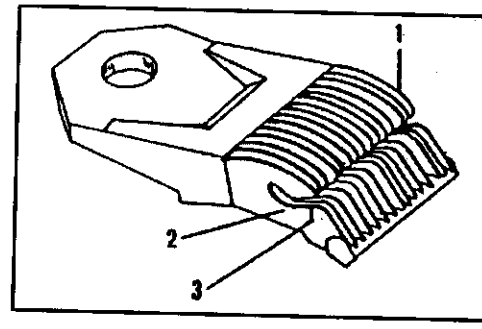
Compound needle

The compound needle used today in the construction of Tricot machines. The needle is made of two separate parts; the main part of the needle, which includes stem, butt and hook, and the closing element which operates with a sliding up-and-down movement in a groove, cut into the stem of the main part of the needle.

The needles are set in tricks cut in the needle bed of the machine, while the closing elements, being cast in units half an inch long, are set in a separate bar. The casting of the closing elements is required to ensure perfectly accurate spacing between them.

- **The Sinker:**

The sinker is a thin plate of metal which is placed between each needle. The sinkers are usually cast in units, one inch long, which in turn are screwed into the sinker bar.

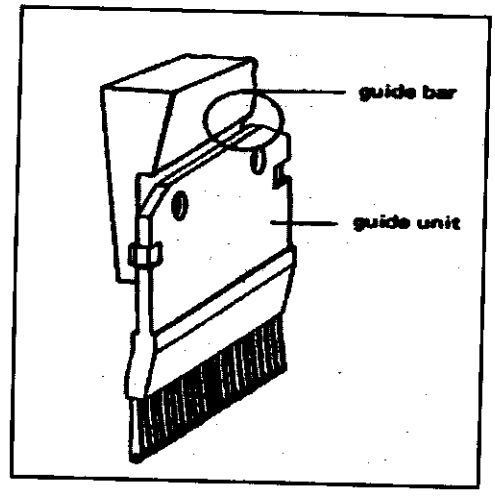


Different names are given to different parts of the sinker according to their operation. The neb of the sinker (1) and throat (2) are used to hold down the fabric, while the belly of the sinker (3) is used as a knocking-over platform.

- **Guides and Guide Bars:**

Each end of yarn from each warp is located in the knitting zone by passing through the eye of a guide. All the guides containing the yarns fed from a single warp, are connected to a guide bar, so that all of them move uniformly with it.

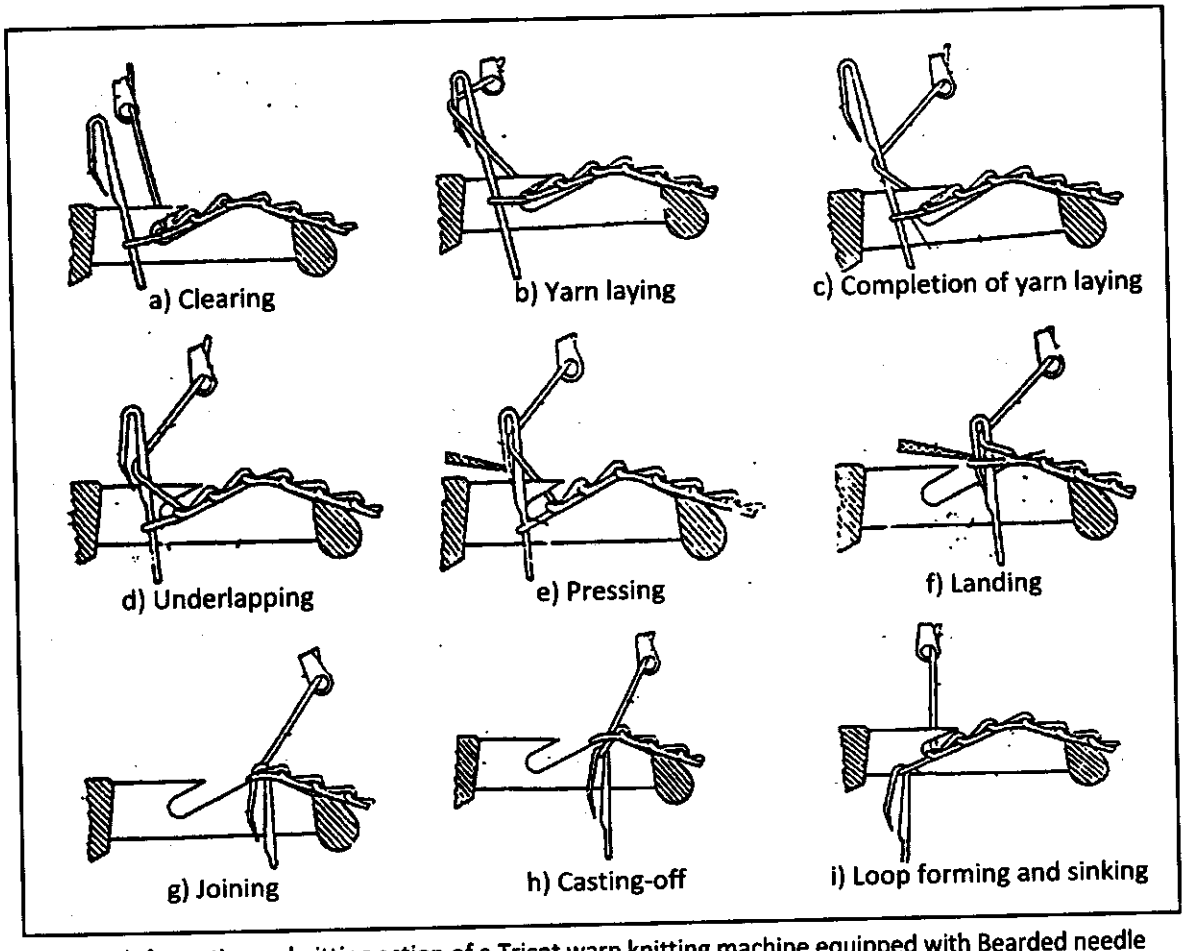
The individual guides are usually cast in one inch units which in turn are fitted on the guide bars. The guides swing between and around the needles in order to wrap the yarn around them to form a new loop. They also shog sideways to connect the wales into a fabric.



Tricot machines are produced with 2, 3, or 4 guide bars, an arrangement which requires the same number of warps to be used. Tricot machines with a larger number of guide bars are produced in very small numbers.

The knitting cycle or Stitch formation of the Tricot Warp Knitting Machine equipped with Bearded needles:

Following figures illustrate the stitch forming process on a one-bar warp knitting machine with spring-bearded needles: (a) clearing and beginning of yarn laying; (b) yarn laying; (c) completion of yarn laying; (d) underlapping; (e) pressing; (f) landing; (g) joining; (h) casting-off; (i) loop forming and sinking.



Stitch formation or knitting action of a Tricot warp knitting machine equipped with Bearded needle

Each warp yarn, when forming all kinds of stitches, must be laid in one needle. At the beginning of the loop forming process, the guide bar swings from the back of the needle to the front of the needle, while the needle stay at the top most position. As a result, each warp yarn passes in a spacing between two adjacent needles to the front face of the needle bed. After the guide bar

has passed between the needles, it shifts one needle spacing in front of the needles and passes again to the back of the needle bed as shown in figure (b). As a result, each warp yarn is laid on the needle hook. Yarn laying is completed when yarns arrive onto the needle stem. For this, the needles lift and the yarns pass onto their stems (figure-c). Only those portions of the yarn which run from the old loops to the guide needles are laid on the needles. For this, at the time of bar racking the centres of the guide holes must not pass below the upper point of the needle head.

After the yarn has passed from the hook onto the needle stem (figure-c), the yarn is underlapped, or brought under the needle hook. For this, the needles are lowered so as to bring the yarns under the needle hooks; the old loop retained in the throat of sinker approaches the needle hook (figure-d). As the yarn is underlapped, the tips of the needle hooks must be disposed between the sinker nibs; this ensures a reliable insertion of the new loop under the needle hook. Further, the presser presses the needles and closes (figure-e) the access under the hook to the old loop.

On further lowering, the old loops slip along the needles onto the hooks, i.e. the operation of landing is carried out. In order to reduce needle hook displacement along the press, the sinkers retreat and shift upwards the old loops as shown in figure (f). The needles continue to move down until the old loops join the new ones as shown in figure (g). The needles continue their descent, while the sinkers again shift forward. The old and new loops enter the sinker throats (figure-h and i). At this moment, the sinker nibs pass into the spaces between the adjacent warp yarn, at which casting-off and loop forming take place. The needles start moving upwards and the sinkers protrude still more forward, and help the needle in executing loop forming and draw-off.

Basic Knitting action of a Tricot Warp Knitting Machine equipped with Compound needles:

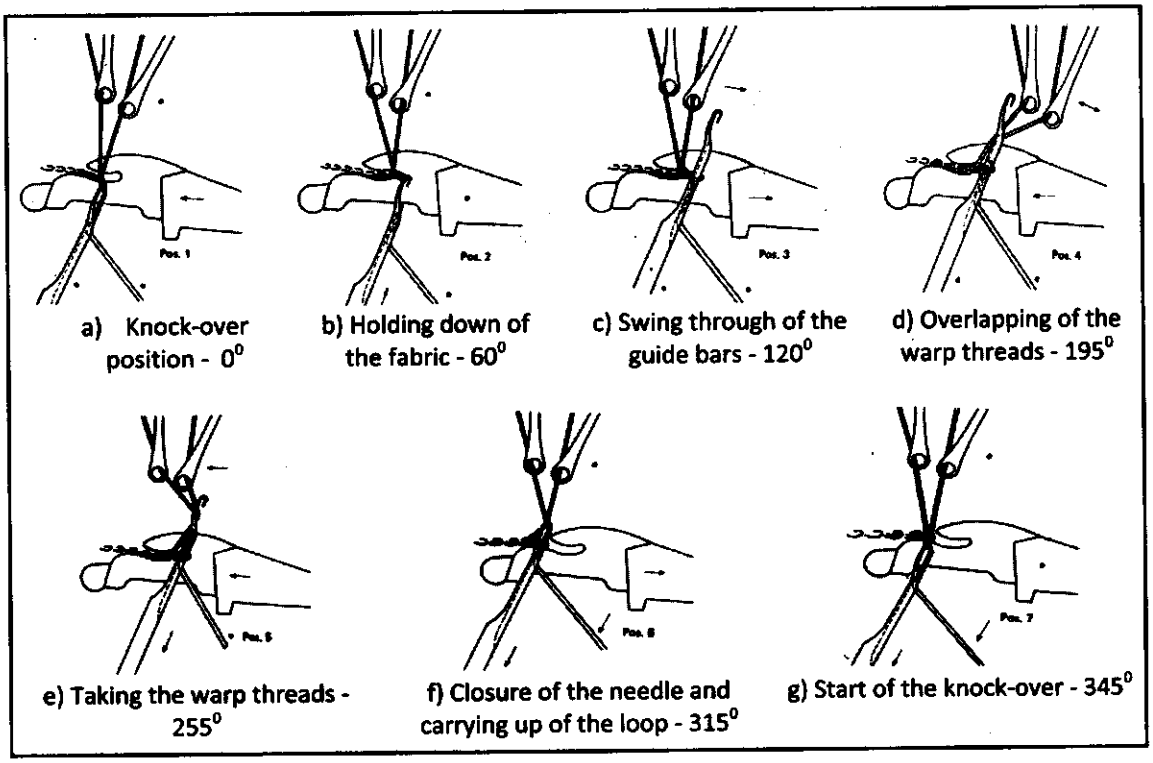
The knitting action of a Tricot warp knitting machine equipped with compound needles and two guide bars is schematically illustrated in the seven diagrams of the following figure. One knitting cycle being explained in the seven stages 'a' to 'g'.

'a' can be regarded as the starting position, with the needles at the knock-over just after completing the production of the previous course. The sinkers move forward in order to hold the fabric in the throats. At the same time, the guide bars shog sideways to position the guides close to the needles to be wrapped during this cycle (0^0).

In position 'b', the main parts of the needles start to rise so that the needle hooks open. The underlap shogging movement is now completed (60^0).

In position 'c', the needles are in the clearing position with the previous loops lying on the stem of the needle. The closing elements rise slightly but do not protrude out of the grooves of the needles. The sinkers move backwards to relax the hold on the fabric. The guide bars start to swing the guides in between the needles on to the hook side (120^0).

Position 'd' illustrates the guides in the extremity of the swing. The guides of both guide bars are now shogged, usually one needle space, on the hook side of the needles thus creating an overlap. The closing elements continue their upward movement inside the loops, resting on the needle stem (195^0).



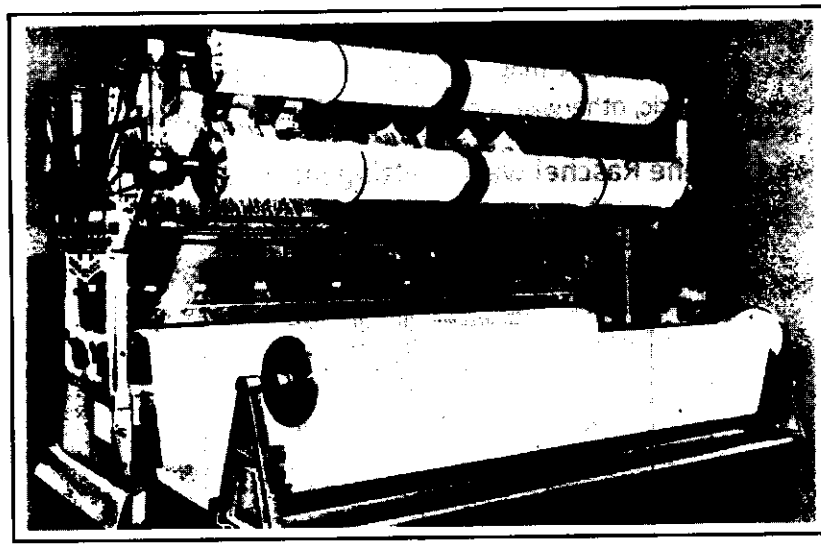
Stitch formation or knitting action of a Tricot warp knitting machine equipped with Compound needle

The swing-back and completion of overlapping is in position 'e'. Since the guides swing out of the needle line, in a space adjacent to the one entered, the yarn is left wrapped inside the needle hooks. The sinkers move in, to tighten the hold on the fabric, while the main body of the needle starts to descend (255^0).

In position 'f', the needles continue to descend. The rate, however, in which the two parts of the needle descend is not equal. The main body of the needle is gaining on the closing element, so that the hook is being closed. The previous loops rest outside the closed hook on the closing element, while the newly wrapped yarn is trapped within the closed hook. The sinkers now move backwards to position their bellies under the hooks. In the same position of the knitting cycle, the guides can start the new underlap shogging movement, which position them infront of the needles to be wrapped during the next knitting cycle (315^0).

Figure 'g' shows the last step of current course production with the needles descending with their respective closing elements into the knock-over position. The guide bars are now in the midst of the underlap shogging movement (345^0).

Raschel warp knitting machine:



Main Features of the Raschel Warp Knitting Machine:

Raschel warp knitting machines have the following important features:

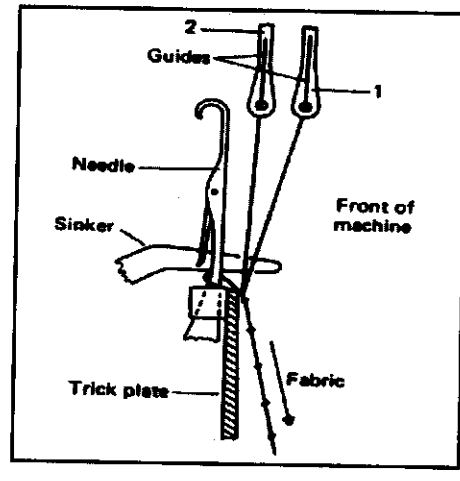
- Raschel machines used latch needles together with a latch wire or blade.
- Raschel machines have a gauge expressed in needles per two inches (5 cm) so that for example, a 36 gauge Raschel will have 18 needles per inch.
- Their chain links are usually numbered in even numbers 0, 2, 4, 6, 8 etc., generally with two links per course.
- Raschel sinkers only perform the function of holding down the loops whilst the needles rise.
- Raschel sinkers are not joined together by a lead across their ends nearest to the needle bar so they can move away towards the back of the machine for the rest of the knitting cycle.
- The needle trick-plate verge acts as a fabric support ledge and knock-over surface.
- The fabric is drawn downwards from the needles almost parallel to the needle bar at an angle of 120 to 160 degrees by a series of take-down rollers.
- The warp beams are arranged above the needle bar centred over the rocker shaft so that warp sheets pass down to the guide bars on either side of it.
- The beams are placed above the machine so it is accessible at the front for fabric inspection and at the back for mechanical attention to the knitting elements.
- The guide bars are threaded commencing with the middle bars and working outwards from either side of the rocker shaft.
- The guide bars are numbered from the front of the machine.
- With the Raschel arrangement there is accommodation for at least four 32 inch diameter beams or large numbers of small diameter pattern beams.
- The accessibility of the Raschel machine, its simple knitting action and its strong and efficient take-down tension makes it particularly suitable for the production of

coarse-gauge openwork structures employing pillar stitch and inlay lapping variations and partly-threaded guide bars which are difficult to knit and hold down with the tricot arrangement of sinkers.

- Additional warp threads may be supplied at the selvedges to ensure that these needles knit fabric, otherwise a progressive press-off of loops may occur.

Knitting Elements of the Raschel warp knitting machine:

The knitting elements of the Raschel warp knitting machine are described as follows,

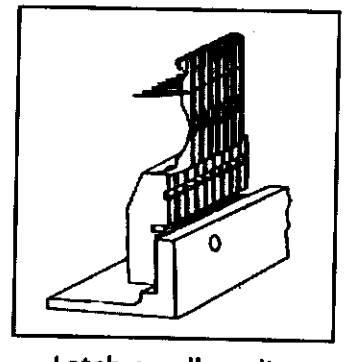


The knitting elements arrangement of a Latch needle Raschel warp knitting machine

- **The Needle:**

Most of the modern Raschel knitting machines built today use compound needles. Many machines however, are still equipped with latch needles. Compound needles are set as in Tricot machines, into tricks which are cut into the needle bar, and both main part and closing element are driven separately to open and close the hook.

The latch needles, especially developed for those machines, are cast in units, one inch long. The latch of the needle depends for its knitting operation, on the yarn.

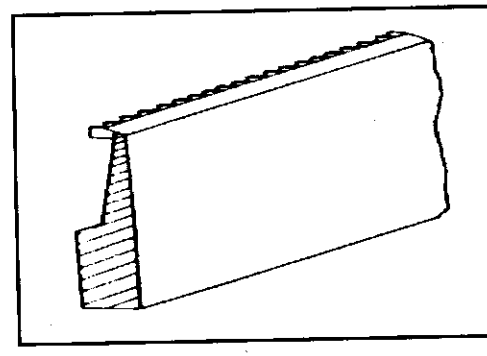


Latch needle unit

The loop within the hook opens the latch when the needle rises for clearing position and closes it when the needle descends for knock-over. A broken end (thus an empty needle) causes the latch to stay closed, so that no loops can be formed. Such a needle has to be manually opened in order to allow loop formation to resume. Raschel machines are constructed in different gauges ranging from 6 to 32 needles per inch.

- **Trick Plate:**

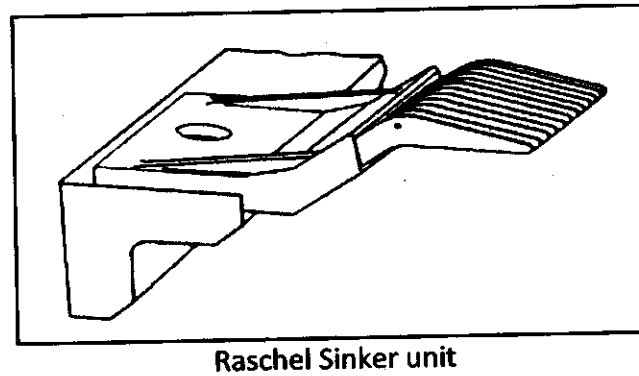
The loop formation in a Raschel machine, takes place on the upper edge of the trick plate. This bar can be considered as a needle bed, since the needles are placed in tricks cut into it. The top edge of the trick plate is designed to ensure perfect knock-over operation which is of utmost importance when producing a fabric with long underlaps.



A section of the Trick Plate

- **The Sinker:**

The sinkers, like the latch needles, are cast in units, one inch long placed in the spaces between the needles, they are used to ensure that the fabric stays down while the needles rise to form their next knitting cycle.

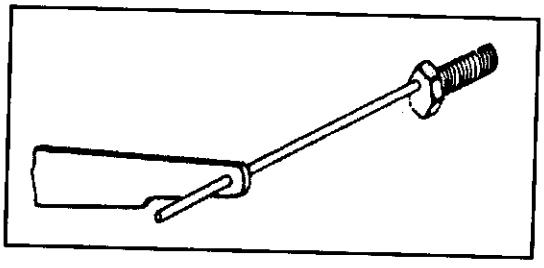


Raschel Sinker unit

It must be remembered that the Raschel machines depend greatly on fabric tension created by the take-up mechanism to ensure the clearing of the needles. The sinkers of Raschel machines are, therefore, only of secondary importance.

- **The Latch Guard:**

A steel wire stretched across the whole width of the machine, parallel to the needles, is used as a latch guard. When the loops of the fabric clear the latches, the latter have sometimes the tendency to flick back and close the hooks of the needles.

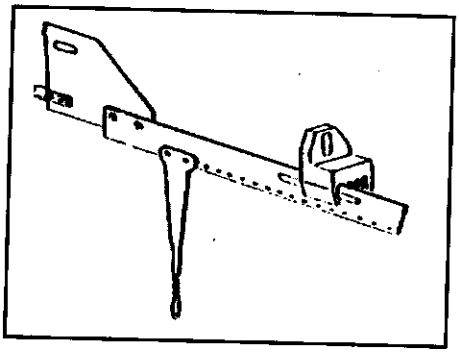


Latch guard

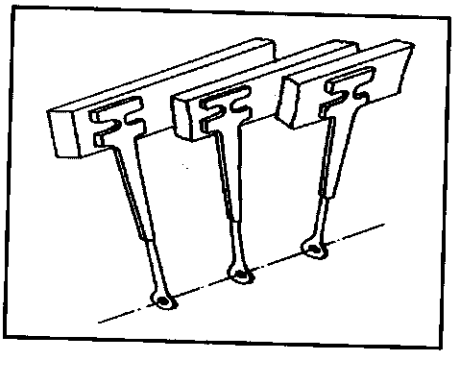
A closed hook does not receive a new yarn and causes a fault in the fabric. The wire is placed on the hook side of the needles so that the flicking latches are stopped and forced down when the needles continue to ascend.

- **Guides and Guide Bars:**

Raschel machines are usually equipped with a larger number of guide bars than the Tricot machines. These bars, numbering in some cases more than 70, allow the greater patterning capability of these machines.

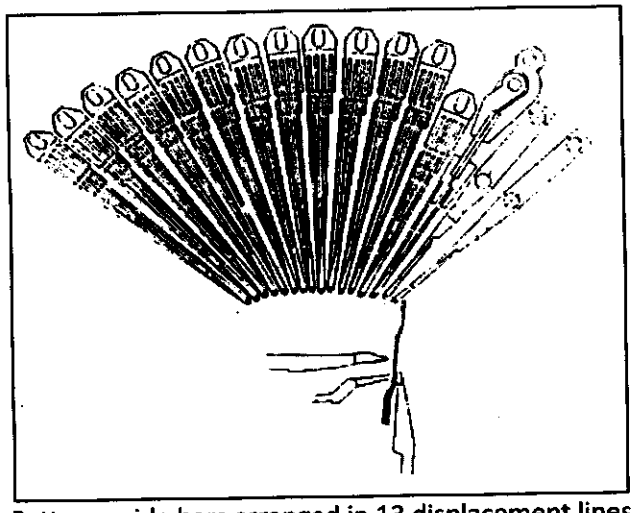


Pattern guide bar with a guide finger

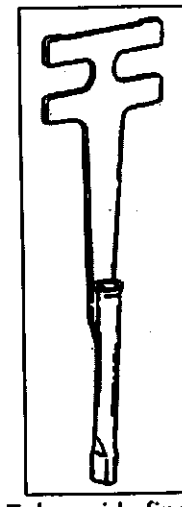


Three guide bars nesting in the same displacement line

Two types of guide bars are used in Raschel knitting. The first type is similar to the one used with Tricot knitting, with guides cast in one inch units, fully threaded and used for the construction of the ground fabric. In most cases one to three such guide bars are used. The second type of guide bars are used to apply the pattern onto the fabric. These bars usually require only one thread for each patterning repeat, so that only a few yarns are threaded across the whole width of such a bar.



Pattern guide bars arranged in 13 displacement lines



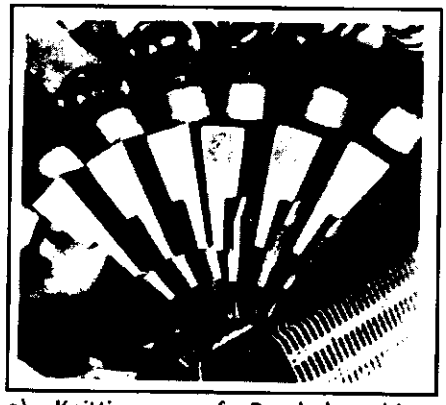
Tube guide finger

To decrease the weight and to allow a greater number of pattern bars to be assembled, these bars are designed as narrow, light-weight strips of metal onto which individual guide fingers are attached. Holes are drilled and threaded into the light-weight guide bars at regular intervals, so that the individual guide fingers, accommodating their yarns, can be fitted in any desired position.

These guide bars, although only partly threaded and containing only a few threads each, are shogged individually according to the pattern. Each of them, therefore, must be mounted in a separate sliding bracket and driven by a separate pattern chain. Being only partly threaded, they allow the machine builder to set them at an angle so that their guide eyes are set in the same displacement line. This principle is called "Nesting" and because the bars are set in groups (nests), each nest can be considered as one guide bar for the swinging movement.

As can be observed 52 pattern guide bars are placed in 13 displacement lines and so require a swing movement similar to 13 fully threaded guide bars. Before passing to the next point, it is important to note that "nesting" imposes restrictions on design. The guide fingers of the bars placed in a common nest should not, in any point of the pattern, cross each other's path, or even come close enough to touch one another. Allocating a crossing lapping movement to two guide bars within the same nest, results in a damage to guides and needles. Raschel machines are sometimes equipped with tube guide fingers which are especially designed to be used with bulky and fancy yarns.

Two different types of guide bar assemblies are illustrated in the following figures (a) and (b). Figure (a) shows the knitting zone of a standard Raschel machine with six fully threaded guide bars. Figure (b) shows a similar machine with three fully threaded guide bars and six pattern bars in three displacement lines.



a) Knitting zone of a Raschel machine equipped with six guide bars

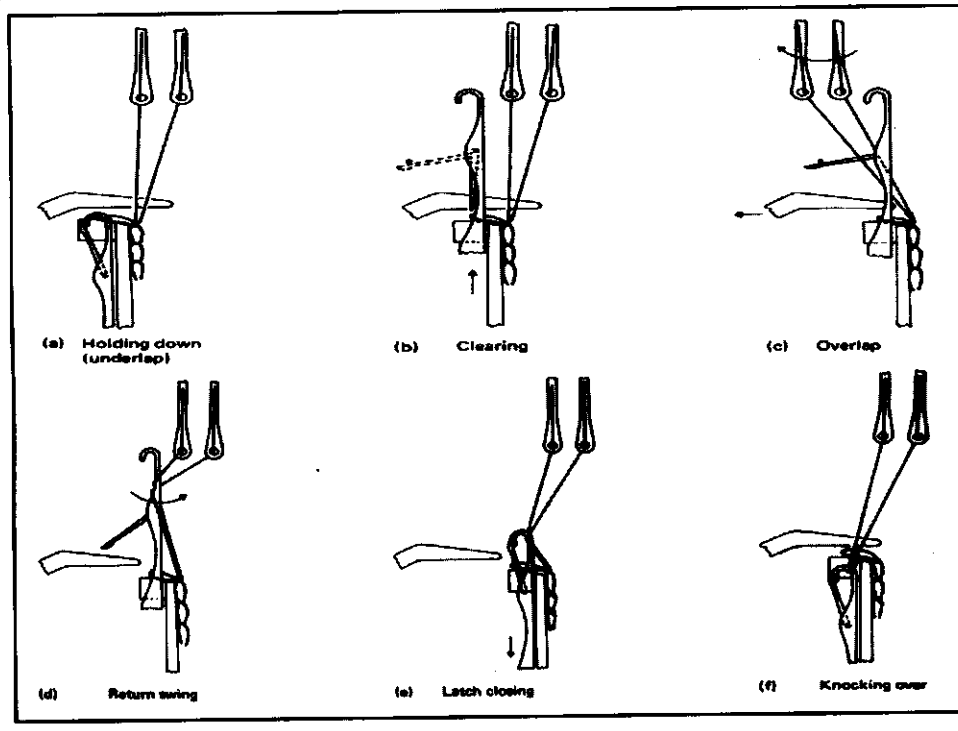
b) Knitting zone of a Raschel machine equipped with three guide bars and six pattern guide bars

To increase knitting speeds, some machines are so designed as to allow only the front bars to complete the overlap movement before the needles start to descend. In this case, all other guide bars are capable of inlay only.

Basic knitting action of a single needle bar Latch needle Raschel warp knitting machine:

The movement of the knitting elements of a Raschel machine is illustrated in the following figures. It is important to note at this stage that Raschel machines are built with different knitting movements, according to the specific requirements of the product. The following explanation is only one example of such a knitting action.

a) The needles are at knock-over position just after the completion of the previous knitting cycle. The sinkers move forward to secure the fabric whilst the needle starts to rise from knock-over. The guide bars now produce the underlap movement.
b) The sinkers move further in and, in conjunction with the take-up tension, secure the fabric position. The needles rise through the previous loops to clearing position. The flicking latches of the needles are stopped by the latch guard mounted on top of the sinkers. The guide bars complete their underlap shogging movement.
c) The needles dwell at clearing position, with the previous loops resting on the stems under the latches. The guide bars swing between the needles to the hook-side. The sinkers start to retreat.
d) Some of the guide bars are shogged sideways perform the overlap, and then all guide bars swing out between the needles. The needles start to descend while the sinkers are at their rearmost position.
e) The guide bars have completed their swinging movement. Underlap movement now starts. The needles descend with the newly wrapped threads in their hooks. The previous loops close the needle latches.
f) Underlap shogging movement continues. The needles are sinking into the trick plate with the previous loops sliding on the latch outside the closed hooks. Completion of the knitting cycle.



The Knitting action of a Compound Needle Raschel Warp Knitting Machine:

The knitting action of Raschel machine equipped with compound needles is different from that of a Tricot machine. In the following series of figures, the loop formation sequence of a multibar Raschel machine is described and it is important to note the following points:

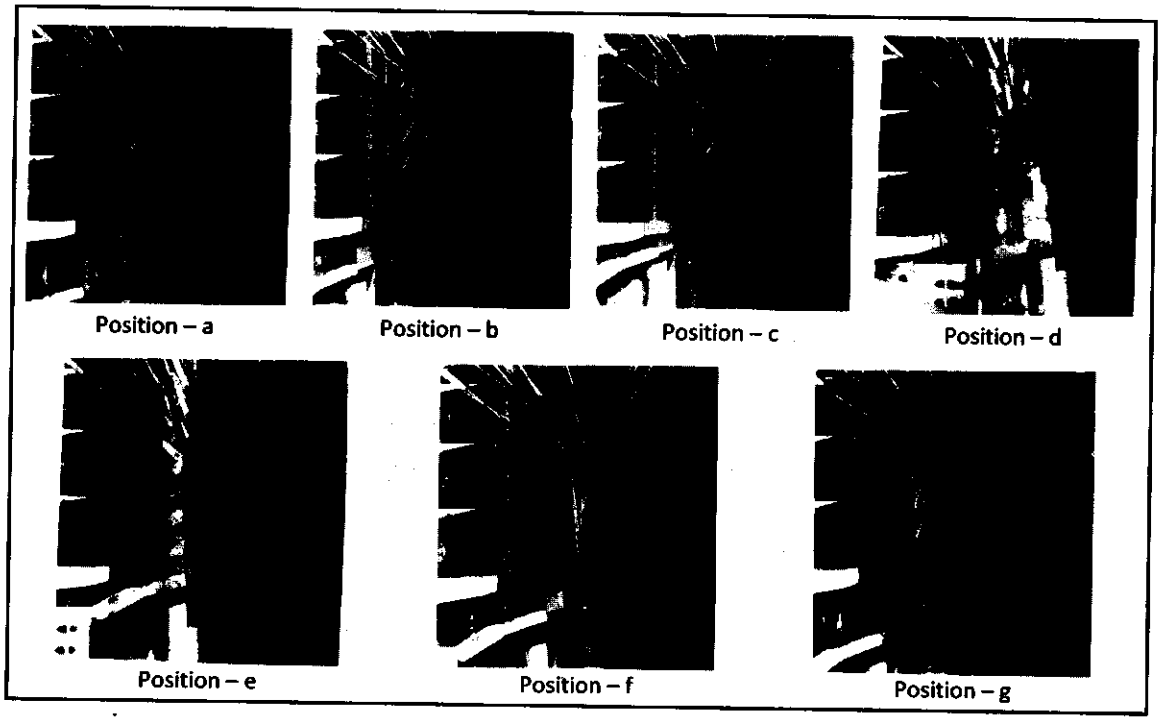
- The sinker bar is stationary,
- The guide bars do not swing, and
- The swinging movement is made by the needle bar, closing element bar and trick plate.

The sequence can be described as follows:

a) The needles are at knock-over position, after the completion of the previous course. Both parts of the needles, together with the trick plate, swing towards the back of the machine and position themselves under the sinkers. Underlap shogging movement is now carried out.
b) The needles rise through the loops of the previous course. The closing elements stay down so that the hooks are opened. The fabric stays down due to take-up tension and is secured by the sinkers.
c) The needles are in the clearing position with the previous loops resting on the stem. Underlap shogging movement is now completed.

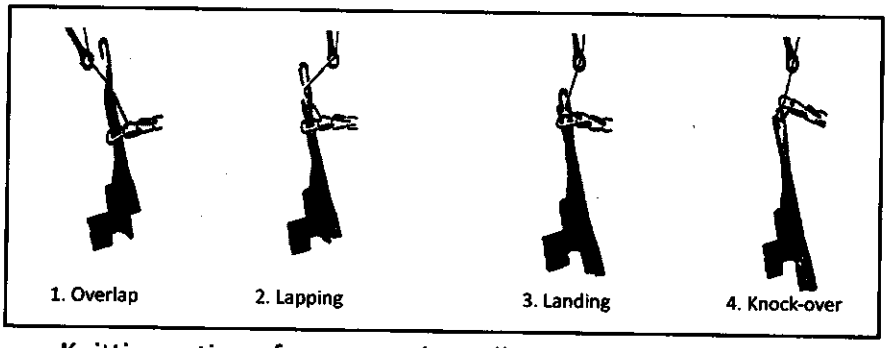
d) The needle bar, closing element bar and trick plate swing to the front of the machine, so that the guides move in between the needles to the hook side. The ground guide bars are now shogged sideways to produce the overlap.

e) The needle bar, closing elements bar and trick plate swing back, so that the guides move between the needles to the back. The needles can start to descend when the ground bars are at the back. The closing elements stay up, so that the hooks are closed, trapping within them the newly wrapped yarns.



f) Both needles and closing elements descend simultaneously and maintain a closed hook. The old loops slide outside the closing elements. Needle bar, closing elements and trick plate continue their swinging towards the sinker. Underlap shogging movement can now start.

g) The needles draw the newly wrapped loops through the previous loops. The swing movement is nearly finished and the guide bars continue to shog the underlap lateral movement.



Knitting action of compound needle warp knitting machine

TWO FULLY THREADED GUIDE BAR STRUCTURES OR FABRICS

In order to reproduce a warp knitted fabric, it is necessary to obtain the information regarding its production. Many different data items are involved such as:

a) Information describing the knitting machine; number of guide bars, machine gauge, width of the needle bed and special attachments used.
b) Information concerning the type and count of the yarn threaded in each guide bar.
c) Lapping movement of each bar.
d) The run-in of each bar.
e) Threading information if the guide bars are not fully and uniformly threaded.
f) Fabric quality and weight.
g) The finishing process.

The above-mentioned information varies widely for different manufacturers and end-uses, so that there is no practical limit to the number of different fabrics that can be produced on modern warp knitting machines.

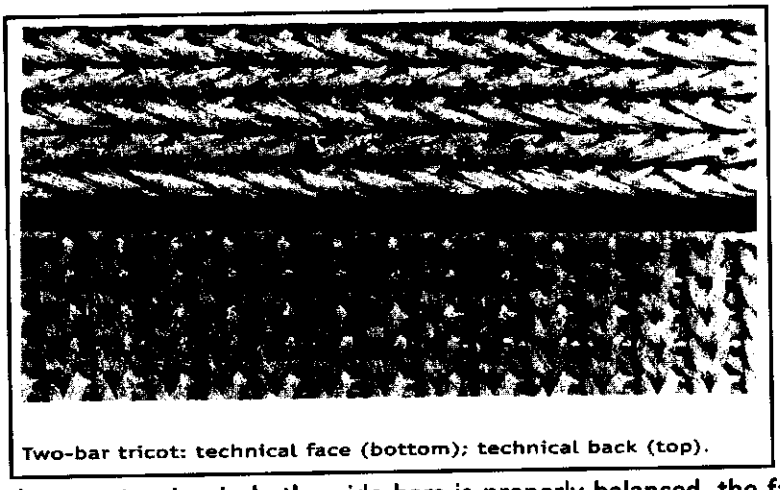
The single-bar structures are not suitable for most commercial applications. They are usually very unstable dimensionally and some of them will even split easily if only slightly damaged. Furthermore, most single-bar structures exhibit an unbalanced loop structure and loop inclination is very pronounced.

The bulk of the fabrics, manufactured today on tricot machines, are constructed by two fully threaded guide bars, fed from two separate warps and producing a different basic lapping movement. The relative movement of the two guide bars in combination with the magnitude of the shogging, determines the appearance as well as the properties of the fabrics.

Tricot Fabric or Full Tricot Structure:

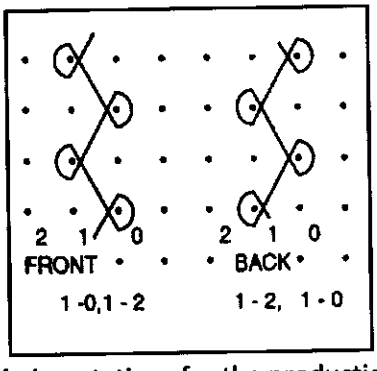
The basic lapping movement of two fully threaded guide bars is the so-called tricot or double tricot. In figure the schematic lapping movement is illustrated with both guide bars knitting the same 1-and-1 lapping movement in opposite directions. Such a lapping movement produces a light-weight fabric since the underlaps are very short.

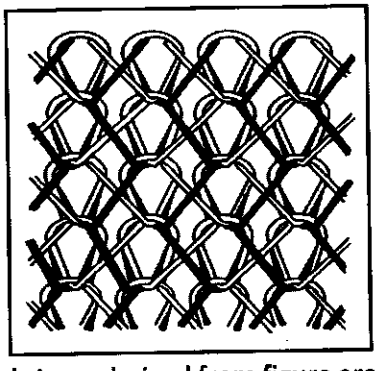
Although the fabric is commercially very attractive, it is only seldom used due to a major disadvantage; each wale of this fabric is connected only to the adjacent wales, so that the fabric splits very easily if a yarn is broken or a stitch dropped.



Two-bar tricot: technical face (bottom); technical back (top).

Providing that the yarn tension in both guide bars is properly balanced, the fabric – as in all fabrics of this nature – exhibits erect loops and the technical face resembles the face of a weft knitted fabric.





The chain notations for the production of this fabric, as derived from figure are:

Front bar: 1 – 0 / 1 – 2
Back bar : 1 – 2 / 1 – 0

As all modern tricot machines are equipped with a pattern mechanism which uses three chain links for each knitted course, the chain notations are:

Front bar: 1 – 0 – 0 / 1 – 2 – 2
Back bar: 1 – 2 – 2 / 1 – 0 – 0

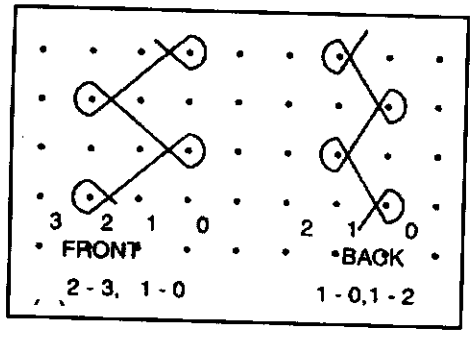
Locknit Fabric:

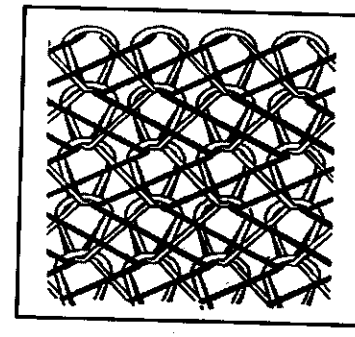
The most widely produced warp knitted fabric is probably locknit. The lapping movement of its two guide bars is illustrated in the following figure. While the back guide bar shogs a 1-and-1 lapping movement, as in tricot, the front guide bar shogs two needle spaces.

The free-floating underlaps, superimposed on the technical back, contribute to a very pleasant touch and together with a considerable elasticity make the fabric most suitable for ladies,

lingerie. In addition, being the lightest non-splitting fabric, further helps to make locknit the most popular of all warp knits.

The locknit construction tends to contract widthwise on leaving the knitting zone, so that its final width may only be 2/3 of the needle bar width. The amount of shrinkage depends mainly on knitting conditions, yarn type, yarn tension, etc.





There is also a tendency in tricot fabrics to curl towards the technical back at the selvedges. This, however, does not represent a major problem, since most of these fabrics are made of thermoplastic yarns and are heat-set during finishing.

As a trend of the last few years, locknit fabrics which were traditionally produced on 28 gauge machines, are becoming more and more popular when knitted on 32 to 40 needles per inch. The yarn consumption of the two guide bars depends on fabric quality, machine gauge, yarn type, and knitting conditions. The chain notations for the production of locknit fabrics, as derived from figure are:

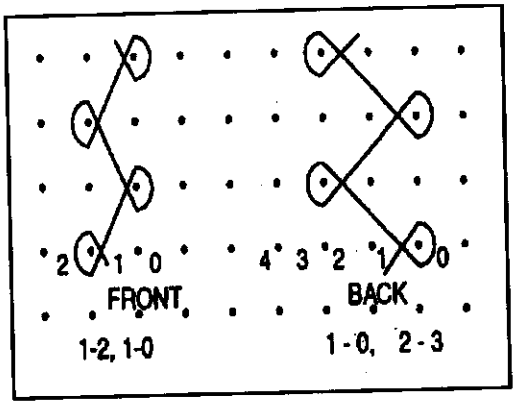
Front bar: $2-3-2/1-0-1$
Back bar: $1-0-0/1-2-2$

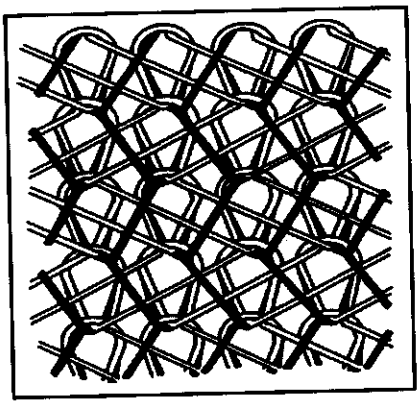
Reverse Locknit Fabric:

This fabric belongs to the other group of two fully threaded guide bar fabrics, namely the semi-stable and stable structures. In this group of structures, the longer underlaps produced by the back guide bar are locked under the short underlaps of the front guide bar and are restricted in movement. It is made with a longer underlap on the back bar and a shorter one on the front guide bar. Reverse locknit is considered only a semi-stable fabric and still shrinks considerably on leaving the knitting zone.

The lapping movements of both guide bars for the production of reverse locknit are illustrated in the figure and the chain notations as derived from it are:

Front bar: $1-2-2/1-0-0$
Back bar: $1-0-1/2-3-2$

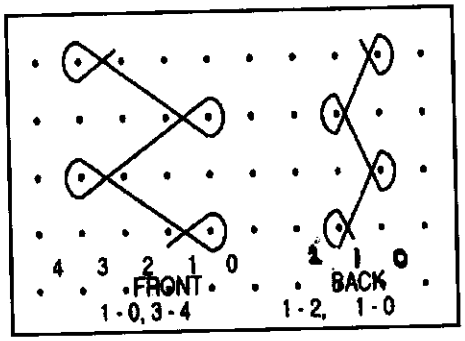


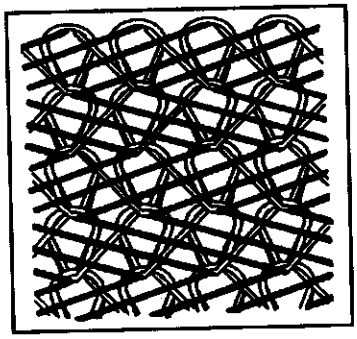


Satin Fabric (Three-Needle Structure):

A fabric with the same lapping movement on the back guide bar and an increased lapping movement on the front bar is called a satin fabric. The lapping movement of this fabric is drafted schematically in figure and as can be observed, the front bar shogs one needle space longer than in locknit. While the technical face is similar in appearance to locknit, the technical back is smoother and shinier due to the underlaps of the front guide bar which are longer and more parallel to each other.

Like all structures which are made with long underlaps on the front guide bar, this fabric shrinks considerably immediately after leaving the needles. At the same time the fabric is elastic and very comfortable to wear.



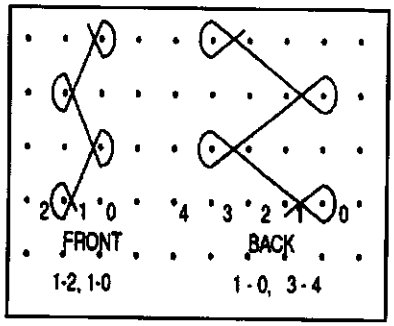


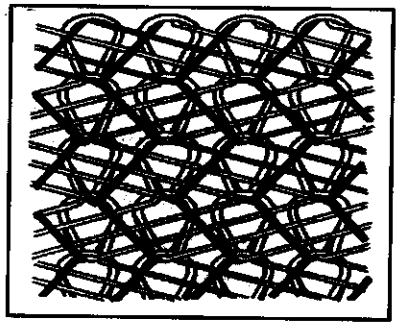
Chain notations for the production of three-needle satin fabric are:

Front bar: 1 – 0 – 1 / 3 – 4 – 3
Back bar: 1 – 2 – 2 / 1 – 0 – 0

Sharkskin Fabric:

The sharkskin fabric is constructed as a reverse version of satin. The loop structure shows the longer underlaps of the back guide bar locked under the short underlaps of the front guide bar. These trapped underlaps restrict the shrinking potential of the fabric which is therefore more rigid and more stable than those previously described.



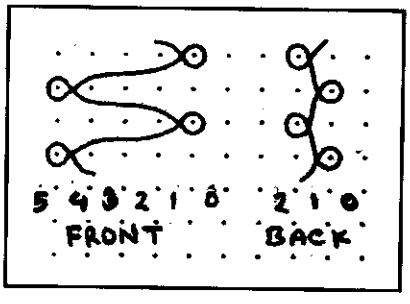


The surface of the technical back is rough which is probably the reason for the name "Sharkskin". The lapping movements are illustrated in figure and the chain notations are:

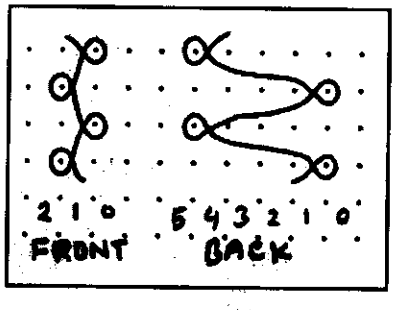
Front bar: 1 – 2 – 2 / 1 – 0 – 0
Back bar: 1 – 0 – 1 / 3 – 4 – 3

Four-Needle Structure:

Fabric with longer underlaps on the front guide bar are also manufactured. Such is the four-needle satin with a 4-and-1 lapping movement as illustrated in figure. As for three-needle satin, this fabric exhibits a very smooth and shiny technical back due to the long parallel underlaps. Like all fabrics with free and long front bar underlaps , it shrinks on leaving the knitting zone and curls at the selvedges towards the technical back.



Satin Structure



Sharkskin Fabric

It must be remembered that the longer the underlap floating on the surface of the technical back, the heavier the fabric and greater the risk of snagging. The chain notations of this fabric:

Front bar: 4 – 5 – 3 / 1 – 0 – 2
Back bar: 1 – 0 – 0 / 1 – 2 – 2

A 4-and-1 movement of the back guide bar produces even higher stability and decrease shrinkage even further. This fabric is called four-needle sharkskin and the lapping movement is illustrated in figure. The chain notations of this fabric are:

Front bar: 1 – 2 – 2 / 1 – 0 – 0
Back bar: 1 – 0 – 2 / 4 – 5 – 3

WARP KNITTING MACHINERY

Introduction to Warp Knitting Machinery:

In the past, it was usual to distinguish between Tricot and Raschel, by the needle used in each machine type. Tricot machines were equipped with bearded needles, while Raschel machines only used latch needles.

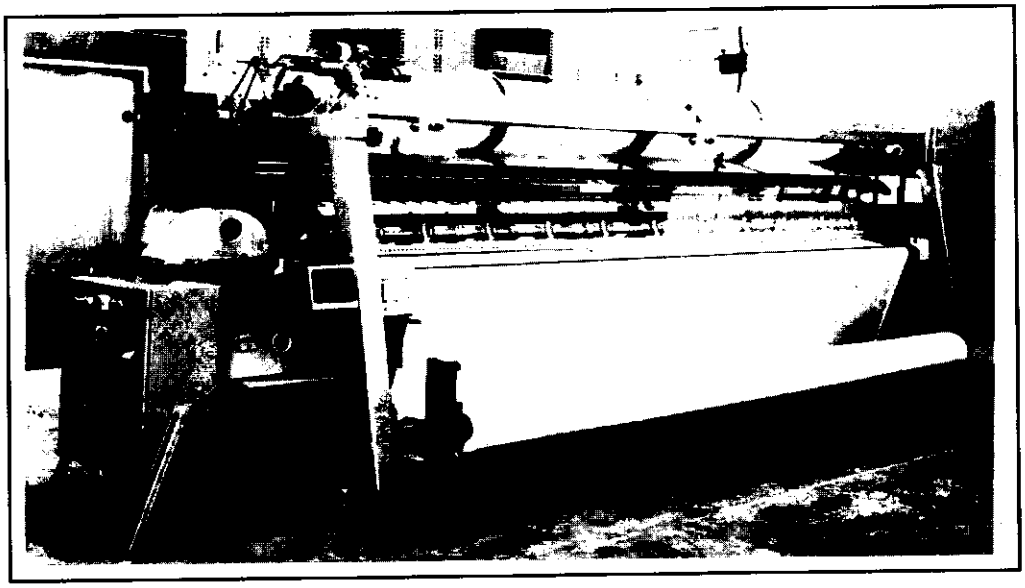
With the production of modern warp knitting machines, however, the compound needle replaced the bearded needle in Tricot and penetrated into the Raschel sector as well. The classification of machines by the needle type is, therefore, no longer possible. An accurate definition can be made by regarding the type of sinkers with which the machine is equipped and the role they play in loop formation.

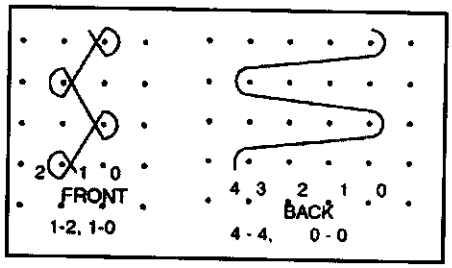
The sinkers used for Tricot knitting machines control the fabric throughout the knitting cycle. The fabric is held in the throats of the sinkers while the needles rise to clear and the new loops are knocked over in-between them.

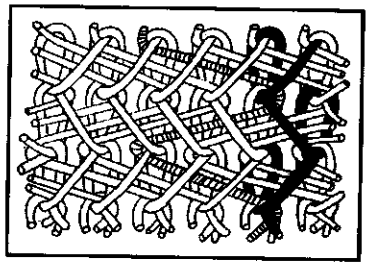
In Raschel knitting however, the fabric is controlled by a high take-up tension and the sinkers are only used to ensure that the fabric stays down when the needles rise.

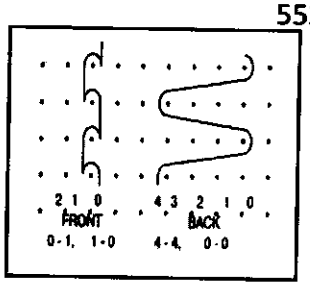
It is for this reason, that the fabric produced on a Raschel machine is pulled tightly downwards from the knitting zone, at an angle of about 160^0 to the backs of the needles. On Tricot machines, high take-up tension is not necessary, and the fabric is pulled gently from the knitting zone at a right angle to the back of the needles.

Tricot warp knitting machine:





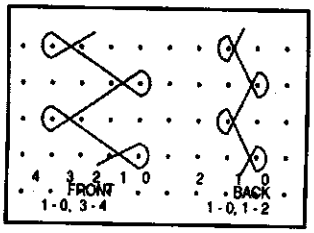


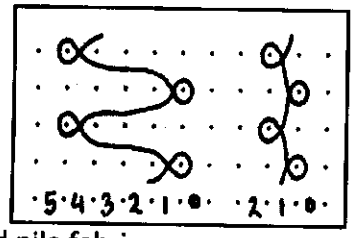


Pile Fabrics or Loop raised Fabric:

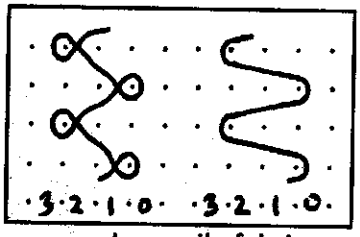
Two-bar fabrics are frequently produced of finished as pile fabrics in order to improve their appearance or their thermal properties. A pile can be produced either by raising the long underlaps of the front guide bar or by producing pile loops according to a lapping movement or knitting conditions.

For brushed fabrics, the long underlaps produced by the front guide bar, are raised during the finishing process by rollers covered with card-clothing. The metal card rollers raise the pile gradually and after a few such stages, the pile is formed. A different amount of fibres can be broken to form varying effects.





Brushed pile fabric



Loop pile fabric

It is also possible to shear the pile so that a velour effect is produced. The lapping movement of a typical brushed fabric construction is illustrated in the above figure. In this fabric, the lapping movements of both bars are carried out in the same direction. In this way the fibres raised out of the long underlaps of the front guide bar can be easily pulled with no resistance from the back guide bar underlaps. Furthermore, the threads of the back guide bar help to reduce the fabric width which occurs anyway during this mechanical treatment. The density and height of pile can be increased by increasing the front guide bar underlaps to four, five or six needle spaces.

Great quantities of brushed fabrics are made with triacetate yarns in the front guide bar and polyamide yarns in the back guide bar.

Another type of pile fabric is constructed with loop pile. One way to produce this type of fabric is to overfeed the yarn of the back warp, while knitting a reverse locknit construction. The excess yarn protrudes between the underlaps of the front guide bar and forms a pile on the technical back. This method of pile loop production cannot be controlled so that the distribution of pile loops may not be even.

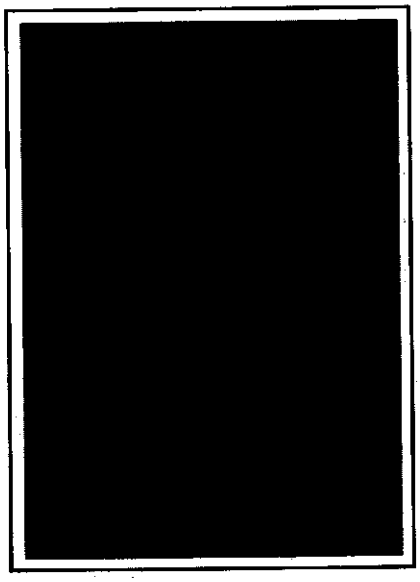
SPECIAL KNIT FABRIC PRODUCTION

Knitted Pile Fabrics

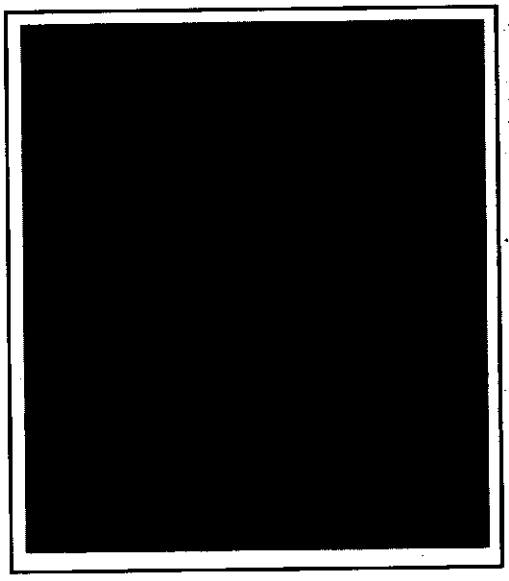
The production of pile knits has steadily grown in variety, importance, and volume. They are constructed as fleece, high pile, terry, and velour knits. Depending upon the type of construction, they are used fir fur fabrics, rugs, and fashion apparel fabrics.

Fleece knit fabric:

Technically, fleece fabrics are not truly of a pile construction. Fleece fabrics are knitted so that, when finished, they will have a short to medium nap that has a soft, pleasant hand, will provide warmth and body, as well as moisture wicking and absorption, if desired.



Face side



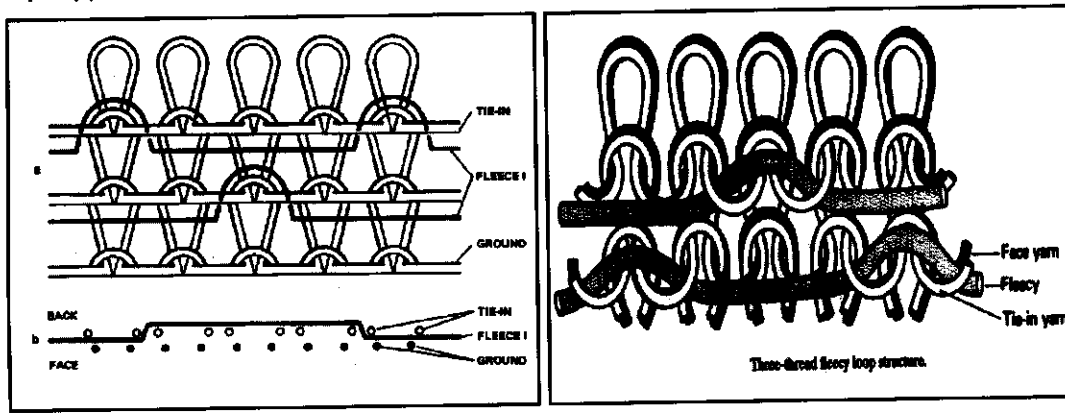
Back side

The kinds of fibres used are dependent upon the use objective. They are used for such purposes as liners, active sportswear, outerwear, and plush toys.

Fleece knits can be made on circular knit machines in any one of three different types of construction. The machines may be complex, utilizing either spring or latch needles employing sinker-top, dial, cylinder, or dial/cylinder mechanisms. With this equipment, various effects can be produced.

Three thread fleece:

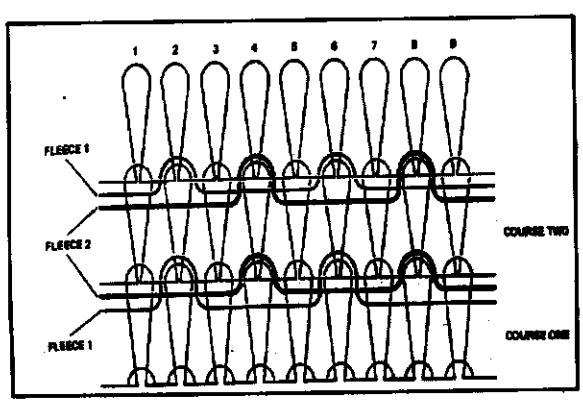
One type of fleece knit construction is the three-yarn system, where three yarns are fed sequentially from separate yarn positions around the cylinder of the machine. The first yarn is the backing or fleece yarn. The second and third yarns are the tie-in and ground yarns which are fed successively in a plaiting relationship and knitted so that the fleece yarn is caught at predetermined intervals between them. This results in the fleece yarn being floated on the technical back of the fabric and held in place by the wales of plaited tie-in and ground yarns. The technique hides the fleece yarn from the technical face so that it will be exposed only on the back. The fleece yarn, which may be coarse spun and low twist, can thus subsequently be readily napped and given other surface finishes.



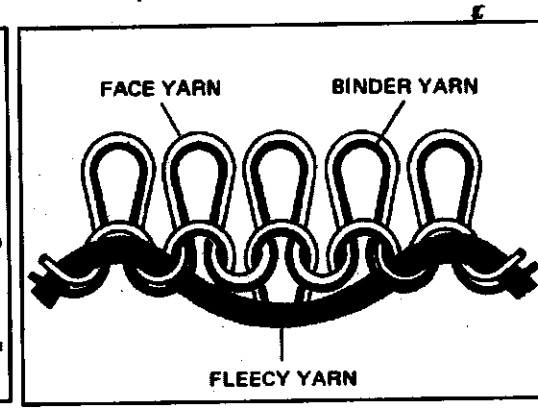
Schematic of three-yarn fleece construction

Two thread fleece:

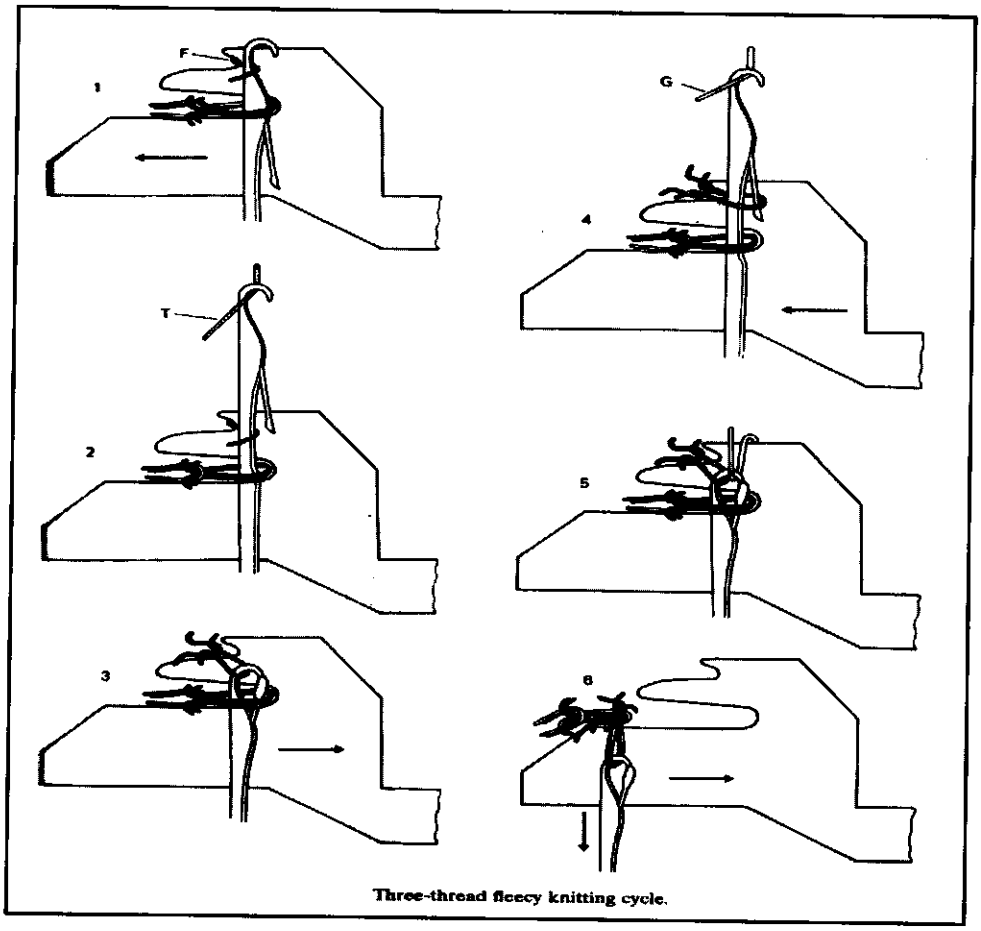
Another type of fleece knit is the two-yarn system. One yarn, which provides the ground or body is knitted in either a single or double jersey construction. The second yarn, which may be coarser and heavier to accommodate subsequent napping, is the floating or inlay yarn that is tucked at predetermined intervals on selected needles. This is the most productive method of making fleece knits, but there is a disadvantage of "grin-through" to the technical face unless it is camouflaged by knitting design effects, such as a double lay-in.



Schematic of two-yarn double lay-in fleece construction



Structure of pile knit showing sliver yarn before raising



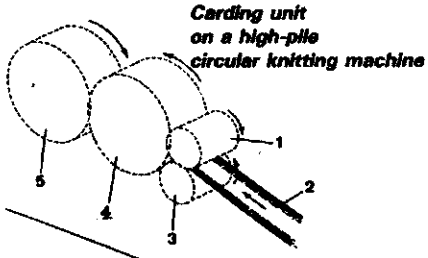
Three thread fleecy knitting cycle

Single thread fleece:

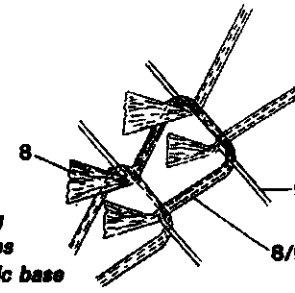
The third type of fleece construction is the one-yarn system. A single or plied yarn is knitted according to a predetermined pattern of knit and tuck combinations that would provide floats which are to be subsequently napped. Since the yarn must be strong enough and fine enough for knitting purposes, the use of coarse, low twist yarns are precluded. The use of only fine yarns as well as the resulting additional napping and other finishing costs makes this type of fleece more expensive.

High Pile Knit Fabrics or Sliver Knit Fabrics:

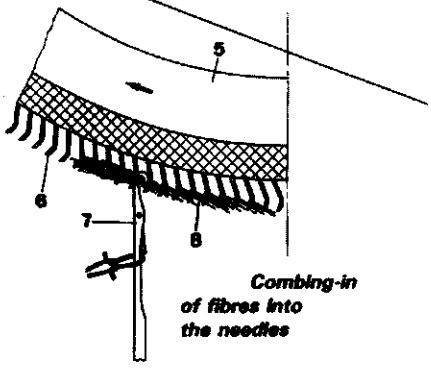
Both weft and warp knitting machines are used to produce imitation fur fabrics and rugs utilizing acrylic, modacrylic, polypropylene, or nylon as determined to be appropriate for the end product. The fabrics are similar in appearance to their original counterparts but are more flexible and have better drape. These fabrics are lightweight and easy to care for. They usually can be laundered and cold tumble-dried, unless the garment construction requires dry-cleaning. When the pile is crushed or distorted due to washing, packing, or storing, it should be combed or brushed with a soft or medium bristle brush.



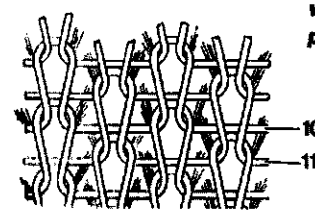
Carding unit on a high-pile circular knitting machine



Binding of fibres in fabric base



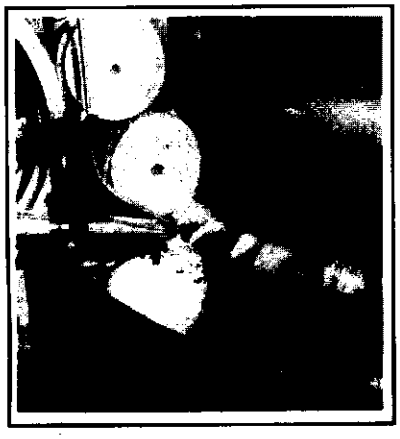
Combing-in of fibres into the needles



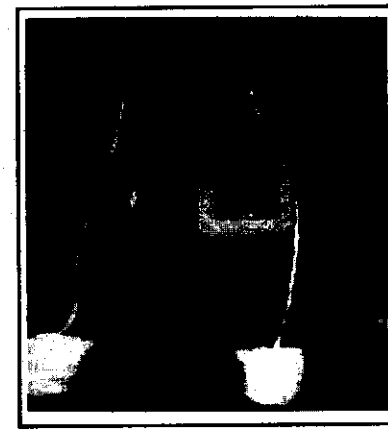
High-pile fabric with 1:1 staggered plain structure

Legends for Figures

1	*feed roller*
2	*sliver*
3	*feed roller*
4	*carding roller*
5	*doffer*
6	*wire*
7	*needle*
8	*fibres*
9	*ground yarn*
10, 11	*stitch rows 1:1*

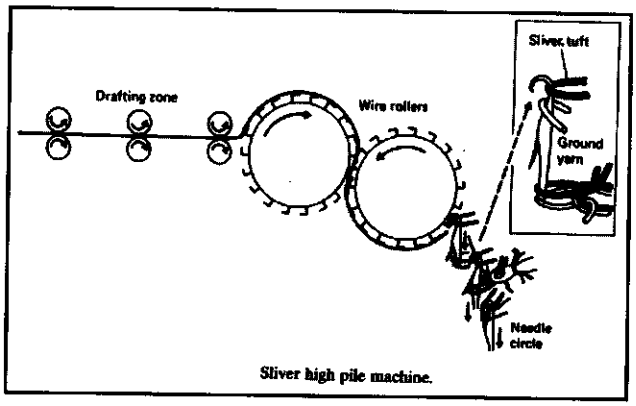


Feeding-in of fibres into selected needles



High-pile circular knitting machine

The techniques for knitting high pile fabrics are quite complex. The slower and more common method uses a plain knit with heavy yarn for the background and a carded sliver for the pile. As the needles pull the ground yarn to form loops, they catch and draw the sliver through, causing the fibres to get locked into place as the stitch is tightened. Production runs from 5 to 11 yards (4.5 to 10m) per hour.



Sliver high pile machine

The production of sliver or high-pile furry fabrics on circular knitting machines is based on the plain technique, using latch needles and holding-down/knocking-over sinkers. Special equipment, a so-called carding device, is employed to feed-in fibres into the latch needles at each knitting feeder. Normally each carding unit consists of two feed rollers for the sliver, a carding roller and a doffer. The feed rollers draw in the sliver and present it to the carding roller, which has a much higher surface speed in relation to the feed rollers. As a result the fibres are stretched (laid more or less linear) and parallelised. The doffer takes over the fibres from the carding roller and combs them into the needles with specially shaped wires. At this fibre combing point the needle is in cleared position.

For the production of coloured or structure-patterned high-pile fabrics, or combinations containing colour and structure, the needles at each combing point are selected according to the pattern in order to obtain fibres of the corresponding colour. It can be seen that the combed-in fibres are processed together with the ground yarn during loop formation. The fibres protrude from the fabric base on the technical left side.

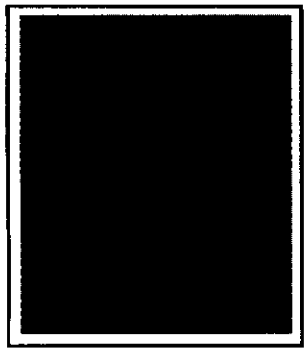
A faster method uses circular-knitting units operating on a cut loop and ground-yarn principle. Another technique is the cut-pile and ground-yarn method on a Rachel machine. High-pile fabrics can also be made on double-knit equipment to knit plain and Jacquard fleece with the aid of special devices including an inlay yarn carrier.

Plush Fabrics or Knitted Terry Fabrics:

Knitted terry fabrics are made of a variation of the jersey knit construction where two yarns are fed simultaneously into the same needles. The fabric is knitted by a plaiting technique which causes one yarn always to appear on the face and the other always on the back of the cloth. As the fabric is knitted, the face yarn is pulled out by small devices to form the loop pile, leaving the other yarn to serve as the ground. Knitted terry is produced in weights ranging in suitability for robes and beachwear to fashion apparel.

Circular knitted plush or terry is a fabric with yarn loops protruding from the fabric base on one or on both fabric sides. Most of the plush fabrics produced have one-sided loops. Plush can be

produced on plain or rib circular knitting machines. The most common method of production uses the plain circular knitting technique with combined holding-down / knocking-over sinkers for making one sided plush fabrics. The loops are actually enlarged sinker loops and they protrude from the fabric base on the technical left side.



Face side

Back side

The most important demands are a firm fixing of the plush loops in the fabric base and a very uniform loop length. The more uniform the loop length is, the less material is lost when the loops are cut to produce cut-pile fabrics. Therefore the base fabric should not be too loosely stitched. On the technical right side a precise plating of the plush yarn through the ground yarn is extremely important during the cutting process for cut-pile fabrics. In usage this pre-requisite is largely responsible for the firmness of the pile.

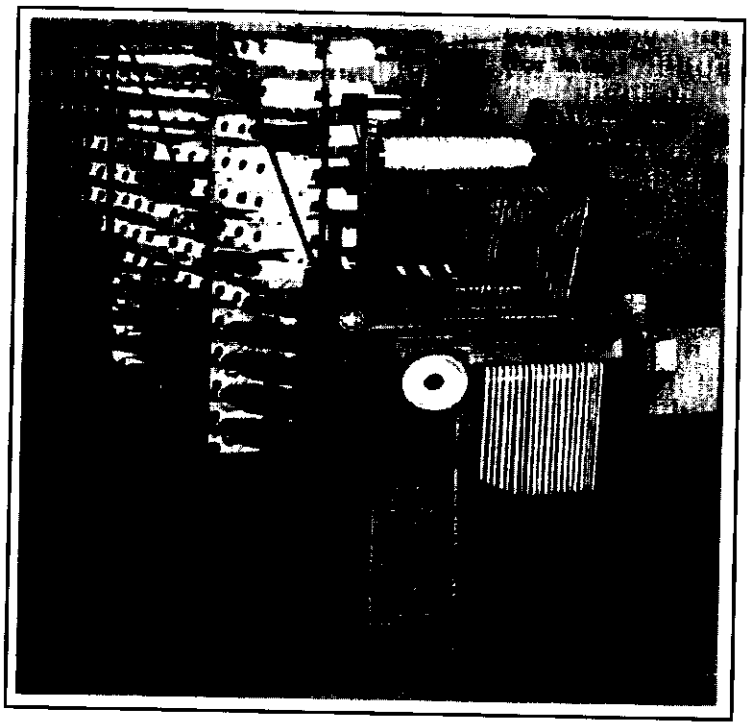
Single-sided plated plush or terry is a popular leisure and sports wear structure found in both fabric and sock form having the form fitting elasticity of single jersey. The elongated plush sinker loops show as a pile between the wales on the technical back as a result of having been formed over a different surface to that of the normal length ground sinker loops with which they are plated.

Terry knits tend to be more flexible, softer, and more absorbent than woven terry cloth. However, they are not as sturdy or durable. They do not hold their shape as well and they tend to snag, causing the loop yarn to pull and trail. Should such a pull occur, it should not be cut because it would cause a run. Rather, it should be drawn through to the back of the material.

Velour Knit Fabric or Henkel plush Fabric:

Knitted velour fabrics are constructed in the same manner as knitted terry. After the material is knitted, the loop pile is sheared at a uniform height and then brushed. So velour is achieved during finishing by cropping or shearing the loops in both directions, to leave the individual fibres exposed as a soft velvety surface whilst the ground loops remain intact. It requires a fine gauge structure and involves a considerable loss of cropped yarn. The bearded needle sinker wheel machine has long been renowned for this type of fabric construction. This produces a soft, suedelike surface that is somewhat like that of velvet. However, knitted velour is softer and has better drapability. It is used for such fashion apparel as men's shirts and women's dresses.

The Crochet Warp Knitting Machine



Crochet Warp Knitting Machine

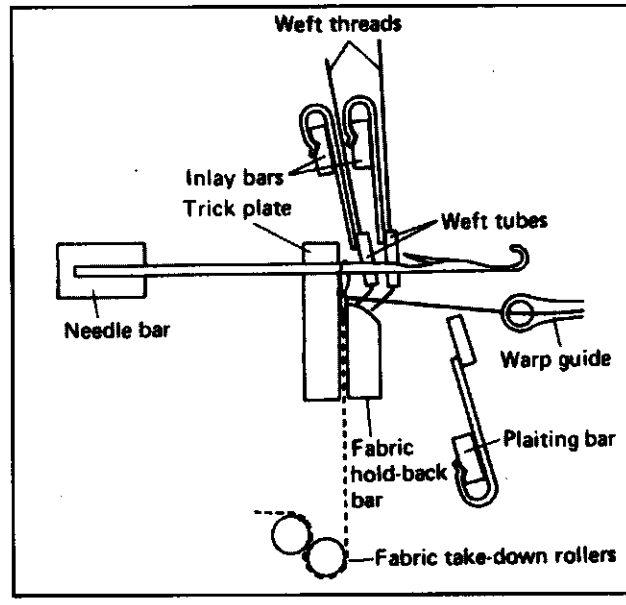
Features of a Typical Crochet Machine:

On crochet machines, the warp chains are separate from the weft inlay and it is the latter threads which join the chaining wales to each other. The crochet galloon machine, as developed by Sander and Graff and popularized by kholer, is essentially a highly versatile Raschel with the following unique features:

a) A single horizontal needle bar whose simple reciprocating action can be used to operate individually tricked latch, carbine or embroidery needles.

b) There are no sinkers, instead a fixed hold-back bar is fitted in front of the knock-over verge to prevent the fabric moving out with the needles.

c) The closed lap pillar stitches and inlay threads are controlled and supplied as separate warp and weft respectively. Each needle is lapped from below by its own warp guide which is clipped to a bar whose automatic one-needle overlap and return underlap shog is fixed and is controlled from an eccentric cam whilst its upwards and downwards swing is derived from a rocker shaft.



Knitting Elements in a Crochet warp knitting machine

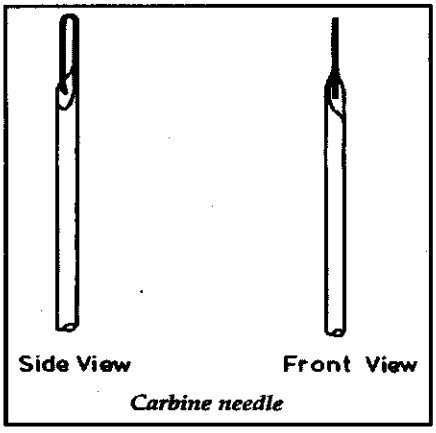
d) The warp yarn is often placed low at the front of the machine. The weft yarn, which is often placed above and towards the back of the machine, supplies the carrier tubes clipped to the spring-loaded inlay bars fitted above the needle bar and shogged at the rate of one link per course from pattern chains around a drum at one end of the machine. There are usually up to two warp guide bars and up to sixteen weft inlay bars, which may be mechanically or electronically controlled.

e) Special attachments are available for producing fancy effects such as cut and uncut fringe edges, pile, braiding (equivalent to fall-plate) and snail shell designs.

f) Very approximately, the knitting widths of crochet machines may vary between 16 and 122 inches (400 mm and 3100 mm), in gauges often expressed in needles per centimeter between 2 and 10 (E 5 to E 24) and machines run at speeds between 200 and 350 courses per minute.

Needles used in Crochet Machine:

- **The patent or carbine bearded needle:** It (A needle similar in shape to a bearded needle but with the beard shielded by a shoulder on the stem. The needle may only be lapped in one direction for the yarn to pass under the beard. A presser is not necessary as the needle is self-acting, the shoulder passing the loop on to the beard. It is mainly used in crochet-type machines) is used for fine structures and has a sideways crimped beard placed in a permanently-pressed position. Although warp threads can only be fed into the beard from the left, the old overlaps are automatically cleared and landed by the movement of the needle. It is still the most frequently used needle, achieving speeds up to 2500 rpm. Reduced machine speed and high needle wear make its use uneconomical for knitting single end cotton yarns.



Carbine needle

- **Embroidery or Lace needles:** They are carbine needles with pointed heads that can penetrate pre-woven structures to produce embroidery effects. The needles can be arranged for coarser gauges or for fancy set-outs, when the floating inlay threads may be cut to produce separated fringed edgings.

- **The compound needle:** It patented by Müller produces less stress on the yarn during loop formation so a wider range of yarns can be used, and compound needles last up to six times longer than bearded needles.

- **Latch needles:** It operate at uneconomic speeds and have a short life due to latch breakage.

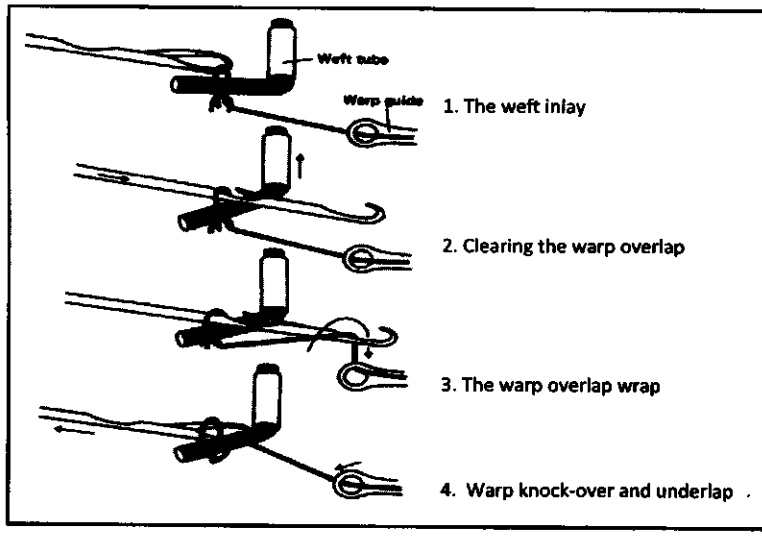
The knitting action of The Crochet Machine:

The knitting action or stitch formation to produce one course of loops on a crochet machine equipped with latch needles consists of the following stages:

1. The weft inlay
2. Clearing the warp overlap
3. The warp overlap wrap
4. Warp knock-over and underlap

The essence of these stages consists in the following operations:

1. **The weft inlay:**
   Whilst the needle is withdrawn into its trick, during knock-over of the previous of warp overlaps, the weft inlay tube is lowered so that, as it traverses in an underlap shog, the weft is laid below the level of the needle and on top of the warp thread which extends from its head to the warp guide.
2. **Clearing the warp overlap:**
   The weft tube rises slightly on completion of its traverse movement to allow the needle to move out of its trick to clear its old warp overlap.
3. **The warp overlap wrap:**
   The warp guide rises between the needles and automatically overlaps from the left lowering itself again on the right side of its needle.

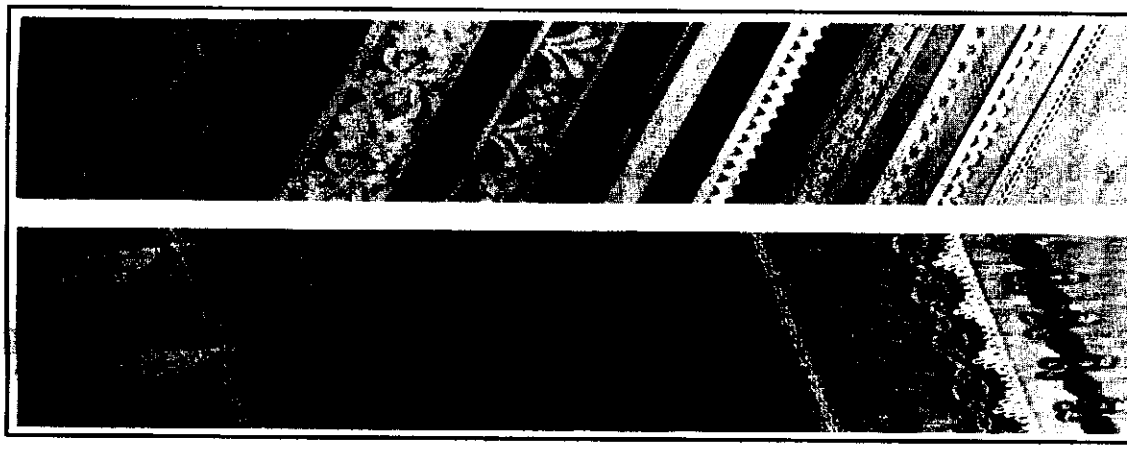


Knitting action of a Crochet warp knitting machine

4. **Warp knock-over and underlap:**
   The needle now retires into its trick to knock-over the old overlap, whilst the warp guide is cammed under its needle to the start position for its next overlap thus completing the closed lap pillar

Products of the Crochet Machine:

Crochet machines, with their simple construction, ease of pattern and width changing, and use of individual yarn packages or beams provide the opportunity for short runs on coarse-gauge or fine-gauge fancy and open-work structures and edgings or trimmings, as well as the specialist production of wide fancy fabrics or narrow elastic laces. Crochet machine finds wide spread application in the production of various types of edgings or trimmings, so it is sometimes described as a "Trimming machine". A range of crochet fabrics is illustrated in the following figure.



Different types of Crochet Fabrics

The Straight Bar Frame

The main features of a Straight bar frame:

The Straight bar frame is a special type of weft knitting machine. It has the following unique features:

- Straight bar frames is a specific type of machine having a vertical bar of bearded needles whose movement is controlled by circular engineering cams attached to a revolving cam-shaft in the base of the machine.
- The length of the machine is divided into a number of knitting heads (sections or divisions) and each head is capable of knitting a separate but identically-dimensioned fashion-shaped garment panel.
- The needles press their beards against a fixed pressing edge; loop formation prior to intermeshing is achieved by individually horizontally-moving loop-forming sinkers, and knock-over occurs when the needles descend below the knock-over bits.
- At either edge of each knitting head, a group of rackably-controlled points transfer loops to fashion shape the garment panel at the selvedges by widening or narrowing the knitting width. On completion of the garment panel, it is pressed-off the needles.

Knitting motions of the Straight bar frame:

The three directions of motion required for the knitting action are provided from two separate sources. The rotary motion of the cam-shaft produces the vertical and horizontal movement of the fashioning points and the needle bar. The sideways reciprocating movement for the yarn carriers and for introducing the sinkers in seriatim sequence via the slurcock is obtained from a coulier or draw cam attached to a shaft set at right angles to the main cam-shaft at the back of the machine, which oscillates a draw lever. A variable draw ensures that the stroke of the draw is related to the varying knitting width thus more courses per minute are knitted on narrower widths. Operating speeds of a hundred courses per minute can be achieved.

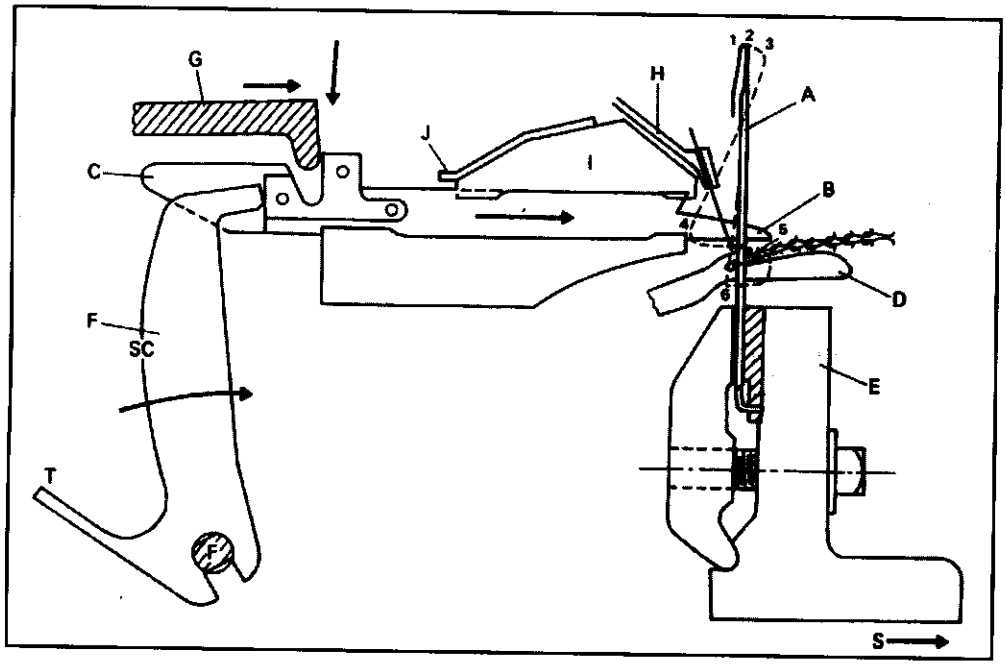
The knitting head of the Straight bar frame:

The following figure shows the cross-section of the knitting head containing the different elements:

A. Bearded needle, having a cranked end for location in the tricked and drilled needle bar.
B. Sinker, only one between every other needle space, with a reinforced back and at the front, a catch to sink the yarn around the needles, and a 'neb' to separate the old and new loops until knock-over.

C. Divider, occupying each remaining space, usually having the same shaped front as the sinker but with an extended tail at the back.

D. Knocking-over Bit, one directly beneath each sinker and divider, having a 'throat' for holding the loops and a 'nose' for knocking-over.



Knitting head of a Straight bar frame

E. Needle Bar, having a compound horizontal and vertical movement.

F. Striking Jack, fulcrummed at its lower end, each with its nose resting on a sinker back, and a 'spring' exerting pressure on its 'tail'.

G. Catch Bar, extending the full width of the knitting head, having forward and backward, as well as vertical movement.

H. Yarn carrier, which traverses in alternate directions across the head from one course to the next, up to six carriers may be available. The carrier is connected to a reciprocating carrier rail by friction and when the carrier is arrested by its carrier stop, the carrier rail completes its full traverse, driven by the coulier cam by punching through the carrier friction.

I & J. Falling Bar, is a stop which cushions the advance of the sinkers and dividers.

Knitting action of a Plain Straight bar Frame:

The following figures show the movement of the knitting elements to produce one course of loops:

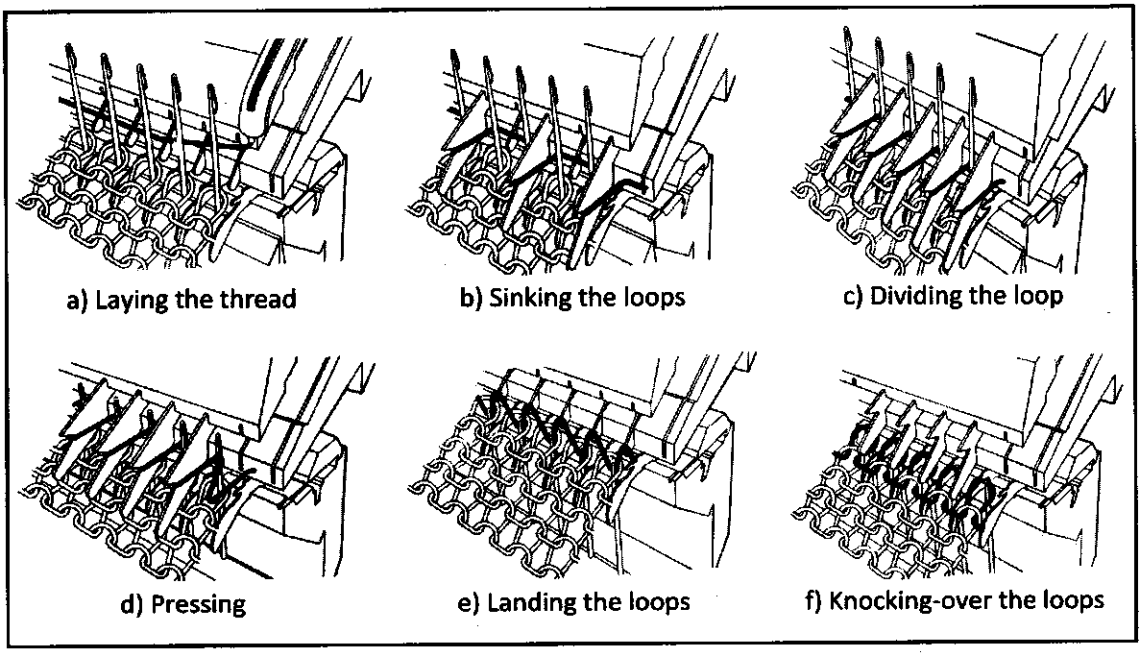
a) Thread laying:

The carrier moves across the knitting head laying the yarn on the noses of the sinkers and dividers and the beard side of the needles.

b) Sinking:
The slurcock (one for each knitting head) travelling behind the carrier, contacts the jacks and is shaped so that each jack in turn pushes its sinker forwards to kink a loop around every two adjacent needles.

c) Dividing:
The catch bar moves the dividers forwards collectively, whilst the needle bar tips slightly outwards to allow the double loops to be divided into equal sized needle loops around every needle.

d) Pressing and e) Landing:
The needle bar descends placing the new loops inside the hooks of the beards. The catch bar is now lowered so that the sinkers as well as the dividers are collectively controlled by it for the rest of the knitting cycle. They now start to withdraw. The needle bar moves towards the sinker verge causing the beards to be pressed. A further downward movement of the needle bar 'lands' the previous course of loops, resting on the knocking-over bits, on to the closed beards.



Knitting action or Movement of the knitting elements to produce one course of loops

The drop-off: As the needle bar moves away from the pressing-edge, the sinkers and dividers withdraw so that the newly-formed course of loops drops off their noses onto the knocking-over bits.

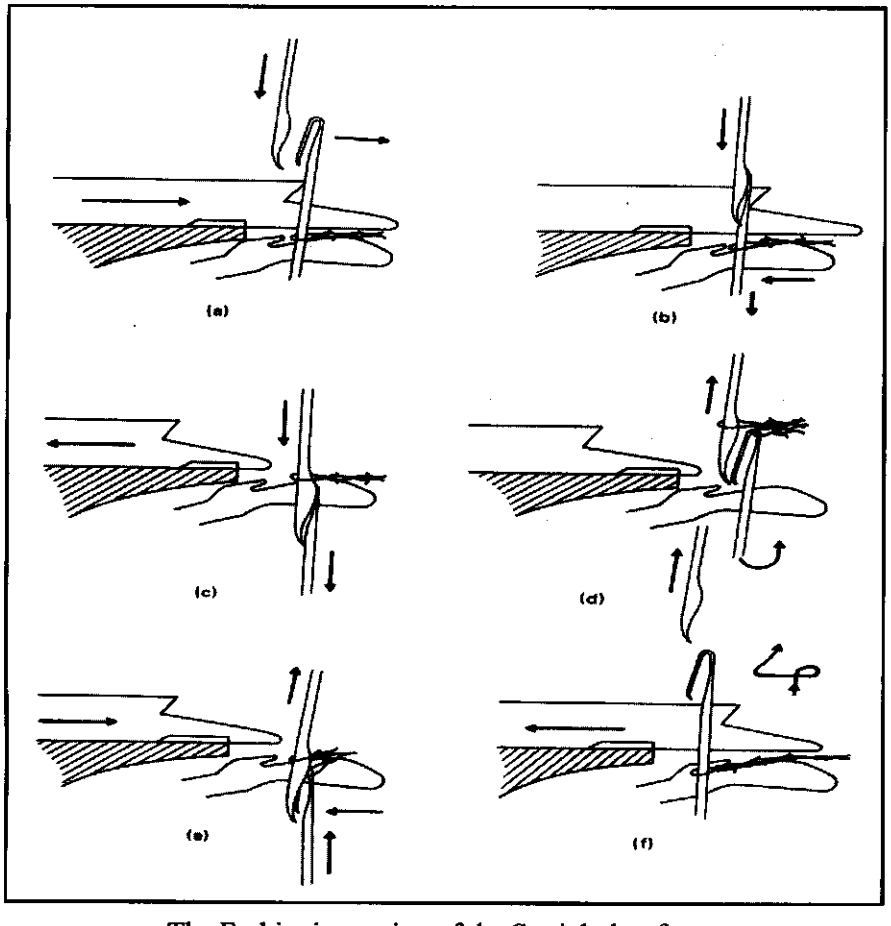
f) Completion of knock-over:
The needle bar descends to its lowest position. As the heads descend below the belly of the knocking-over bits, the old course of loops is collectively knocked-over.

Holding –down: As the sinkers and dividers move collectively forward to hold down the fabric, the needle bar rises to the thread-laying position. The catch bar is slightly raised to release the sinkers for individual movement at the start of the next course.

On coarser gauge machines it is possible to accommodate sinkers with reinforced butts between every needle space thus eliminating dividers and their action. Some machines have selvedge dividers with a lower forward ledge so that when the yarn carrier stops over one divider the next divider inwards from it will be the last to take that traverse of yarn which will slide into its specially-shaped lower throat and form a tight selvedge.

The Fashioning action of the Straight bar frame:

The fashioning action or loop transfer for either narrowing or widening is performed in following steps:



The Fashioning action of the Straight bar frame

a) The fashioning points or transfer needles descend and the needle bar tips backwards to clear them.

b) The needle bar moves towards the points causing the beards of needles engaged with points to be pressed and boxed or located in the grooves of the points.

c) The sinkers and dividers, which are collectively controlled by the catch bar, retire, and the needles and points descend together below the knocking-over bits so that the loops are cast-off onto the points.

d) The needles and points now rise and move clear of each other so that the points can make the sideways 'fashion rack' at the selvedge either by one needle for widening or by one, two or four needles for narrowing.

e) The needles and points now descend and the needles box with the points again so they receive the transferred loops. As the needles and points descend below the sinkers, the sinkers and dividers move forwards to hold down the loops.

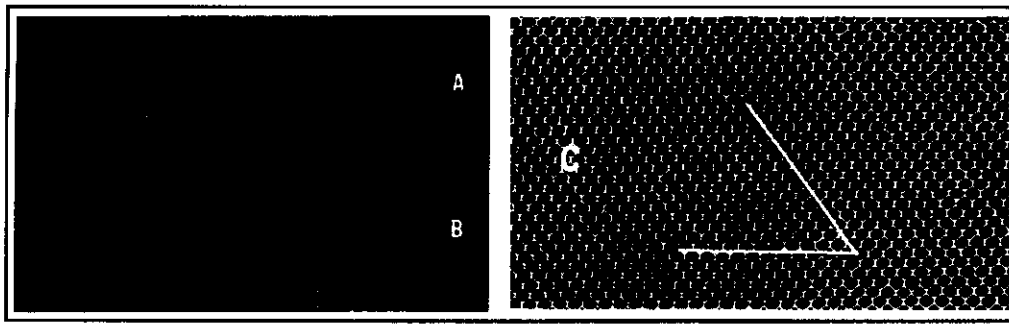
f) Once the needles have slid up into the grooves of the points to receive the loops, the points rise to their high inoperative position. The needle bar rises causing the transferred loops to slip down onto the stems and the cam shaft is shogged back to the left again so that knitting can restart.

Netting or Net Fabrics

The main features of Net fabrics:

Netting is an open-mesh form of fabric construction that is held together by knots or fused thermoplastic yarns at each point where the yarns cross one another. There are several types of mesh; they are square, hexagonal, and octagonal. The range of mesh sizes is from coarse and open to fine and shear. Netting may be made of any kind of fibre and may be given a soft or stiff sizing. Net fabrics are relatively fragile and require care in handling and cleaning. Torn net fabrics cannot be satisfactorily mended because the repair would be apparent. If the sizing is water soluble, the fabric should be dry-cleaned.

Early nets were made by hand-knotting yarns at each point of intersection to produce a specific geometric pattern. Prior to 1809, nets were made by hand, but in that year a new machine produced knotted nets so like hand-knotted fabrics that few people could distinguish between them. The comparatively large mesh of knotted nets does not slip, spread, or distort during use. Knotted nets are used for hammocks and fishing nets.



A - Tulle, B - Net, C - Bobbinet fabric

In recent years most light weight nets have been constructed on either Tricot or Raschel knitting machines, so the yarns are only interlooped and not knotted. These knitted nets lack the stability of those constructed by knotting. Their primary use is in apparel, although some are used as decorative window hangings.

Types of Nets:

There is a variety of netting; some are produced under specific trademarks. Among the best known standard fabrics are noted here. These nets are classified as bobbinet, fishnet, filet, maline, or tulle.

- **Bobbinet:** It is a hexagonal mesh that may be very thin and transparent (bridal illusion) or fairly coarse and opaque (casement cloth), depending on the yarn count of the material used to produce it. Most bobbinet sold in the United States is produced in England and France.
- **Tulle:** it is a fine, stiff hexagonal net made from silk or nylon yarns. It is very similar to bobbinet but lighter in weight than bridal illusion; some references do not separate bobbinet and tulle. It is generally used for trimming or over draping of dress goods.
- **Fishnet:** It is a coarse open-mesh construction created by knotting the mesh in a manner similar to a fisherman's knot.
- **Filet net** is made with a square mesh, and **maline net**, used in millinery, is a fine, very thin, diaphanous, open diamond shape with hexagonal holes.

Lace Fabrics

The main features of Lace fabric:

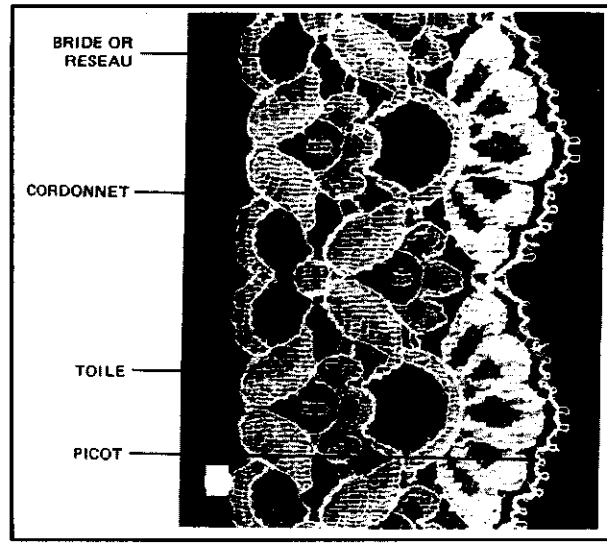
Lace is an open work fabric consisting of a network of yarns formed into intricate designs. Lace may be hand or machine made, and intricate patterns can be produced by either technique. Both narrow and wide lace fabrics are available. The edges of the fabric may be straight or curved.

It is an important trimming, for it is used for table cloths, curtains, handkerchiefs, dresses, and underwear. Lace consists of two elements:

- The pattern, flower, or group, which forms the closer-worked and more solid portion, and
- The ground or filling, which serves to hold the pattern together.

Parts of Lace Construction:

In identifying various kinds of lace, references have been made to their designs. These patterns are constructed of different parts, each having a particular designation.



- Bride, or Reseau: It is the fine yarn that forms the mesh which provides the sheer ground (background) between the prominent parts of the pattern.
- Cordonnet: It is the heavy yarn that outlines the pattern.
- Picot: It is a decorative loop used both in the pattern and on the edge of the lace.
- Toile: It represents the predominant parts of the pattern made by braiding, knotting, looping, or twisting the yarn.

Uses of Laces:

Lace is a decorative fabric used in apparel and home furnishings. Narrow laces are used for trims and insertions; wide lace fabrics are used for curtains, table cloths, and garments.

Laces are made in different widths for different uses. For example, a narrow lace with a scalloped edge is used for trimming a baby's dress; a lace with slits or eyelets is so made that ribbon may be run through it.

There are seven major uses of laces:

1. **All-over laces:** An all-over lace is a fabric upto 36" wide with the design or pattern spread over the width of the fabric and repeated in its length. Many kinds of design motifs and colours are used. The fabric can be produced in widths of over one yard (1 m) that are devoid of scallops. The fabric is cut and sold from the bolt like woven dress goods. The dressmaker cuts it to pattern and makes it up into formal evening, dinner, and cocktail dresses and blouses.
2. **Flouncing:** Flouncing applies to laces 18 to 36 inches wide with a plain edge at the top and a scalloped edge at the bottom of the fabric. It is used for wide ruffles or flounces. Often these flounces are arranged in tiers to form a skirt.
3. **Galloon:** A galloon is a lace upto 18 inches wide with a scalloped edge at top and bottom. It may be used as an insertion between two cut edges of fabric, or it may be applique'd to a fabric in bands or as a border.
4. **Insertion:** Insertion is a band of lace sewn between two pieces of fabric or on a single piece of fabric at the straight top or bottom edges. A variety of insertion is footing, which has a straight edge at top and bottom but no pattern. Footing is often used at the bodice or at the bottom hem of a slip.
5. **Beading:** Beading has slots through which ribbon may be run. These slots may be found in edgings or galloons but are much more common in insertions.
6. **Edging:** An edging is a lace never more than 18" wide that is straight at the top and scalloped at the bottom. It is sewn to the edge of a dress, gown, blouse, handkerchief, or lingerie.
7. **Medallion:** A medallion is a lace in a single design that can be appliquéd to a fabric ground for ornamentation. It is sometimes used in the corners of napkins, or towels or as an ornament for a dress, blouse, or lingerie.

Quality and Care of Lace:

The quality of lace is determined by several factors. If it is made by hand, it is considered better than machine made. But the workmanship and the intricacy of the design are important. The kind of yarn (such as linen versus cotton), the fineness of yarn, and the closeness of the mesh are very significant.

The yarns used in lace are fairly tightly twisted to withstand the manipulations required to produce the material, so modern machine-made lace is less delicate than it appears. Lace

can snag easily. Whatever the quality, the construction of lace requires some care in handling to prevent snagging and pattern distortion. The material is quite open; thus, dimensional stability may be a problem in laundering and dry cleaning. Lace should either be laundered by hand or dry cleaned, depending upon its nature. If it is to be laundered, lace should be either washed by hand squeezing suds through it without rubbing or by putting it into a mesh or cloth bag and machine washing at a gentle cycle. Properly heat-set nylon and polyester lace can be handled with minimal difficulty. Ironing or pressing should be done carefully by placing a cloth over the lace to avoid tearing.

As was just indicated, lace is important in both clothing and home furnishings. The International Fabricare Institute suggests to consumers the following guide lines for the wear and care of clothing containing lace:

1. Laces snag and tear easily; even your jewelry can snag delicate lace. For this reason, extreme care must be used when wearing lace. Laces are difficult to mend and the mend is usually visible.
2. Lace clothing should have ample side and under arm seams which are well bound. Narrow seams will pull out with strain in wear.
3. Unfinished or machine-stitched button holes fray readily.
4. Protect lace, especially silk lace, from perspiration, deodorant, and antiperspirant damage, as this may weaken the fibres.
5. Lace garments should be folded and placed in drawers to relieve points of strain.

Types of lace:

The two main types of laces are "real" or handmade, and machine made. Linen thread is usually used for real lace and also expensive laces, but cotton, rayon, nylon, silk or other yarns are now used for various qualities and types and also for machine lace.

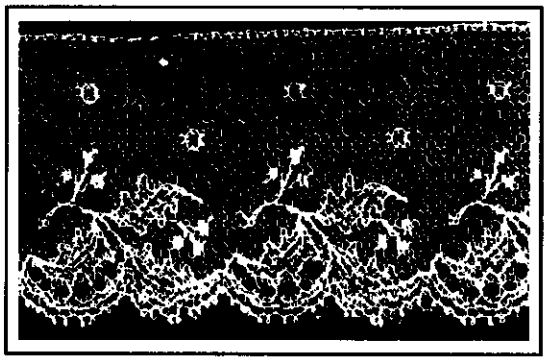
The former is softer, more irregular in mesh and pattern, and more expensive. Handmade laces are created by manipulating a single yarn or group of yarns with bobbins, needles, and hooks to produce intricate stitch formations. The major classifications of handmade laces are bobbin lace (pillow), needle point lace, crocheted (including Duchesse), embroidered lace, darned (including some filet lace), knotted, tatting.

Handmade laces have always been highly prized as trimming for apparel and as decorative pieces for the home. Unusually beautiful and intricately designed laces are retained in families as heirlooms and are displayed in museums as works of art. Today, such laces as needle point, bobbin, darned, crocheted, and knotted are duplicated so expertly by machine that the average consumer is not able to determine whether a lace is machine-made or handmade.

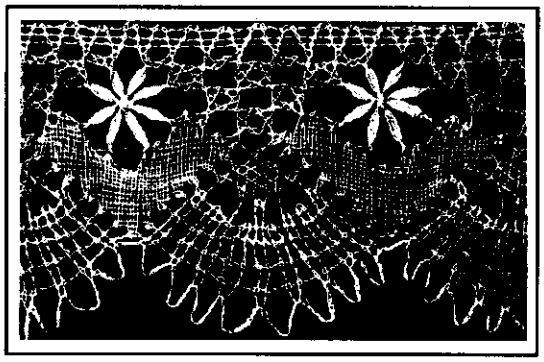
a) Handmade Lace or Real Lace:

1. Bobbin Lace:

Sometimes called pillow lace, the lace design is drawn either on a pillow or on a paper that is placed over the pillow. Small pegs or pins are stuck into the pillow along the design, and a large number of small bobbins of thread are manipulated around the pegs or pins to produce the lace. A number of threads, each on its own bobbin, are interlaced by twisting and plaiting around the pins to produce the motif in a mesh construction. As the lace is completed, the pins are pulled out and the lace is removed from the pillow. Making pillow lace requires great skill and dexterity, for as many as three hundred bobbins may be needed to make some patterns.

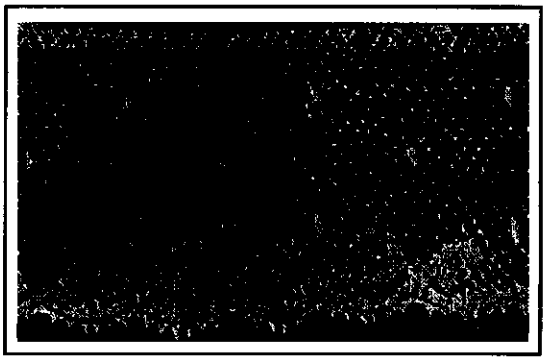


Chantilly lace

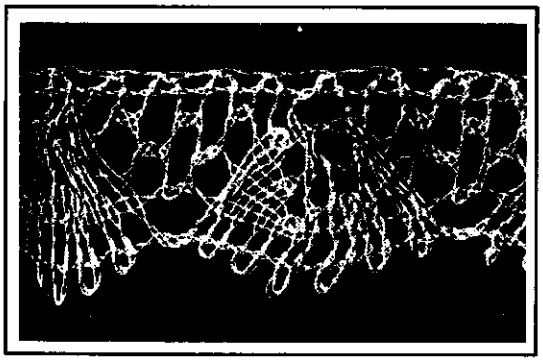


Cluny lace

There are several varieties of bobbin lace. Because of its exquisite large, clothy design, "duchesse" is the queen of the bobbin laces. Duchesse lace was originally from Bruges, Belgium. It has a tape like structure. Other bobbin laces are Binche lace, Chantilly lace,

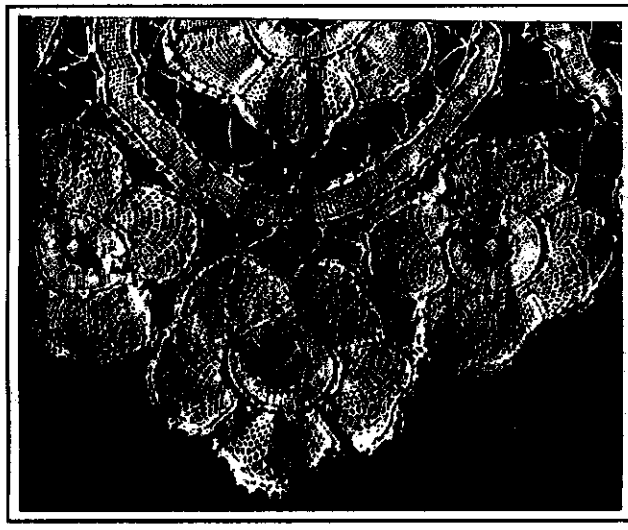


Val or Valenciennes lace

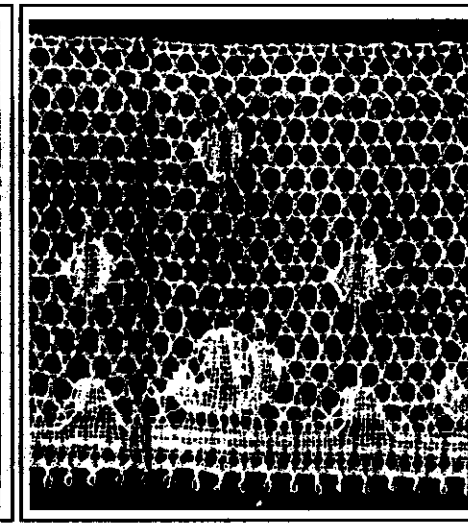


Torchon (Beggar's) lace

Cluny lace, Honiton lace, Lille lace, Maltese lace, Mechlin, Torchon (Beggar's) lace, and Valenciennes lace.



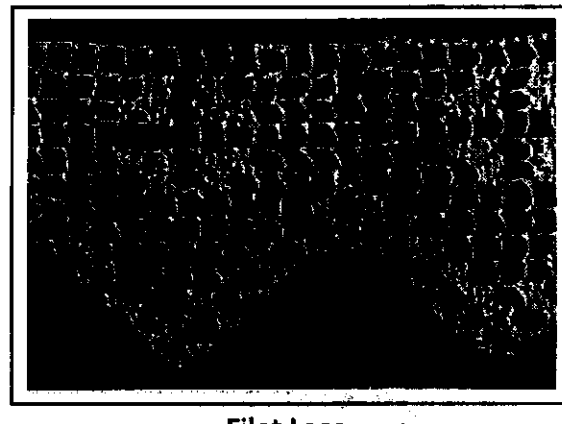
Duchesse lace



Binche lace

2. Darned Lace:

It has a design darned by a chain stitch onto a mesh background. When made by hand, the design of darned lace is sewn with thread and needle passed in and out of a mesh net. There are two principal types of darned lace.



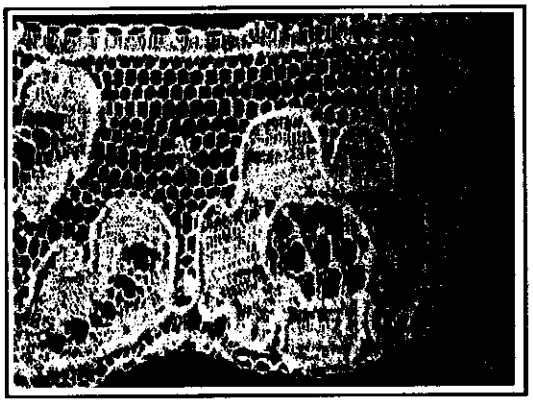
Filet Lace

Antique Lace – has a darned lace pattern on a rectangular mesh ground.
Filet Lace – has a darned lace design on a square mesh ground.

3. Needle point Lace:

The design for needle point is drawn on parchment stitched to a backing of stout linen, and the lace is made by filling in the pattern with button hole stitches. When the lace is completed, the parchment is removed. Needle point lace is made entirely with a sewing needle and thread. A design is drawn on paper, thread is laid over the design, and the thread is then sewn in place with button hole and blanket stitches.

The motifs are of birds, flowers, and scrolls or spiral decorations. There are several types of needle-point lace:



AlenÇon Lace

Venetian point Lace

AlenÇon Lace – has a solid design with a cord out line on a sheer hexagonal ground. It is delicate but durable.

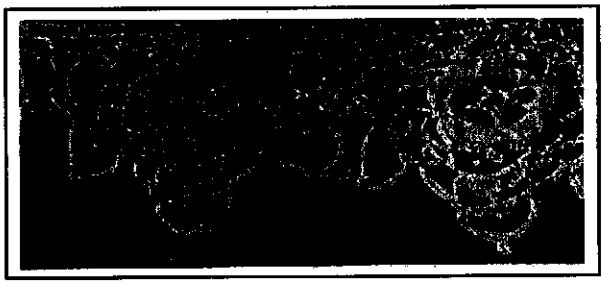
Milan Lace – is a tape lace with a needle point mesh and a loop (picot) edging.

Rose point Lace – is a Venetian needle point lace having a delicate floral and scroll pattern with a cord outline.

Venetian Lace – has floral designs joined by irregularly placed connections (brides) of loops and looped edges.

4. Crocheted Lace:

When handmade, this is made with a crochet hook, to form a series of loops, each one of which is finished with a fine stitch, working usually with specially twisted cotton thread. It originated in Ireland as an imitation of Venetian needle point. It is a comparatively inexpensive heavy lace. Irish crocheted lace (not necessarily made in Ireland) is typified by a rose or shamrock design that stands out from the background.

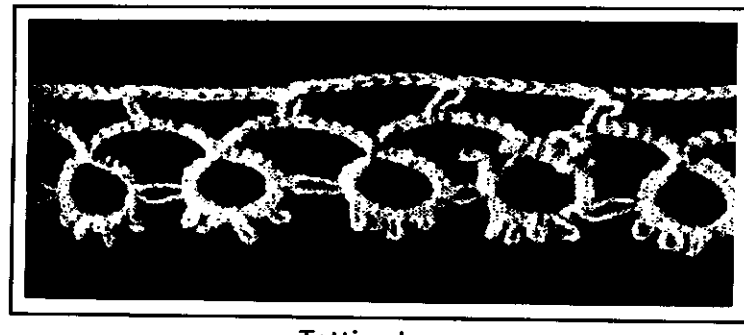


Irish lace

5. Tatting Lace or Knotted Lace:

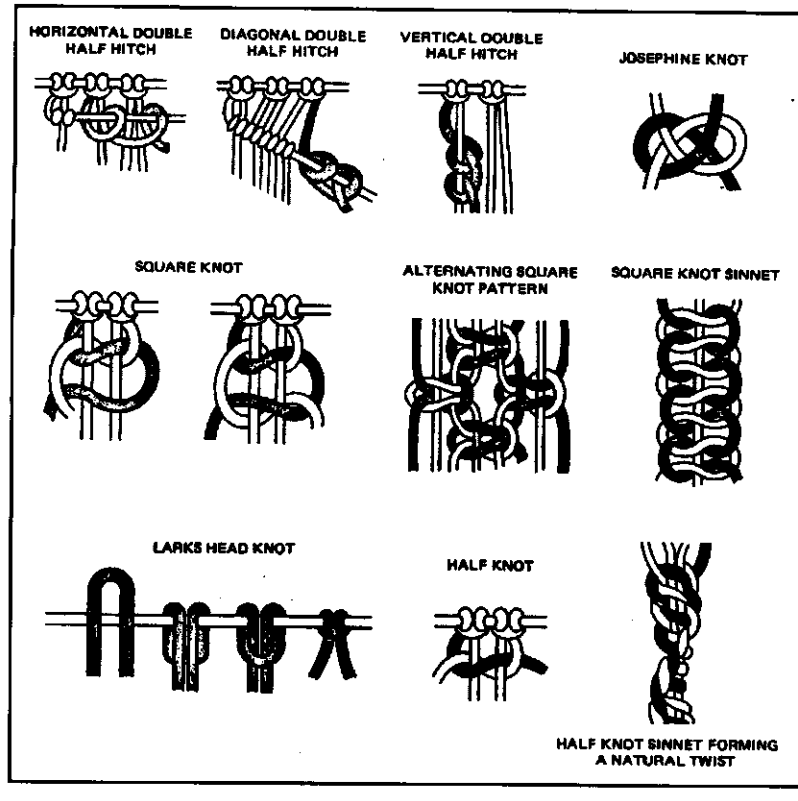
This is made by twisting and knotting thread by means of a small shuttle. When made by pass in a shuttle in and out of loops in a thread, it is called tatting. It is

identified by a circle like motif and picots around the edge of the motif. Clover leaf and wheel designs are the most popular, but other patterns are also made.



Tatting Lace

Macramé Lace – it differs from other laces in texture and appearance. It is generally made of heavy yarn knotted into relatively large designs. The following figures show the basic macramé knots and some variations. Unlike most other laces, it is used for such purposes as women's hats, hand bags, belts and vests.



Filet Lace: characterized by a flat, geometrical design, this lace may be either crocheted or darned. It is very common for house hold use, particularly for doilies, runners antimacassarset, and table cloths. It may also be used for dress trimming.

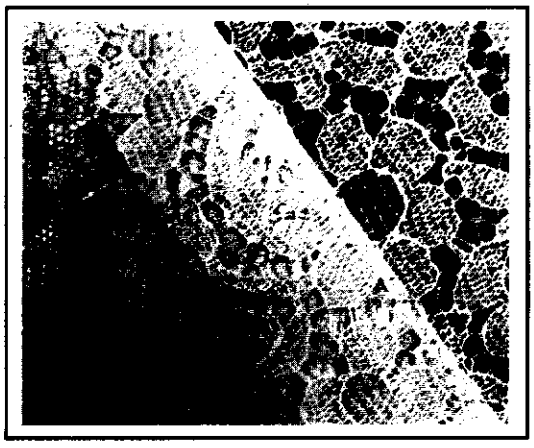
Carrickmacross

Breton

b) Machine Made Lace:

Nearly all the laces classified as "real laces" can be duplicated by machine with slight variations and simplifications.

Machinery for making looped net was invented about1764. But the forerunner of the present lace machine, the bobbinet machine, was patented by John Heathcote in the early 1800_s and was later modified by several other inventors, one of whom was John Levers, whose name has come down to us via the levers machine we now use. In 1813, John leavers developed his first lace machine and by 1837 the principle of the Jacquard loom punched card system was incorporated into the leaver's machine. Since then, several other lace making machines have also come into prominence.



Many of the laces available today are produced on raschel knitting machines or by embroidering a sheer base fabric. Knitted lace is predominant in the market. The name of a lace may derive from the city in which is originally produced or by design features that characterize a particular style. Some of the more common names are AlenÇon, Brussels, Chantilly, Cluny, Schiffli, Valenciennes, and Venetian.

A lace pattern is usually identified or described in terms of the ground mesh, the pattern parts, the basic stitches, and the construction technique used.

1. Leavers Lace:
   The leavers lace machine can produce the most intricate patterns from any type of yarn into fabrics upto ten yards wide. It is a huge, complex machine that takes an operator two to three weeks to thread. Very thin, round, brass bobbins containing up to 300 yds each are individually conveyed by carriages moving back and forth from one warp to another. As each bobbin is moved to a predetermined position, it swings between the warp yarns and wraps its yarn around one warp before it is moved to another. Since there are about 20 bobbins per inch, very intricate designs are possible. The fabrics can be fairly expensive. Leavers lace is used to a great extent in the dress industry.

2. Nottingham Lace:
   The Nottingham machine originated in Nottingham, England. It also utilizes swinging brass bobbins but produces a flat lace that is coarser than leavers lace. Its large overall patterns are used for such purposes as table cloths.

3. Bobbin Lace:
   The Bobbin machine employs the braiding principle. The lace produced has a fairly heavy texture, with an angular appearance and a uniform count. Bobbin lace lacks the fine texture and flowing lines of the laces produced by other machines.

4. Raschel Lace:
   Knitting machines can be constructed to make lace resembling levers and crocheted laces. The Raschel machine, which has its needles set horizontally instead of vertically as for knitting, can produce at high speed inexpensive lace fabrics of manmade filament yarns.

5. Ratiné Lace:
   It is a machine made lace that has a ground of heavy loops resembling that of terry cloth.

6. Schiffli Lace:
   Although the schiffli design closely resembles lace, it is produced by an embroidery technique on the Schiffli machine developed in St. Gall, Switzerland. It is produced now by Swiss descendants from St. Gall living in the northeastern part of New Jersey, around Union City.

   The machine was named Schiffli, which means "little boat", because of the shape of the shuttle. It employs 682 to 1020 needles to produce fine and intricate designs in appliqués and embroideries on all kinds of fabrics, particularly sheer fabrics such as batiste, lawn, and organdy. The pattern is controlled by punched cards similar to those used in the Jacquard loom. The finished material looks like expensive handwork but costs much less. The fabrics produced range from narrow trimmings to widths of up to 15 yards (14 m), including pile construction.