

# 1. Introduction

## 1.1 The different types of textile products and their processes

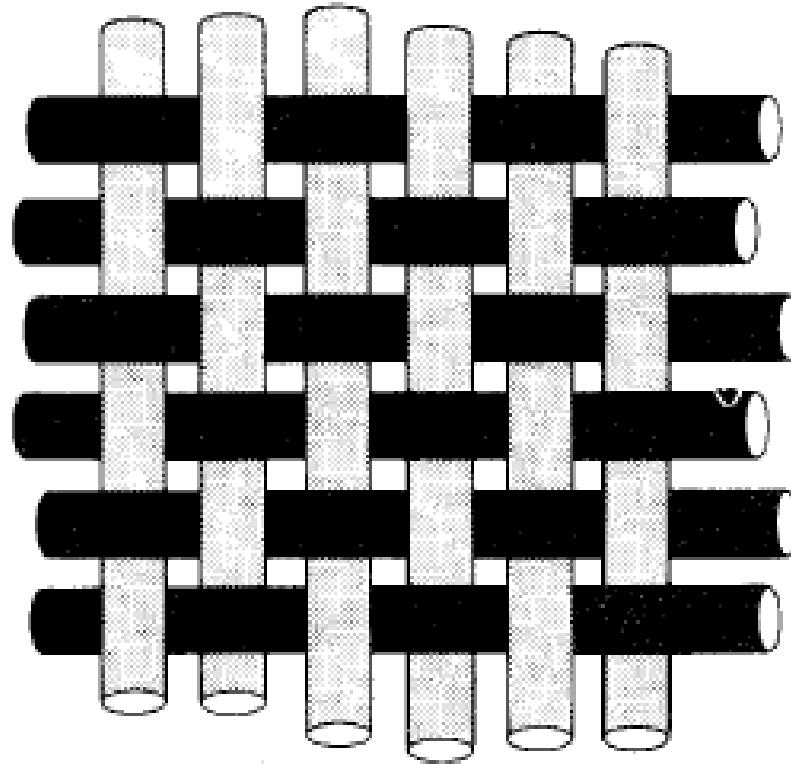
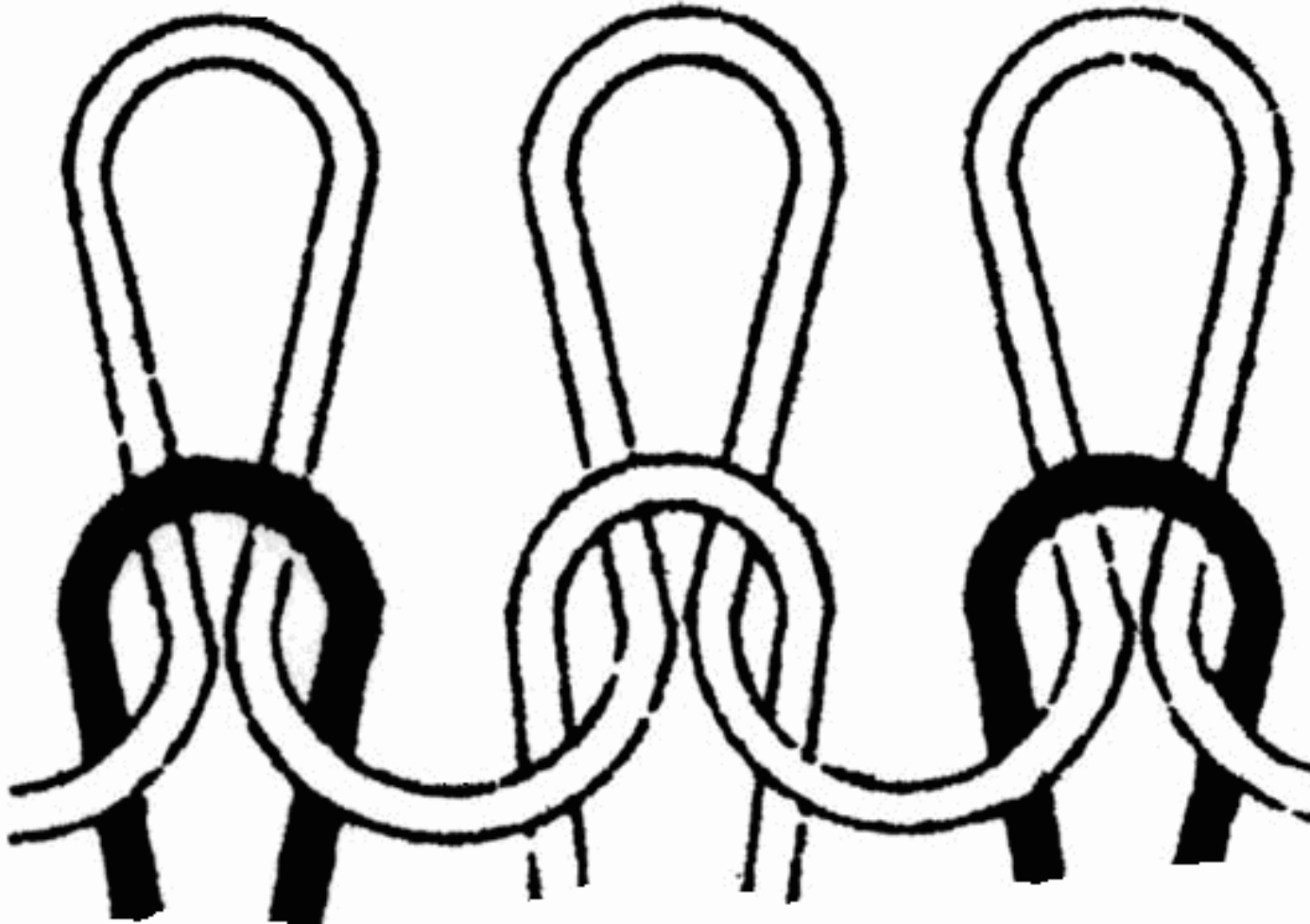


Fig. 1.1 Interweaving.

**1. Woven fabrics:** yarns cross each other at right angles/interweave



**2. Knitted fabric:** yarn is made in to a series of intermeshed loops

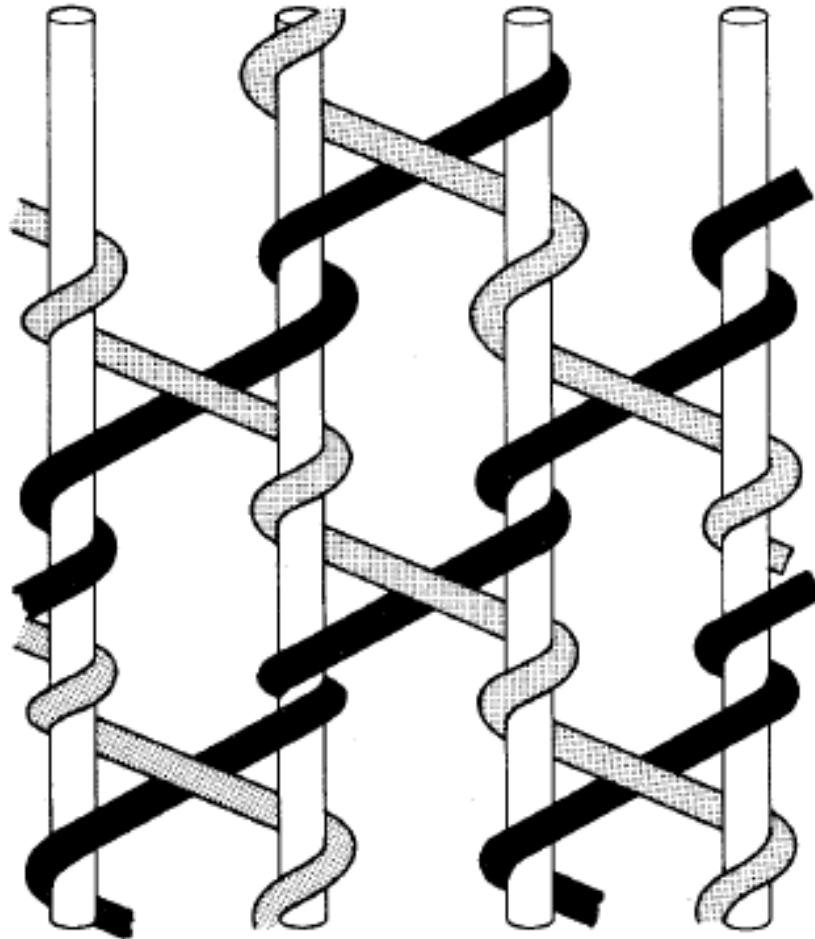


Fig. 1.2 Intertwining and twisting.

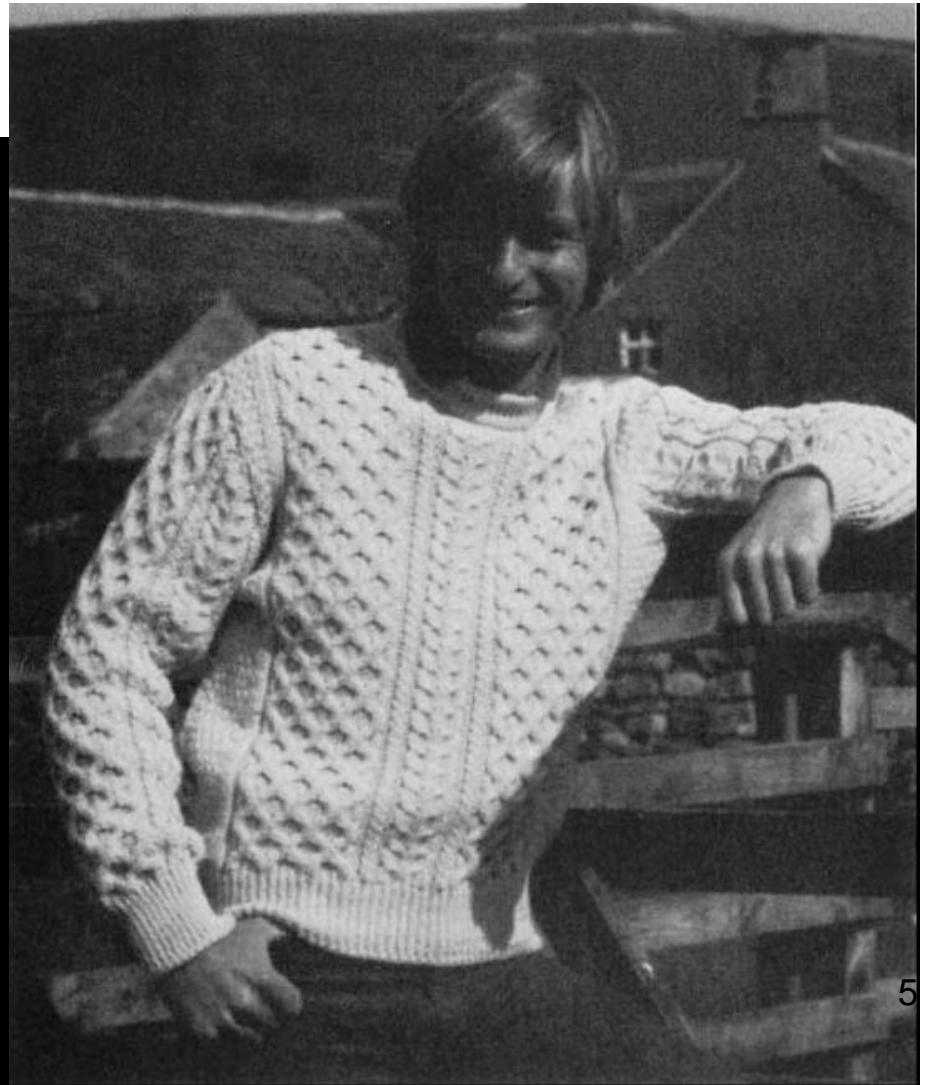
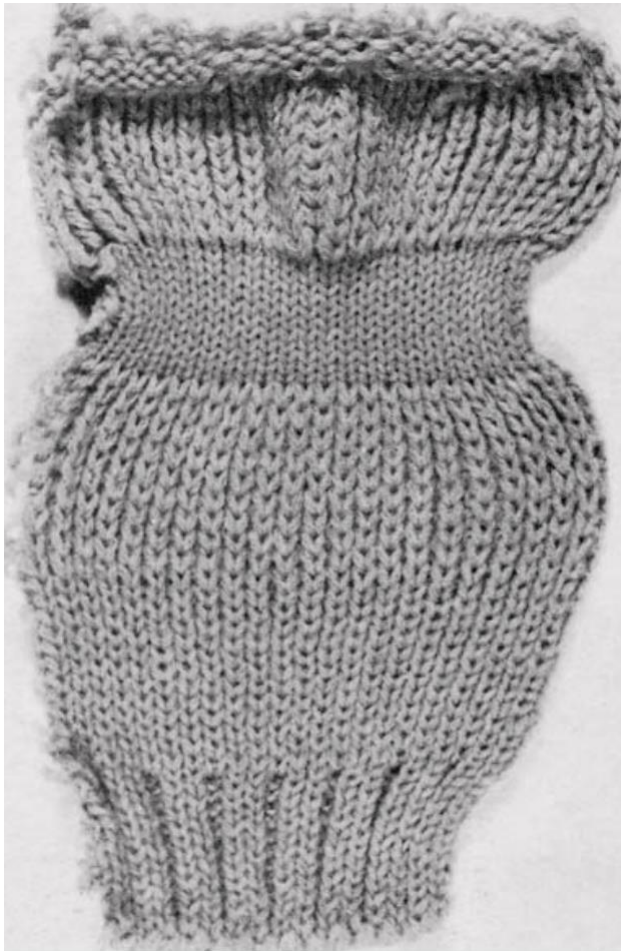
**3. Braided fabrics:** yarns are intertwined, twisted or knotted



**4. Non-woven:** fibers/filaments/yarns are bonded together

# 1.2. Application

## Apparel products



# Technical textiles



# 1.3. Development

- Hand pin knitting: 1st recorded in religious painting in 1350/14th century in **northern Italy**
- Christ's garment was expected to be made by **braiding**
- Stocking hand frame/ weft knitting: invented *in 1589 by William Lee*
- Many researchers made improvements/mechanized weft knitting was introduced in 17th century
- Warp knitting was invented in 1769 by Crane and Porter

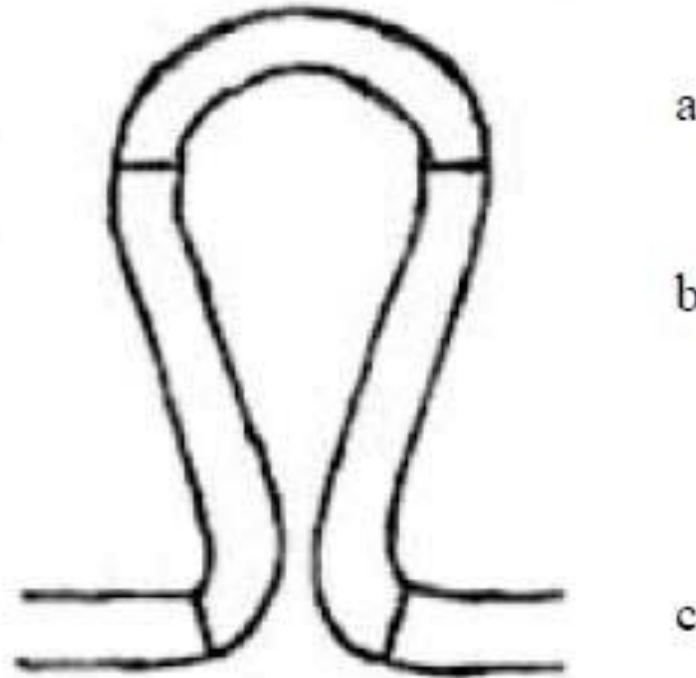
Modernized knitting like  
Seamless garment,  
Fully fashioned garments

are widely produced in Europe, Fareast,  
middle east

## ***1.4. Yarn/filaments used for Knitting***

- can be made from **any filament or yarn** but;
- requires a relatively **fine, smooth, strong yarn with good elastic recovery** properties
- Synthetic fibers are smooth and can be produced to required fineness,
- But poor comfort properties
- 
- ***Texturing processes*** is introduced to increase bulkiness of the fabric

## 2.1. *Parts of a Loop*

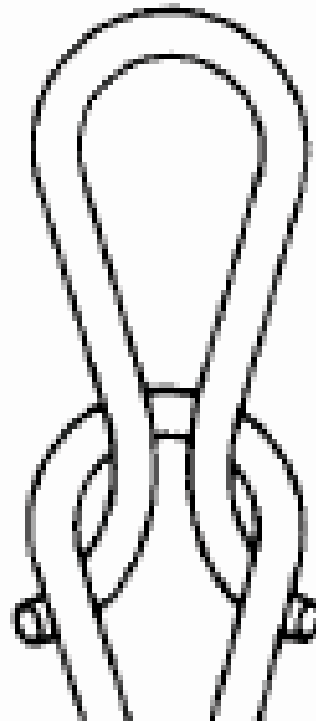
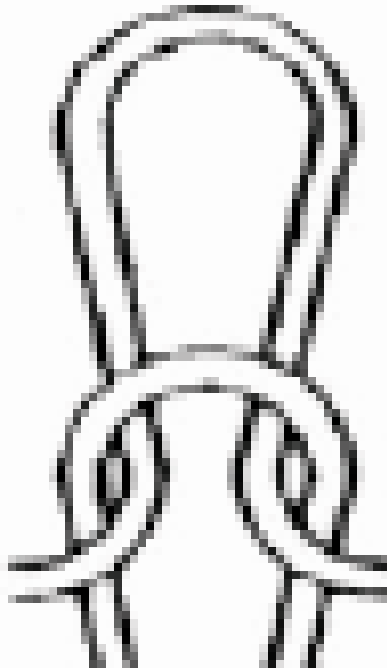


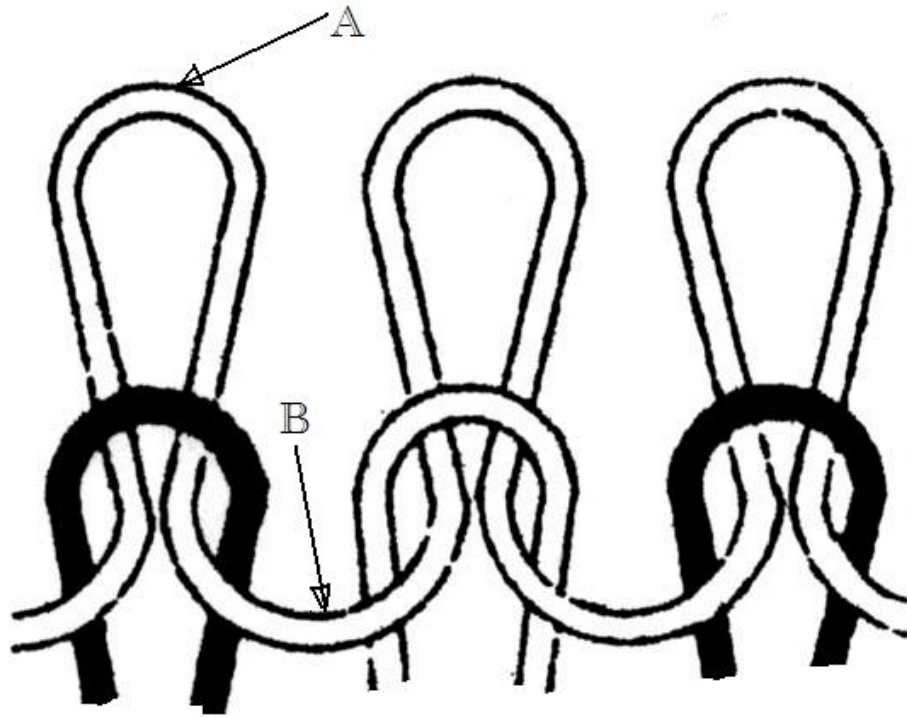
a) Loop head/top

b) loop arms/loop sides

c) loop foot

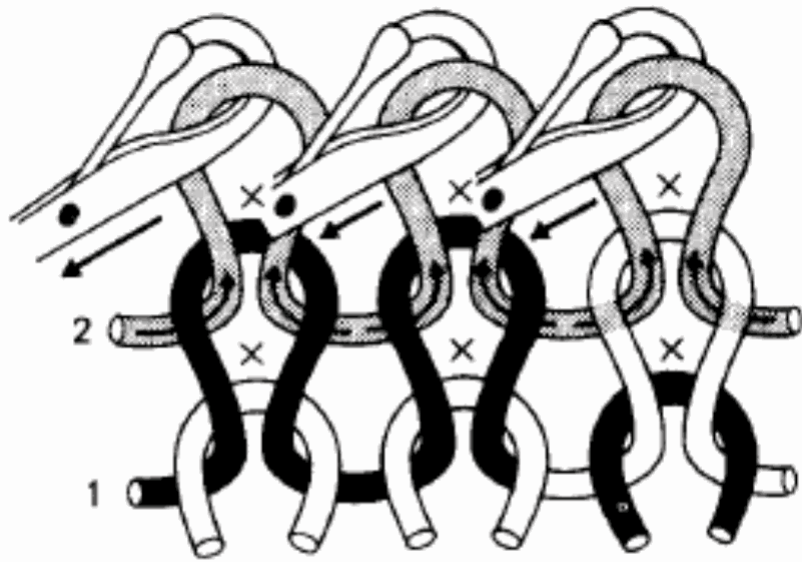
What is the difference of these two loop structures?



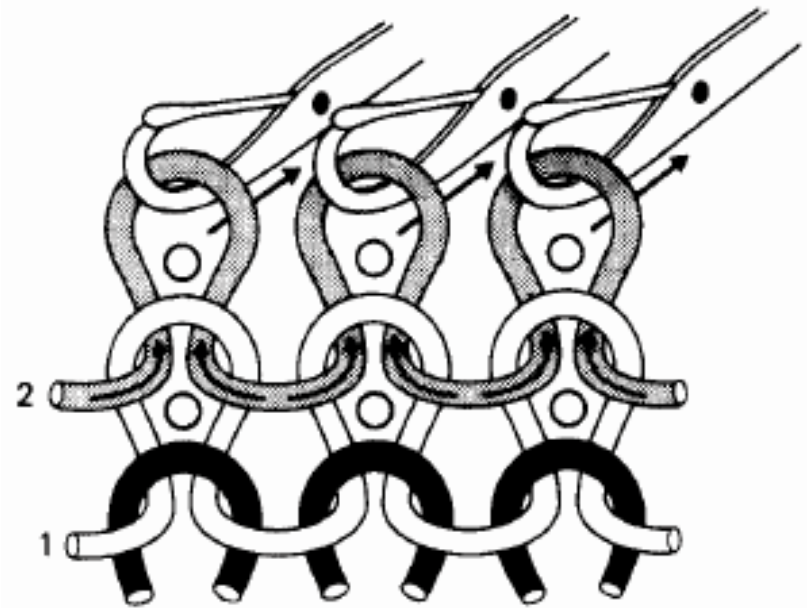
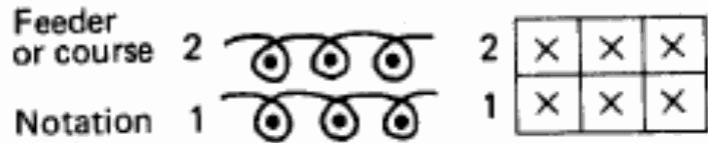


A - needle loop

B - the sinker loop



The technical face of plain

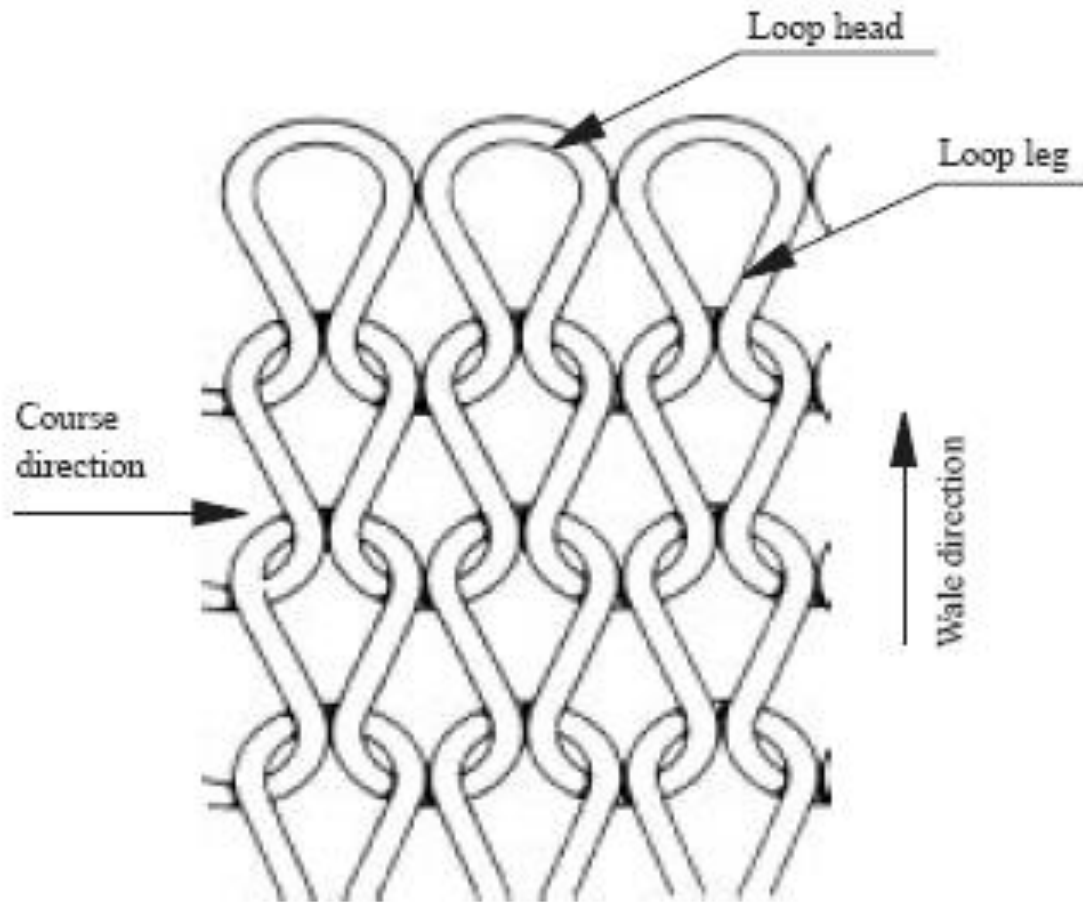


The technical back of plain



Technical face of the fabric

Technical back of the fabric

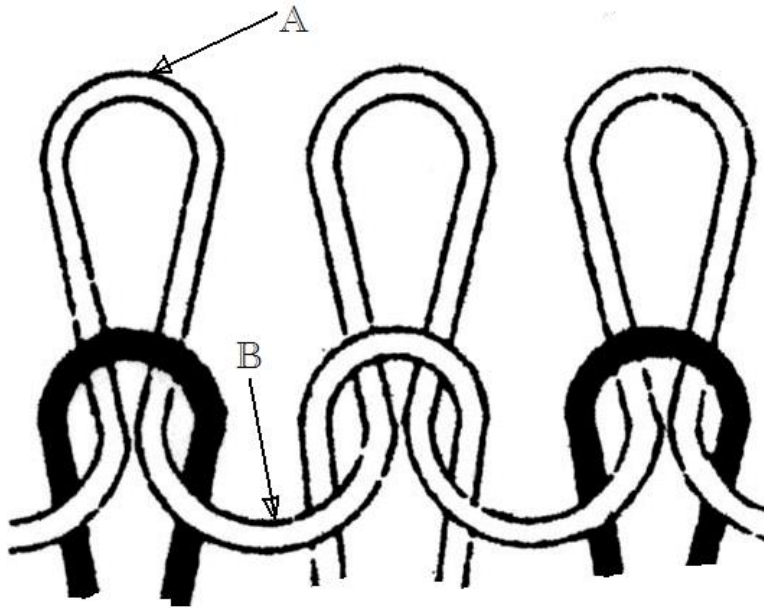


Course – thread lines

Wale - loops line perpendicular to the course line

# 2.2 Elements of Loop Structures

## 1. Needle loop



A- the needle loop

B - the sinker loop

# Needle loop

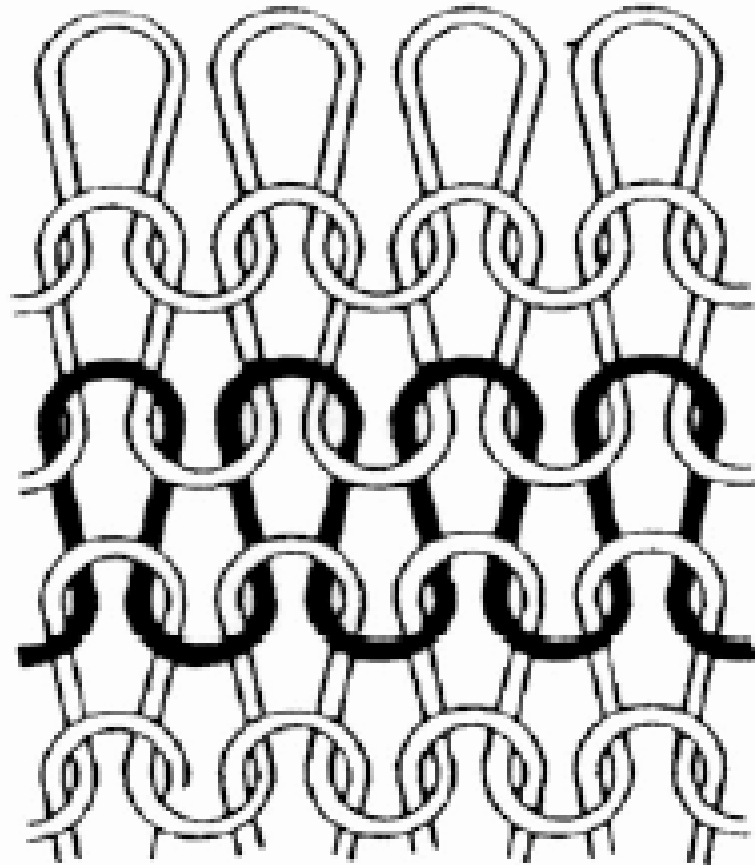
Basic unit of knitted structure

Under sufficient take-away tension, the loop become thinner and long

It has head, legs and feet

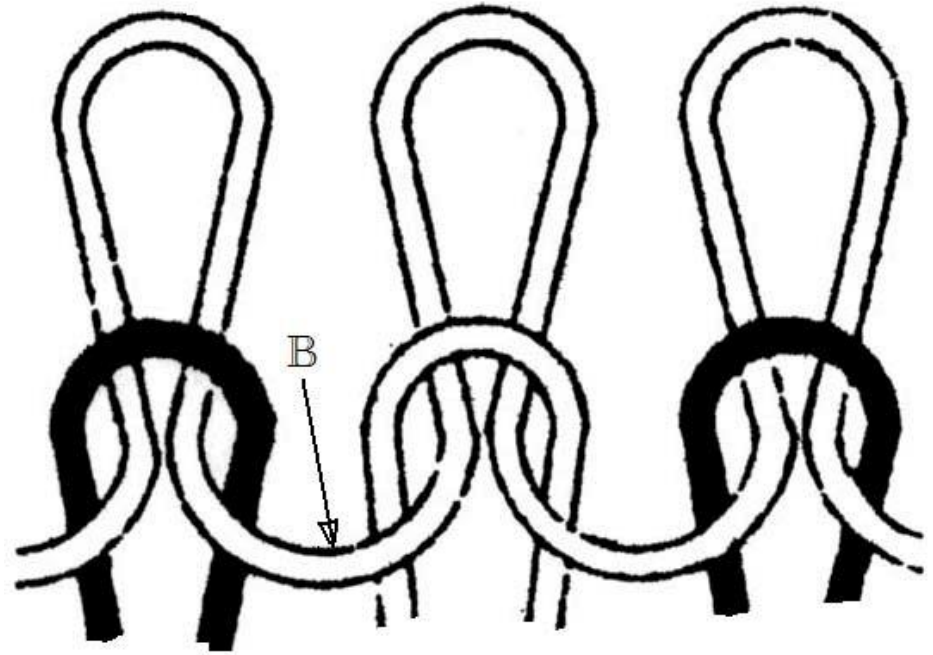
It has four contact points

Foot of one loop is connected with the foot of the consecutive loop



- If the loops are the **first course**, the loops are **not restricted/held** at legs and foot rather it looks like **tuck loops**
- In warp knitting the feet may be **open or closed** at the base of the loop.
- But it is **open** in weft knitting

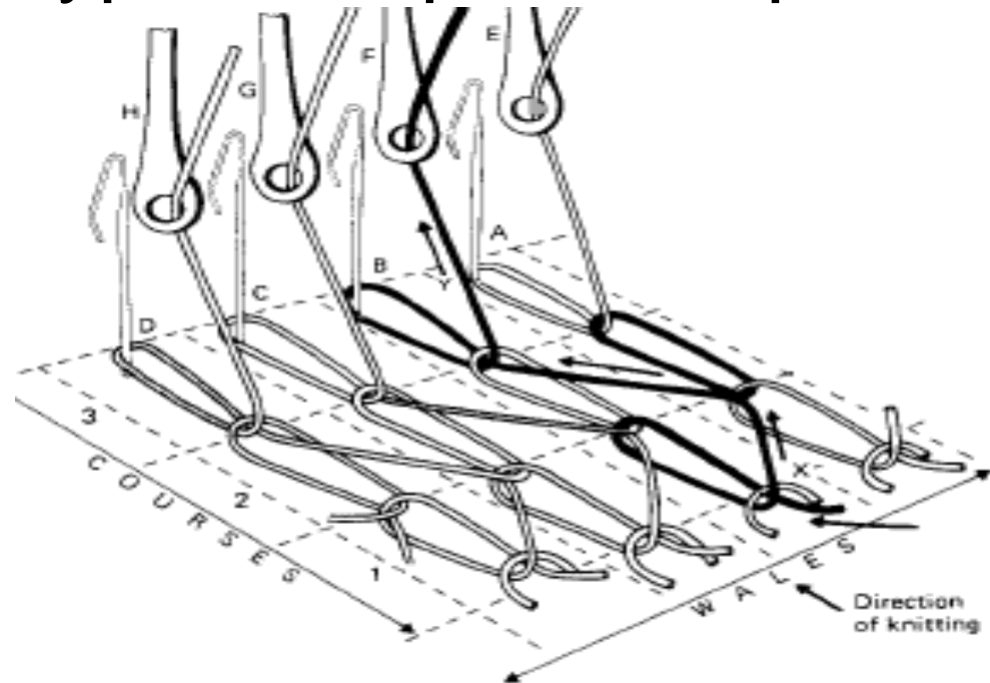
## 2. Sinker loop



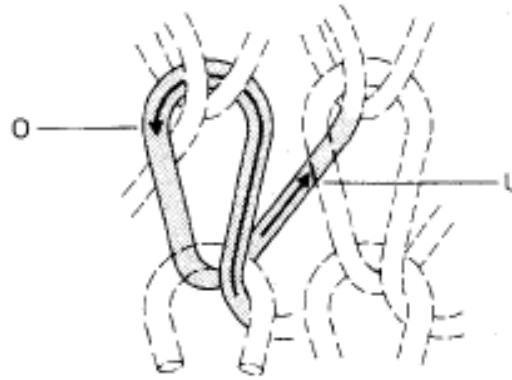
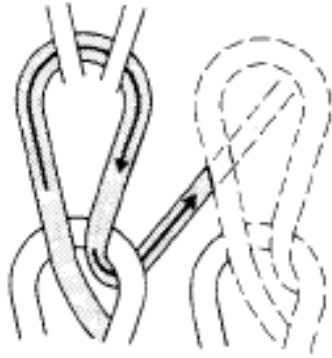
- Sinker loop (8): is the feet of two successive needle loops in the same course
- On bearded needle machines loop forming sinkers form the sinker loop
- But in latch needle it is formed automatically

# 3. Warp knitted laps

- Loops are termed '*laps*' in warp knitting because the warp guides lap their yarn around the needles in order to form the loop structure
- There are two types of laps overlap and under laps



- Overlaps are opened or closed



The side way shoging of the warp guides produces overlaps and under laps

While swinging action of the warp guide helps to form loop arms of the loops/laps

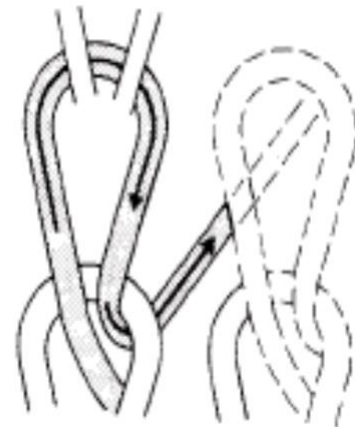
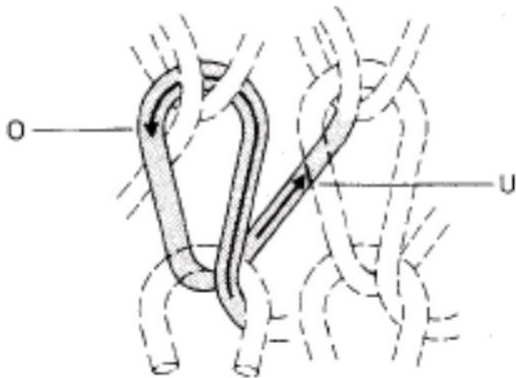
# Closed lap and open lap of

- **Closed lap**

When an under lap follows in the **opposite direction** to the overlap

## Open lap

When an under lap is in the **same direction** as the overlap or when under lap is **omitted** and an over lap is continued where the previous overlap is finished

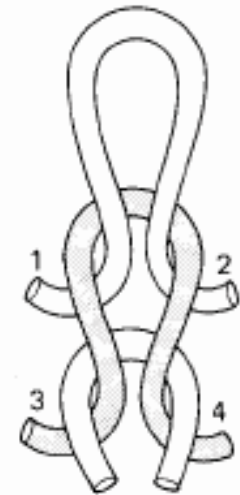


## 4. Wrapping

- Wrapping is a method of producing **vertically-orientated patterning** with warp threads
- It is done on a single jersey weft knitted base structure
- Specially-controlled warp thread **guides** are used which make **unidirectional warp knitted overlaps** into selected needle hooks
- If selected empty needle hooks rise to receive the warp yarn
- Wrapping is done on **empty needle** hooks or on **needles having weft knitted loops**

# 5. The knitted stitch

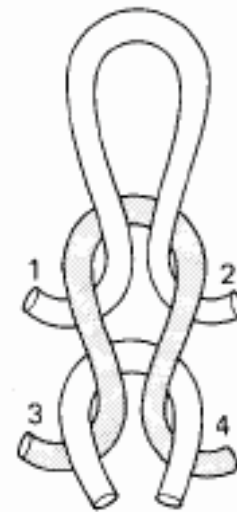
- *is the basic unit of intermeshing*
- *consists of three or more intermeshed needle loops*
- *The centre loop is drawn through the head of the lower loop and is intermeshed through its head by the loop above it.*



- A *needle loop's legs* are prevented from *spreading outwards* by being intermeshed through the head of the loop below it.
- If there is no previous loop to mesh through, the legs of the new loop will spread outwards.
- *Stitch length* is a length of yarn which includes the needle loop or loop head + loop legs + half the sinker loop

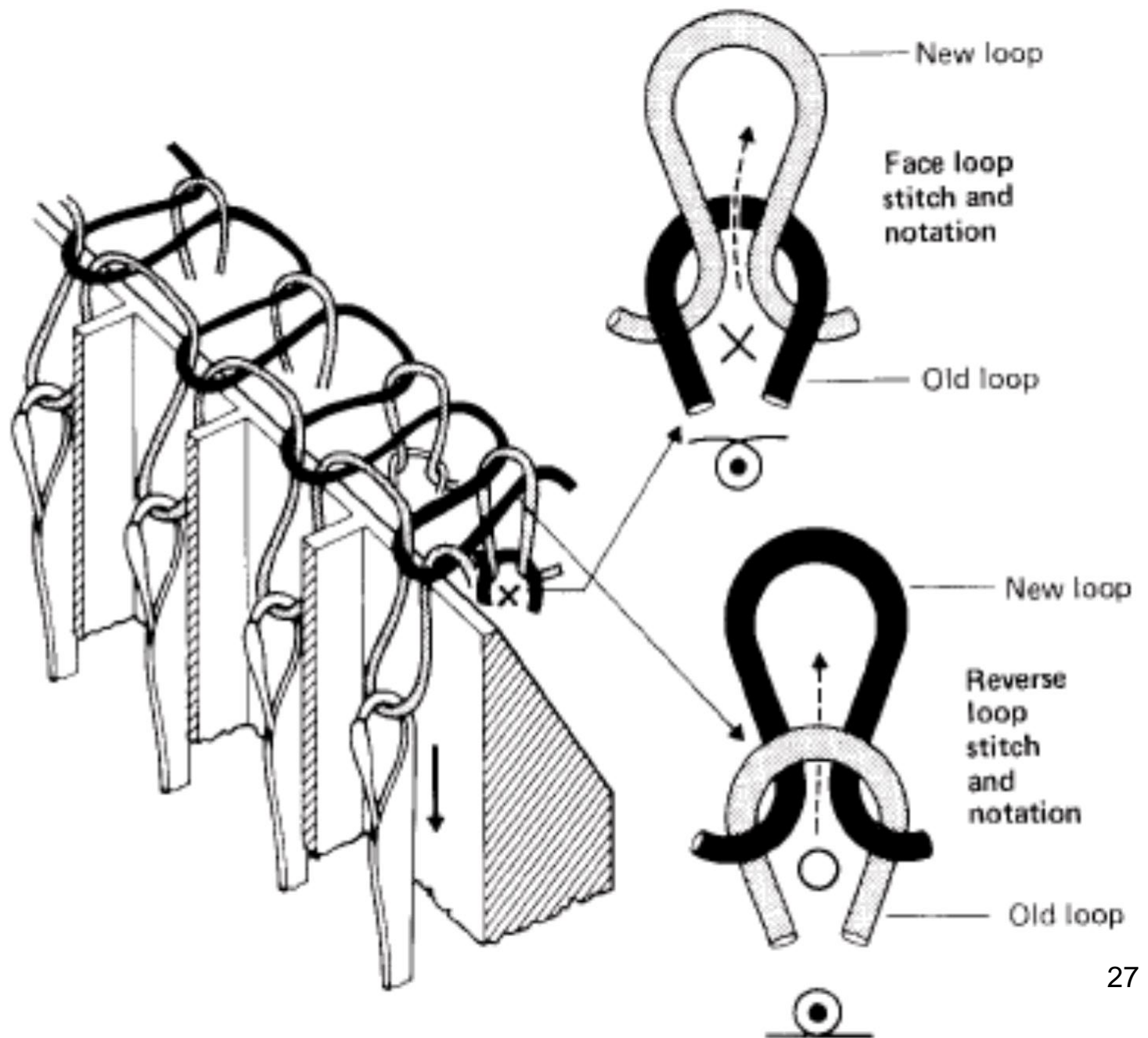
# The four intermeshing points of a loop (middle loop)

- At- 1 and 2 at the head, where the next new loop will be drawn through by the needle
- At 3 and 4 at the base, where the loop has intermeshed with the head of the previously formed loop.



# Face loop stitch

- Shows the new loop coming towards the viewer as it passes through the previous loop
- Called the right side
- hides sinker loops in weft knitting and the under laps in warp knitting
- **loop arms** are shown to the front but **loop feet and loop head** are shown to the back



# Reverse loop stitch

- shows the new loop meshing away from the viewer as it passes under the head of the old loop.
- Also called *left side*
- Show sinker loops in weft knitting and the under laps in warp knitting
- **loop arms** are shown to the back but **loop feet and loop head** are shown to the front

## 6. Single faced structures

- Needles are operating as a **single set**
- They move simultaneously in the **same direction**
- **Adjacent needles** face towards same direction
- one side of the fabric will be fully technical side while the other is technical back

# 7. Double faced structures

- when two sets of **independently-controlled** needles are employed
- or one of the two sets of needles **face in the opposite direction** to the other set.
- Each side of the fabric will have both technical face and technical back

# 8. Balanced structures

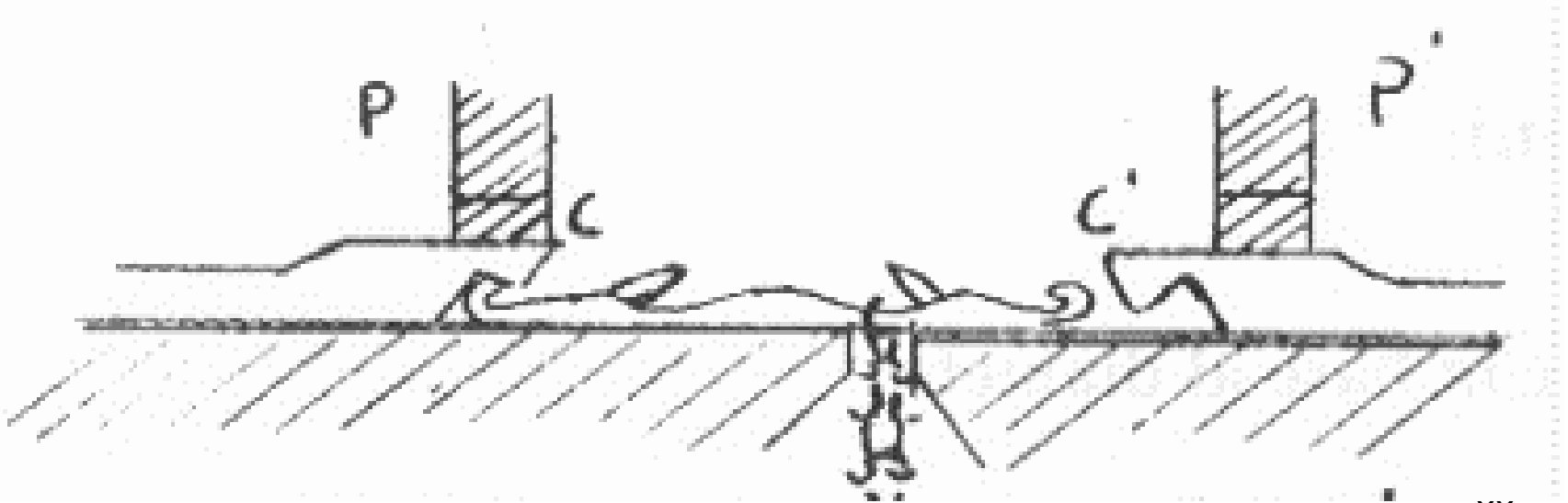
- is a **double-faced structure** that has an identical number of each type of stitch produced on each needle bed
- shows on each fabric surface, usually in the **same sequence**.

## 9. Selvedged and cut-edged fabrics

- A *Selvedged fabric* are fabrics having a '*self-edge*'
- Can only be produced on a **straight machine** whose yarn carrier reciprocates backwards and forwards
- A *cut edge fabric* is usually produced by **tearing** cylindrical tube/circular knitted fabrics

# 10. Face and reverse stitches in the same wale

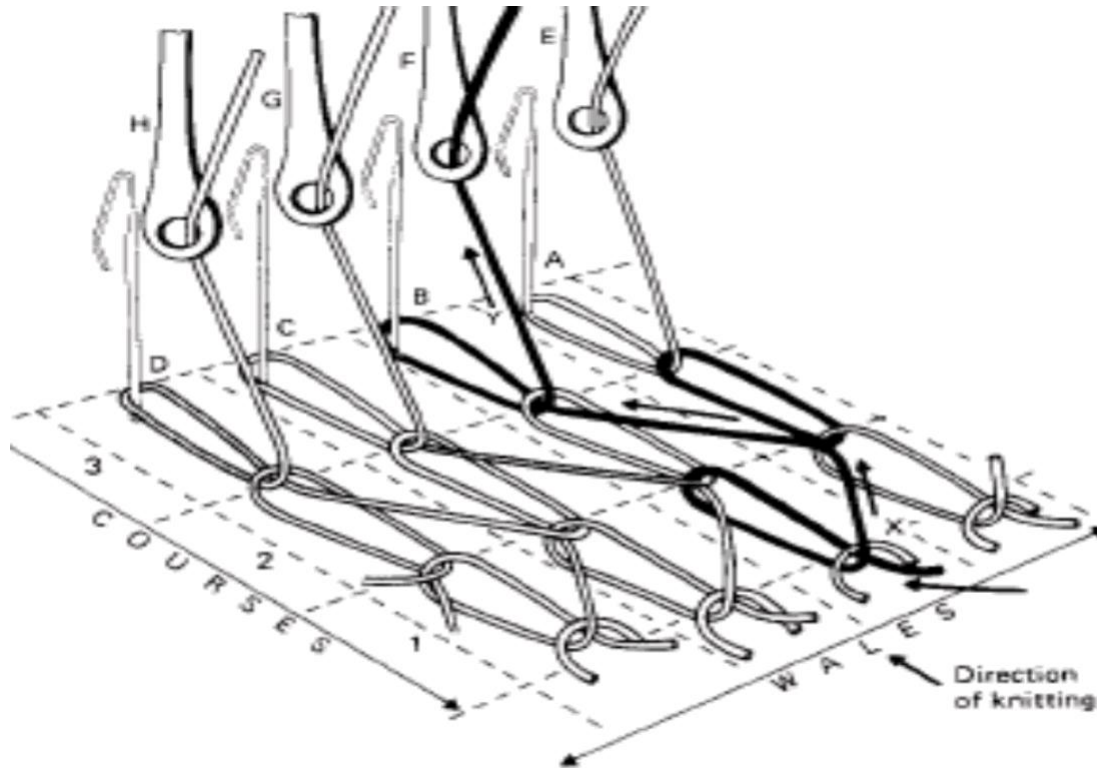
- produced on **purl weft knitting machines** that have **double-headed needles**
- One end produces **face stitch** and the other end produces **reverse stitch**



# 11. Upright loop structures

- Produced only if the **tension** on the yarn on **either side of the needle loop head** is balanced.
- Often exists in weft knitted structures because **balanced sinker loops** enter from either side of the **needle head**
- But it may be disturbed by **racking**, and by **yarns that are prone to twist**

- Warp knitted structures rarely have upright overlaps
- because the equivalent force of the underlaps tends towards one direction
- In one course force is in one side but opposite in the next course



# 12. Knitting notation

- A symbolic representation of a knitting repeat sequence

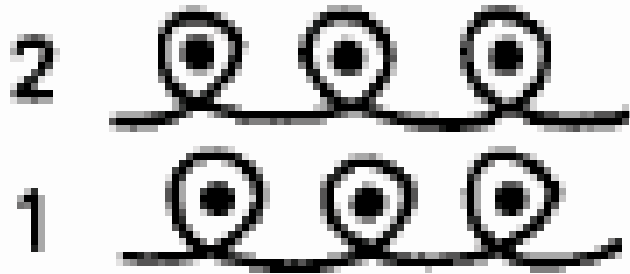
## 1. Use of point paper

Point represents **needle or a loop**

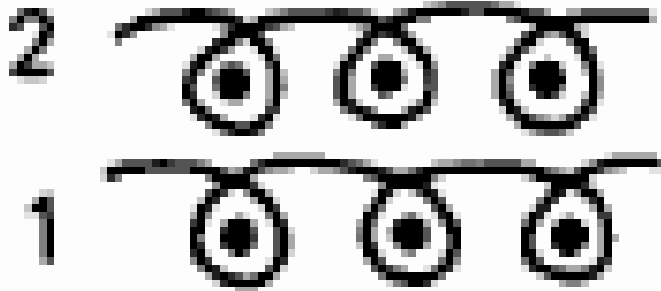
*Rows:* → adjacent needles or the course produced by them.

columns:- a needle (single set of needles) or  
Wales

# Point paper method



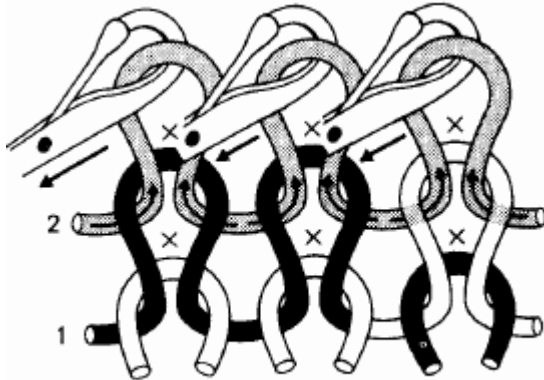
Technical back



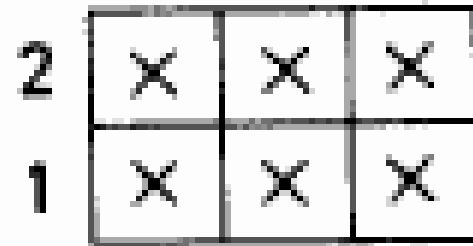
Technical face

# 2. Squared paper

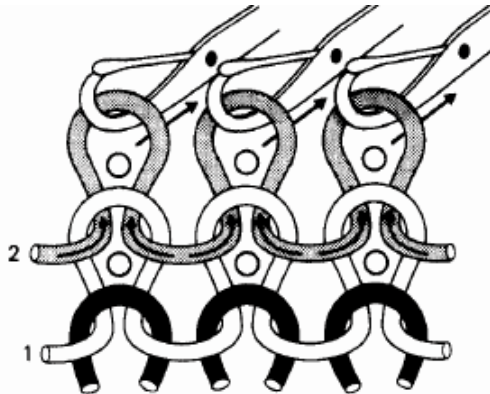
- An 'X' is placed in a square for a face loop



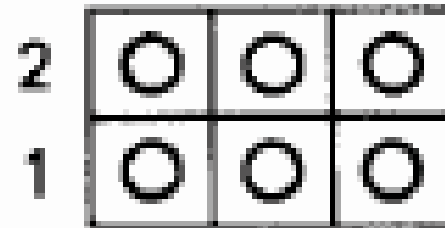
The technical face of plain



- An '0' is placed for a reverse stitch



The technical back of plain

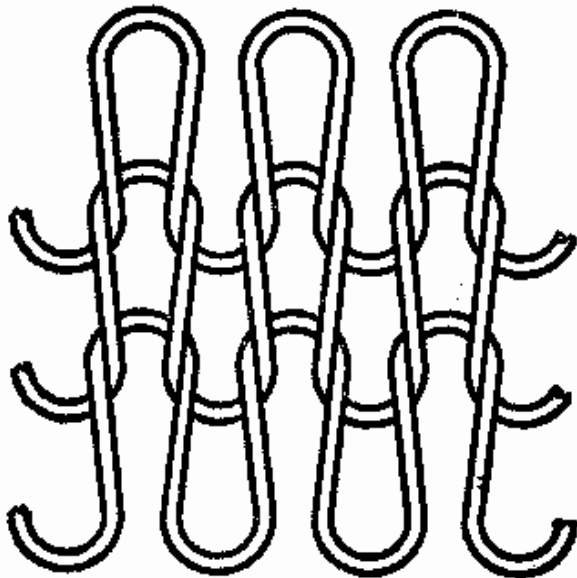


# 3. The four primary base weft knitted structures

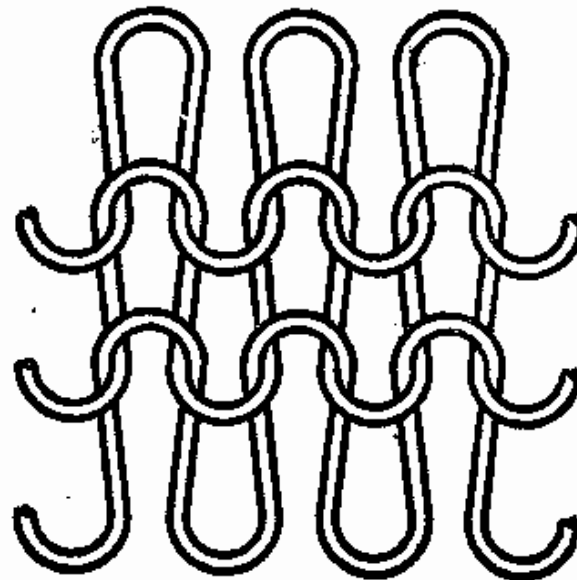
- plain, rib, interlock and purl
- Are the **base structures** from which all weft knitted fabrics and garments are derived
- Each is composed of a **different combination** of face and back stitches
- They can be made alone or in combination
- Examine the **face and back stitch** arrangement and **unraveling state** for each

# 3.1 Plain structure

- Produced by single set of needles
- **Single faced structure** (one side is fully face and the other is back)



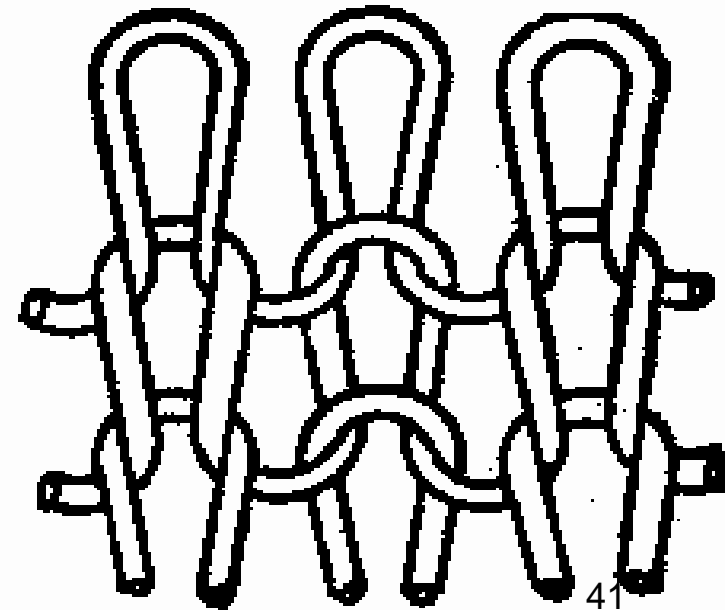
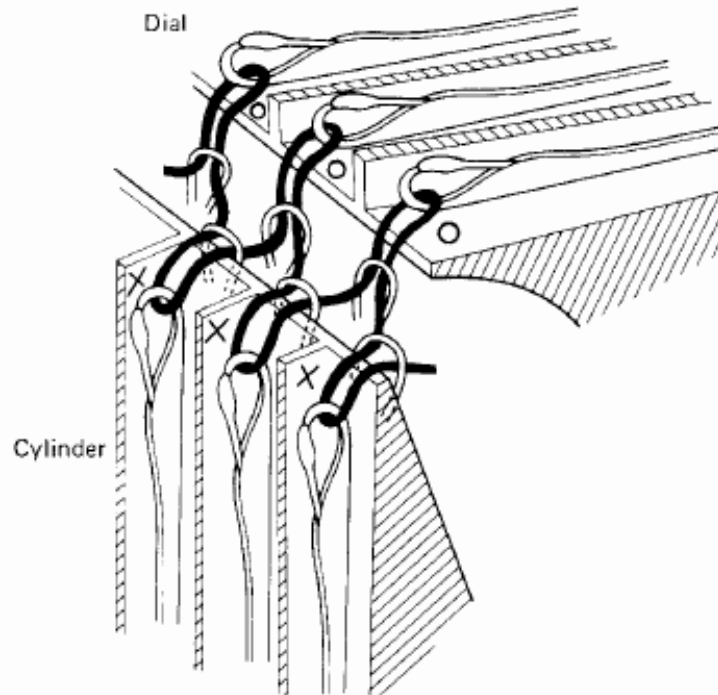
a) Technical face



b) technical back

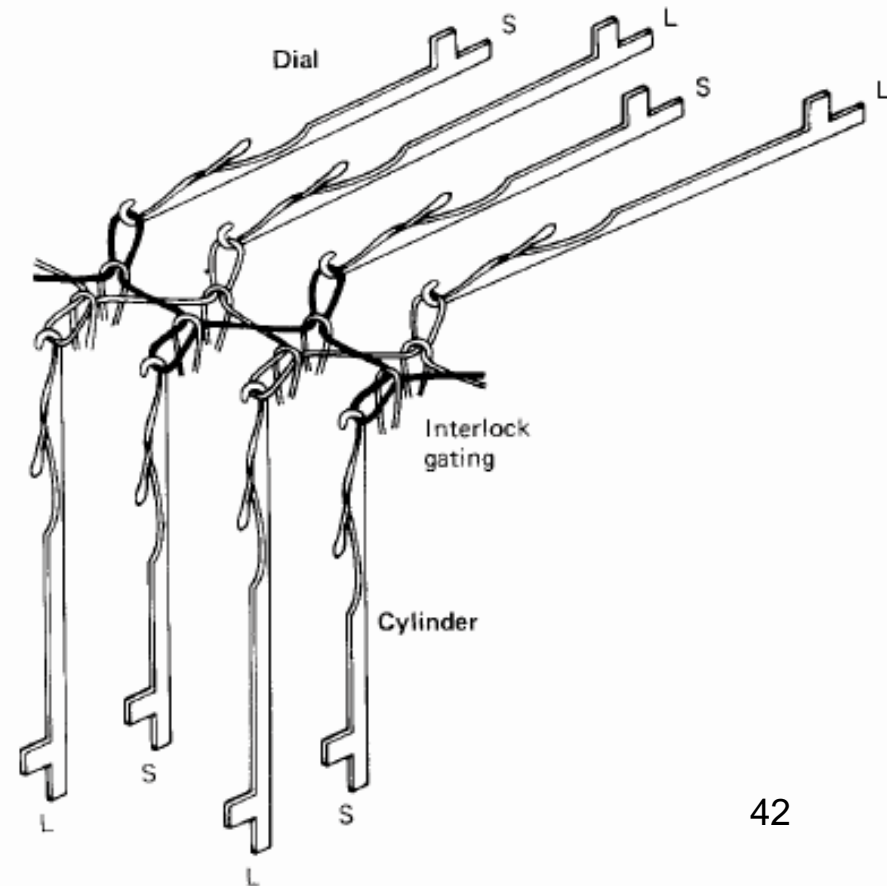
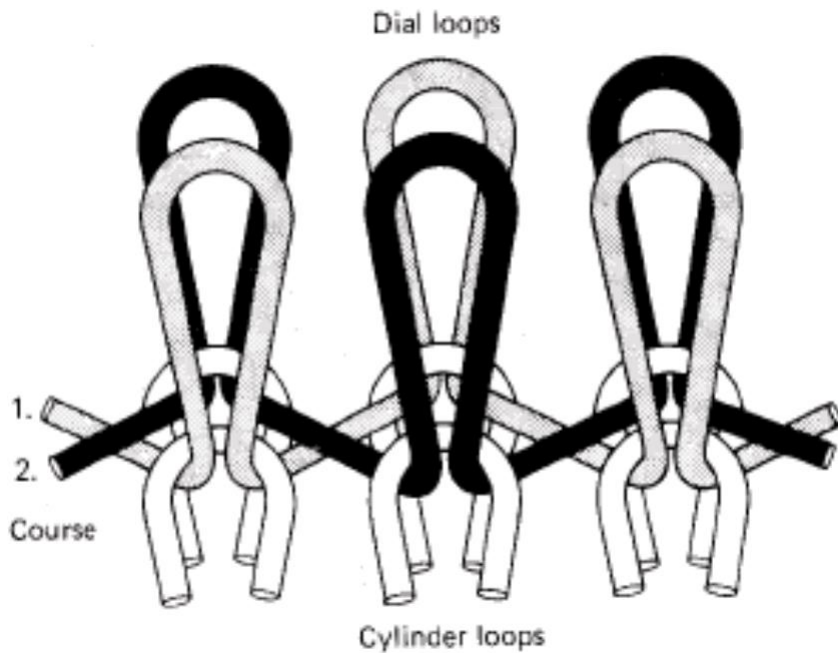
# 3.2 Rib Structure

- Two sets of needles operating in between each other /combination of wales
- As a needle in one set forms face the needle in the other forms back of the same side
- 1x1



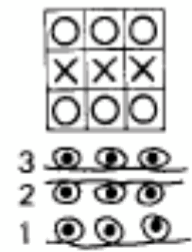
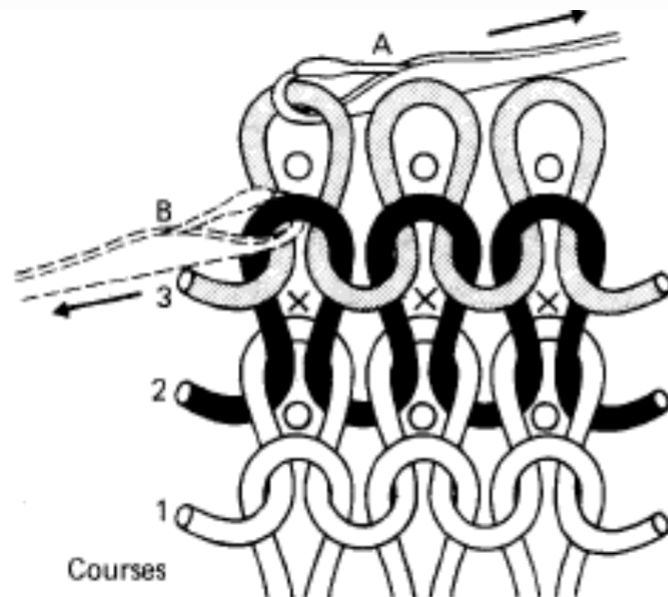
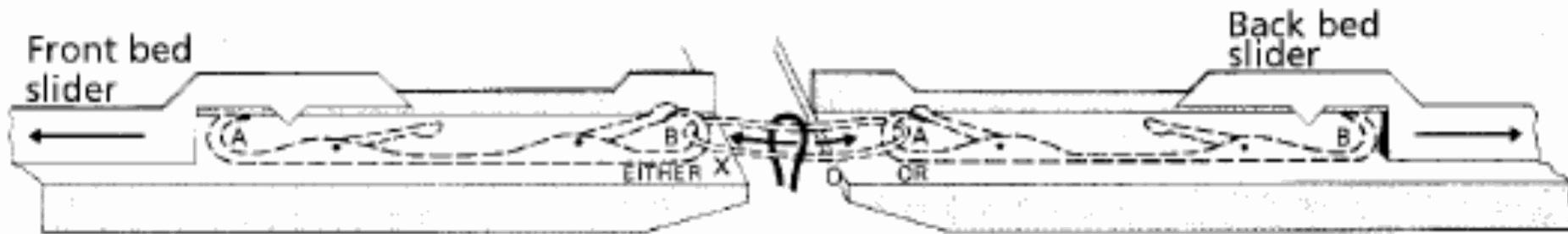
# 3.3 Interlock Structure

- Two sets of needle
- Both sides are technical face
- In each set, needles work turn by turn

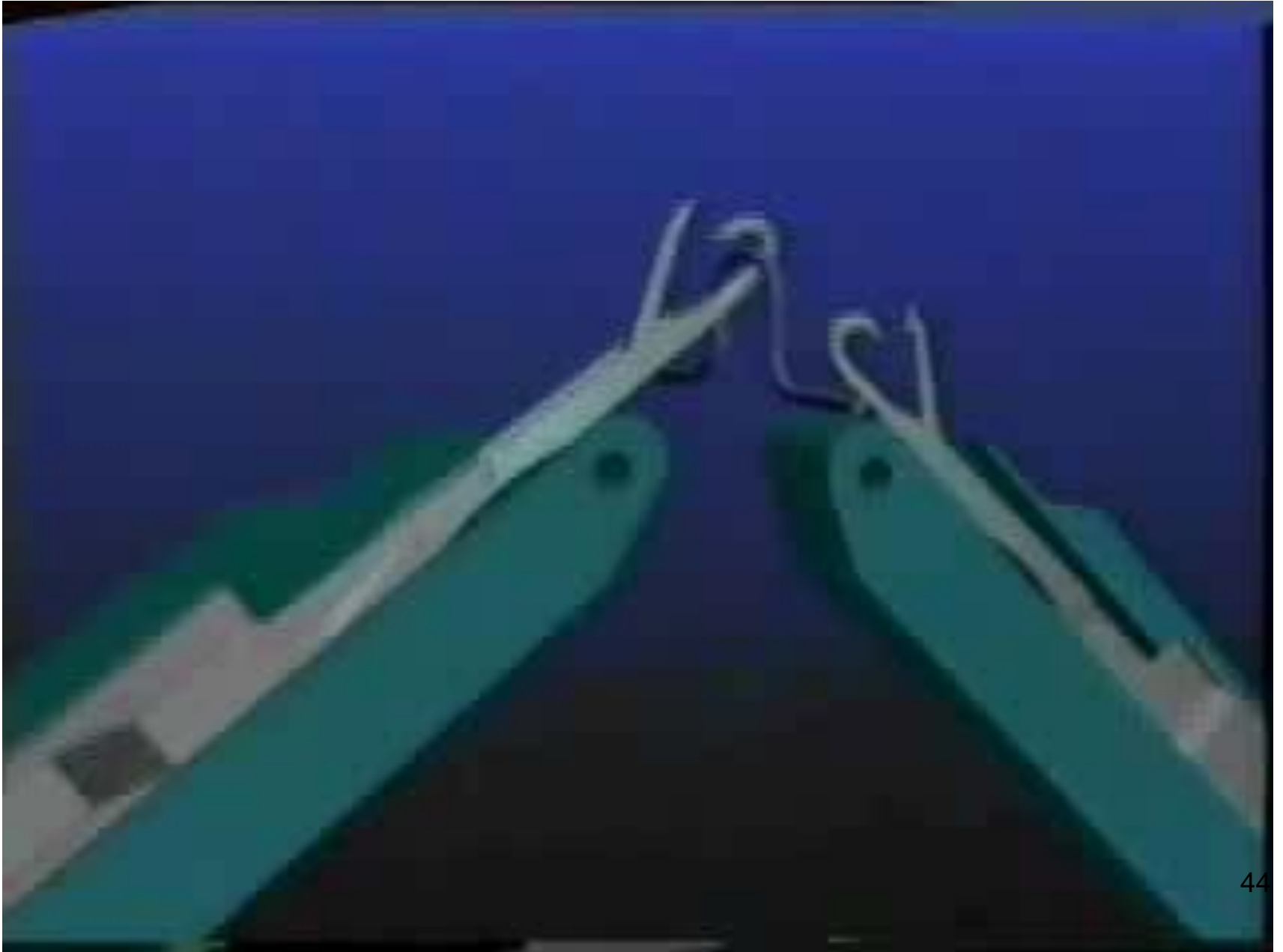


# 3.4 Purl structure

- We get face and reverse stitches in a wale
- Can be formed by double faced needle or v-bed machine

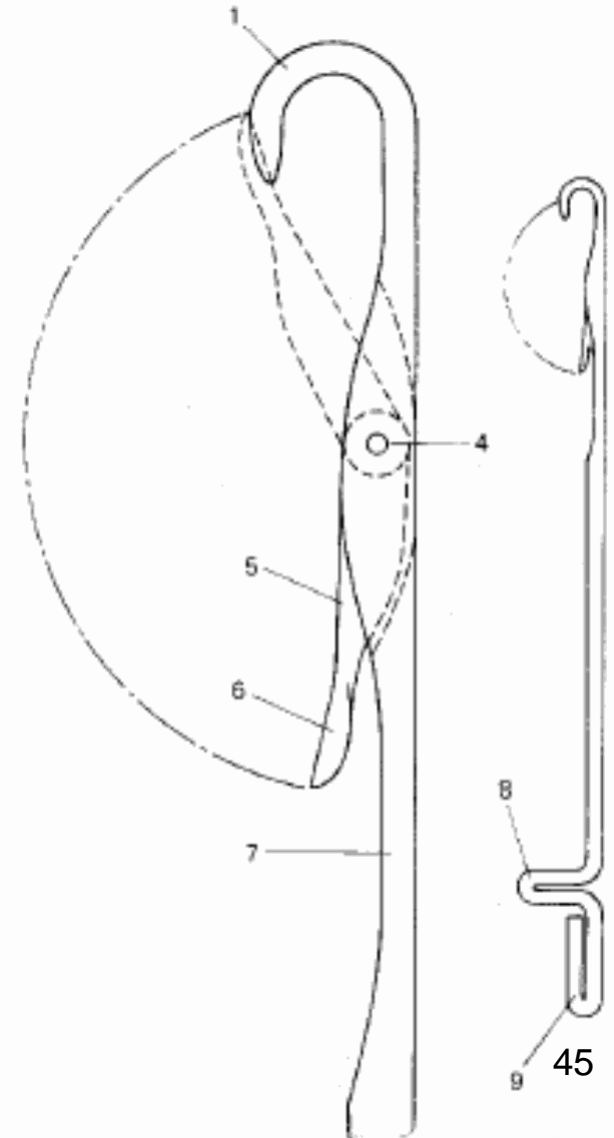


# Latch Needle operation



# Latch Needle

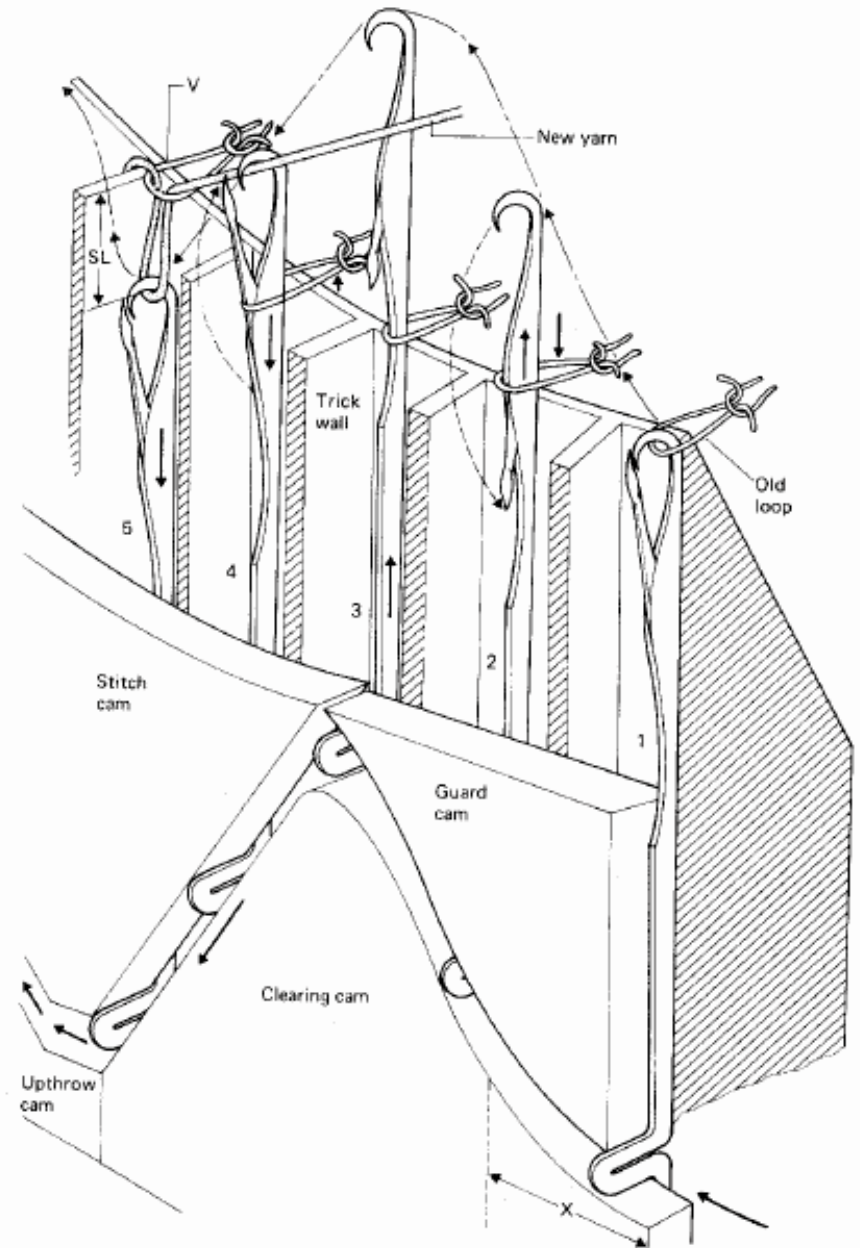
1. *Hook*
2. *Slot*
3. *cheeks or slot walls*
4. *Rivet*
5. *latch-blade*
6. *latch spoon*
7. *Stem*
8. *Butt*
9. *tail*



# The Knitting Action of the Latch Needle

## 1. *The rest position.*

- The **head of the needle hook** is level with the top of the verge of the trick.
- The **loop formed** at the previous feeder is in the closed hook.
- **This loop** is prevented from rising as the needle rises, by *holding-down sinkers*



## *2. Latch opening*

- . As the **needle butt** passes up the incline of the clearing cam, **the old loop**, which is held down by the sinker, slides inside the hook and contacts the latch, turning and opening it.

### *3. Clearing height*

- . When the needle reaches the **top of the cam**, the **old loop** is cleared from the **hook and latch spoon** on to the stem.
- At this point the feeder guide plate acts as a guard to prevent the latch from closing the empty hook

## *4. Yarn feeding and latch closing*

- The **needle** starts to descend the **stitch cam**, with the old loop moving under it, yarn is fed.
- The **old loop** contacts the underside of the latch, causing it to turn and close on to the hook.

## *5. Knocking-over and loop length formation*

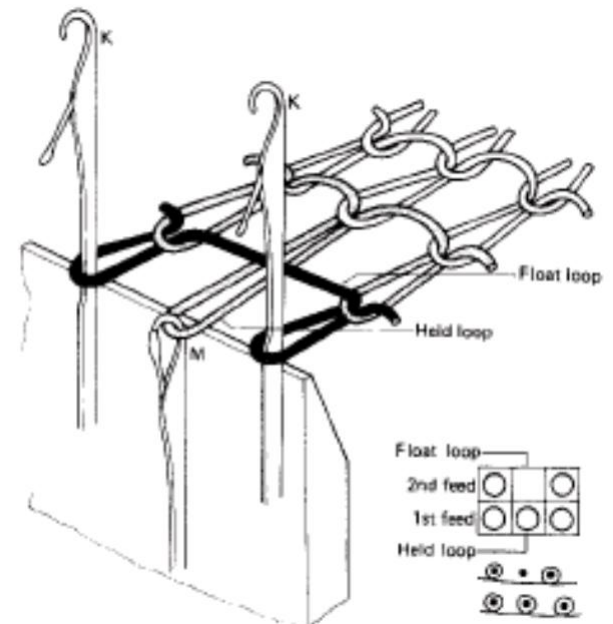
- . As **the head of the needle** descends below the top of the trick, the **old loop slides off** the needle and the new loop is drawn through it.
- The continued descent of the needle draws the loop length, which is approximately twice the distance the head of the needle descends, below the surface of the sinker

# 4. Different Types of Stitch Designs

- **Knitted Loop:-** A loop that is held at its foot by previously formed loop head and holds the foot of newly formed loop by its foot or when a needle receives a new loop and knocks over the old loop
- **Knitted stitches :-** *three or more intermeshed knitted loops*

# The held loop

- An old loop that the needle has retained for one or more knitting cycles.
- Longer loop, takes two or more courses
- As the number of cycles for the needle to be held increase the tension on the yarn increases



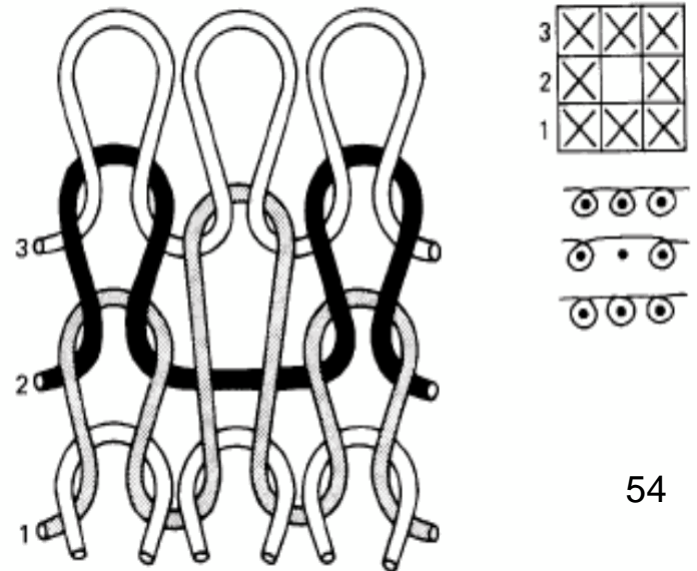
# 4.1 The drop or press-off stitch

- result if a needle releases its old loop without receiving a new one



## 4.2 The float stitch

- Consists of a **held loop**, one or more **float loops** and **knitted loops**
- It is produced when a needle fails to receive the new yarn or the needle gets rest
- Under normal tensions max. cycles for float is 4

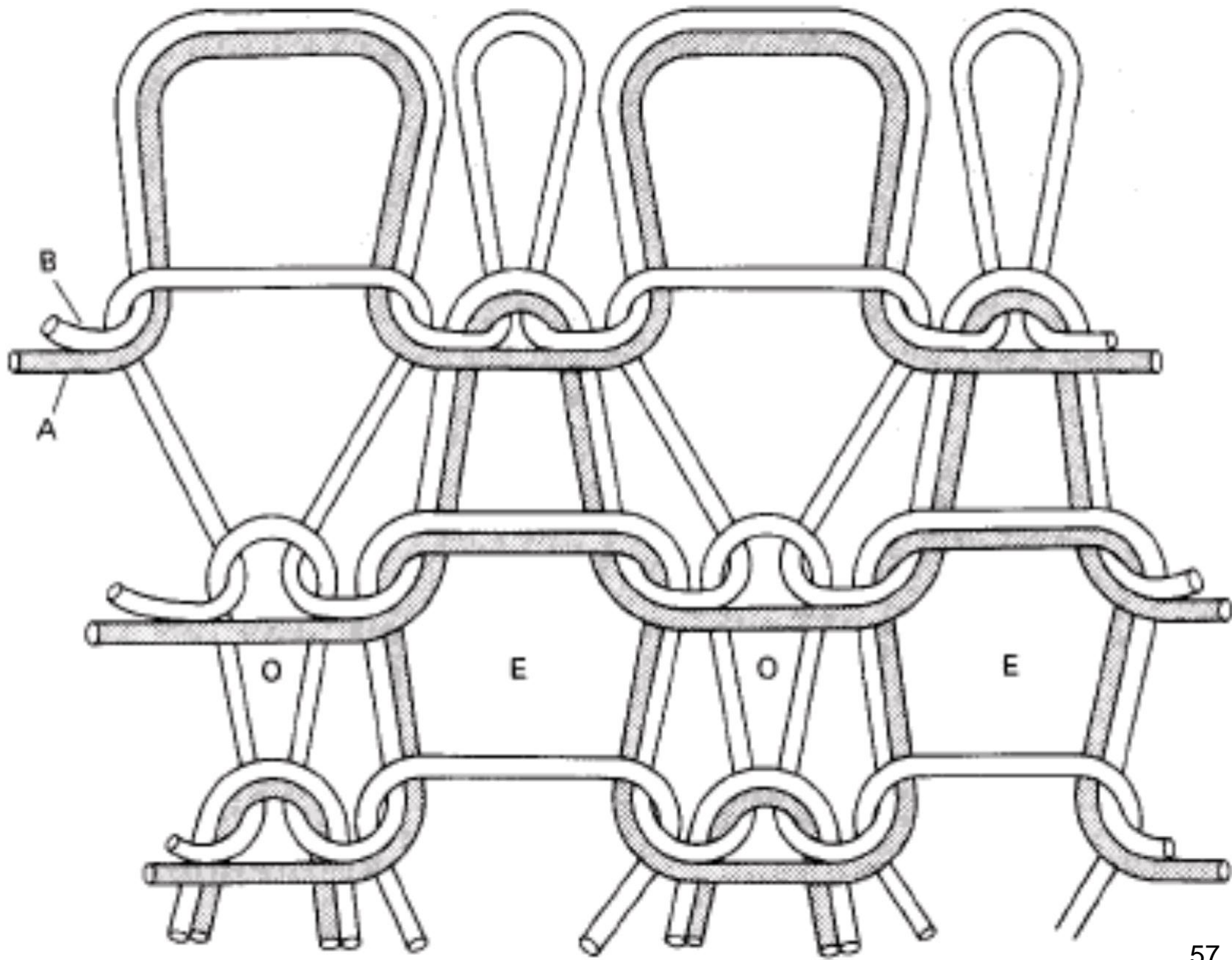


- A floating thread is useful for hiding an unwanted colored yarn
- The float loop assumes u shape
- It is floating on the technical back



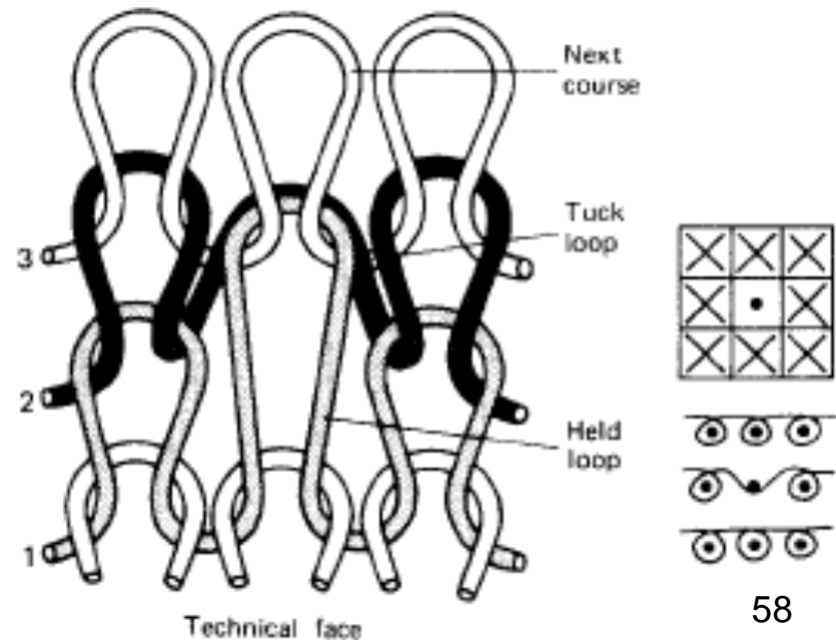
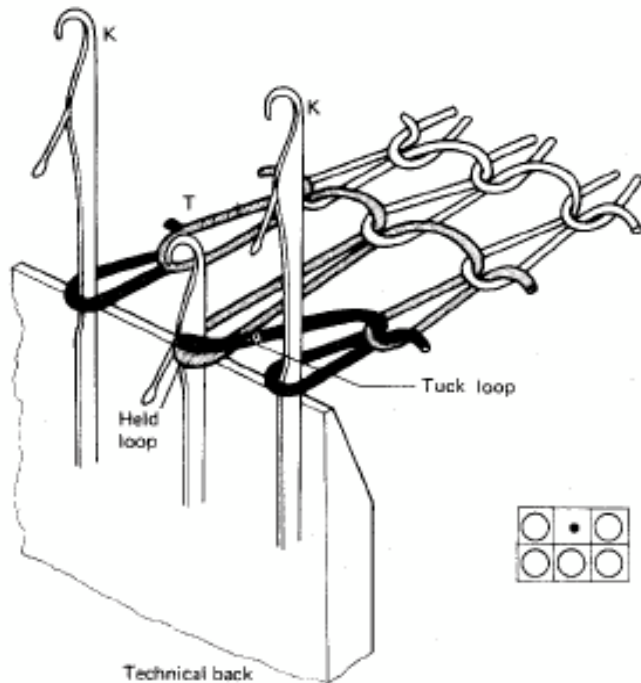
## 4.3 Float plating

- Used in single jersey structure
- involves feeding two yarns **thick and thin** in a plating relationship to needles having forward hooks.
- A **thick yarn** (A), is fed at **a high level** and is received only by needles selected to that height.
- A **fine yarn** (8) is fed at **a lower level** and is received by every needle.

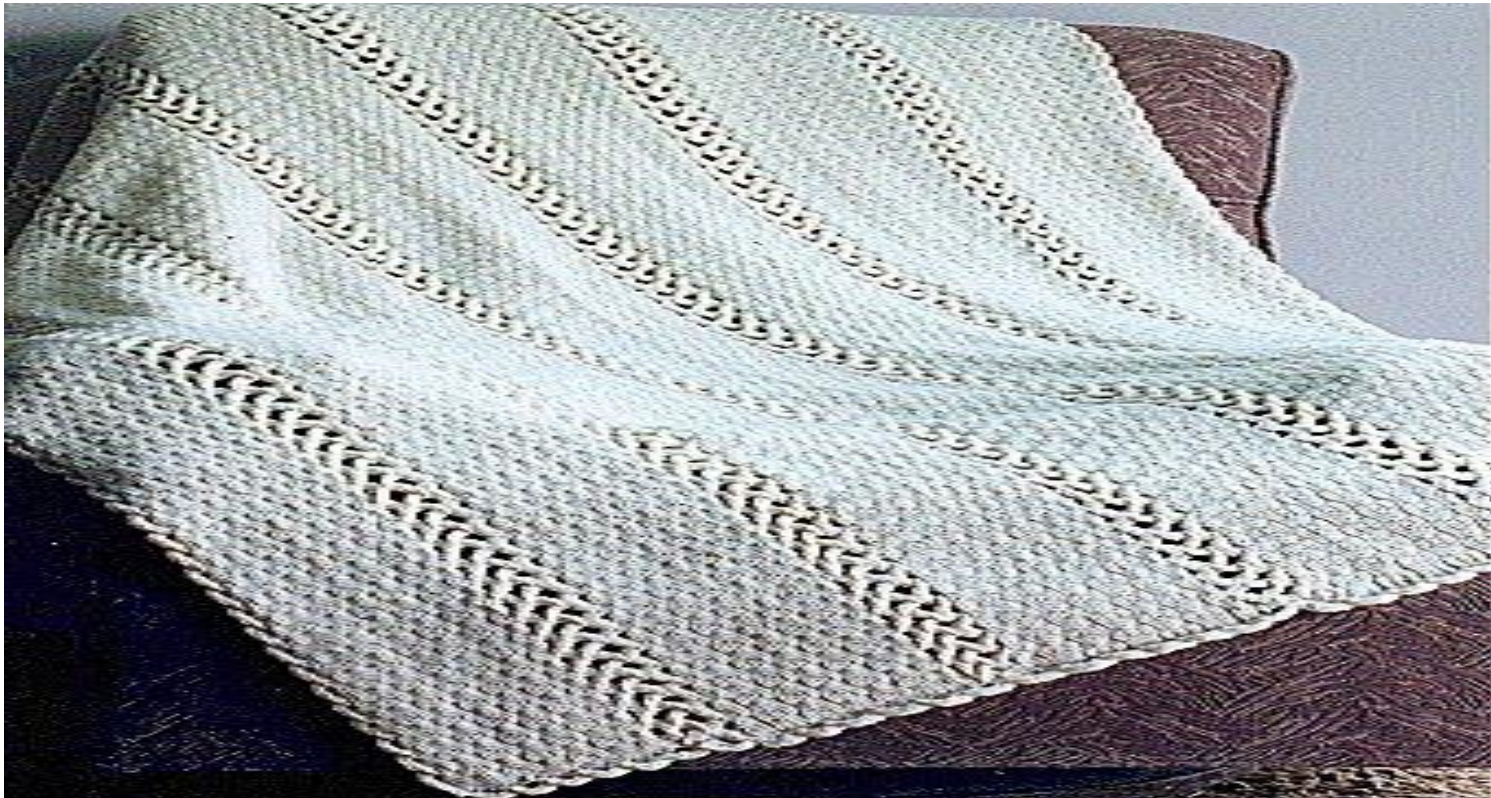


## 4.4 The tuck stitch

- 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 (T)** also **receives the new loop**



- The tuck loop is not held at its feet
- The tuck loop assumes an inverted V or U-shaped configuration.



# Stitch notation for the different types of stitches

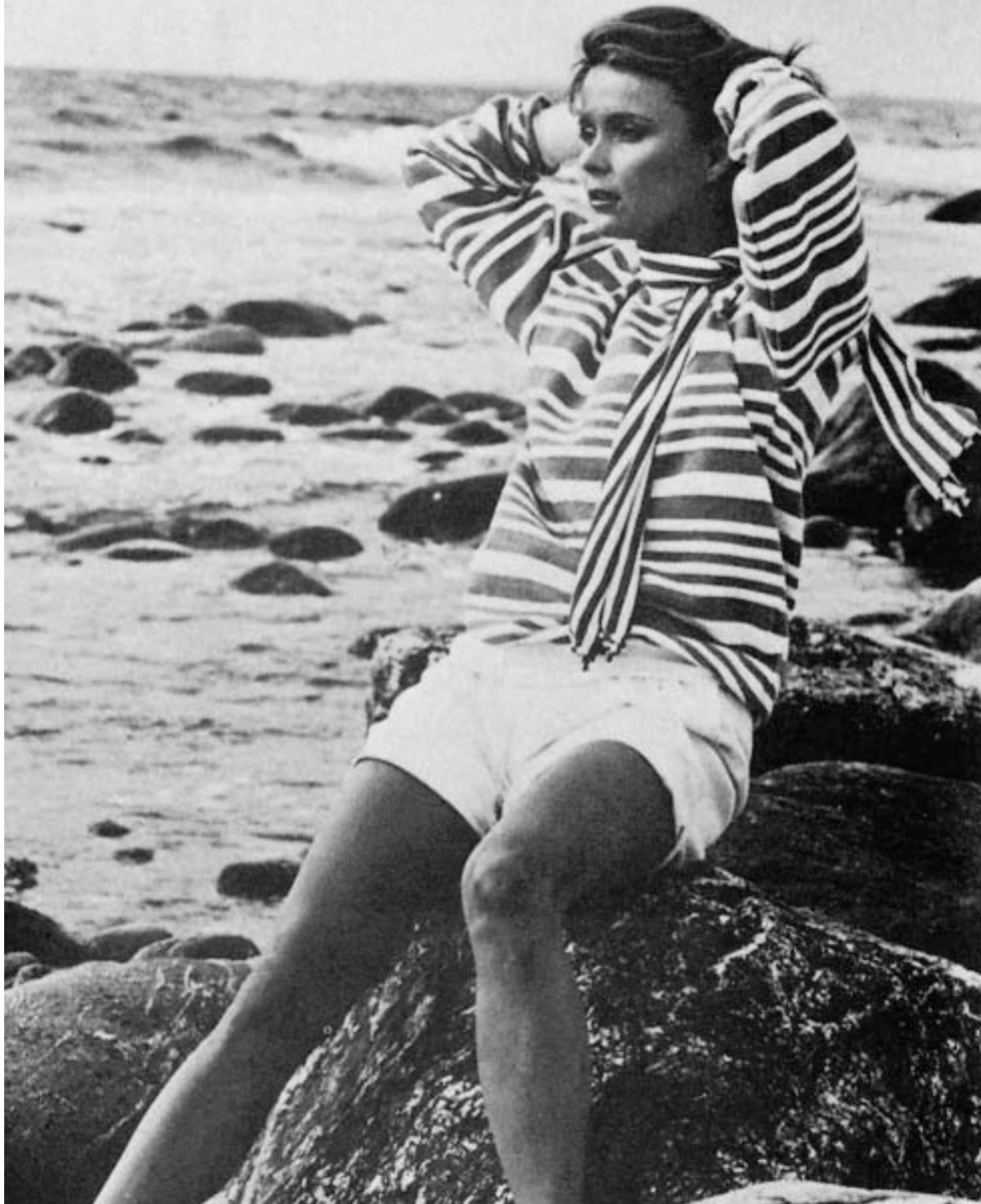
1. Plain
2. Rib
3. Purl
4. Float
5. Tuck
6. Drop/press-off

## 4.5 Coloured stitch designs in weft knitting

- The five elements of fashion are:- **colour**, **style**, **silhouette** (shape or shadow of the garment), **texture** (feel or touch) and **pattern** (model or sample)
- Ornamentation for design purposes may be introduced at the **fiber**, **yarn**, **dyeing**, **finishing** and knitting stages.
- The knitting of stitch designs always involves a **loss of productivity** and **less efficiency** compared with the knitting of plain, non-patterned structures.
- 
- In many cases, more than one **feeder courses** is required to knit each pattern row.
- *Horizontal striping, intarsia, plating, and individual jacquard stitch selection* techniques can be employed to produce designs in coloured stitches.

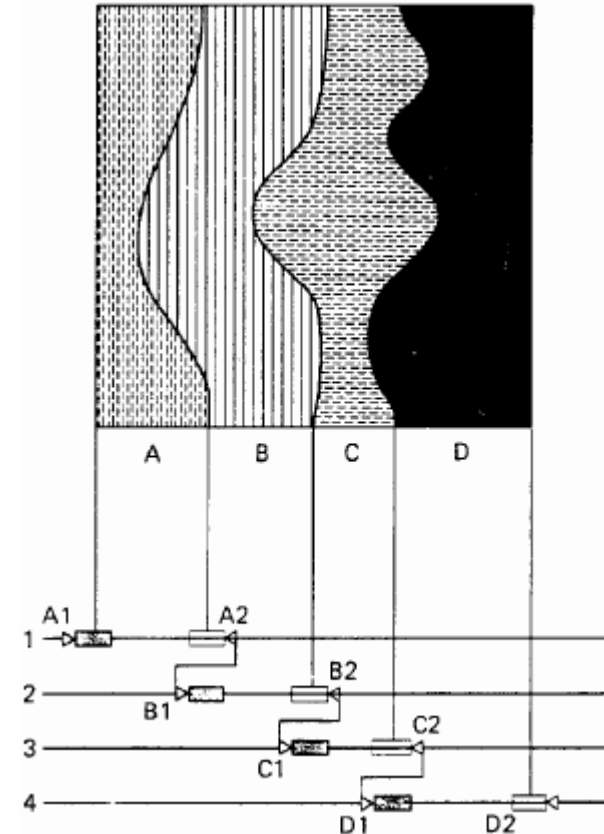
# 1. Horizontal striping

- **In single feeder:-** One yarn is selected, at a time, from a choice of several colored yarns at a machine feed position
- **Multi-feeder machine:-** careful arrangement of the packages of colored yarns
- Useful for the introduction of a draw-thread in a **full-course** and **Splicing** reinforcement on a **part-course** basis,
- Very short length variation gives very **less speed of production** but with the help of **electronic control** its speed and versatility is improved



# 2. Intarsia

- Yarn carrier positioning of four zones
- Each colour (A, B, C and D) is supplied by its own yarn carrier, which travels only between its own **carrier stops** (are capable of being **repositioned**).
- All carriers traverse in the **same direction** at a particular course.
- The stop blocks of adjoining colour zones (e.g. A2 and B1) are **linked** together
- when one **yarn carrier traverse** is decreased the **adjoining carrier traverse** is correspondingly increased.



- *intarsia*: form self-contained areas of pure colors
- Unequalled colour definition is achieved, with a large number of colours
- Careful positioning of the yarn carriers and control of the extent of traverse of each from course to course determines the design and integration of the colored areas into a cohesively-knitted structure.
- Cohesive structure, at the adjacent places, is achieved by → slight overlap
- Each block of needles knits a separate colored area (*field*)



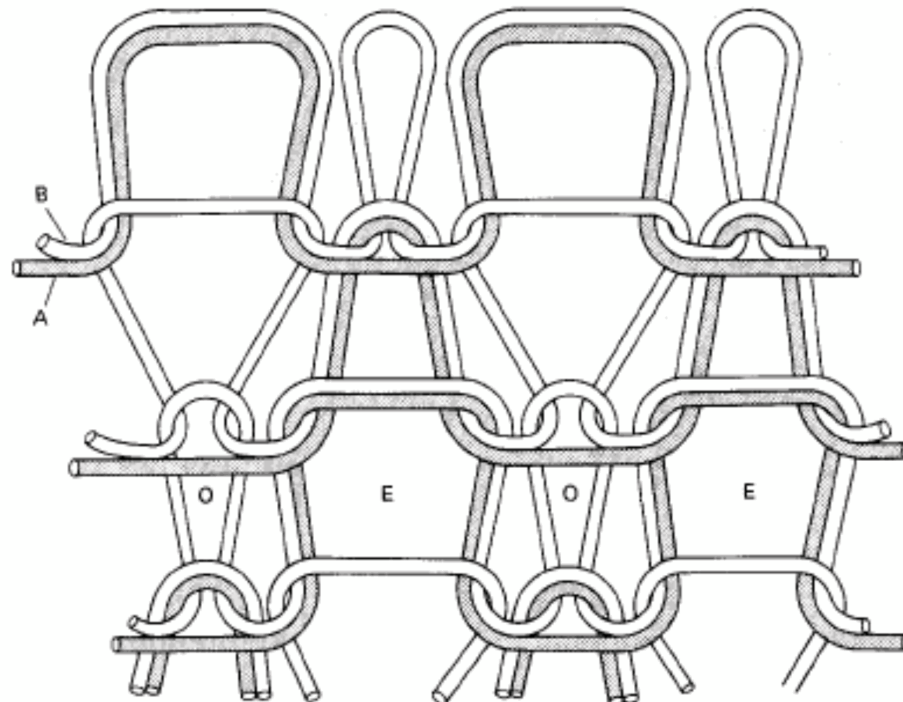
- The yarn passes to next course formation and **does not float** across the backs of needle loops.
- Yarn feeding for intarsia is from **left-to-right** at one course, and **right-to-left** at the next.
- Plain, 1 x 1 rib, or purl can be used
- It can be made by hand knitting, hand operated circular or flat machines

- *pure join of adjoining areas* can only be achieved on a hand-manipulated flat machine with hand-feeding.
- As the *edge yarn* of an area rises to the next course, it *crosses over* and links to the edge yarn of the adjacent color area.
- It is a comparatively *slow, expensive,* but done for the purpose of *fashion design*

# 3. Plating

- Widely used in **single jersey** with float and **interlock**
- However, the use of colored yarns to produce plated designs has diminished in weft knitting.
- Plating requires great **precision** and offers **limited color** choice with poor definition
- In **reverse plating**, two yarns (usually of contrasting colour) are caused to change over positions at the needle head by controlled movement of specially-shaped sinkers or yarn feed guides.
- In **sectional plating** (straight bar frames), the **ground yarn** knits continuously across the **full width** whilst the **plating carrier tubes**, moves through a particular group of needles

- The designs appear to be **pure colour intarsia** because the **main yarn** is **fine** and is **hidden** by the plated, colored bulked yarns.
- **No floating** threads on the inside because the yarn is cut and trapped for the **sectional plate**



## 4. Individual stitch selection

- Most versatile and widely-employed method
- Independent movement of needles is important
- Latch needle Iweft knitting suitable because they are individually tricked and butted
- One or more of knit, tuck, miss, plated, loop transfer and purl needle transfer stitches can be produced

# Rules

1. If a set of needles has

- butts of identical length and position
- fixed cam track/path

then each element will follow

- the same path
- produce identical stitch at that feeder

2. If feeds in the machine has

→ the same arrangement with fixed cams

Then

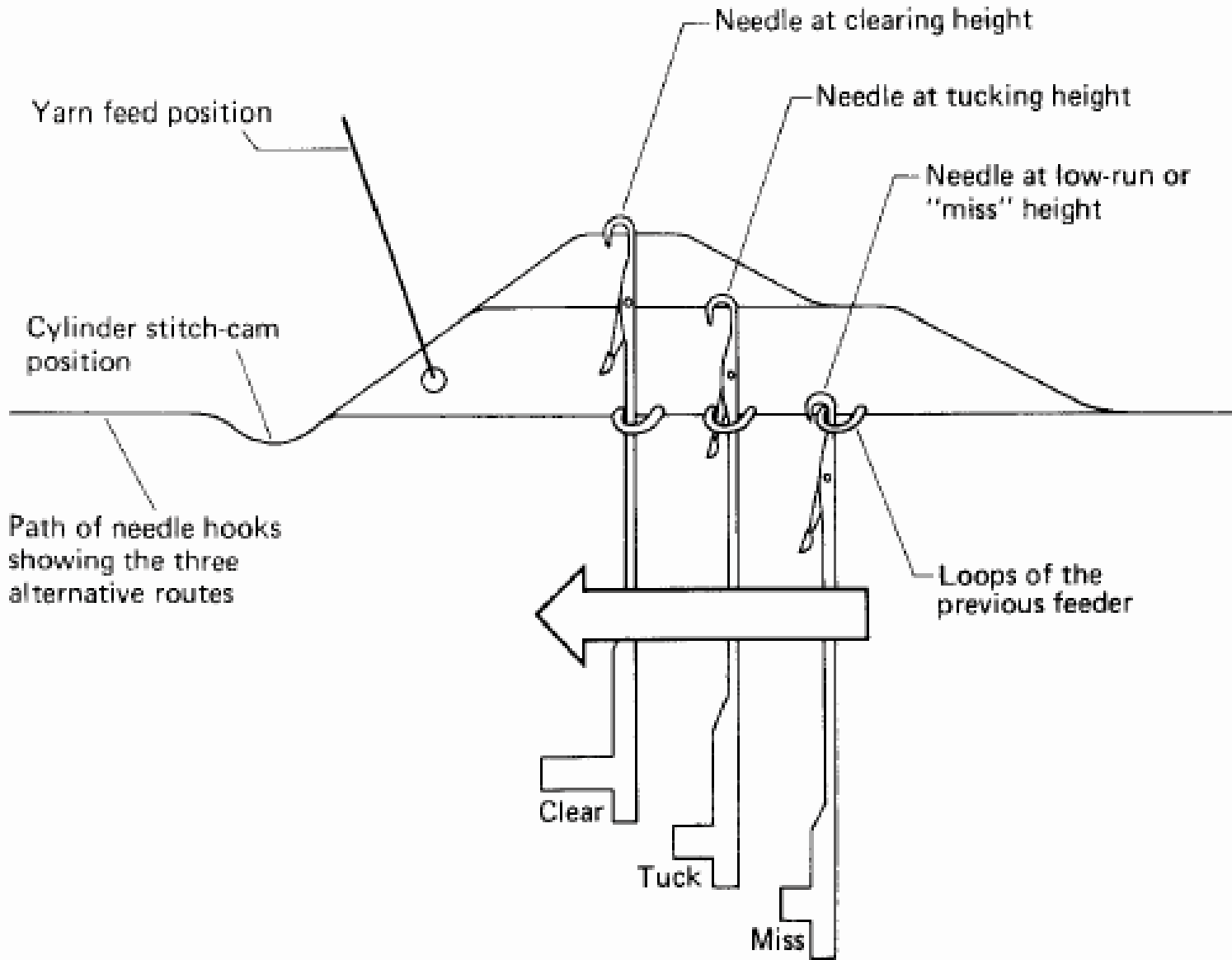
→ identical stitches will be knitted = plain

3. When the butts of adjacent elements

→ follow different paths/height through the same cam system

Then

different stitches may be knitted in adjacent wales of the same feeder course

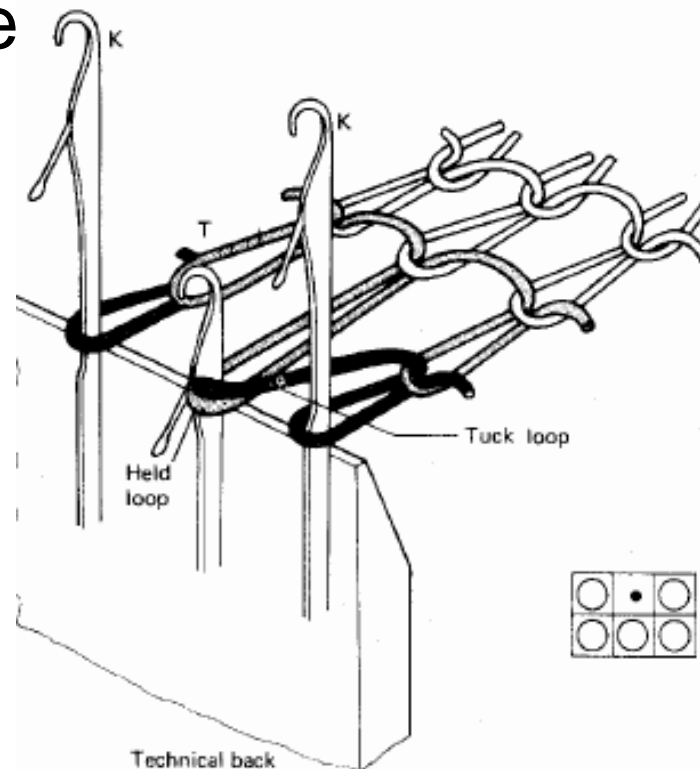


#### 4. When butt of the same needle

→ follows a **different path** through successive cam systems

Then

→ **more than one type of stitch** may be produced in the same wale



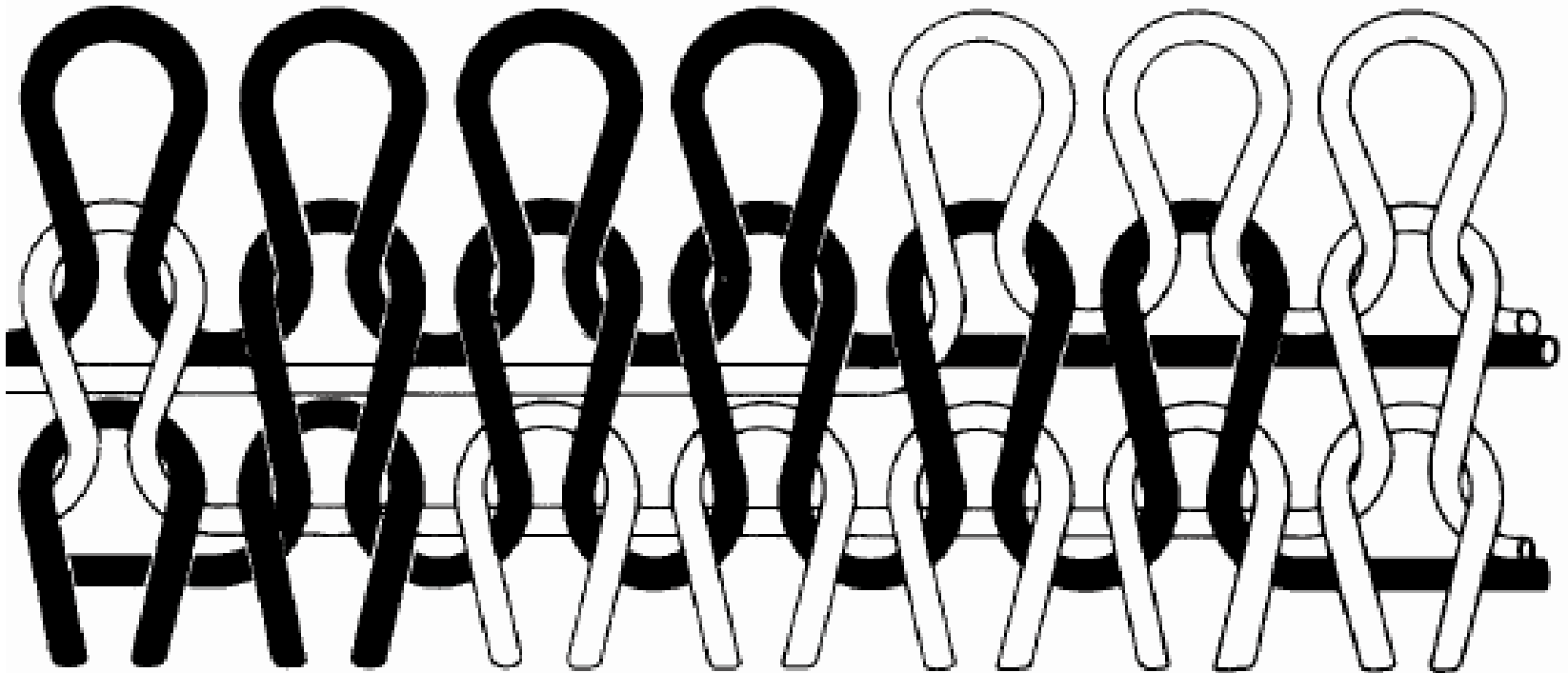
5. Unless the device is of the **variable type** **different selection** with in a wale

→the **design depth** in feeder courses will be the number of **operative feeds** on the machine

## a. Weft knitted jacquards

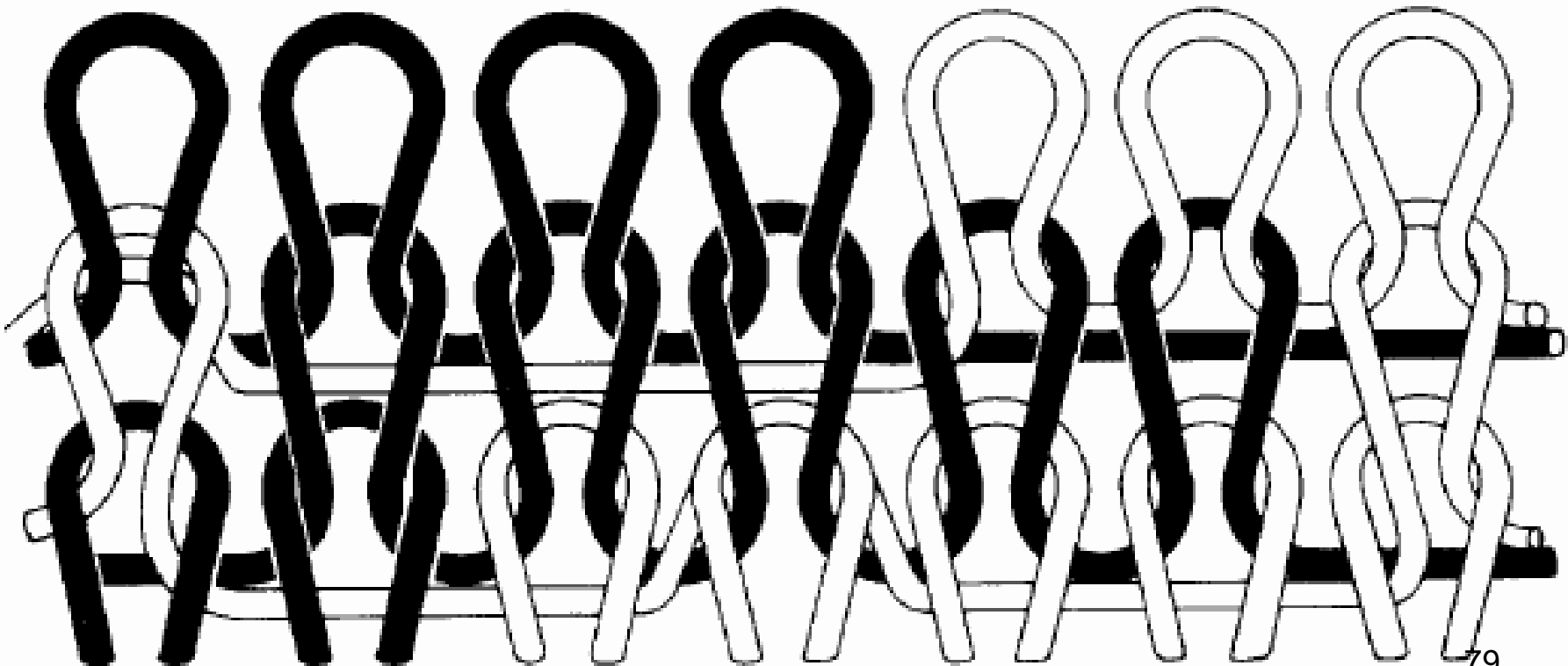
- Produce colored designs on a base structures of **single jersey, 1x1 rib, or purl**
- In **two-colour jacquard**:- certain needles will be selected to **knit** colour A while the others **miss** and vice versa in the next feed for color B  
two feeder courses = one design row
- In **three-colour jacquard**:- each needle set will be selected to knit once and miss twice at a sequence of feeds,  
**three feeder courses** will produce **one design row**

## b. Single-jersey jacquard

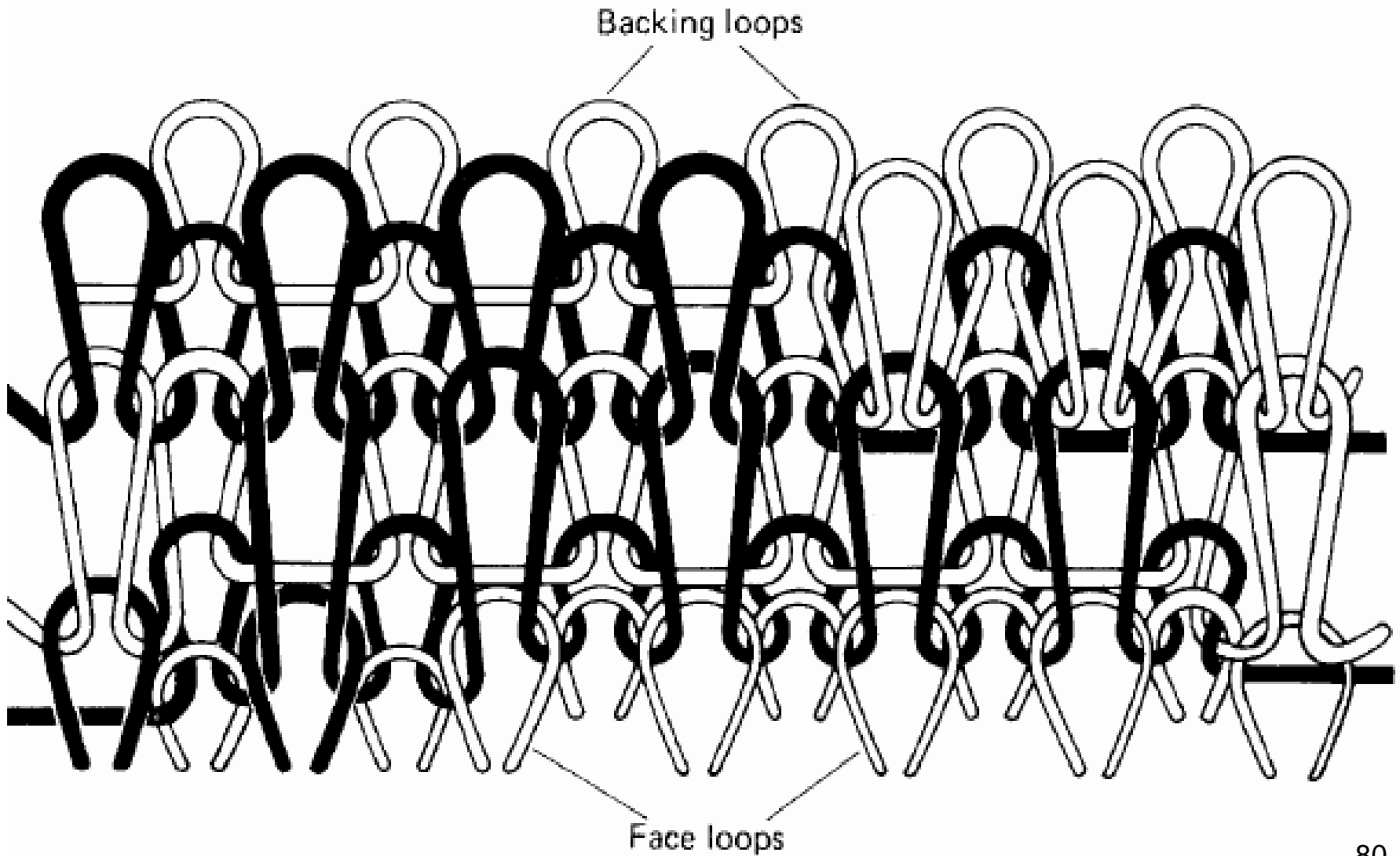


## c. Accordion fabric

- single jersey with the **long floats held** in place on the technical back by **tuck stitches**



# d. Rib jacquard



## Compare

- Number of pattern stitches
- Number of feeds
- Corresponding square paper notation for individual jacquard stitch selection
- Steps of selection of colors

## Definition

Straight accordion = tucking on non-knitting needles

Alternate accordion = tucking on odd needles at odd feeders and even needles at even feeders of non-knitting needles

Selected accordion = tucking on carefully selected non-knitting needles

# 4.6 Loop transfer stitches

- Applied in weft knitting
- The transfer of a full or part **needle loop or sinker loop** onto an adjacent needle for one or more courses
- To produce a design or change the stitch structure
- Used in ladies' stockings, when producing the double-thickness, plain fabric

- To form the **rib border** of a garment part in running and doubling **rib loop fabric** on the needles of a straight bar frame
- when running the loops of two separate fabrics, for linking these fabrics together.
- Loop transfer by hand is a tedious, but automatic loop transfer requires a **specific arrangement** of **specially shaped** needles

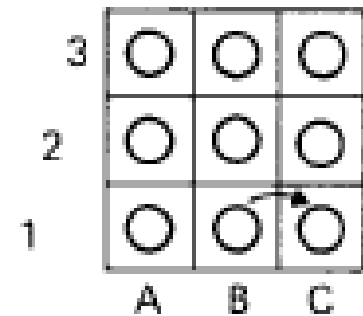
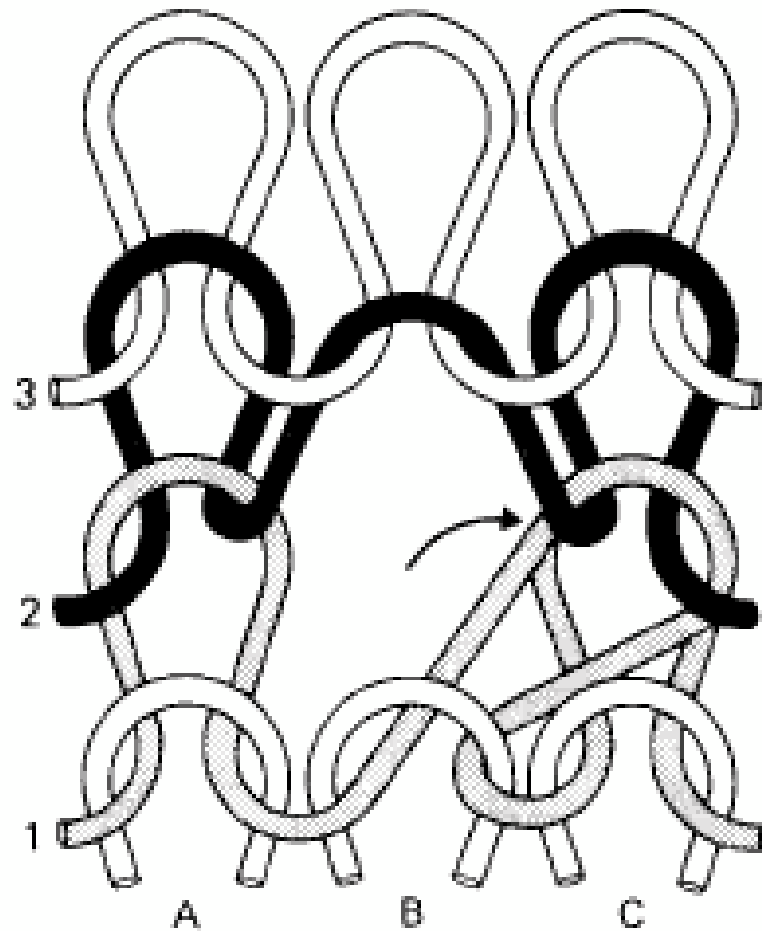
# The four main types of transfer stitches

1. *Plain needle loop transfer stitch*: produced by transference of a loop from one needle to another in the **same bed**.
2. *Fancy lacing stitches*, produced by sharing the plain loop to right and left as well
3. *Rib loop transfer stitches*, produced by transferring a loop from one needle bed to the other.
4. *Sinker loop transfer stitches*:- sinker loop is taken by the two adjacent needles for 1 or more courses

# 1. Plain loop transfer stitches

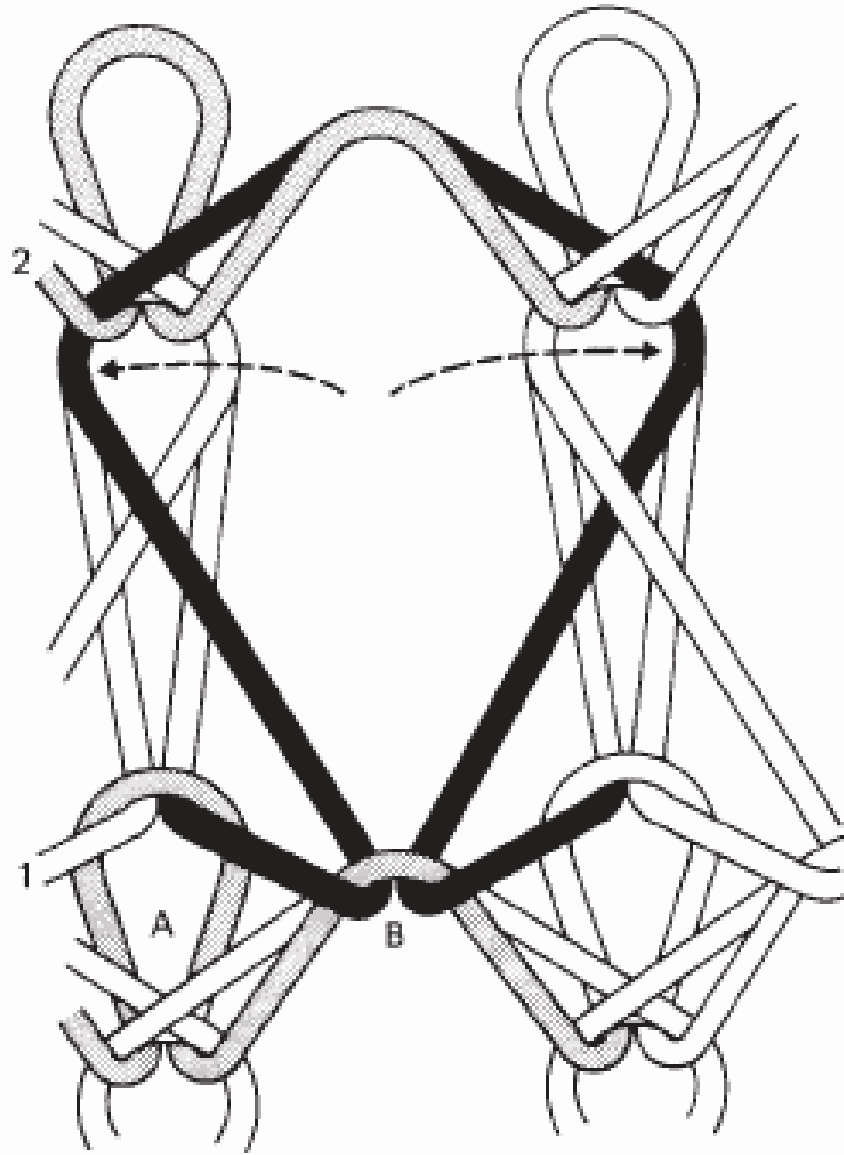
- Most commonly achieved on *straight bar frames* using specially-shaped needles
- In designs it is termed *a lace stitch* whereas in selvedge shaping it is termed *fashioning*.
- When a needle loses its loop and is required to knit at the next cycle, the loop it forms appears like *tuck loop*.

# Plain loop transfer stitches



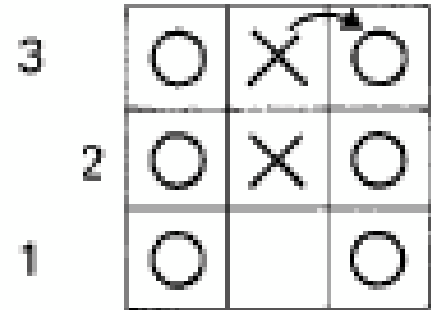
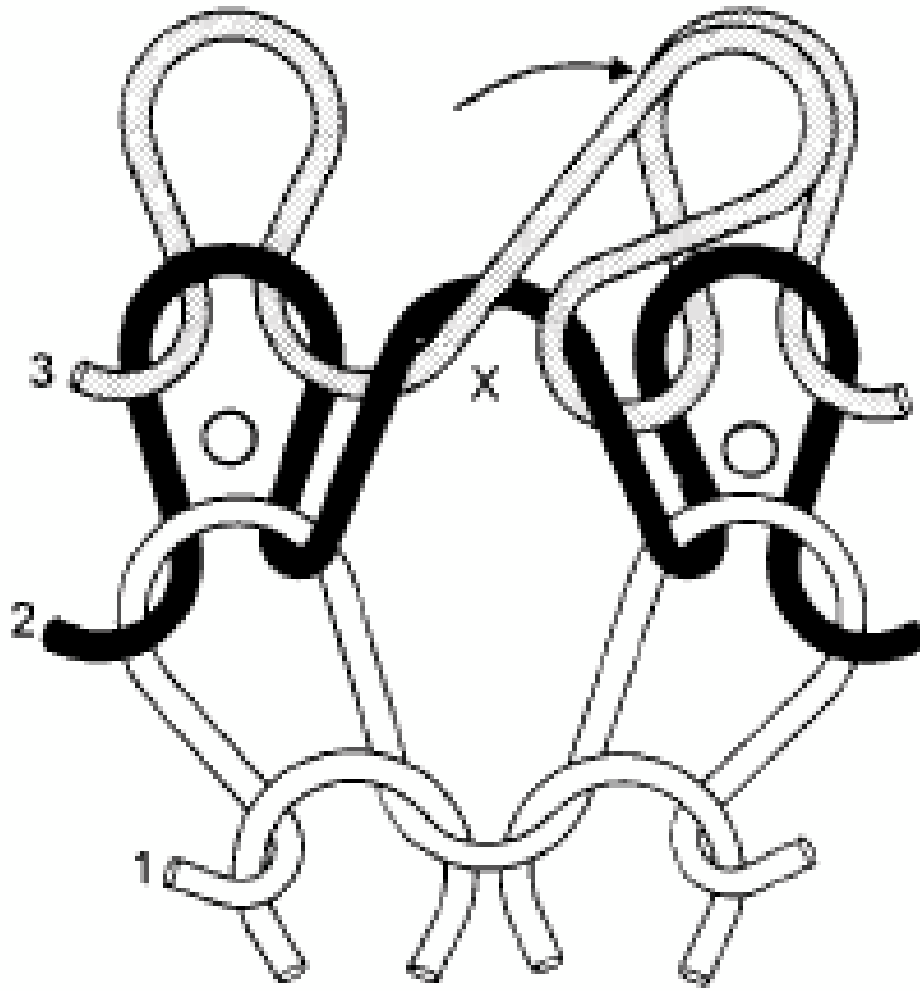
## 2. Fancy lacing stitches

- The **bearded needle sinker wheel machine** is most common for this type of stitch
  - **1<sup>st</sup> course** of long loops is knitted
  - Every second loop will be a **held loop**
  - Two legs of the second needle loop are spread sideways onto the neighbor loops
- **2<sup>nd</sup> course** is knitted with short loops
- tucking occurs at every second loops of the second course



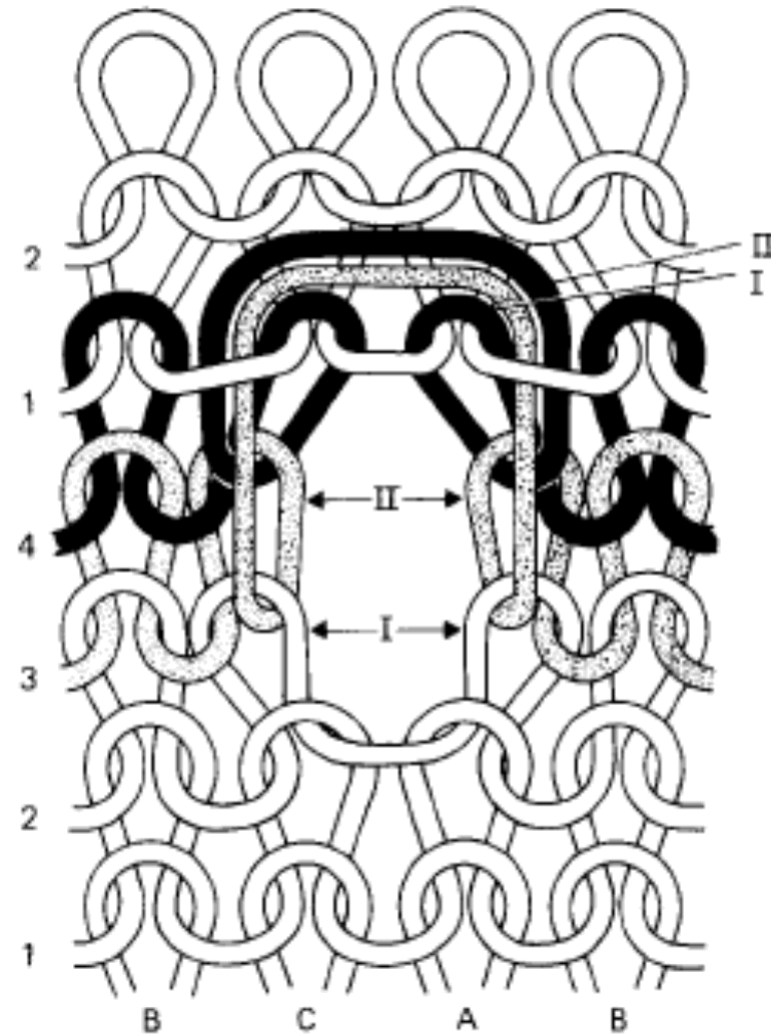
### 3. Rib loop transfer stitches

- very popular and formed on flatrib machines
- 1<sup>st</sup> course, needles are knitting only in one bed.
- 2<sup>nd</sup> course, an empty needle in the opposite bed commences knitting, producing 1 ¥ 1 rib
- 3<sup>rd</sup> course, this needle transfers its loop to a needle knitting in the opposite bed.

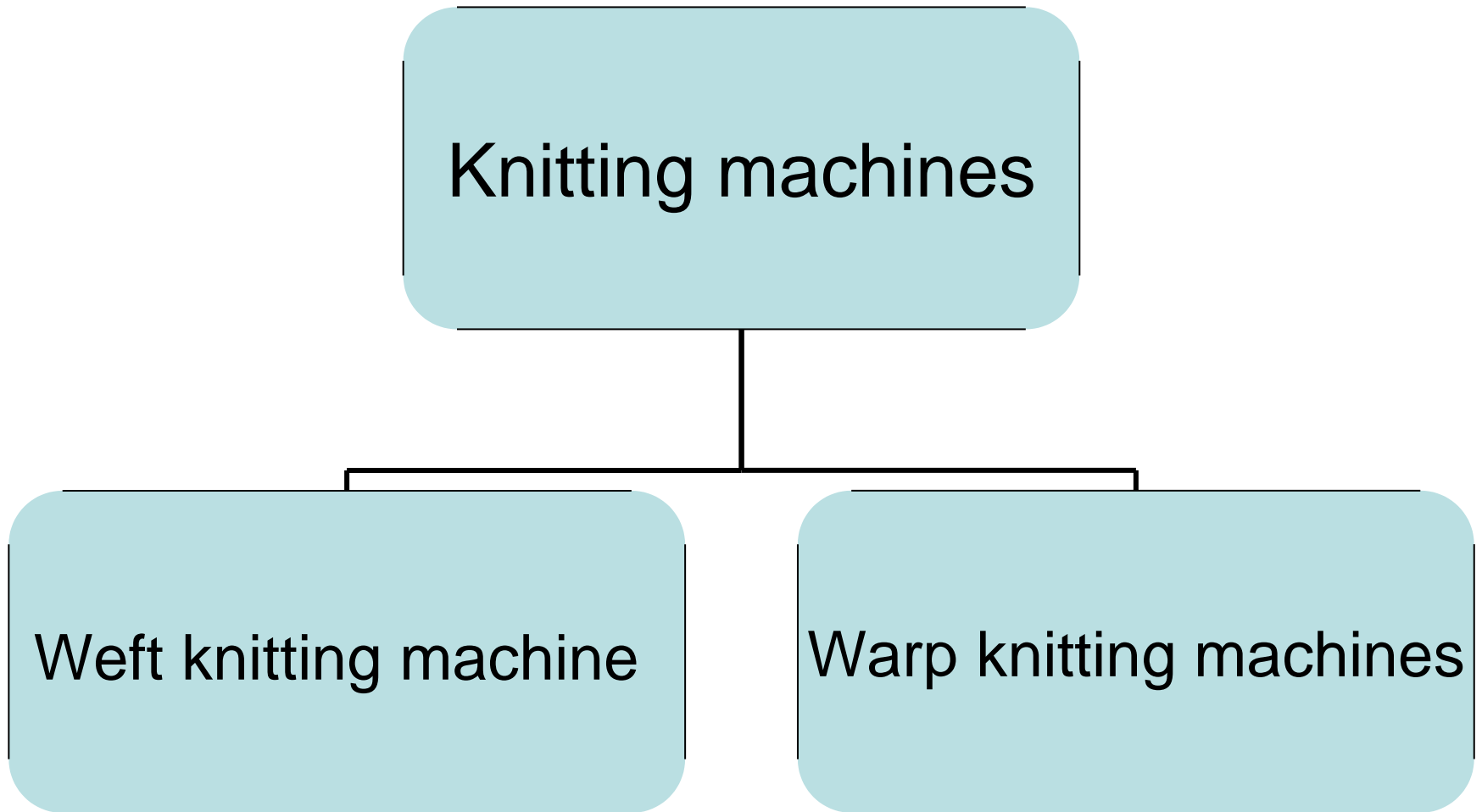


## 4. Sinker loop transfer stitches

- *Pe/erine eye/et*:- are formed at courses where adjacent plain wales move outwards as a result of the absence of connecting sinker loops.
- Sinker loops of two adjacent courses are hold up together



# 5. Classification of knitting machines



**Weft knitting**

```
graph TD; A[Weft knitting] --- B[Straight bar frame]; A --- C[Flat machines]; A --- D[Circular machines];
```

**Straight bar frame**

**Flat machines**

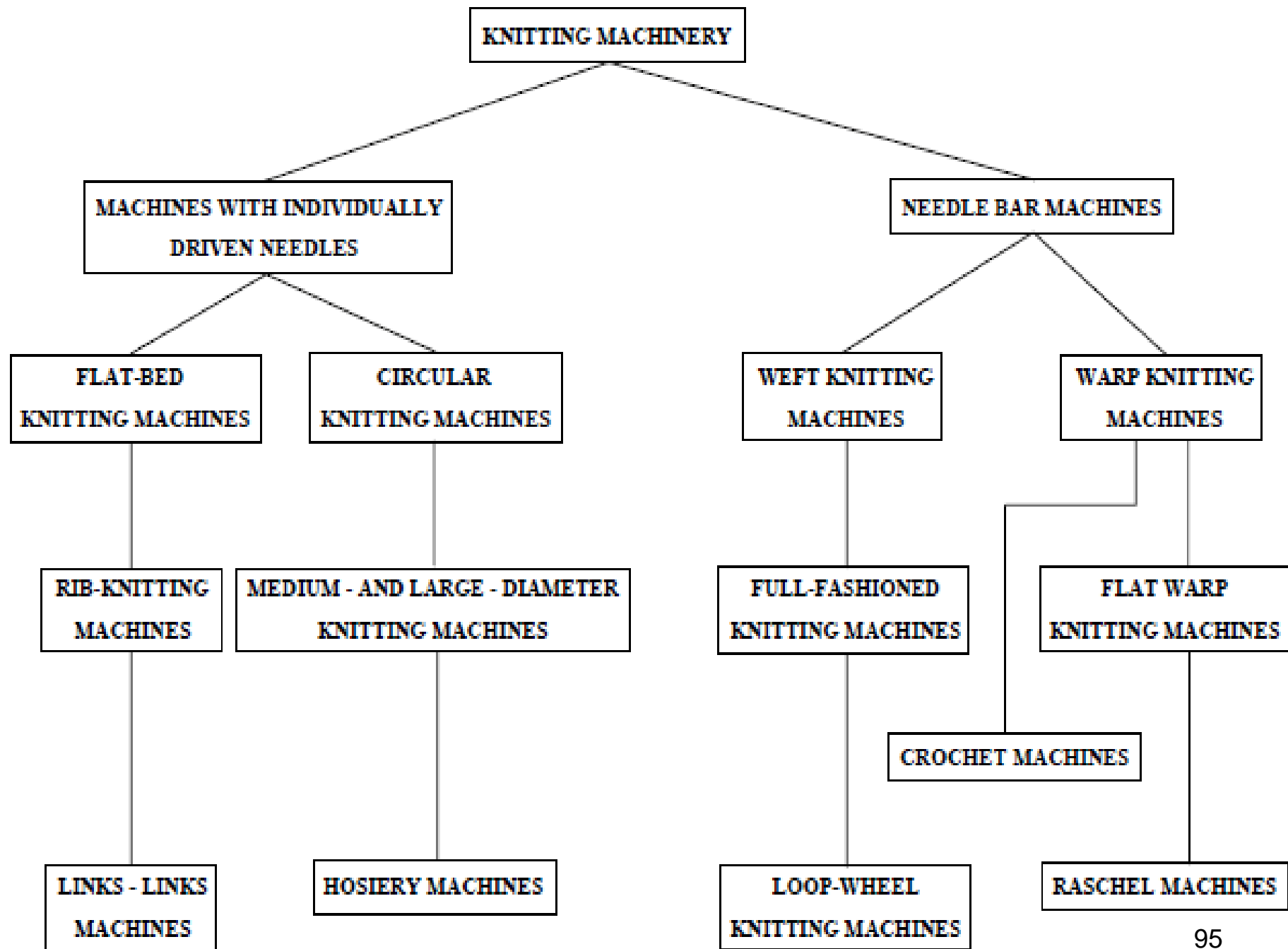
**Circular machines**

Warp Knitting m/cs

```
graph TD; A[Warp Knitting m/cs] --- B[Tricot machines  
(Automatic warp knitting m/c)]; A --- C[Raschel machines]
```

Tricot machines  
*(Automatic warp knitting m/c)*

Raschel machines



# Weft Knitting m/cs

## Bearded needle machines

## Latch needle machines

Straight bar

Circular

Flat bar

Circular

- 
- 1 or 2 needle bed
  - Fully fashioned
  - produce shaped knit wear

- 1 needle bed
- Sinker wheel or loop wheel
- produce fabric

- 
- 1 needle bed or
  - 2 needle bed
  - V-bed/flat for **purl**
  - produce knit wear

- 1 needle bed for **plain**
- 2 needle bed for **rib, interlock**
- double cylinder for **purl**

-Produce garment  
or fabric

# Weft knitting machines

1. Straight bar frame machines
  - Have a **vertical bar** of bearded needles
  - The needle movement is controlled by **circular engineering cams**
  - The length of the machine is divided into a number of knitting heads ('*sections*')
  - Each head is capable of knitting a **separate fashion-shaped** garment.

## 2. Flat bed machines

- Has **two stationary beds** arranged in an inverted V formation or link to link.
- Latch needles slide in the tricks during the knitting action.
- Needle butt is controlled by the **angular cams** of a bi-directional cam system.
- They are two types
  - 90 – 100° V bed machines
  - 180° linked link to link machines

# 3. Circular knitting machines

- needle beds are arranged in **circular cylinders** and/or dials
- Include **latch, bearded** needle machinery
- knitting a wide range of fabric structures, garment and cylinder diameters
- Are most common type of machines

# Warp knitting

In the past

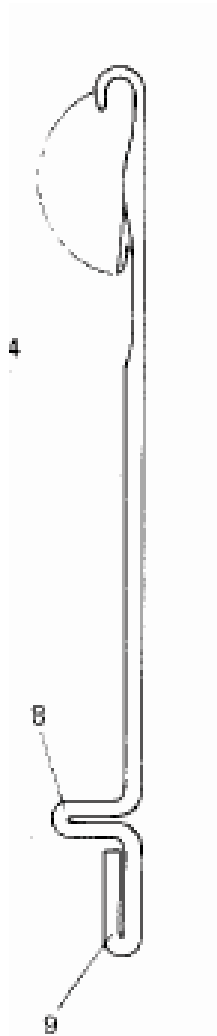
- Tricot machines mainly employed *bearded need/es* with a presser bar
- Raschels machines used */atch need/es* with its blade.
- But now a days they also use *compound needles*

## 6. Basic operating Parts of knitting machines

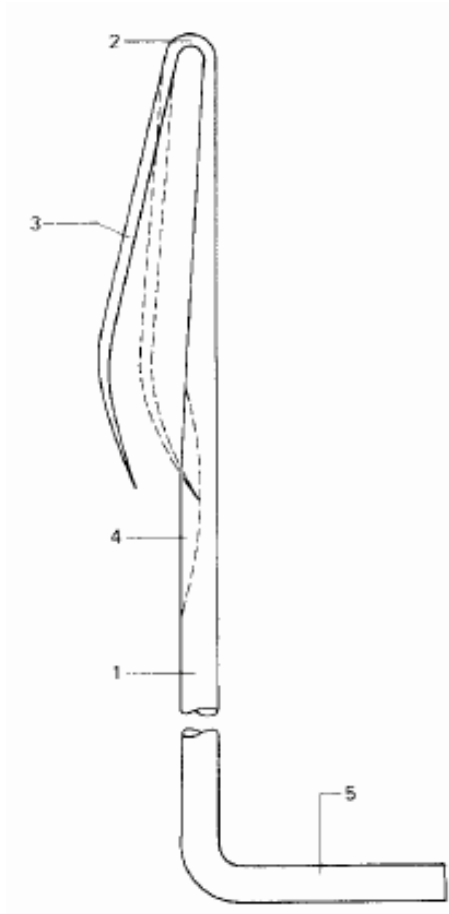
1. **Needle**:- basic knitting element
2. **Needle bed**:- Bar/frame on which needles & jacks are arranged
3. **Sinker**:- for loop *formation, Holding-down, or Knocking-over*
4. **Jack**:- provides versatility of latch needle selection & movement
5. **Positive feed devices**:- device used to control yarn feeding rate
6. **yarn carriage**:- yarn feeding or may move the needle up & down
7. **Cam**:- converts the rotary drives → reciprocating action
8. **Pattern wheel**:- to select and move individual elements/needles
9. **Guide bar**:- Bar on which thread guides are arranged in warp knittg
10. **Thread guide**:- guides and feed thread to needle in warp knitting

# Needle

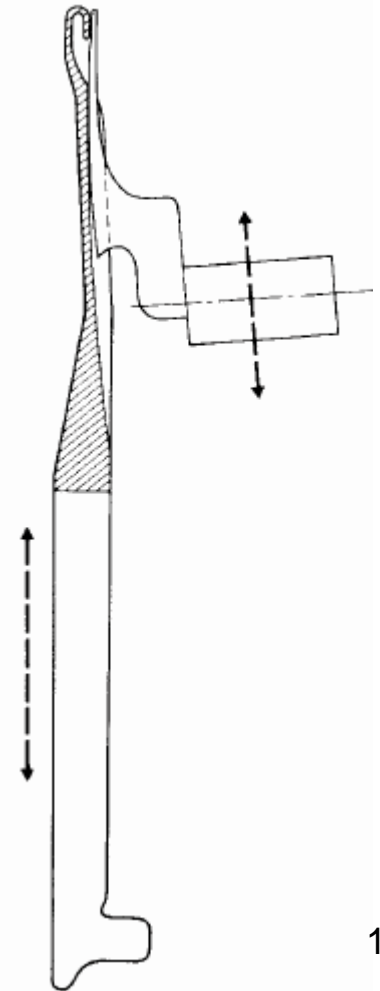
Latch needle



Bearded needle



Compound needle



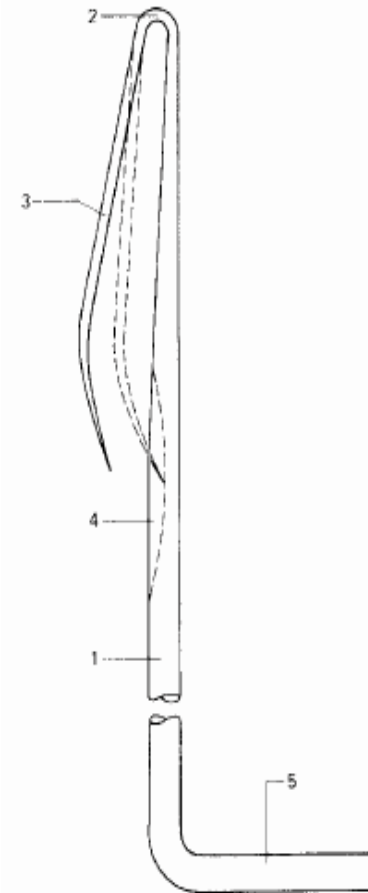
# Latch Needle

1. *Hook*:- draws and retains the new loop
2. *Siot* :- receives the latch-blade
3. *Rivet*:- hold and rotate latch
4. *Latch-blade*:- locates the latch in the needle
5. *Latch spoon*:- extension of the blade  
→bridges the gap between the hook and the stem
6. *Stem*:- carries the loop in the clearing Irest position
7. *Butt*:- enables the needle to be reciprocated
8. *Tail* :- gives additional support to the needle and keep the needle in its trick



# Bearded needle

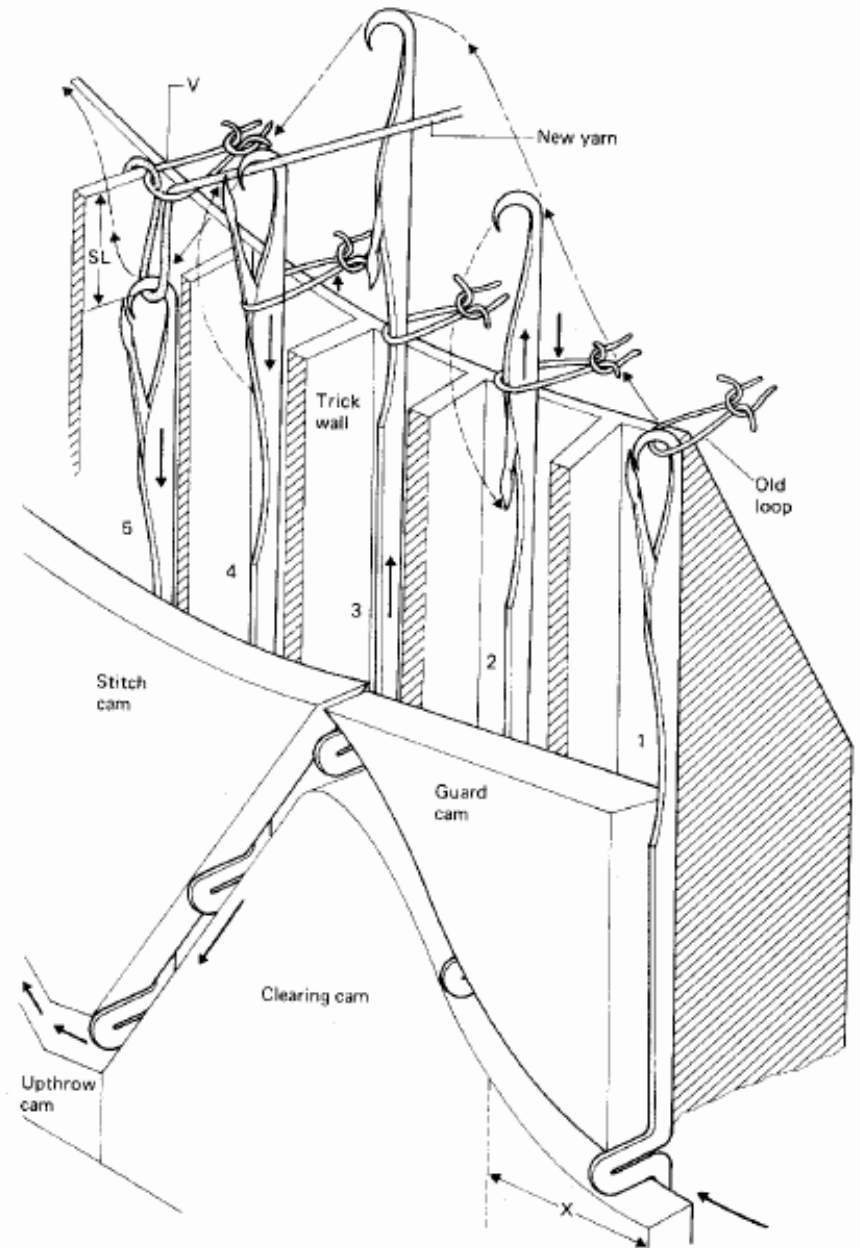
1. **Stem**:- around which the needle loop is formed
2. **Head**:- where the stem is turned into a hook to draw the new loop through the old loop
3. **Beard**:- curved downwards continuation of the hook  
→ to separate the **trapped new loop** from the old loop as it slides off the needle beard
4. **Eye/groove**:- cut in the stem  
→ to receive the pointed tip of the beard when it is pressed, thus enclosing the new loop
5. **Shank**:- the bent bottom part  
→ for driving the needle



# The Knitting Action of the Latch Needle

## 1. The rest position.

- The **head of the needle hook** is level with the top of the verge of the trick.
- The **loop formed** at the previous feeder is in the closed hook.
- **This loop** is prevented from rising as the needle rises, by *holding-down sinkers*



## *2. Latch opening*

- . As the **needle butt** passes up the incline of the clearing cam, **the old loop**, which is held down by the sinker, slides inside the hook and contacts the latch, turning and opening it.

### *3. Clearing height*

- . When the needle reaches the **top of the cam**, the **old loop** is cleared from the **hook and latch spoon** on to the stem.
- At this point the feeder guide plate acts as a guard to prevent the latch from closing the empty hook

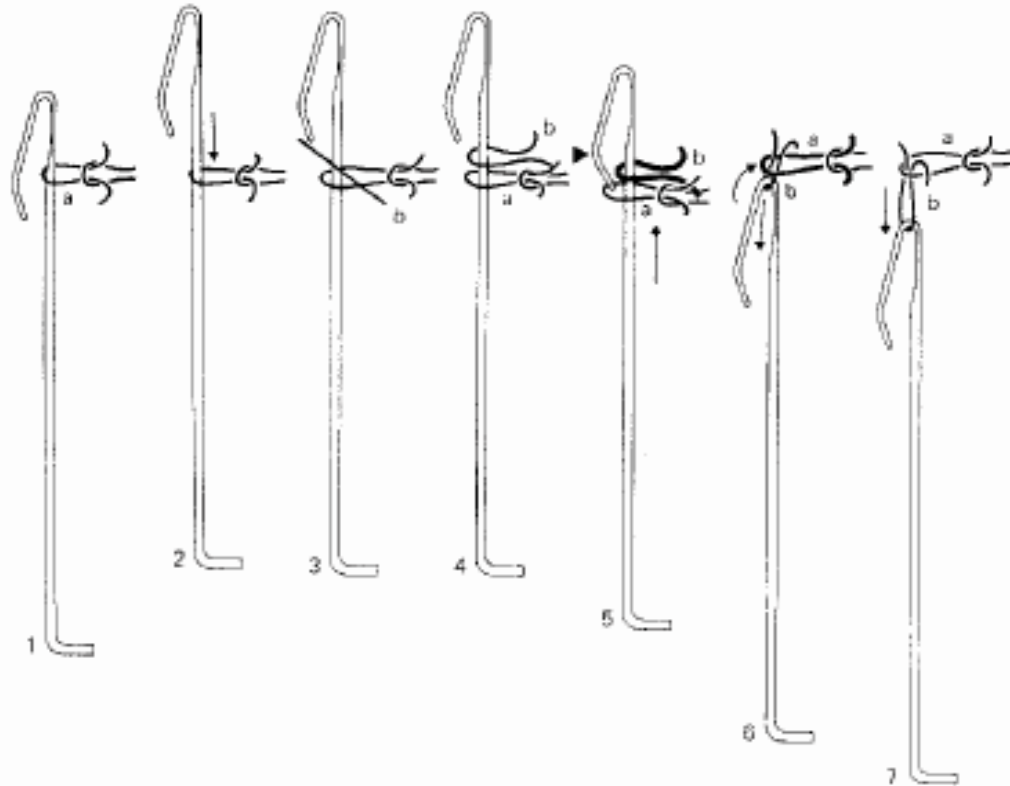
## *4. Yarn feeding and latch closing*

- The **needle** starts to descend the **stitch cam**, with the old loop moving under it, yarn is fed.
- The **old loop** contacts the underside of the latch, causing it to turn and close on to the hook.

## *5. Knocking-over and loop length formation*

- . As **the head of the needle** descends below the top of the trick, the **old loop slides off** the needle and the new loop is drawn through it.
- The continued descent of the needle draws the loop length, which is approximately twice the distance the head of the needle descends, below the surface of the sinker

# The Knitting Action of the Bearded Needle



1. **Rest position**:- old loop (a) held inside the hook.
2. **Clearing height**:- the old loop is cleared from the hook down the stem

3. Yarn feeding position
4. yarn is *formed* into a 'new' loop
5. **Hook closing**:- beard is closed
  - enclosing the **new loop** and
  - excluding the **old loop** onto the outside of the closed hook
6. **Knocking over**:- As the needle moves down
  - The new loop is *drawn through* the head of the old loop
  - The old loop slides off the closed hook of the needle  
*cast-off or knocked-over*
7. Loop length is drawn

# Comparison

## **Latch needle**

- Expensive and intricate to manufacture
- Self-acting or automatic loop-controlled so stitch selection is achievable
- Use with computer-controlled electronic selection device

# Bearded needle

- 1<sup>st</sup> to be produced
- Cheapest and simplest to manufacture
- Essentially a *frame needie*, the needles move collectively

B/s → problem in individual pressing

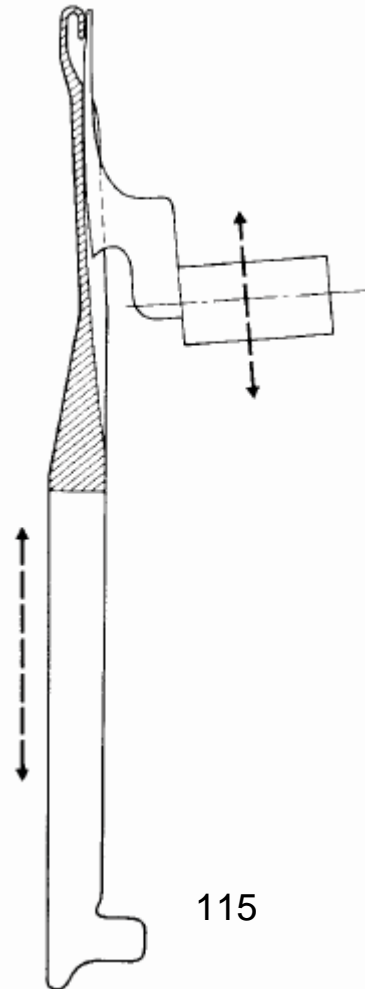
→ problem in individual needle mov.t

- Ease of flexing and deflection of the bearded needle made the sinker wheel and **straight bar frames** useful for **loop transfer** effects
- Unable to meet requirements of modern knitting machinery **like...**
  - individual needle selection of stitches,
  - use of two needle beds and
  - high productivity

# Compound Needle

Consists of two separately-controlled parts  
the *open hook* and the *sliding closing element*

- They rise and fall as a single unit but, at the top of the rise, the **hook moves faster** to open the hook
- at the start of the fall the hook descends faster to close the hook.
- It is easier to drive the hooks and tongues collectively from two separate bars in warp knitting than to move each hook and tongue individually in weft knitting



# Disadvantage of compound needle over latch needle

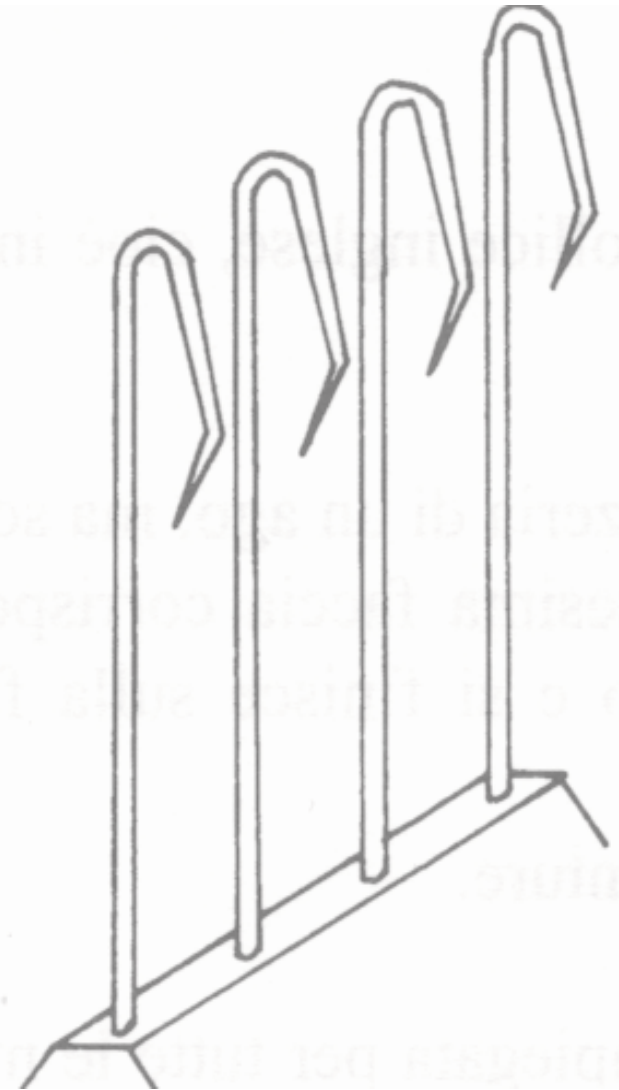
- more **intricate and expensive** to manufacture
- The two parts must be **separately and precisely** controlled
- Yarn feeding is very critical because, if the yarn lands on the tongue, it will not enter the open hook, whereas in latch needle knitting the closing latch will flick the yarn into the hook.
- problem when knitting multiple tucks
- **Lifting of the tongue out of its guide groove** at high speeds or as the result of dirt or fly can be a problem, particularly if it splits filament yarns.
- Surface friction may generate heat and may result problems

# Advantage of compound needle over latch needle

- The vertical clearing height is not so high
- Shorter vertical stroke
- When clearing and knocking-over, less stretching of needle loops and robbing of yarn from adjacent sinker loops = **less stress on needle loops**
- **Tight & uniform** stitches can be produced
- short, smooth, simple harmonic motion = less vibration
- No latch that hits hook and damage it there fore we can make the hook thinner and slimmer in diameter  
→ thicker yarn feeding possible

# Needle bed

- The needles can be **fixed on needle bar** or can be **driven individually** in a grooved plate, according to the type of knitting machine.
- All knitting machines can be equipped with one or two needle-beds, according to the model.



- The needle-bed of a knitting machine can be **flat or circular**
- It is made up of a steel body provided with grooves where the needles with hook and butt turned upward slide.
- The milled **grooves guide** the needles during the knitting process.
- The needle-bed is characterized by two elements:
  - the operating width
  - the gauge

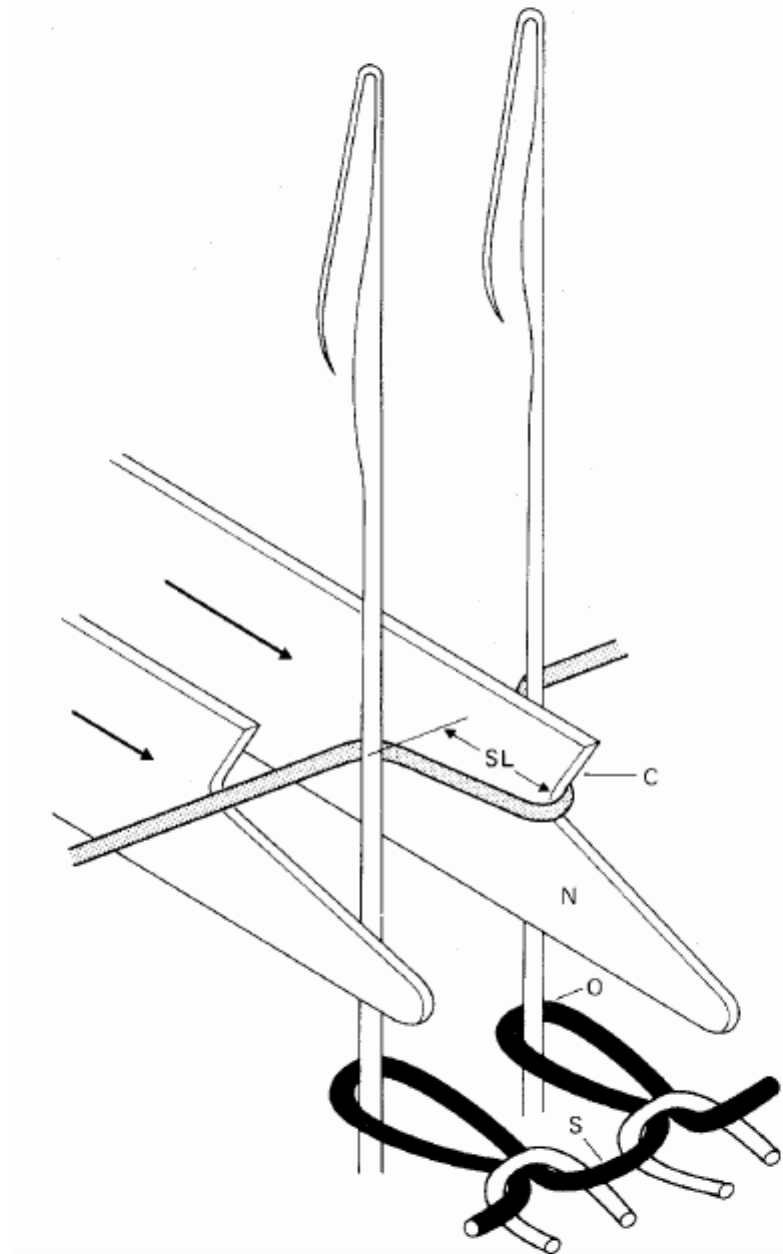
- The **operating width** is the **maximum working area** and varies according to the type of machine
- Eg. in a flat-bed machine → **the distance between the first and the last needle**
- In circular knitting machines → **the needle-bed diameter**
- The **gauge** is the **population of needles on a certain length of bed.**
- The English Gauge (E) → the number of needles in an inch, 2.54cm (x needles/inch)
- The gauge refers always and only to one of **the two needle-beds.**
- used for all the weft knitting and warp knitting frames

# Special types of gauges

- the English Raschel Gauge (ER) → number of needles included in 2 inches, 5.08cm  
used for Raschel looms
- GG Gauge is → the number of needles included in 1.5 inches, 3.81cm  
used for flat-bed full-fashioned machines and for English circular machines.
- French Gauge → the number of needles included in 1.5 French inches (4.16 cm)  
used for loop wheel circular machines.

# Sinker

- A thin metal plate with an individual or a collective action
- may perform one or more of the following functions, dependent upon the type of machines
- *Loop formation (C)*
- *Holding-down*
- *Knocking-over*



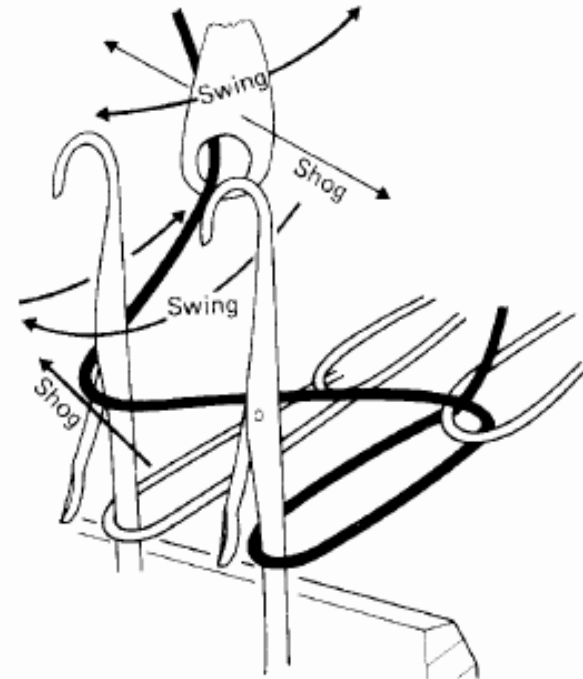
# Loop formation

- On bearded needle weft knitting machines of the **straight bar frame** and **sinker wheel** type main function of sinker is

= **loop formation**

- Latch needle, weft and warp knitting the main function of sinker is

= **Not loop formation**



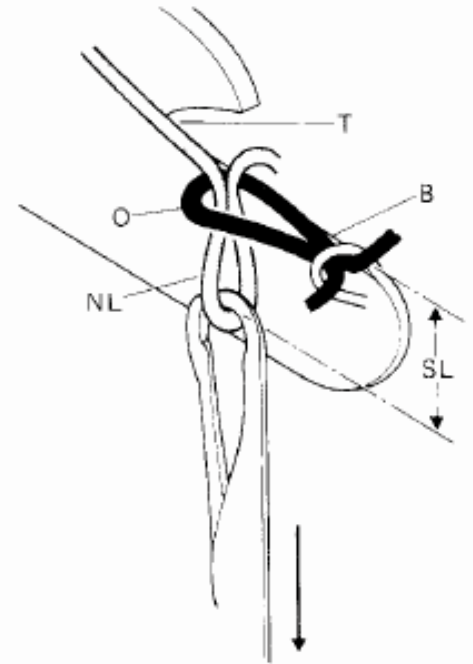
*to hold down the old loops, N, T*

- *to hold down the **old loops** at a **lower level** on the needle stems than the **new loops***
- to prevent the **old loops** from being lifted as the needles rise to clear them from their hooks.
- On tricot warp knitting machines and single bed weft knitting machines, a *slot, T*
- On raschel warp knitting machine the sole function of the sinker is *a **web holder***
- Holding-down sinkers enable **tighter structures**, reduced minimum draw-off tension, higher speeds, knitting can be commenced on empty needles

- Holding-down sinkers are often **unnecessary** when knitting with **two needle bed** machines → the second bed restrains the fabric loops whilst the other set of needles moves.
- However, if **single bed knitting** or held loop structure is knitted, a form of holding-down element may still be required

# *knock-over*

- upper surface or *beiiy* (8) supports the old loop (O) as the new loop (NL) is drawn through it.
- On raschel warp knitting machines, many V-bed flats, and cylinder and dial circular 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 versatility 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.

# Flat knitting machines

*Two types*

## *1. V-bed machines*

- Have two rib gated, needle - beds,
- Set at between 90 and 104 degrees to each other
- **The takedown tension** and the needles in the other bed help to hold the old loops down on the needle stems as the needles rise to clear.
- **Latch opening brushes** are attached to the cam-plates of both needle beds to ensure that the needle latches are fully opened

## 2. *Fiat bed puri (iinks-iinks) machines*

- Have horizontal needle beds
- They use *double-headed iatch needles* that are transferred to knit in either of two directly opposed needle beds
- These complex and slow machines (links-links) are no longer built because the *modern electronic V-bed machines* can knit all the links-links designs using the facilities of rib loop transfer and needle bed racking.

# Flat machine gauges

- Flat machines are normally gauged on the *English system (E)* of *needles per inch* (npi).
- The *Metric system*, which is based on the *distance in tenths of a millimeter* from the centre of one needle to the next, is rarely used.
- Metric system is a direct system, with a higher gauge number indicating a coarser gauge
- Generally, *flat machine* gauges range from **E 5 to E 14**, with the main gauges being **5, 7 and 10**, but there are machines as coarse as E 2.5 and as fine as E 18 or even finer now being built.
- All flat machines can be *hair-gauged* by removing every alternate needle; thus, an E 10 gauge machine will become an E 5 gauge.

# The cam system of the V-bed hand flat machine

- The single knitting system **cam-box** is symmetrically designed for knitting a course of loops on both the **front bed and back bed** needles during a right-to-left traverse and a second course during the return left-to-right cam box traverse.
- The needle butts will **enter** the traversing cam system from **the right** during a **left-to-right** carriage traverse and from the left during a right-to-left traverse.
- For each needle bed there are two raising cams (R), two cardigan cams (C) and two stitch cams (8).

Back needle  
hook

SIAI

SILI

Undt ... dt of "''''''--|

AS CRI

A S.III

Front needle  
hook

Fig. 18.3 Cam system of simple hand Bat.

- In the direction of traverse, the leading **raising** cam is responsible for **knitting** and the trailing raising cam acts as a **guard cam**.
- **Stitch** cams are used to draw **loop length** and can be set
- A **raising cam** lifts the needle to **tuck height**,
- but if the **cardigan cam** above it is in action the needle is lifted to **full clearing height**.
- Thus, the cardigan cam is taken out of action if a tuck stitch is required.
- To produce a **miss stitch**, both the **raising cam** and the **cardigan cam** are out of action.
- To produce a course of **tubular plain knitting**, a pair of raising cams that are diagonally opposite each other in each bed (RL and RR) are out of action.
- *A **Single cam system** machine* will knit **one course** of rib in one traverse whereas a ***double cam system** machine* will knit **two courses** of rib per traverse.

Back needle  
hook

SIAI

SILI

Undt ... dt of "''''''--|

AS CRI

A S.II

Front needle  
hook

Fig. 18.3 Cam system of simple hand Bat.

# The knitting action of the V'bed hand flat machine

## 1 *The rest position*

- The tops of the heads of the needles are level with the edge of the [knock-over bits](#).
- The butts of the needles assume a straight line until contacting the raising cams R(R) because the leading stitch cams S and AS (L) are lifted to an inactive position.
- This action prevents needles from being unnecessarily lowered and a strain being placed on the old loops prior to the start-up of the knitting action.

## 2 *Clearing*

- The needle butts are lifted as they contact the leading edge of cams R (R), which raises the needles to 'tucking in the hook' height with the cams S (L) acting as guard cams.
- The needles are lifted to full clearing height as their butts pass over the top of cardigan cams C (R) and C (L).

## 3 *Yarn reeding*

- The yarn is fed as the needles descend under the control of guard cam (G).
- The required loop length is drawn by each needle as it descends the stitch cam S (R).

#### 4 *Knocking-over.*

- To produce *synchronized knocking-over* of both needle beds simultaneously, the *stitch cam S (R)* in the front system is set *lower* than the auxiliary stitch cam *AS (R)*, so that the AS (R) is rendered ineffective.
- If, however, *delayed timing or the knock-over* is employed, knock-over in the front bed will occur after knock-over in the back bed.
- In this case, stitch cam S (R) is not set as low as AS (R) so that the depth setting of the AS (R) cam produces the knock-over action.
- *Delayed timing* is only normally *used on gauges finer than 8 npi*

On hand flat machines, the cams are often of the sinkable setting type so that they can be set either:

1. *ruiiy in action* out from the cam plate so that they **act on every needle butt**,
  2. *partiy withdrawn* into the cam-plate so that they miss the low (short) butts, which pass undisturbed across their surface, or
  3. *ruiiy withdrawn* into the cam-plate so that all butts pass **undisturbed across their surface**.
- Two or more cam systems can be arranged in a single carriage = two or more feeders/traver.
  - Split cams can be used on a bed

# Straight bar frame

- Produces Underwear and knitwear
- Popular gauges of 51 G and 60 G (needles/1.5inch) for stocking
- Today, **outerwear** straight bar frames with **16 knitting sections**, each **32 or 34 inches** wide, may be as long as 23.5 m
- The normal gauge range is from 9 to 33.

Gauges (G)	9	21	24	33
Yarn count (Ne)	2110's	2124's	2128's	2140's

Garment part	Bodies	Sleeve
Knitting section width	71 – 91cm	51 – 56 cm

# Knitting action of the plain straight bar frame

A. *Bearded needie*

B. *Sinker*

only **one between every** other needle space  
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**.

E. *Needie bar*

Having a compound horizontal and vertical movement.

F. *Striking jack,*

Fulcrummed at its lower end, each one with its '**nose**' resting on a sinker back, and a '**spring**' exerting pressure on its '**tail**'.

G. *catch bar*,

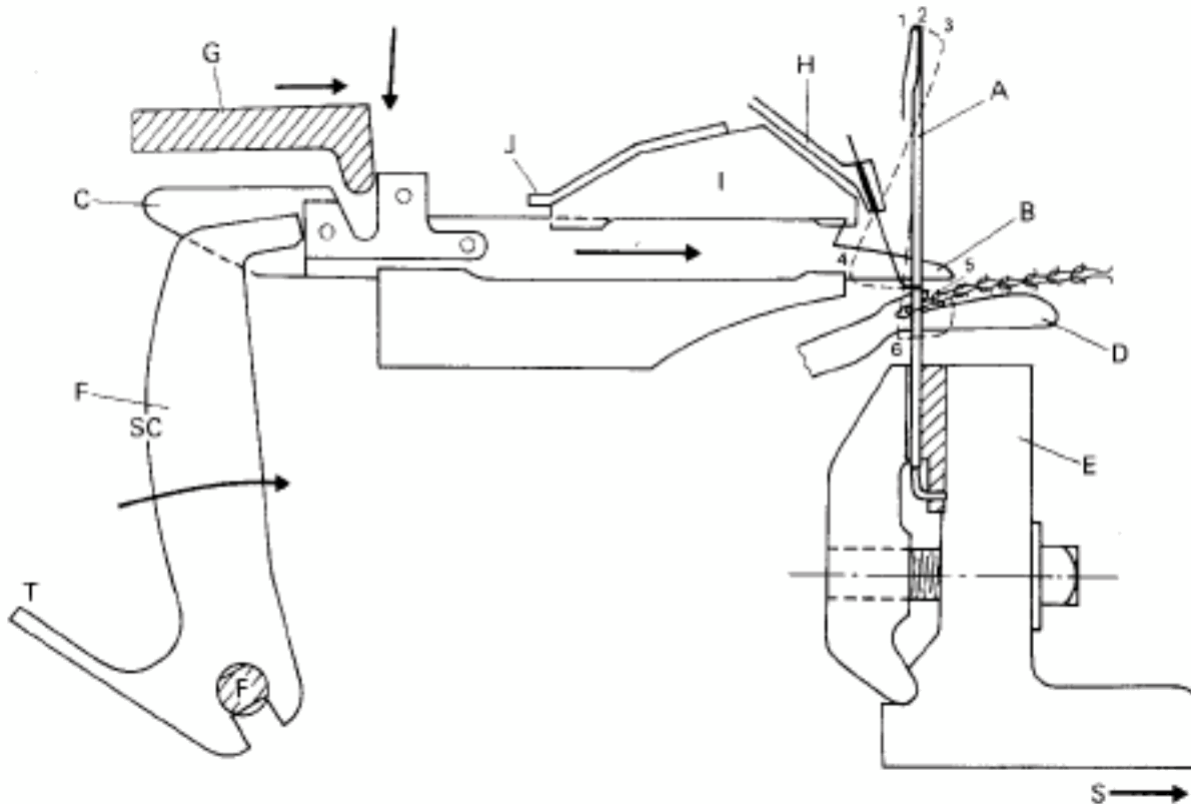
Extending the full width of the knitting head, having forward and backward, as well as vertical, movement.

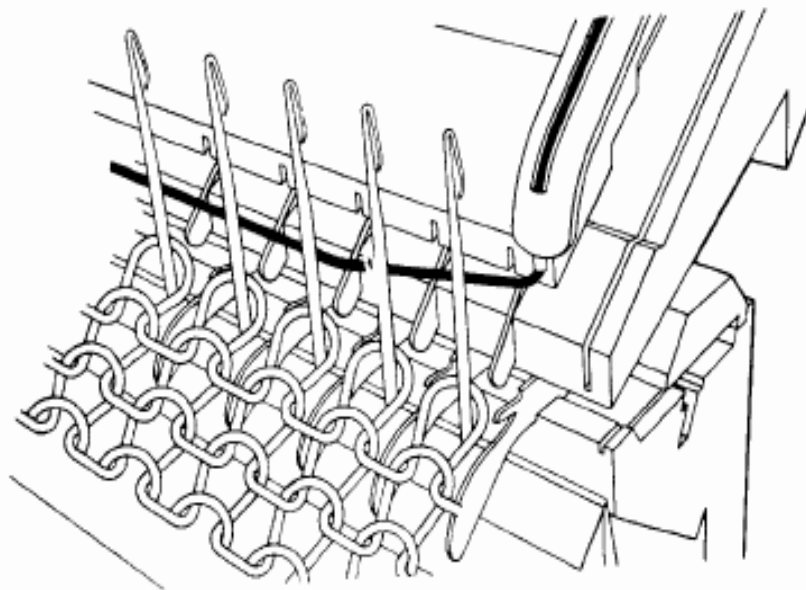
H. *Yarn carrier*

which traverses in alternate directions across the head from one course to the next

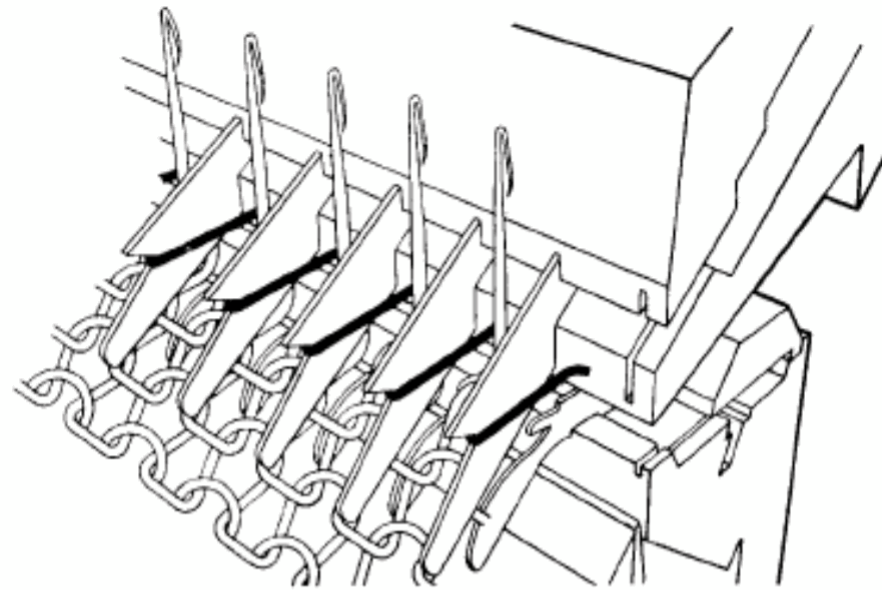
J. *Failing bar*,

which is a stop that cushions the advance of the sinkers and dividers

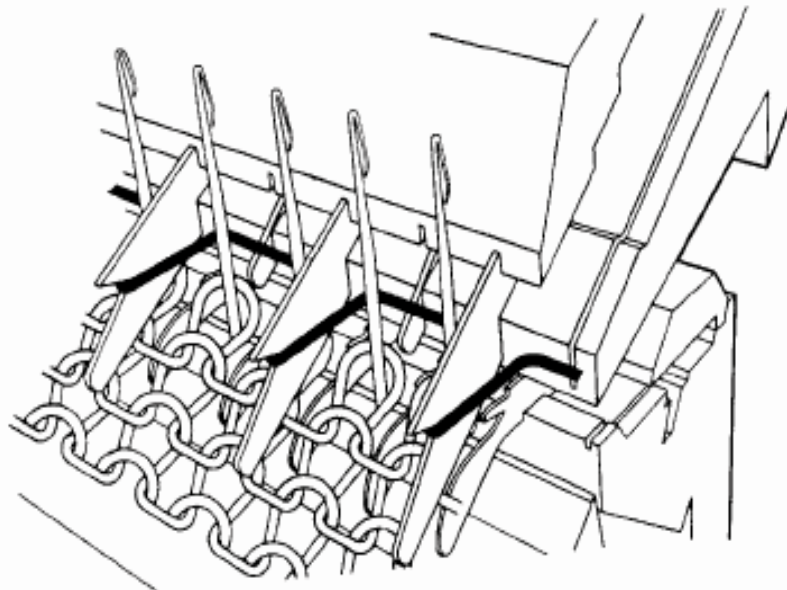




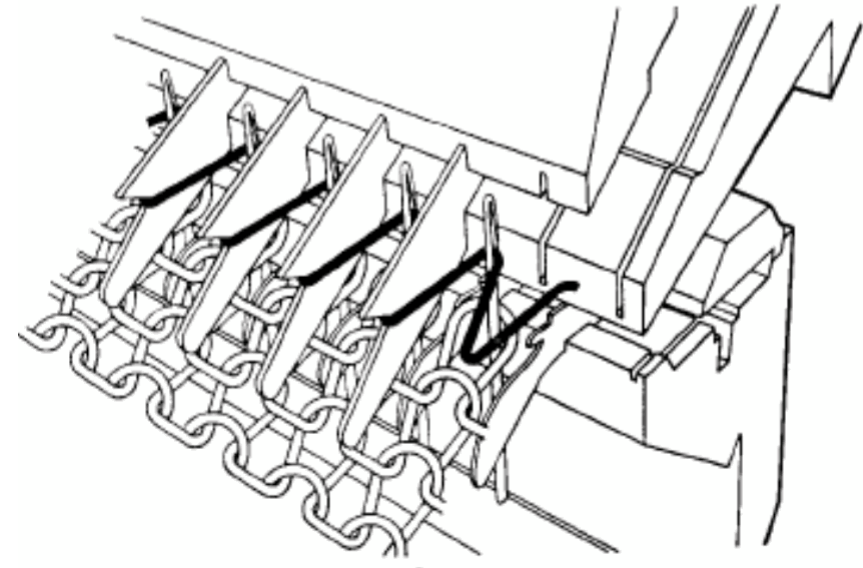
(a) Laying the thread



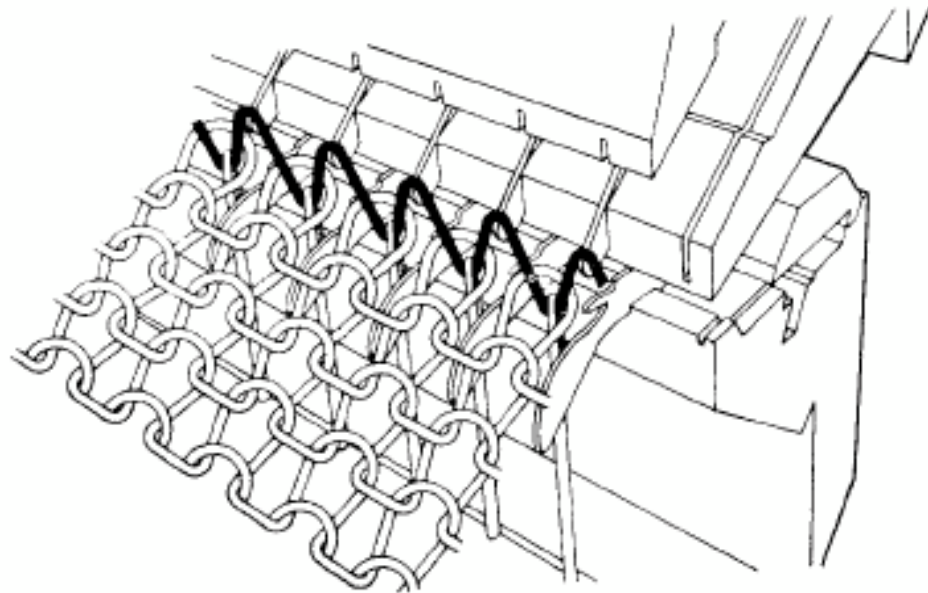
(c) Dividing the loop



(b) Sinking the loops

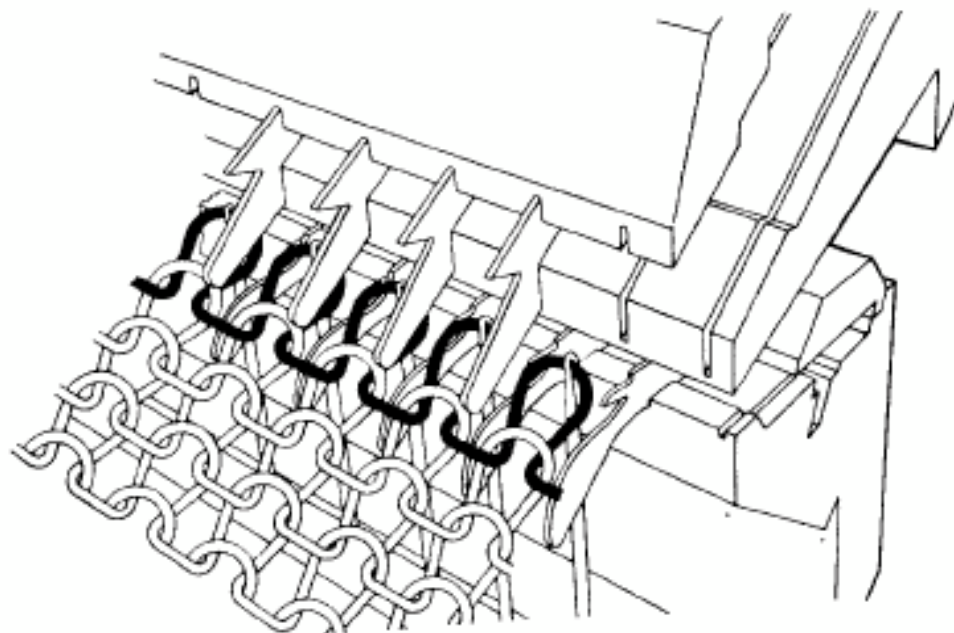


(d) Pressing



(e)

Landing the loops



(f)

Knocking-over the loops

## Loop transfer stitch formation

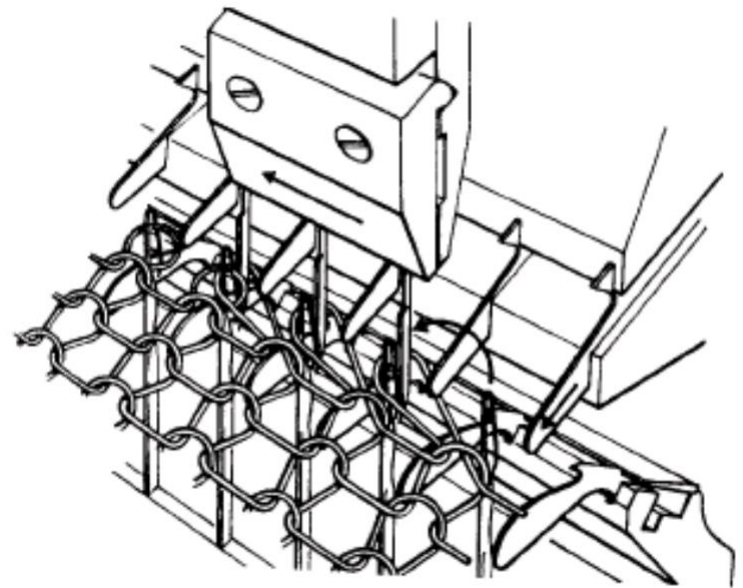


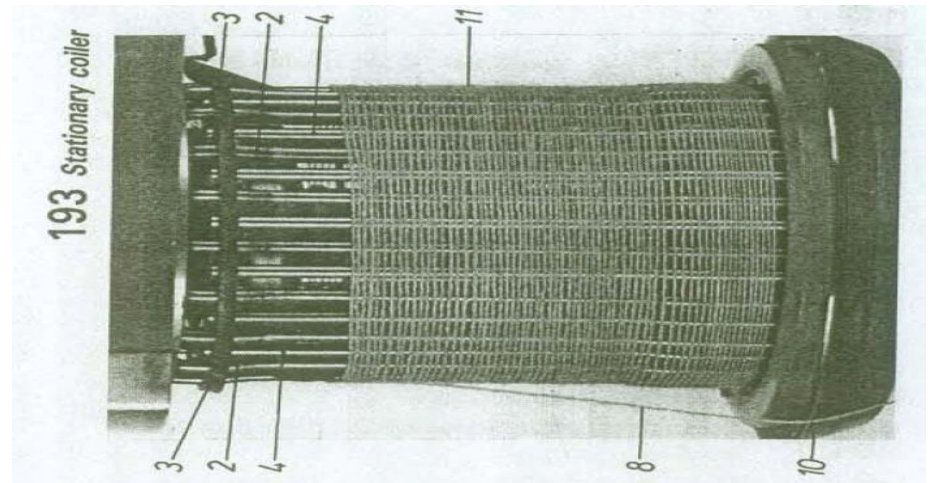
Fig. 17.4 Fashioning points.

# Design and development

- **Few new straight bar frames** are now being built. Instead, existing machines are being 'recruited' (up-dated) to meet the challenge of the V-bed machines, with their ever-improving patterning and shaping facilities
- It can produce different kinds of patterns like **lace, colored designs, tuck stitches** and combinations of these stitches

# Positive Feed devices

- › Quality of Knitted fabrics retards b/s of Defects like **puckered fabrics, bowing, streak, boardy, barrie effect, needle lines...**
- › Most of these defects are caused by yarn/metal slippage →  **$\Delta$ yarn input tension** →  $\Delta$ feed rate →  $\Delta$ loop length → Fabric quality
- › A device is developed to control yarn feeding rate called **positive/measured feed devices**



# Defects in Knitted fabrics

Barrie effect



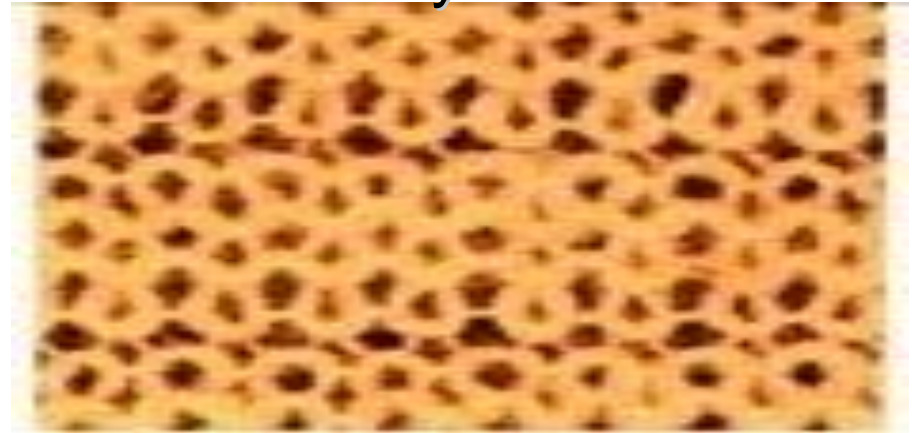
Hole



Thick Yarn



Thin yarn



# Direct and Indirect Yarn Feed in Flat Knitting

- › In some m/cs the front and back needle bed cam-plates are joined together so that cam carriage is derived as a single unit.
- › This causes an unbalanced yarn path, which in turn leads to yarn tension variation
- › But in electronically-controlled power flats the drive is separate

# Direct Yarn Feed

Ex. Hand flat machines

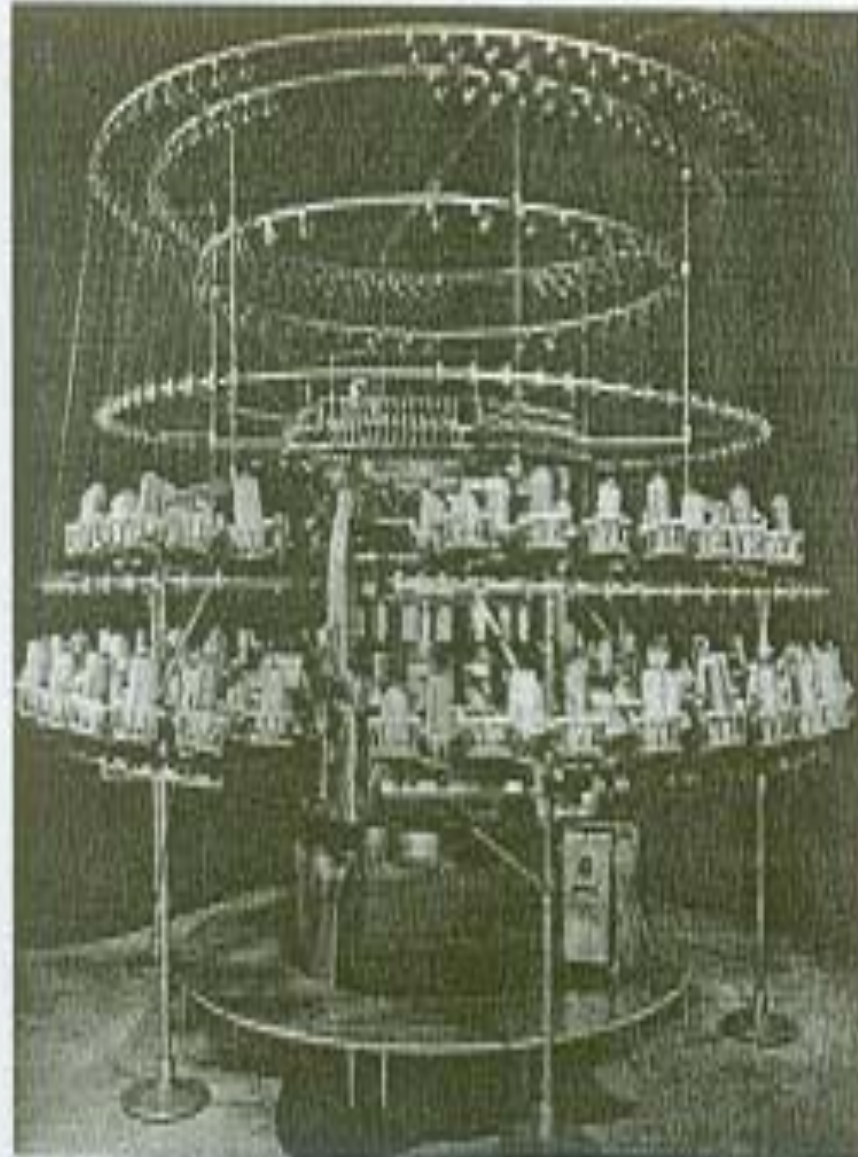
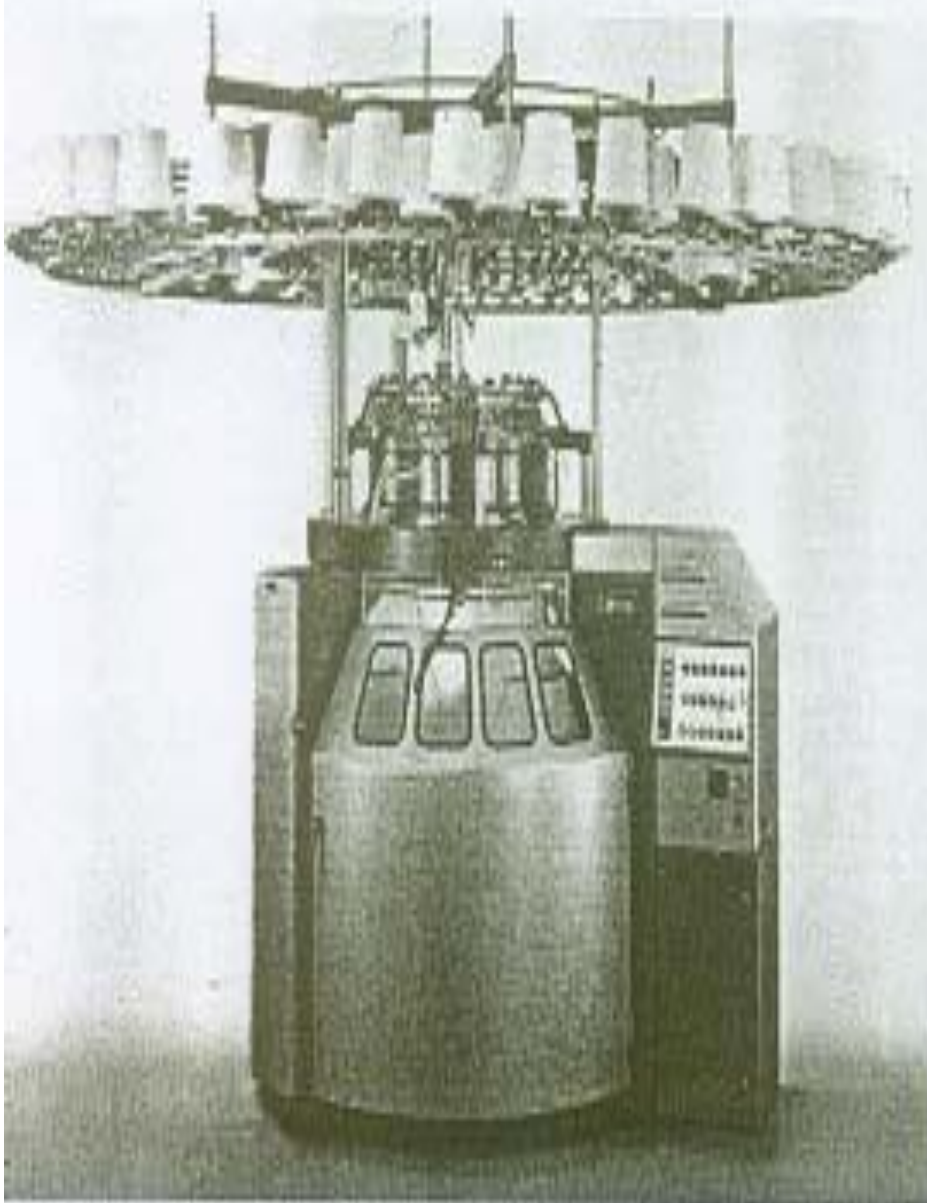


# Indirect Yarn Feed

Ex. Power flat machines



## 4. Yarn Supply in Circular Knitting machine



# A cone carrier device

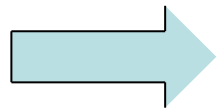
cones are systematically arranged to reduce tensions

The vertical height ( $\diamond$ 600mm)

Investigations  $\rightarrow$  yarn tension is 1.4 to 1.6 times larger when packages are placed most distant as compared to the closest



# Yarn Feed devices on circular knitting m/c



constant rate/feeder;

yarn metering devices

Ex. Circular knitg. for rib and interlock structures



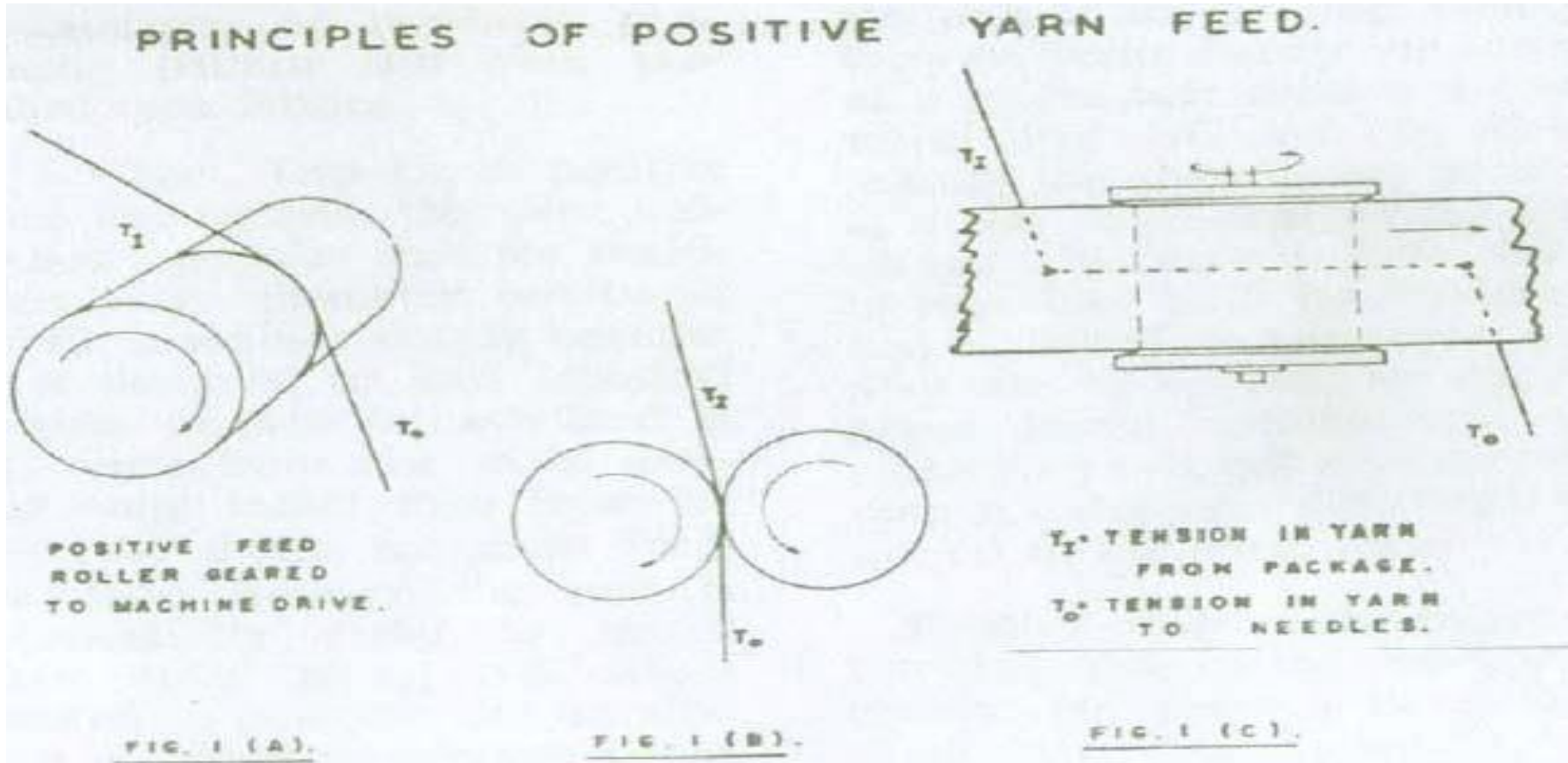
variable rate/feeder;

yarn storage devices

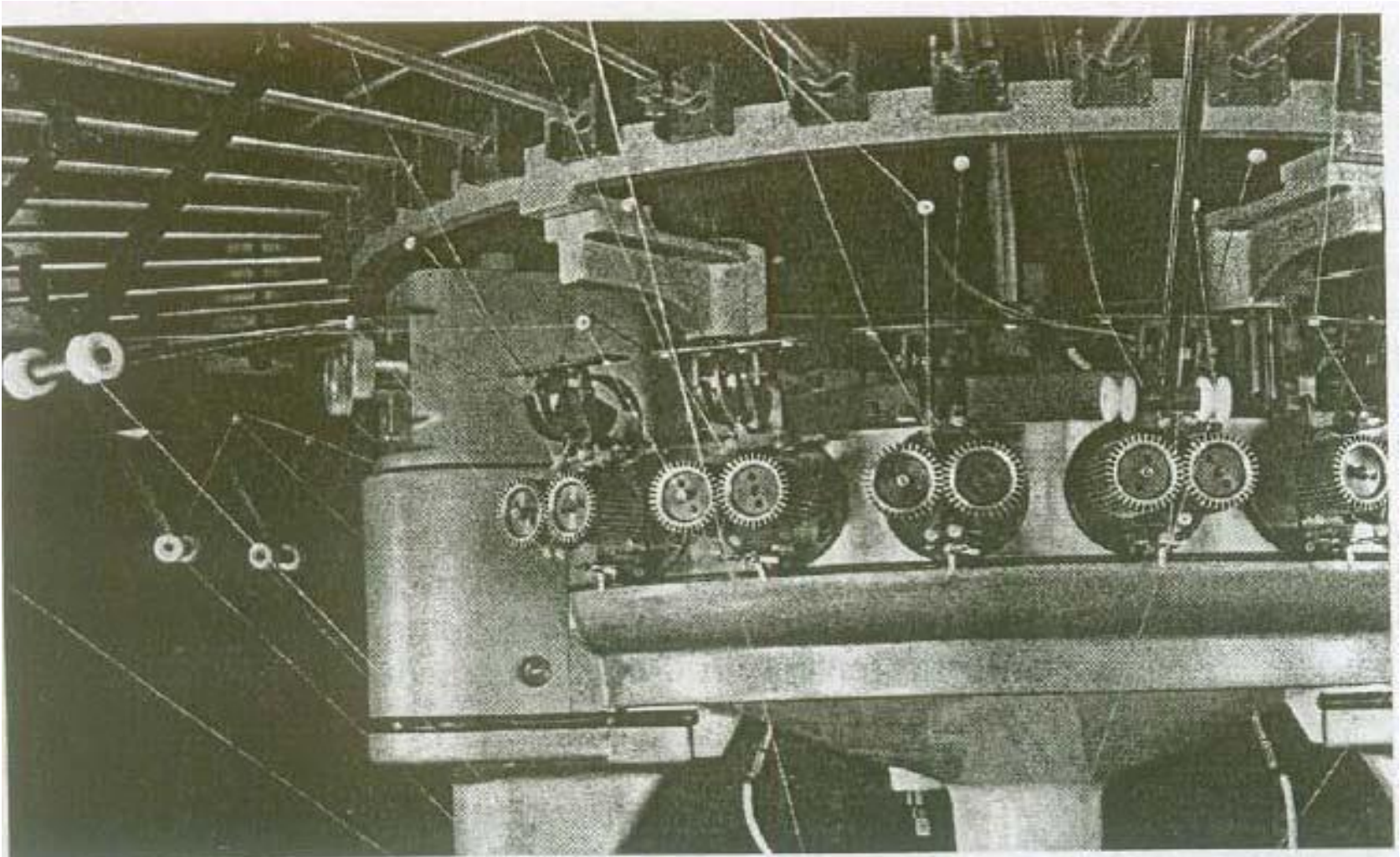
Ex. Jacquard circular knitting machine for patterning

# 1. constant rate/feeder/ yarn metering devices

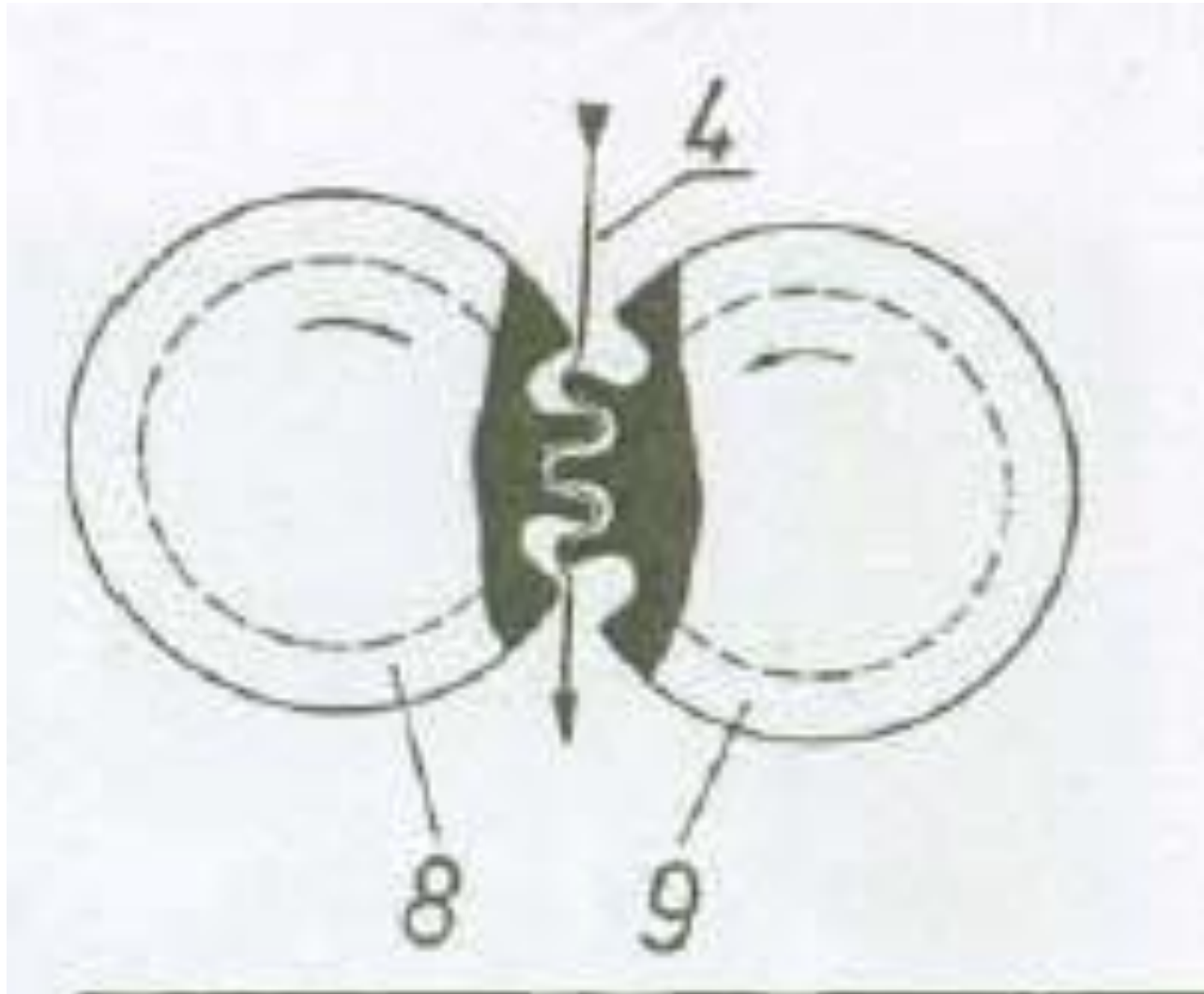
Ensures the equality of  $V_s$  of m/c &  $V_y$  ( $V_s = V_y$ )  
By controlling slippage ( $\mu$ )



# 1. Gear wheel yarn feeding device



# Gear wheel yarn feeding device



# 2. Tape Delivery Devices

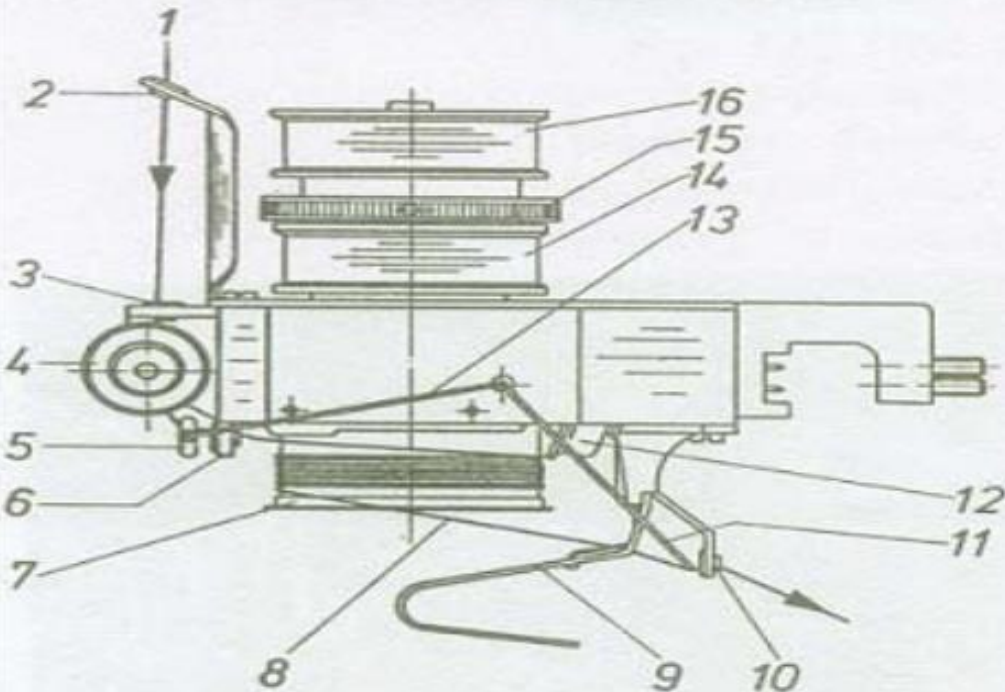
- Advantage

- More uniform yarn delivery, less slippage
- Central adjustment

## Disadvantage

- › Tape is prone to contamination with fluff and spin finish deposits; specially cotton

### 3. Constant feed rate with yarn reserve

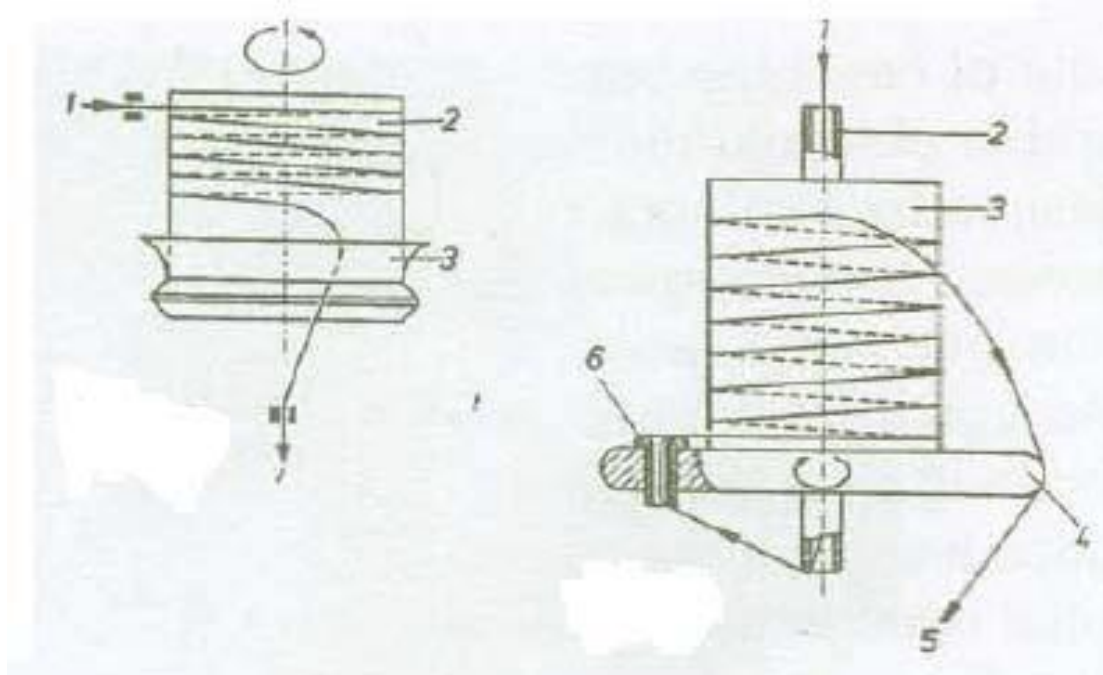


- 1 yarn entry
- 2 yarn guide eyelet
- 3 yarn guide eyelet
- 4 yarn brake
- 5 yarn feeler
- 6 yarn guide eyelet
- 7 winding roll
- 8 let-off yarn
- 9 guide bracket
- 10 yarn guide eyelet
- 11 yarn feeler
- 12 security wheel for yarn winding
- 13 wire strap
- 14 bottom drive roll
- 15 clutch
- 16 top drive roll

10-15 coils  
2.0-2.3 m

## 2. variable yarn delivery rate with yarn reserve

Needle withdraws the required yarn length

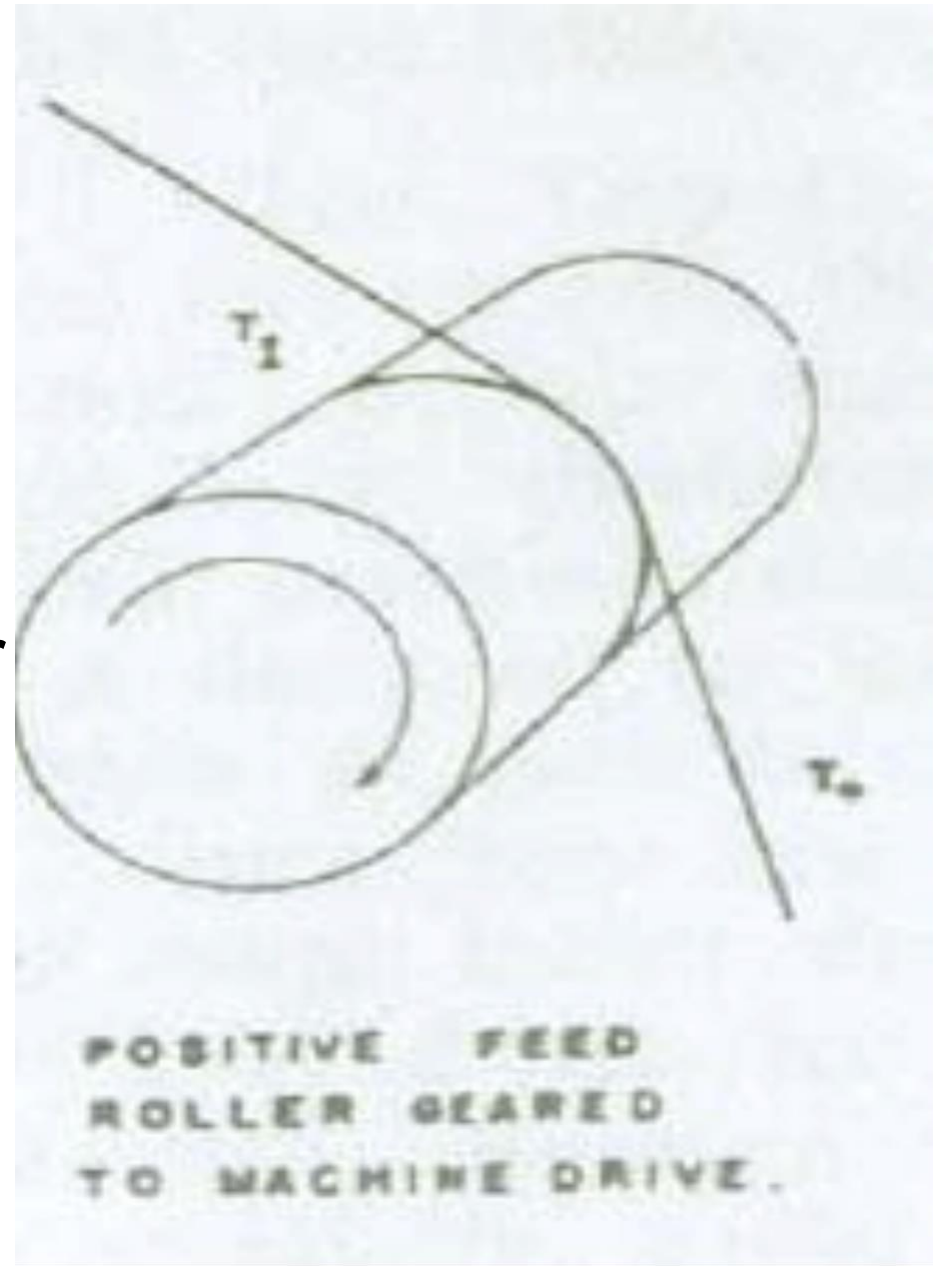


- Rotating coiler, tangential yarn take-up and over end yarn let-off
- Stationary coiler, and rotating ring

# Mechanism of Positive Yarn Feed

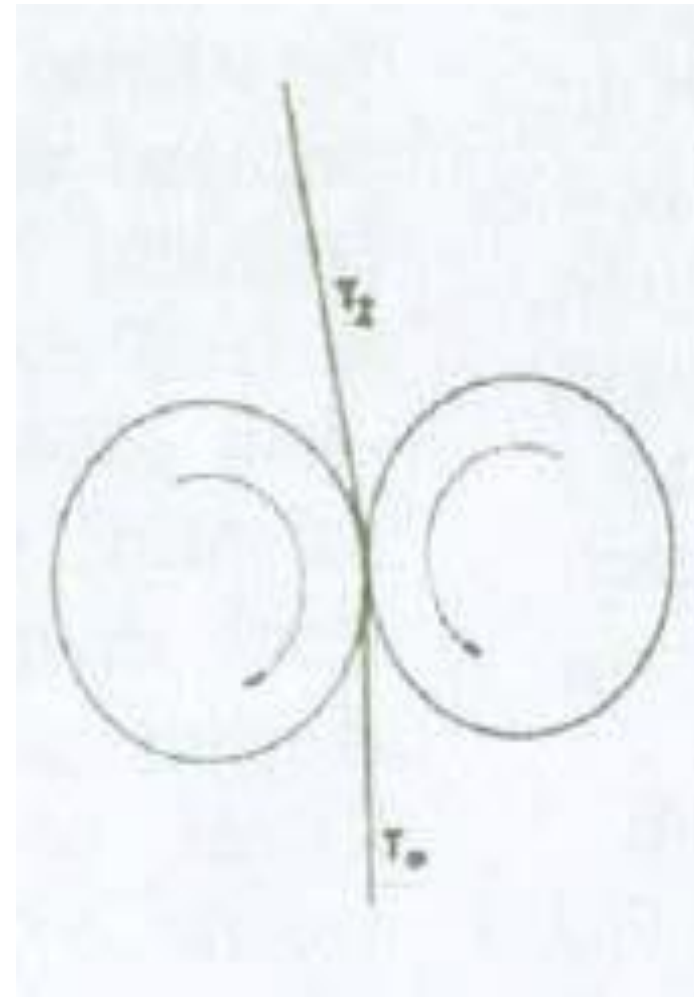
## 1. The Roller yarn (wrapping over)

- › as drum tensioners
- › less slipping
- › Variations occur when knitting bulked or stretched yarns,
- › cheaper and practical



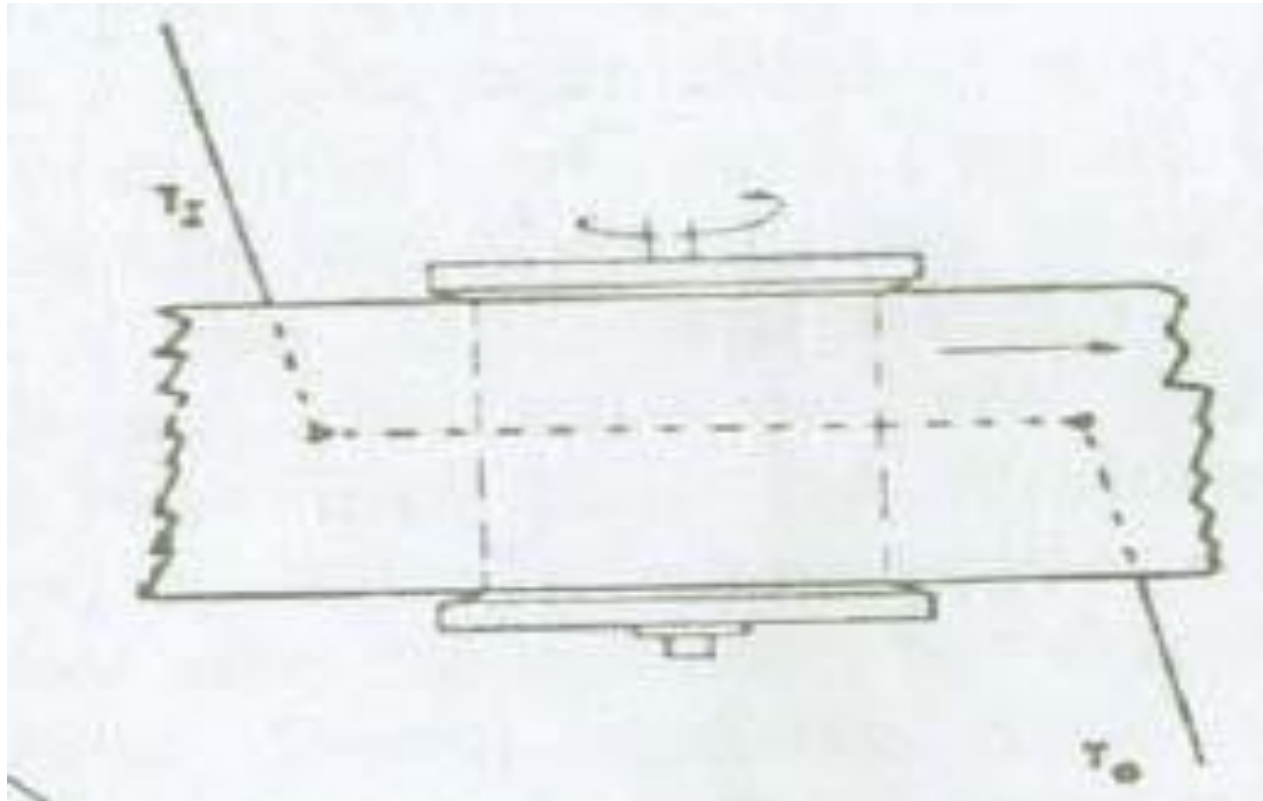
## 2. The Nip type positive feed grips

- Grips the running yarn between two rollers
- Positively and negatively driven
- commercially adopted, being favored by certain hosiery machine builders
- certain flat bed machines have installed these types of feeding units



### 3. The Trip-Tape positive feed

- Tape and roller
- Most popular for multi-feed large diameter outerwear fabric machines
- Used for constant rate of feeding



# 4. Two surface guide

- Disc tensioners
- The yarn passes between two discs
- It provide two frictional surface



# Positive Feed devices and their role

- $\text{motor rpm} \cdot \text{Op}_1 / \text{Op}_2 \cdot \text{Op}_3 / \text{Op}_4 \cdot d = \text{yarn speed}$  if no slippage

- But if there is slippage of yarn

→ A yarn tension

→ A yarn feed rate

→ A loop length in the fabric

- But loop length determines **Oimensional properties** of knitted fabrics.
- Oimensional properties are **fabric areal density, width, thickness, shrinkage, elasticity, tightness factor, rigidity etc...**
- Which in turn influences chemical properties like

degree of absorption

- Positive feed has been designed to establish loop length control in the knitting process which results in better quality of fabrics
- It provides greater fabric control even for **automated and high production machines**, efficiently and economically
- To increase feeding uniformity, high coefficient of friction with a high resistance to abrasion is required in the yarn and feeding units

# Circular Knitting Machines

- All over the world, the **majority of knit fabrics** are manufactured on **circular knitting** machines.

Because of

- The **high performance** level of these machines
- The **different materials** and the **range of yarn counts** that they are able to process
- The **wide variety of designs** and stitches it can produce
- The knitted fabrics can meet the needs of a very large end user market;

from the **traditional** outerwear and underwear sectors → **hosiery, household, car interiors etc...**

# Classification of knitting machines

## According to machine diameter

1. **Large-diameter** circular knitting machines (from 24 to 40 inches)
2. **Medium-diameter** circular knitting machines (from 8 to 22 inches)
3. **Small-diameter** circular knitting machines (from 3 to 6 inches)

## According to number of needle-beds

1. **Single-bed** (for jersey and derived stitches: fleece, terry, piquet, floating Jacquard)
2. **Double-bed**
  - a. **Dial-cylinder** knitting machines with  $90^\circ$  needle-beds (for rib knit and similar: cardigan stitches (open vertically in the front), Milanese rib (sets of ribs change angle), bourrelet, Rodier, cable (groups of rib cross each other), eyelet (holes are produced) and Jacquard stitches, as well as all interlock and intelock-derived stitches).
  - b. **Double-cylinder** knitting machines with  $180^\circ$  needle-bed (for stitches based on the links-links construction)

# Basic Structure of a Large'diameter Circular Knitting Machine

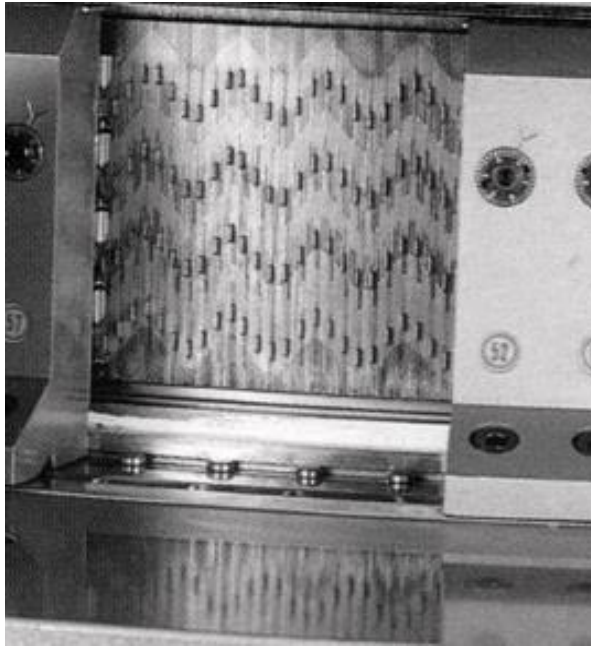
- The feed systems are placed along the **circumference** of the circular needle-bed.

Circular knitting machines can be divided into two basic models:

1. The **needle-beds rotate** and the **cam frame stands still**
  2. The needle-beds stand still and the cam frame revolves.
- On single-bed machines, the cam frame is stationary, while the needle-bed revolves.

# The Main Components of a Single-bed Machine

- To increase **selection possibilities** the number of needle butts and the corresponding cam tracks are increased
- Fig. 4 cam tracks
- Now a days up to 5 is possible
- Sinkers are driven by special cams

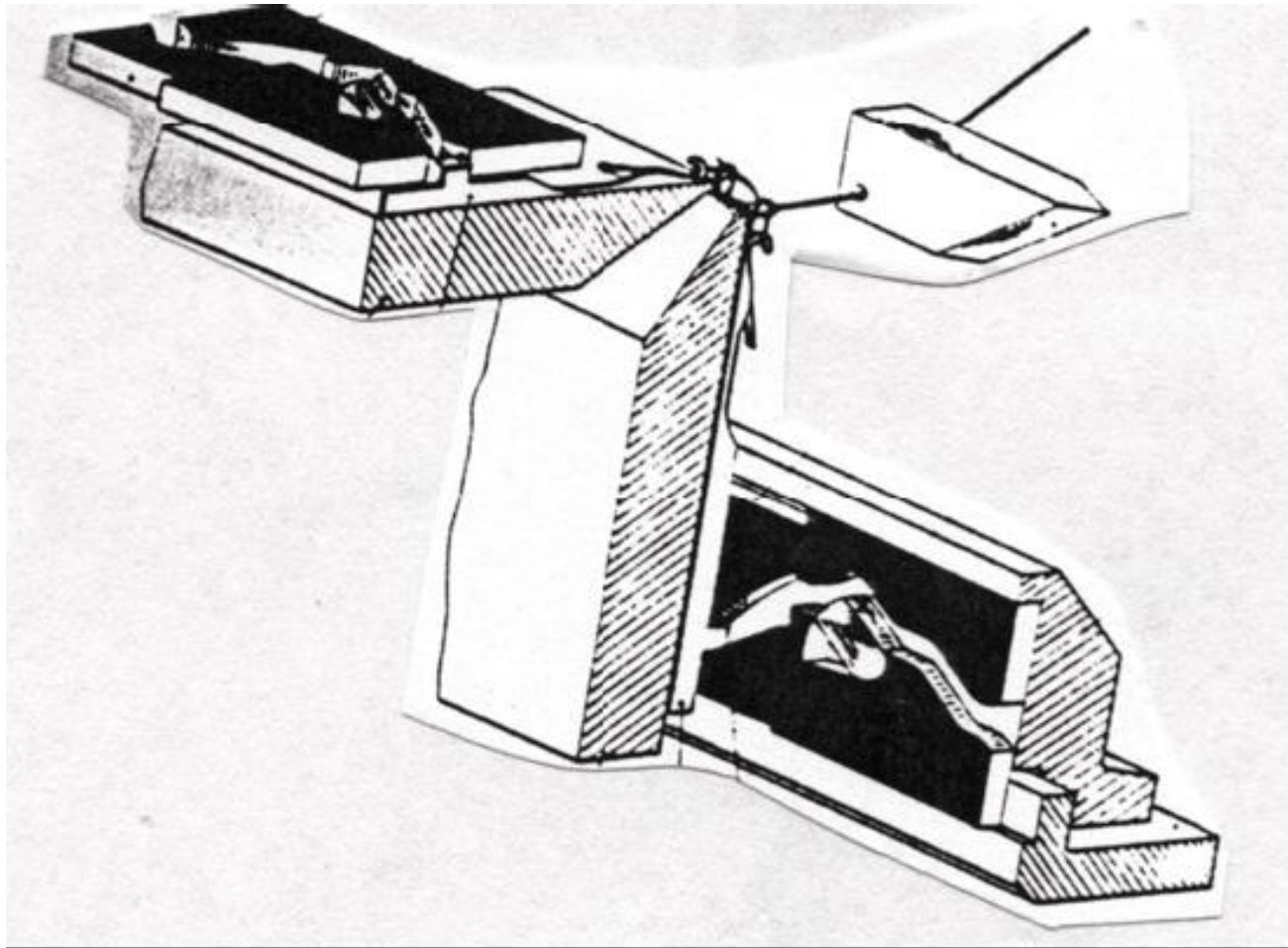


# The Main Components of a Double-bed Machine

Double-bed circular knitting machine are equipped with two series of needles:

1. needles fits in the **circular needle-bed**, called "**cylinder**"
  2. needles accommodated inside radial grooves positioned at 90° with respect to the cylinder, on a special circular plate called "**dial**".
- Double-bed circular knitting machines usually incorporate **latch needles**, but some manufacturers also offer machines equipped with **compound needles**.
  - Two cam frames, one **around the cylinder** and the other **above the dial**.

# Dial and cylinder cam tracks



## Two technical options are available for this type of machine

- Revolving cam frames and stationary needle-beds (for **continuous fabric** manufacturing machines)
- Stationary cam frames and revolving needle-beds (for **cloth manufacturing** machines)
- For selection purpose some machines have up to **four tracks** on the **cylinder** and **two tracks** on the **dial**.

# Technical evolution

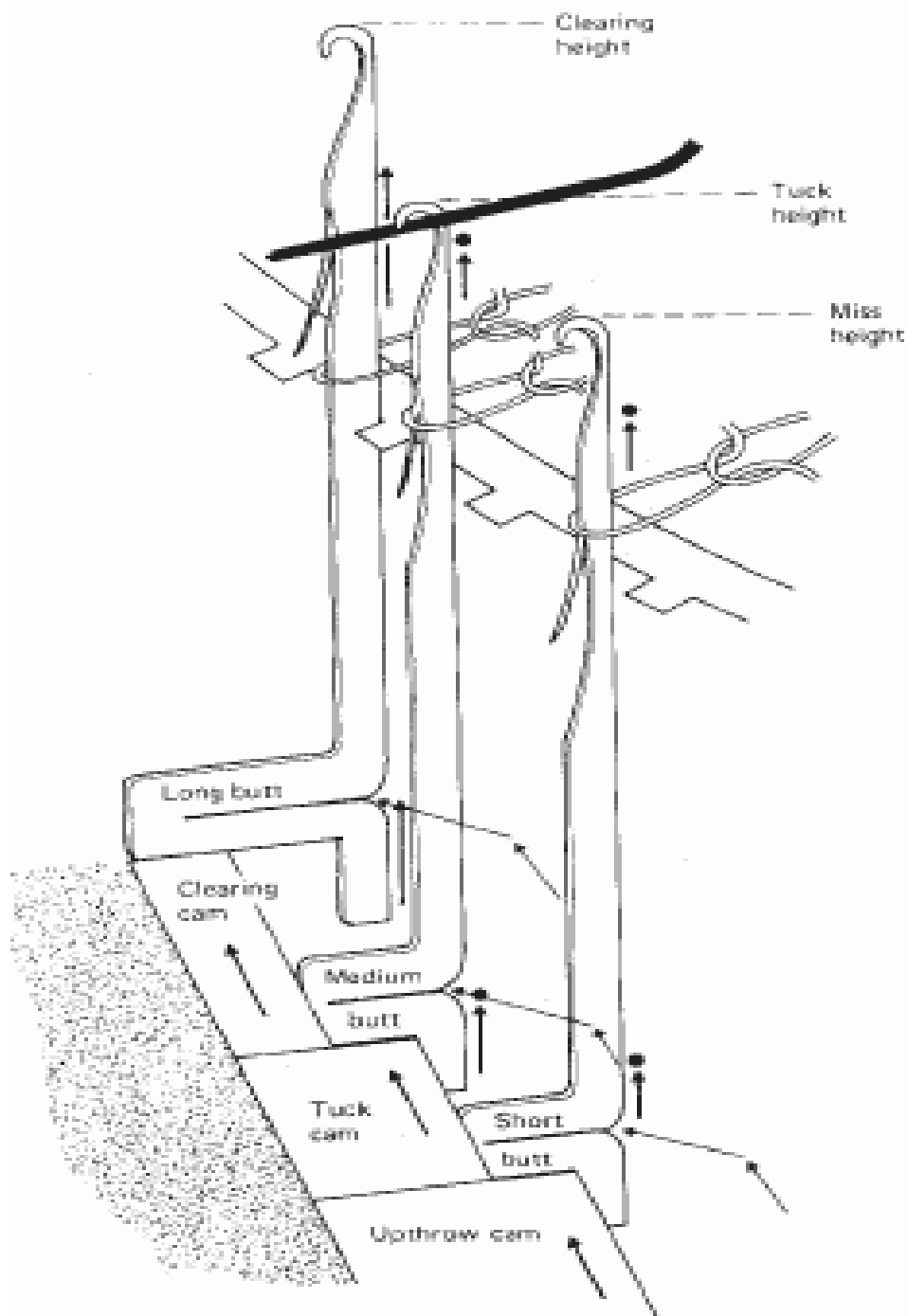
- To increase productivity the number of feeds has to be increased above all on single-bed jersey knitting machines.
- Feeds are increased by increasing diameter
- Today, 3 to 4 feed systems per inch for single bed machines and
- 2 to 2.4 feed systems per inch for rib knitting machines are quite common
- Curvilinear cam system allows a constant control of the needle butt during the entire knitting cycle.
- This method grants higher speeds and safer working conditions.

# Selection Systems

- Different length of butt and cam size  
differentiated control of cams acting on high and low butt needles,
- Different but and cam track positions  
needles with multilevel butts, where each butt level matches a cam track
- selection techniques based on Jacquard motions.

## Different length of butt and cam size

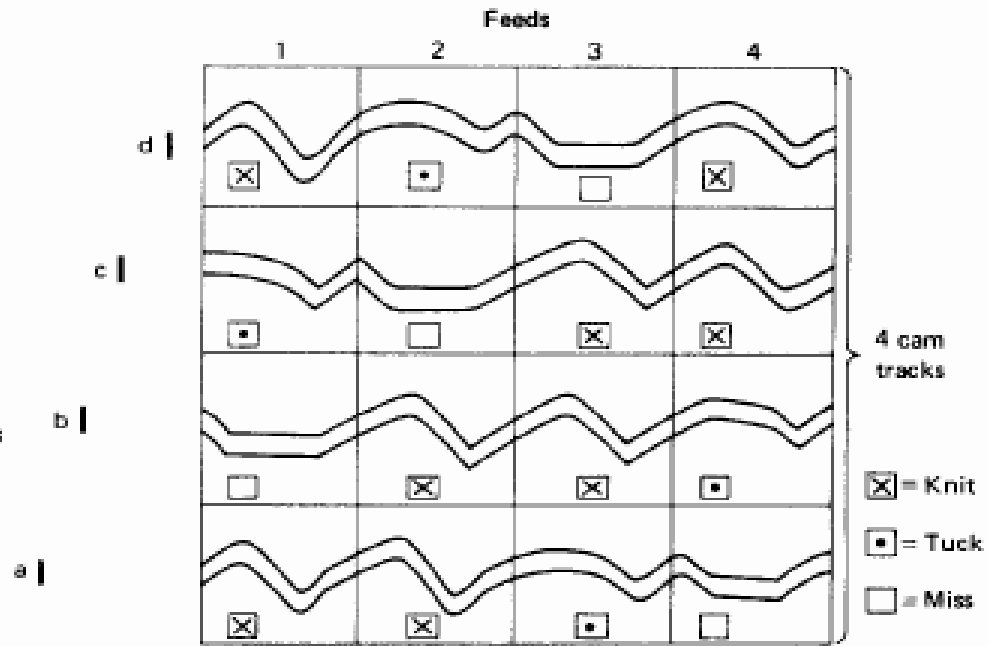
- butts of normal length extend into the track formed between cams and guide their elements by contact with the profiled edges,
- a butt of shorter length don't reach into the track and will thus pass across the face of the cam



# Different but and cam track positions

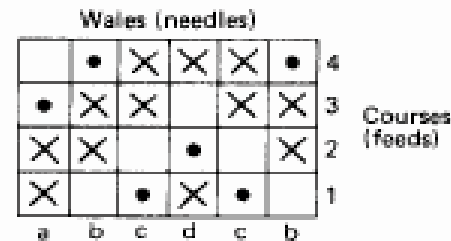
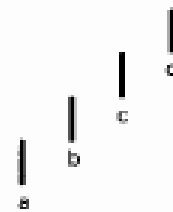
- Single bed machines can have up to 4 to 5 butt levels
- double bed machines, cylinder needles have 4-level butts and dial needles 2-level butts.
- The total number of different heights often directly influences the width repeat in wales (pattern width in a course) =  $W$
- The total number of a stitch cam arrangements with in a given track often directly influences the width repeat in courses (pattern height in a wale) =  $H$
- There fore we do have  $W \times H$  stitches in a pattern area

Each needle has one butt controlled by one of the cam tracks

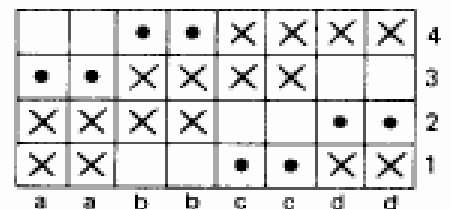
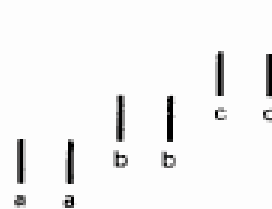


Needles

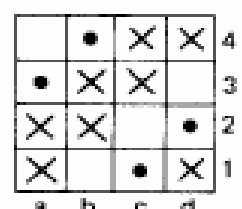
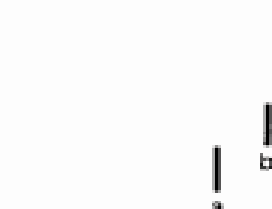
A



B



C



# Jacquard Selection

- Large **clusters** of needles can work **independently** and
- Each **single needle** in a cluster can work **independently** from the others (needle-by-needle selection).
- The Jacquard systems of circular knitting machines can be divided into two categories:
  - Mechanical Jacquard selection systems
  - Electronic Jacquard selection systems

# Mechanical Jacquard Selection System

There are many systems used ,

But the common types are

- needle sliders (most common)
- Disc selection
- pattern wheels

Under each needle there is a slider with 3 butts:

a lower butt for needle raising,

an upper butt for loop knocking-over/lowering

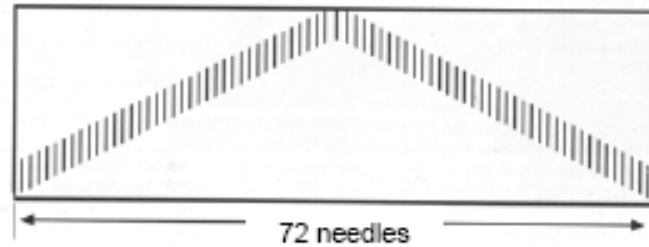
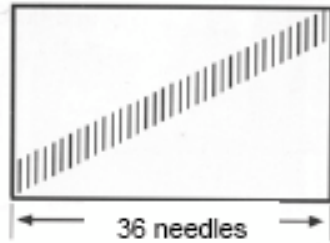
an intermediate selection butt that can be positioned at different levels.

A selection lever acts on the intermediate selection butt.

- › When the lever is idle (i.e. in external position) the slider maintains a vertical position and is pushed upward by the raising cams → its needle is working
- › When the selection lever is active (i.e. in internal position) the slider is pushed into the guide groove → its needle is not knitting
- › The selection lever is controlled externally and each manufacturer has developed its own solution to control the selection lever (e.g. fixed turrets with plug-in cartridges for pattern selection, punched cards system, reeds etc.)

The selection butts of sliders are usually arranged as follows:

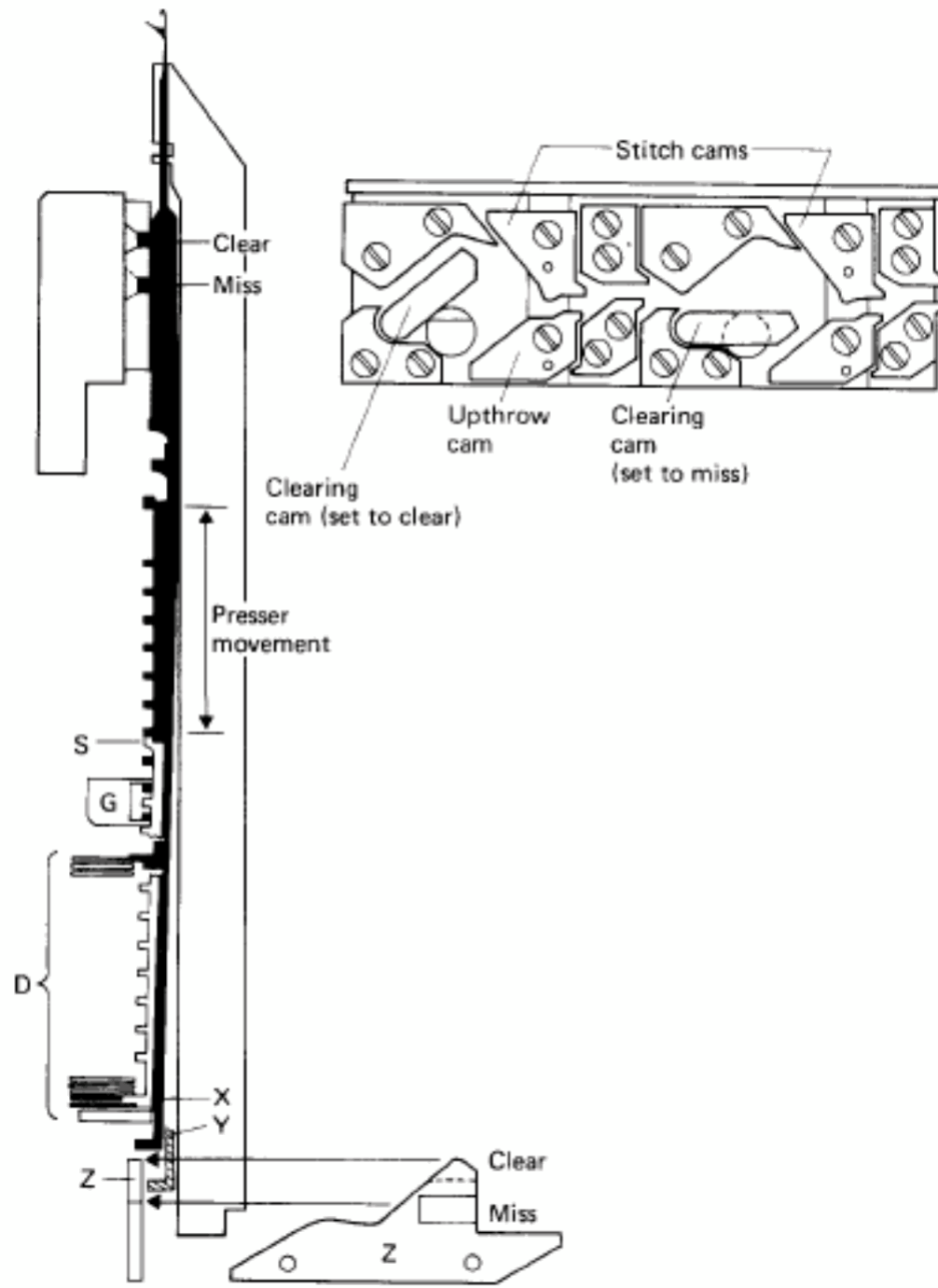
- diagonally
- symmetrically



- With the **slider butts arranged diagonally**, the pattern design includes in its width a number of wales = the number of selectors.
- In symmetrical arrangement, **the width of the pattern design is twice the number of selection levels**.
- The **sliders arrangement** can remain unchanged for each **machine revolution** and in this case the height of the design pattern is given by the no. of feed systems of the machine divided by the number of pattern colours.
- If the arrangement of the sliders are changed after every machine revolution height of the design pattern will be changed .

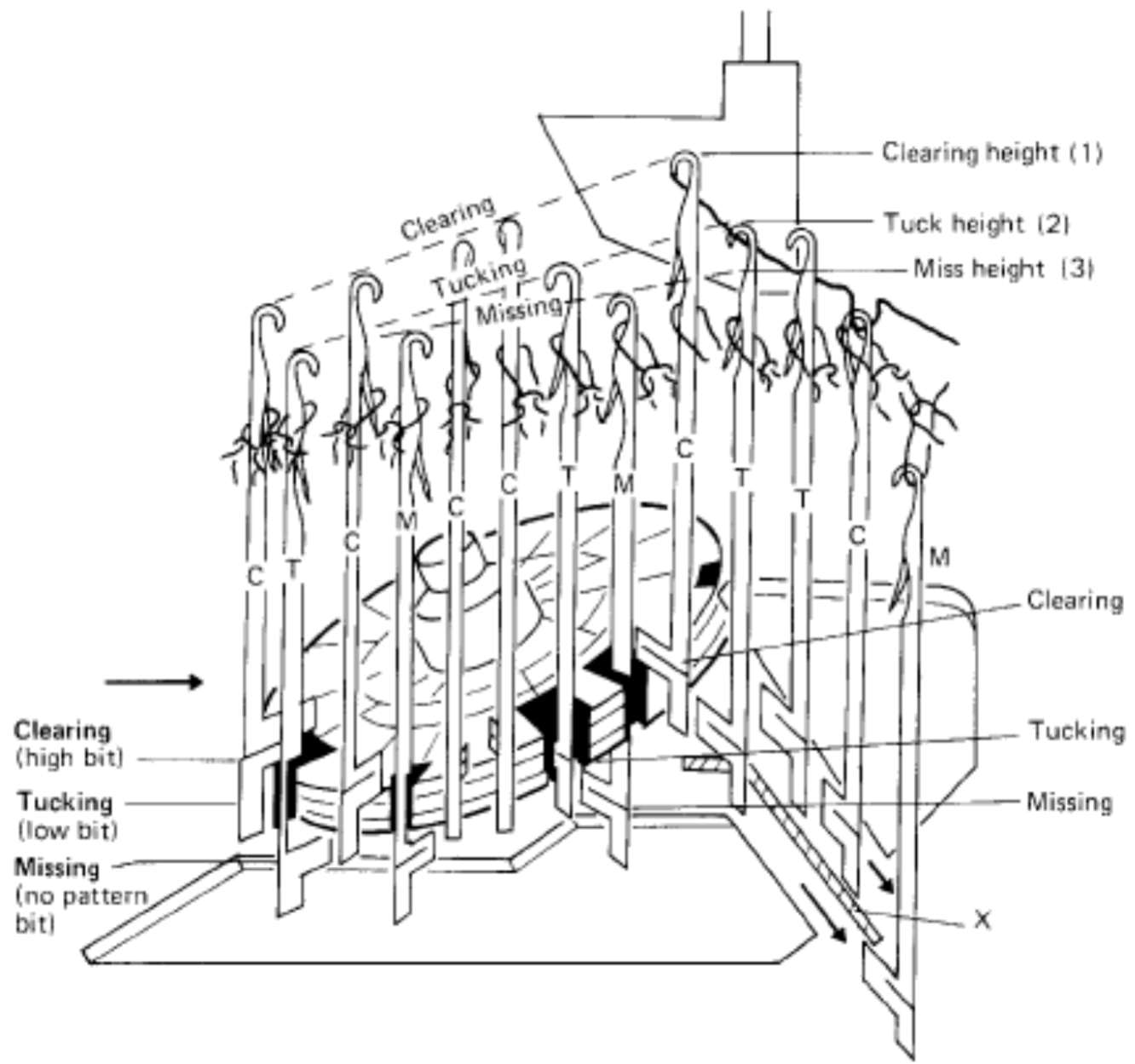
# Needle selection by disc

- Revolving stacks of discs at each feed selection position
- When a disc tooth contacts the bottom half-butt of a **presser** (X in Fig. ), it causes the jack tail (Y), supports it to be retracted into the cylinder so that its tail butt **misses the raising cam** (Z) and the needle which is supported by the jack is not lifted to knit
- The total number of teeth in a selection disc determines the pattern width, which may be 144 wales in 28 gauge.
- At any cylinder revolution, a disc at the same height at each stack will be selecting.
- After each revolution, **the pressers** may be **raised or lowered** to a different height so that their half-butts are aligned with a **different disc selection**.
- In this way, as many as 18 discs, each for a selection at a different cylinder revolution, may be accommodated at **each stack**.



# Pattern wheel

- The pattern wheel is a **cheap, simple device** occupying little space,
- The wheels, **tricked to the same gauge** as the revolving cylinder needles, are driven in the opposite direction, either by the needle butts meshing with their **tricks** or by **gearing** from the cylinder.
- The inclined pattern wheel, like all selection devices, is normally **placed at each feeder**.
- It is set at an angle of 20-40° in place of the solid **raising cam** so that, as it turns, it lifts any element whose **butt rests on a pattern bit**.



With a three-position wheel,

- a needle entering an **empty trick** will remain at **miss height**
- a needle supported by a low bit will be lifted to **tuck height**,
- a needle supported by a **high bit** will be lifted to clear
- Needles left at miss height are lowered by a **wing cam (X)** to ensure that they do not accidentally receive yarn.

# Electronic needle selection

- Electro-magnetic needle selection principle

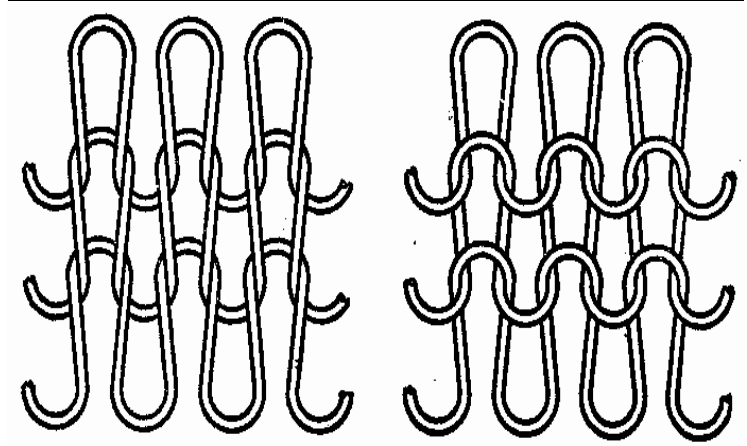
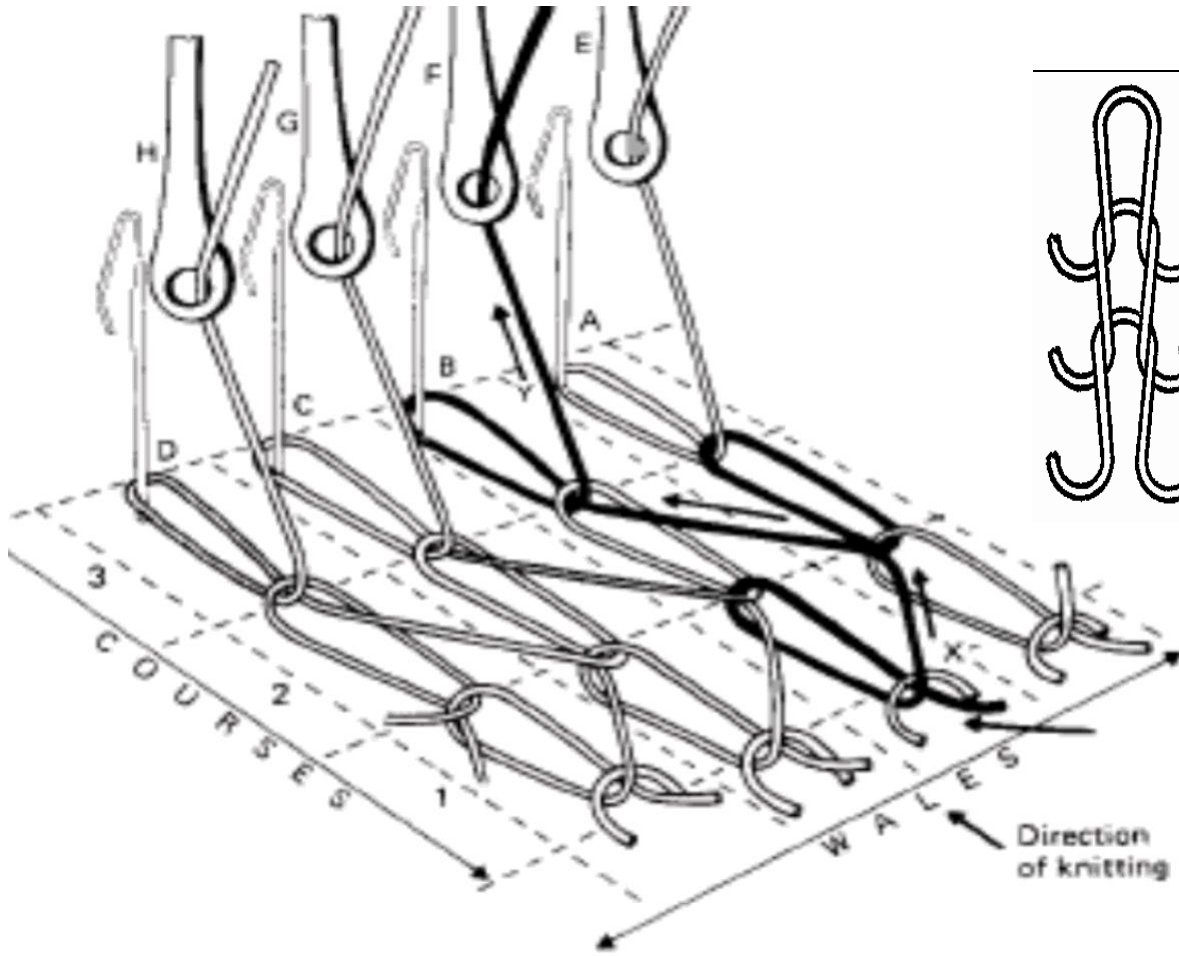
Ex. the *Moratron* type

- For each feeder, a **photo transistor** scans its own **track of an endless 35-mm film**, giving a **selection** for **each jack control spring** as it passes the control position of the feeder.
- If the position on the film has a **transparent spot**, light is transmitted to generate an **impulse**.
- If the position on the film is opaque, no impulse is generated for that control spring.
- The **impulse is magnified** to energize a coil and thus neutralize its permanent magnet at the control position at the precise moment when the jack control spring is guided onto it.
- The **spring is thus not held by the magnet** and stands vertically to pass on the far side of a wedge-shaped control cam.

# Warp knitting machines

- In a warp knitted structure, 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**
- Beams supply the warp sheets in parallel form to the guide bars
- Pattern movement of guide bars determines the **timing and configuration** of the **lapping movements** in the form of overlaps and underlaps.
- To ensure **uniform** conditions of **warp feed and tension**, the yarn ends are supplied from **flanged beams** attached to shafts that turn to unwind the warp sheet in parallel

formation.



# The warp beams



# Guides and guide bars

- Each **guide bar** is normally supplied with a warp sheet from **its own beam** for knitting
- The minimum number of guide bars and warp sheets for commercially acceptable structures is usually two.
- Warp guides are **thin metal plates** drilled with a hole in their lower end through which a warp end is threaded
- They are held together at their upper end as a **single unit in a metal lead** and are **spaced to the same gauge** as the needles.
- The **leads** are attached to a **guide bar** so that the guides hang down from it,
- The guides, when at rest, takes the midway between two adjacent needles.
- 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.

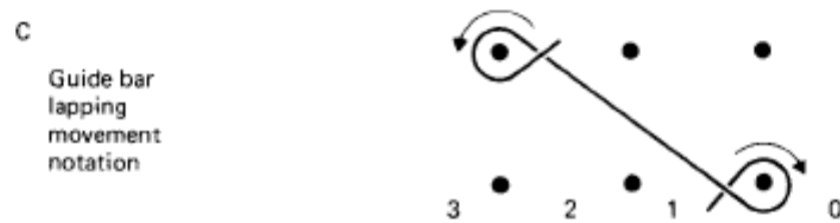
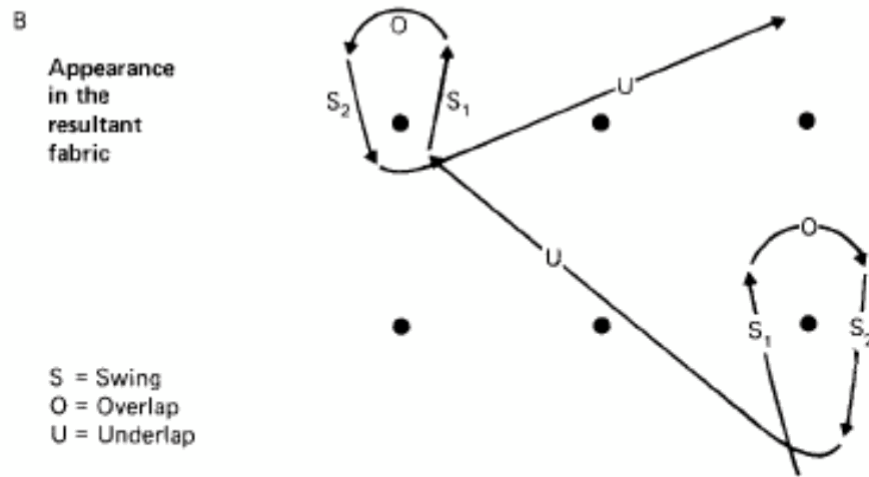
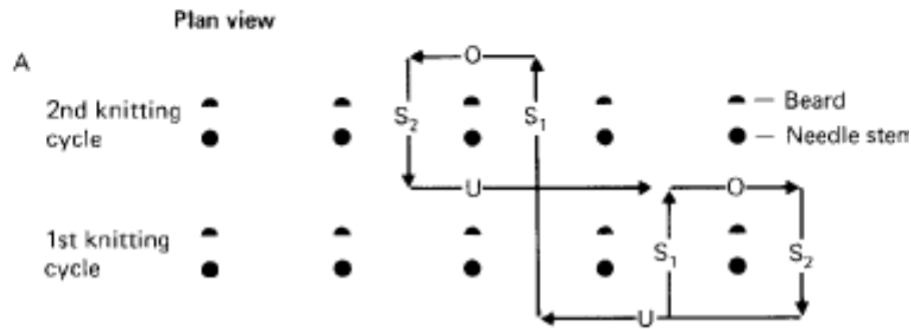
# Single needle bar structures

## *Swinging motion (A-A)*

- they are pivoted on a common rockershaft
- Make a collective action
- Rotates back towards needles and back to front again
- for loop arm formation,

## *Shogging movement (8-8)*

- for under laps and needle loop head/top formation



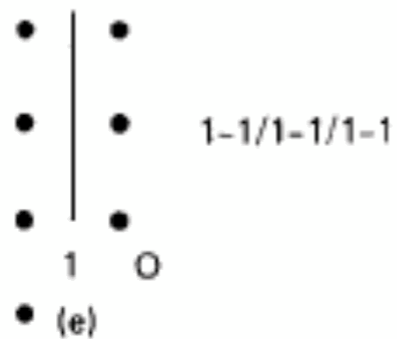
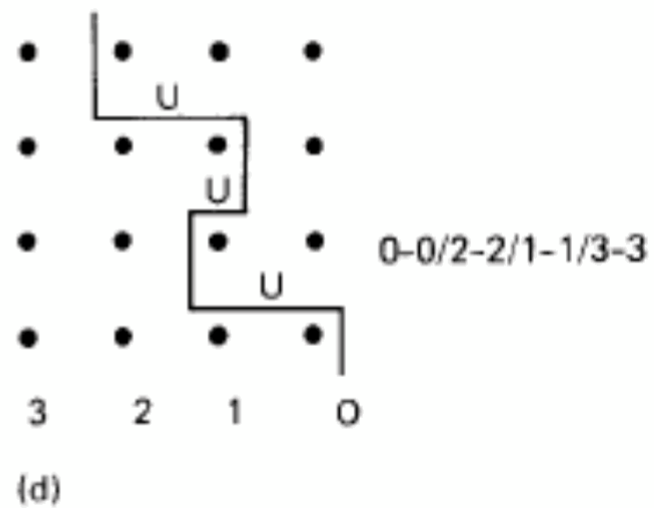
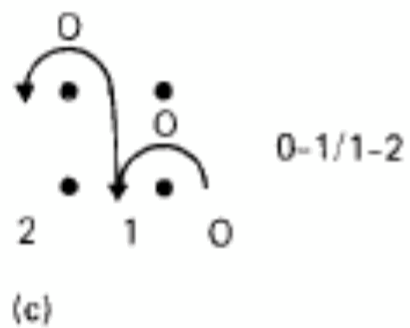
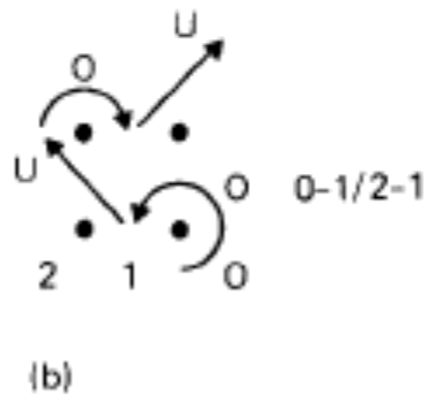
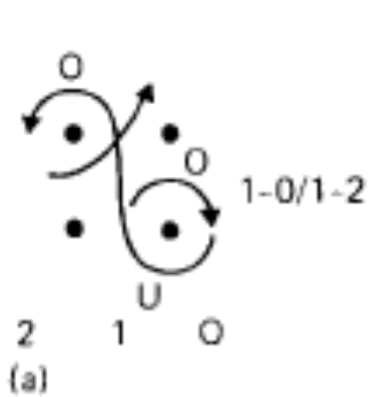
D

Chain notation  
(2 links per course)

Overlap movements 1-0, 2-3  
Underlap movements 0/2, 3/1

# The five basic overlap/underlap variations

1. An overlap followed by an underlap in the opposite direction (closed lap) (a).
  2. An overlap followed by an underlap in the same direction (open lap) (b).
  3. Only overlaps and no underlaps (open laps) (c).
  4. Only underlaps and no overlaps (laying-in) (d).
  5. Neither overlaps nor underlaps (miss-lapping) (e).
- Movements 4 and 5 require the overlaps of another guide bar in front in order to hold them into the structure.



# Classes of warp knitting machines

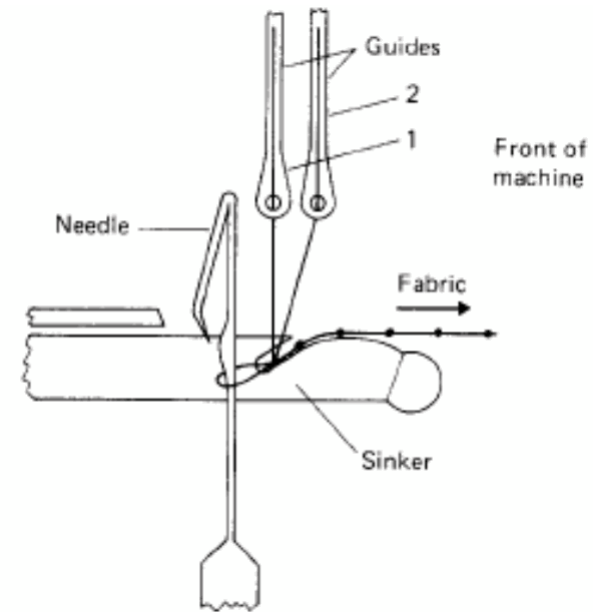
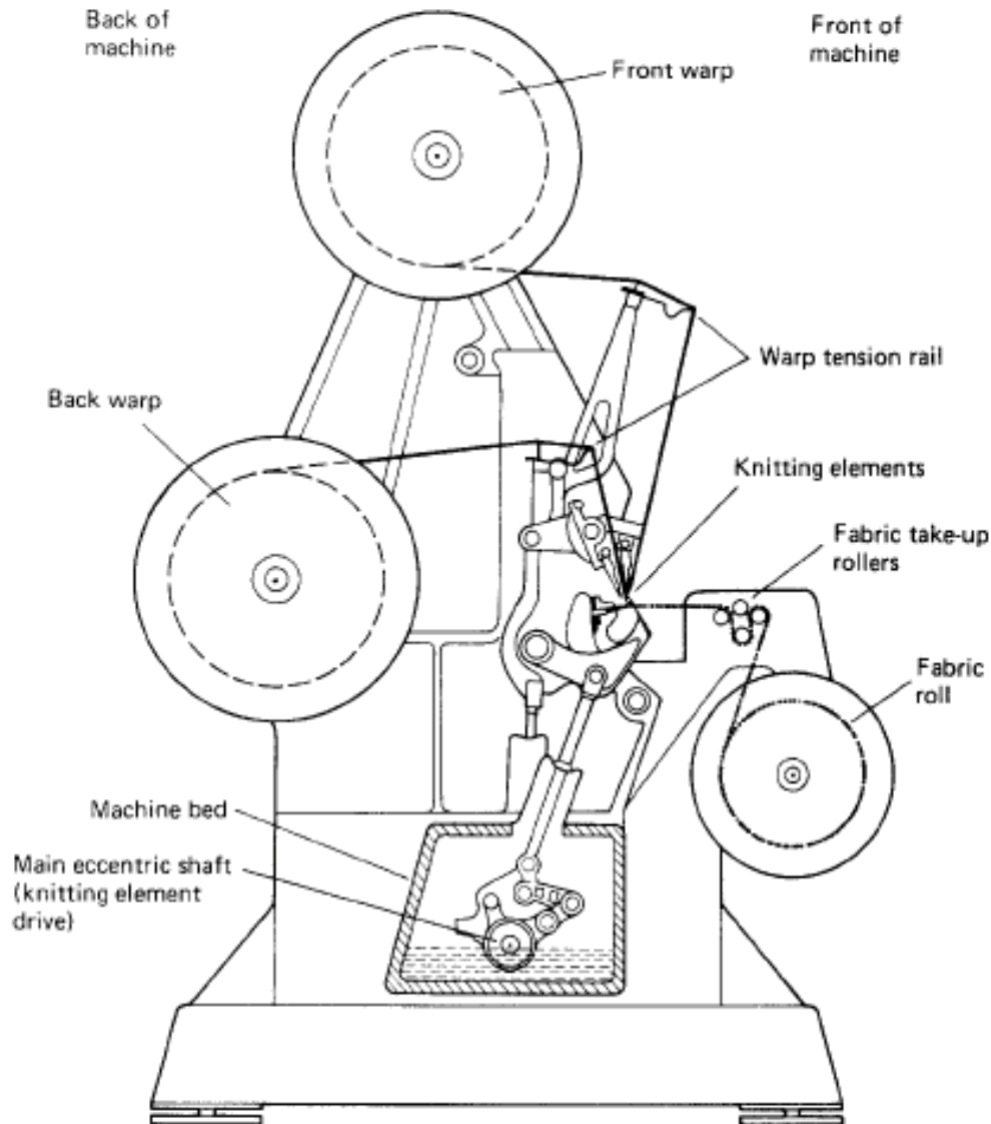
## Characteristics of tricot and raschel machines

- The two major classes of warp knitting machines are *tricot* and *rascheis*
- (In some countries tricot machines are termed *automatic warp knitting machines*).

## Tricot machines

- The maximum number of guide bars are four, majority of tricot machines employ only *two guide bars*.
- In the past, the two guide bar *tricot* machine proved most popular in *E 28 and E 32 gauge*, with knitting widths of *84 and 168 inches* using 40-denier nylon.
- It is possible to knit from 10-denier nylon up to 1120's cotton count.
- Machine gauges can range from E 10 for coarse staple fibre yarns to E 20-E 24 for textured yarn fabrics and E 36-E 44 gauge for fine fabrics, in knitting widths up to 260 inches (660 cm).

# The tricot machine



# The knitting cycle of the bearded needle tricot machine

## *The rest position (a)*

- › The **needles** have risen to 2/3 of their full height from knock-over and have their beards towards the back of the machine.
- › The **pressers** withdrawn and the **guides** are at the front of the machine
- › The **sinkers** are in forward position, holding the old overlaps in their throats

## 2. *Backward swing and overiap shog (b, c).*

The guides

- › Swing through the needles to the beard side
- › Shog to side, yarn overlaps across the beards

## 3. *The return swing and second rise (c, d).*

- › The guides swing to the front
- › the needles rise to their full height so that the newly-formed overlaps slip off the beards onto the stems above the old overlaps.

#### **4. *Pressing (e).***

- › The **needle bar/needles** descends so that the open beards cover the new overlaps.
- › There is a slight pause whilst the presser advances and closes the beards.

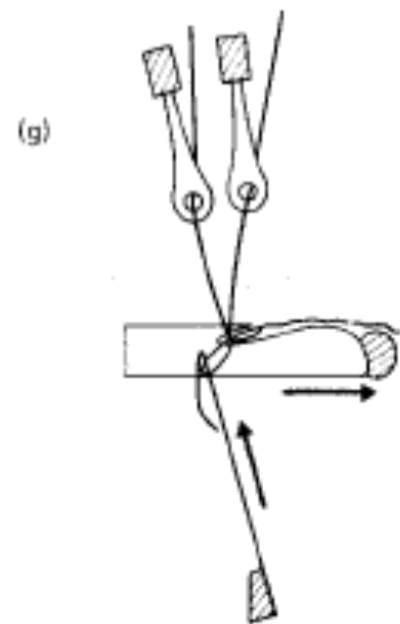
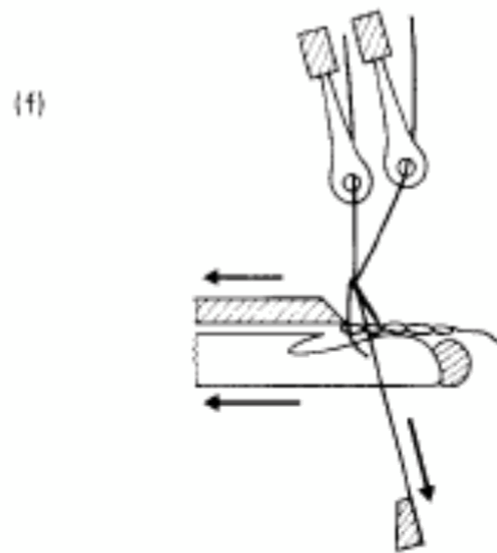
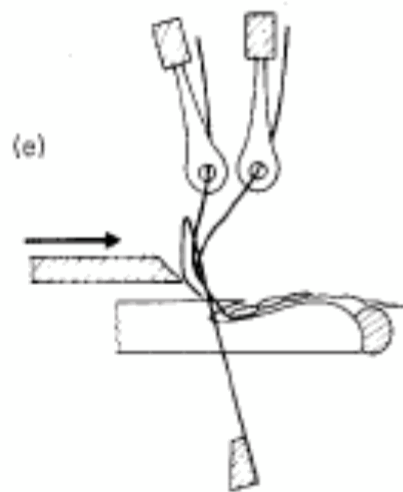
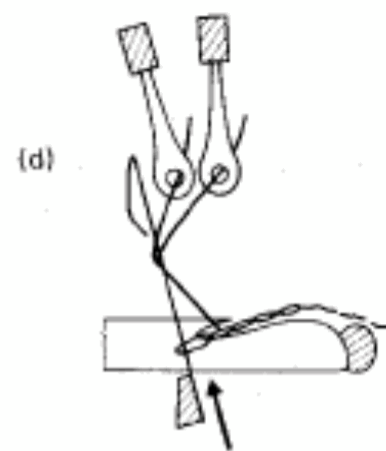
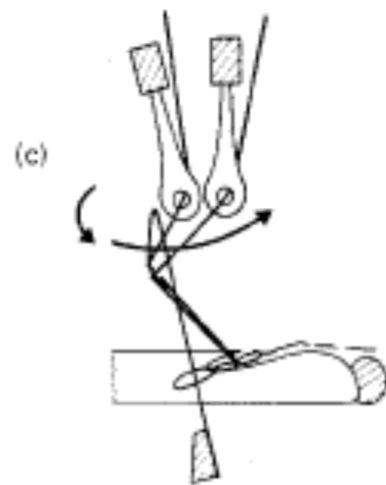
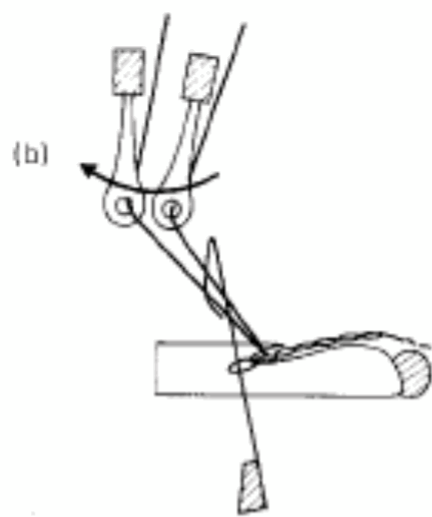
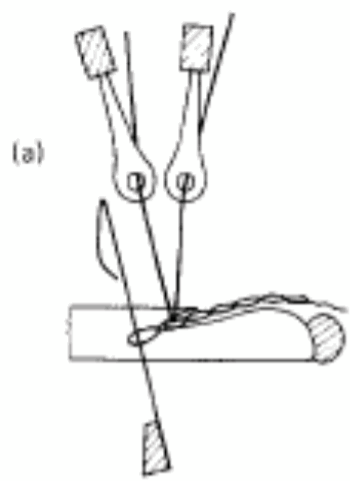
#### **5. *Landing (f).***

- › As the **sinkers withdraw**, the upward curve of their bellies lands the **old overlaps** onto the **closed beards**.

#### **6. *Knock-over and underlap shog (g).***

- › The presser is withdrawn
- › The continued **descent of the needle bar** causes the old overlaps to be knocked-over
- › The **underlap shog** which can occur at any time between **pressing and knock-over**

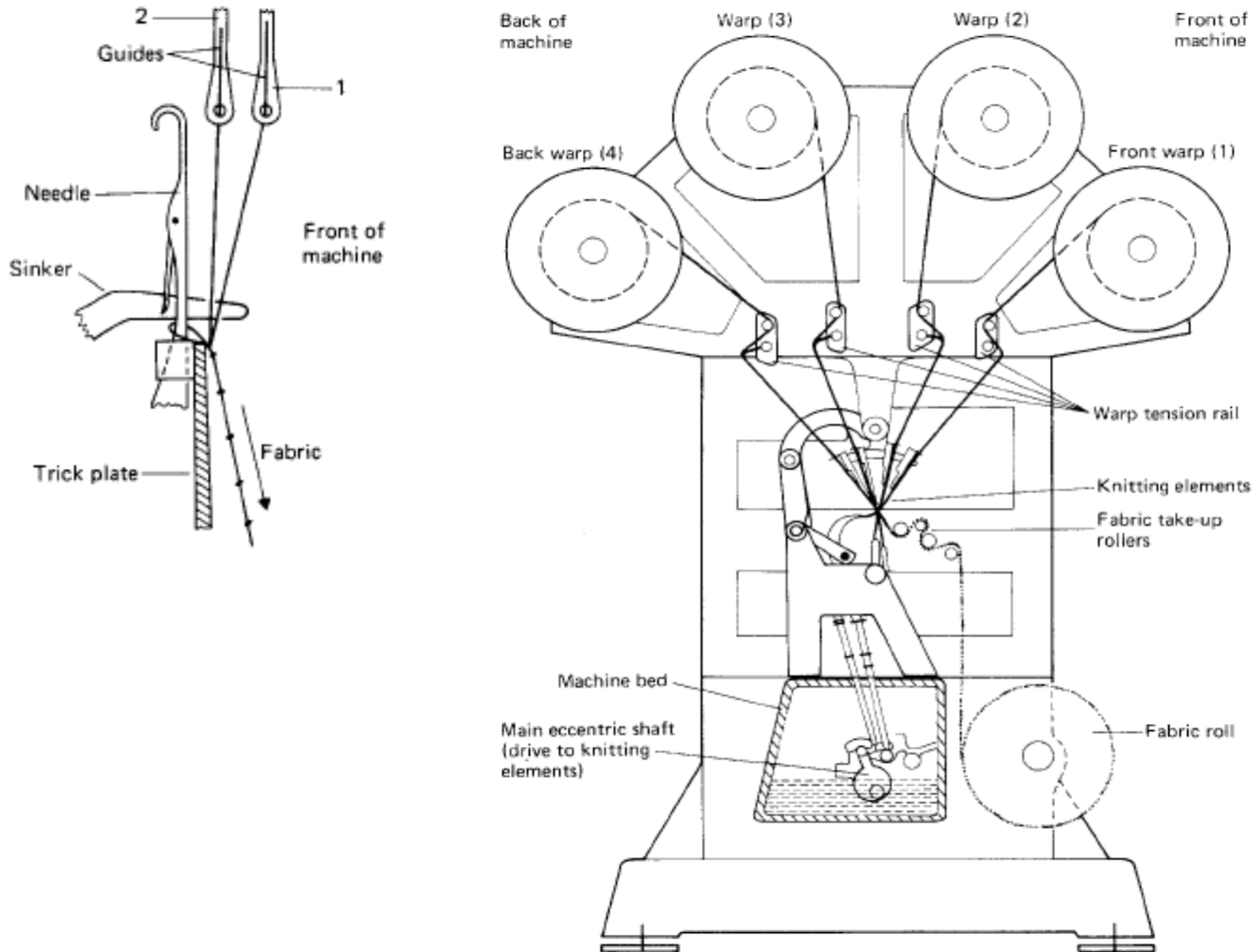
7. *The sinkers now move forward* to hold down the fabric loops and push them away from the ascending needles, which are rising to the rest position.



# The Raschel machine

- *Raschei machines* originally had a gauge expressed in **needles per 2 inches** (5 cm)
- Now, the standard **E gauge** (needles per inch) is generally used.
- There is a wide gauge range, from **E 1 to E 32**
- Raschel sinkers perform only the function of holding down the loops whilst the needles rise
- They are **not joined together by a lead** across their ends nearest to the needle bar **so they can move away clear** of the needles, towards the back of the machine, for the rest of the knitting cycle.
- The needle **trickplate verge** acts as a **fabric support** and knock-over surface.

› The warp beams are arranged **above the needle bar**, centred over the rockershaft, so that warp sheets pass down to the guide bars on either side of it



# The knitting action of the single needle bar raschel machine

## 1. *Holding down.*

- › The **guide bars** are at the front of the machine, completing their underlap shog.
- › The **inker bar** moves forward to hold the fabric down whilst the **needle bar** starts to **rise** from knock-over.

## 2. *clearing*

- › As the needle bar rises to its full height, the old overlaps slip down onto the stems after opening the latches,
- › The **inker bar** then starts to **withdraw** to allow the guide bars to overlap.

## 3 *Overlap.*

- › The guide bars swing to the back of the machine and then shog for the overlap.

## 4. *Return swing.*

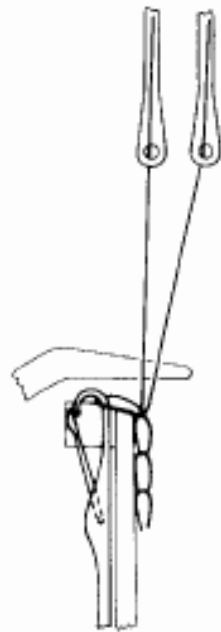
- › As the guide bars swing to the front, the warp threads wrap into the needle hooks.

## 5. *Latch closing.*

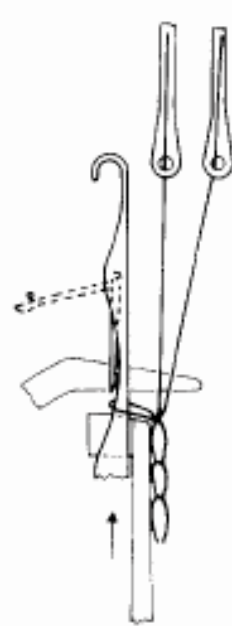
- › The needle bar descends so that the old overlaps contact and close the latches, trapping the new overlaps inside.
- › The sinker bar now starts to move forward.

## 6. *Knocking-over and underlap.*

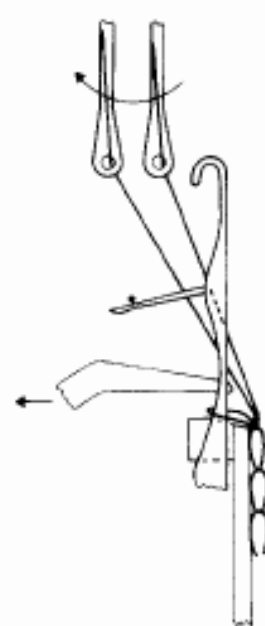
- › As the **needle bar** continues to **descend**, its head passes below the surface of the trick-plate, drawing the new overlap through the old overlap which is cast-off
- › As the sinkers advance over the trick-plate, the **underlap shog of the guide bar** is commenced.



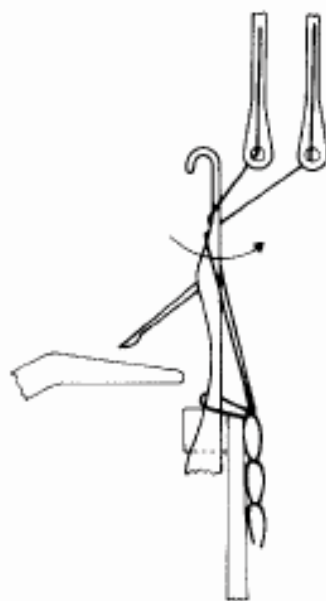
(a) Holding down  
(underlap)



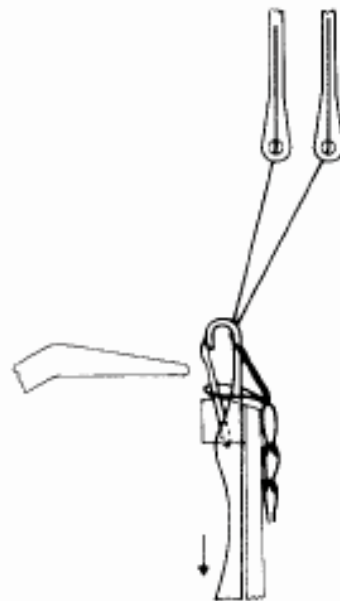
(b) Clearing



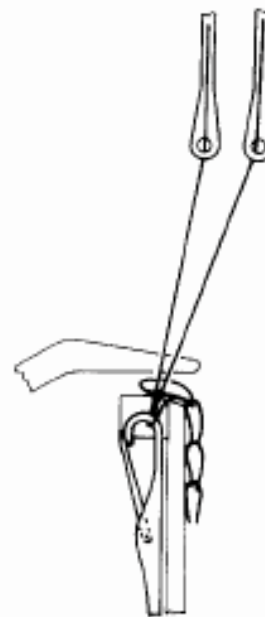
(c) Overlap



(d) Return swing

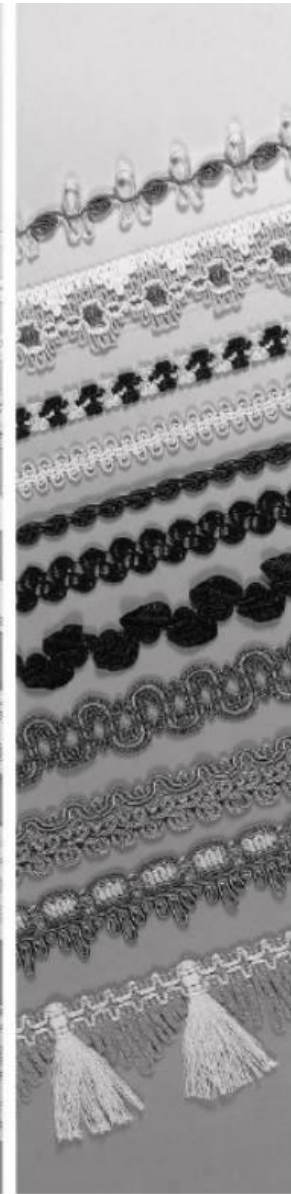
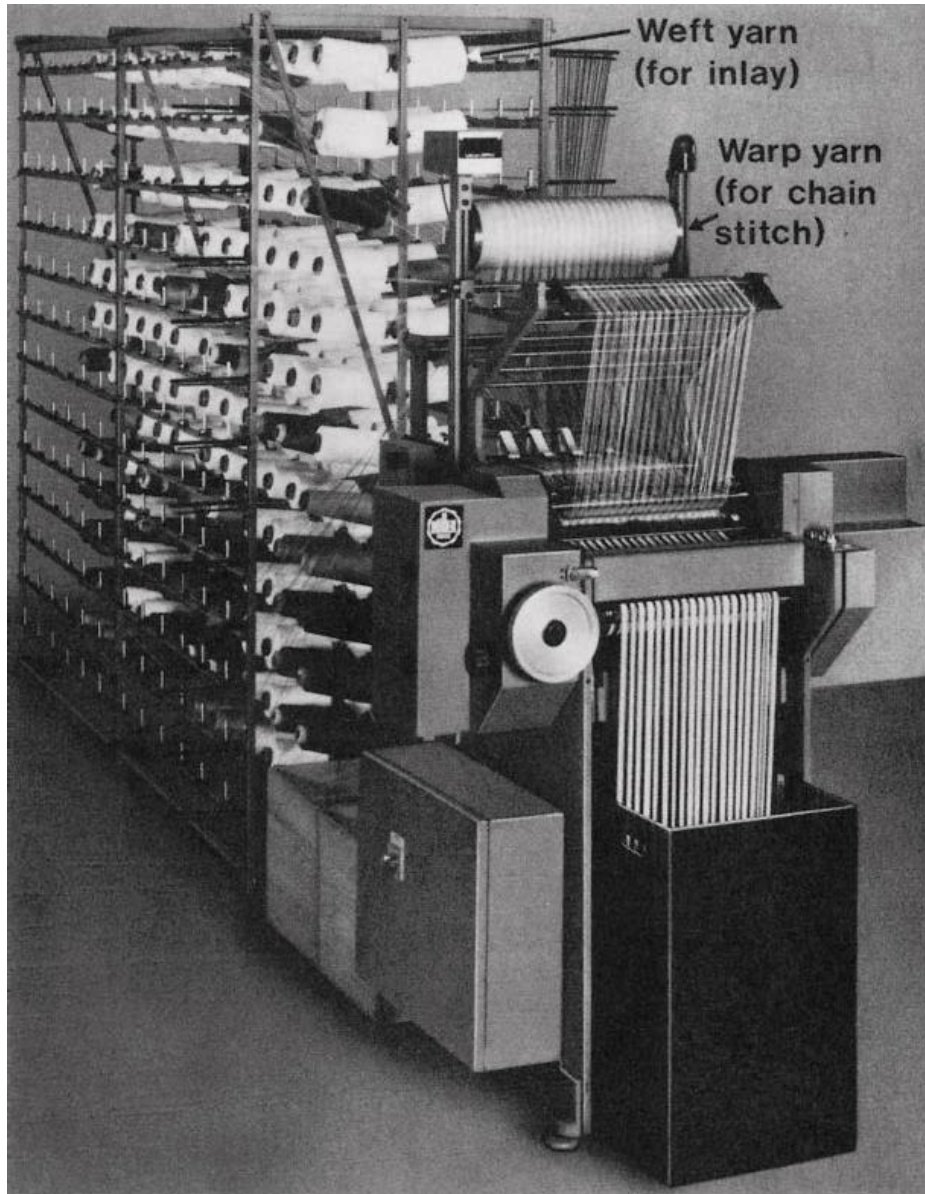


(e) Latch closing



(f) Knocking over

# The crochet machine



# Comparison of weft and warp knitting

## Yarn feeding and loop formation

### 1. In *weft knitting* machine

- **yarn feeding and loop formation** occur at each needle in sequence across the needle bed during the **same knitting cycle**.
- All, or a number of, the **needles** are supplied with the **same weft yarn** during the same knitting cycle

### 2. In *warp knitting* machine

- There is a simultaneous **yarn-feeding** and **loop forming** action occurring at every needle in the needle bar during the same knitting cycle .
- **All needles** in a needle bar are simultaneously **lapped** by separate **warp guides**.
- As all needles receive their **overlaps simultaneously**, a guide underlapping from **one needle to another** will be passing from one knitting cycle or **course to the next**.

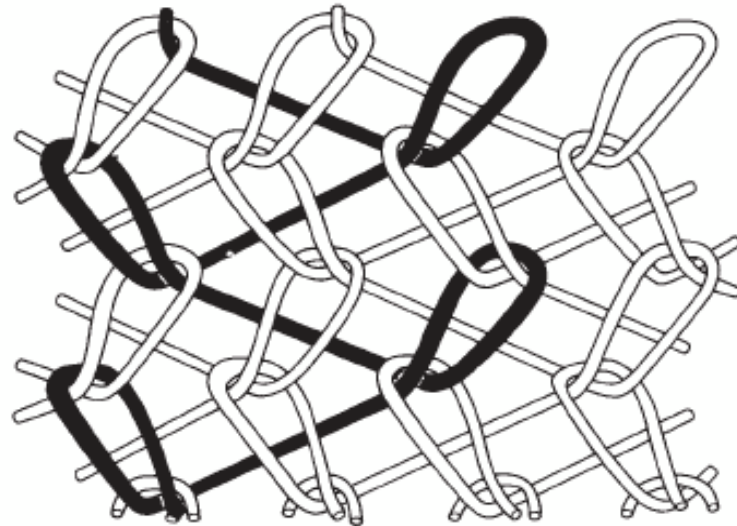
# Design possibilities

## In weft knitting

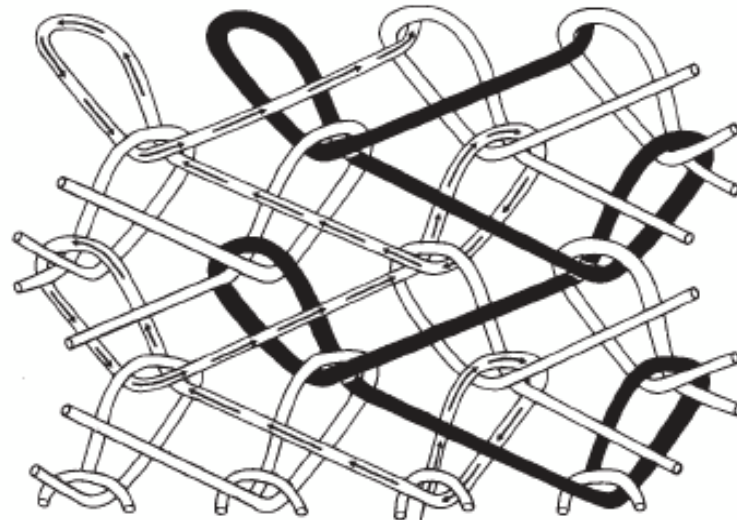
- › Individual needle selection
- › Cam shape, size, cam butt size and position are used for design
- › Design possibility is very wide

## In warp knitting

- › Guides movement control, shogging and swinging, helps to design new structure
- › Number of guide bars
- › Relative to weft knitting design possibility is less

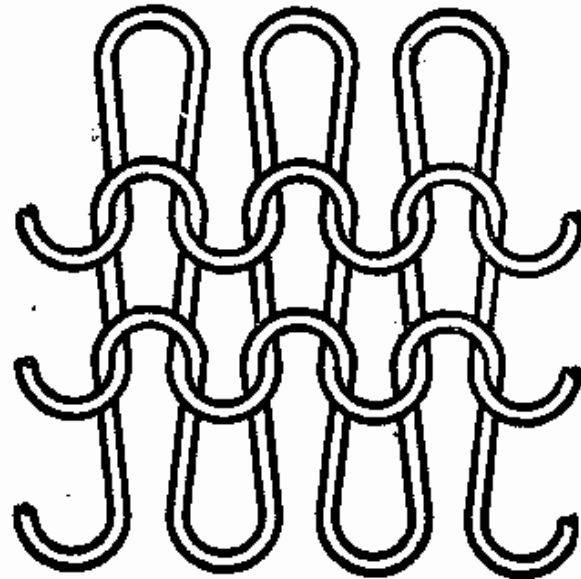
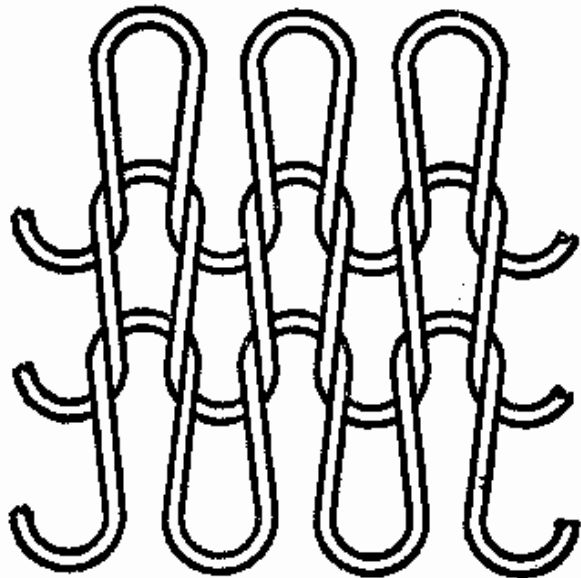
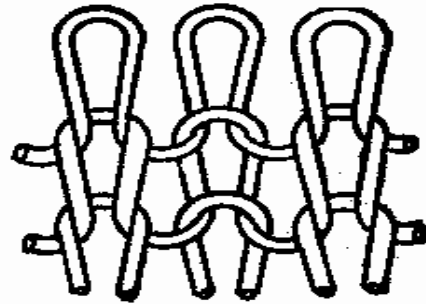


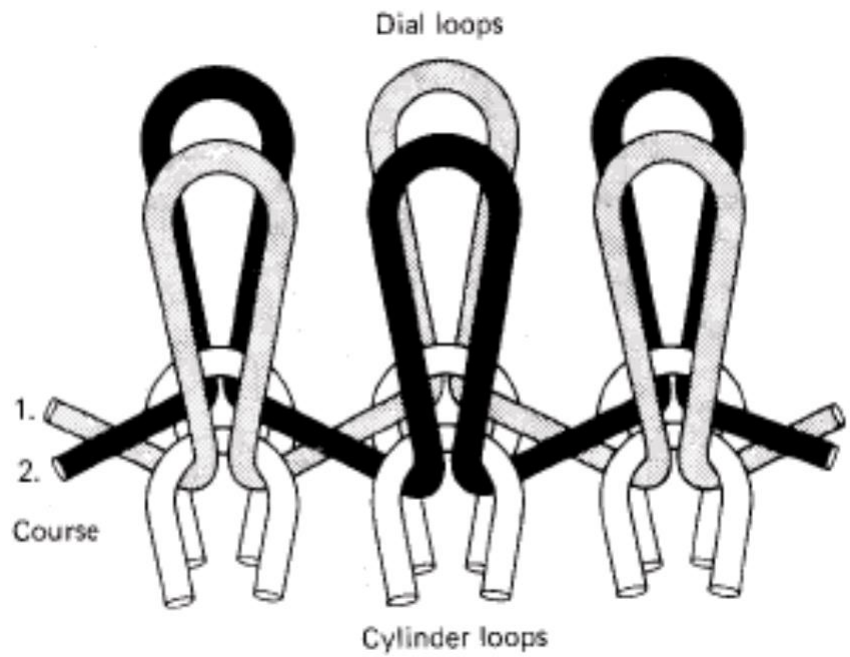
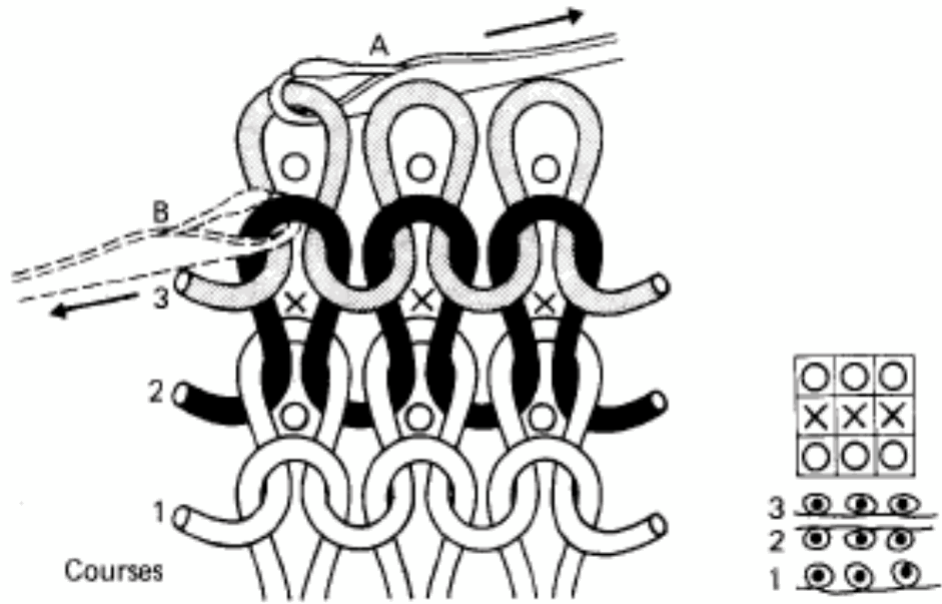
(a) Technical Face



(b) Technical Back

# Unraveling





# Dimensional properties and geometry of Knitted fabrics

- Geometry of knitted structures is based on the prediction, measurement and control of individual loop length in a fabric
- Loop length is precisely controlled during knitting and loop shape is controlled during relaxation after knitting
- During knitting loop length is controlled by positive feed devices

# Fabric tightness factor (k)

- Is the extent to which the fabric area is covered by the yarn

$$k = \frac{\sqrt{tex}}{I(mm)}$$

- Where I is loop length
- For all types of yarns and knitted structures

$$1 \blacklozenge k \blacklozenge 2$$

- Plain single jersey fabrics  $1.29 \blacklozenge k \blacklozenge 1.64$

- Therefore average value of k generally is 1.5

- Ex. For 30tex yarn find the loop length, by using average value of  $k = 1.5$ ,  $I = (\sqrt{tex})/k = (\sqrt{30})/1.5 = 3.65\text{mm}$

- Optimum tex = constant/(gauge)<sup>2</sup>, single jersey, c=1650, for double jersey c = 1400

- For 30inch diameter machine and E12 find the number of needles and course length on the machine given  $l = 3.65\text{mm}$
- $N = dE = 30 \times 12 = 360$
- $L = N \times l = 360 \times 3.65\text{mm}$

Main factors affecting **dimensional property** of knitted fabrics are

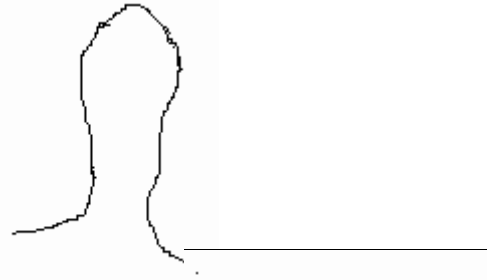
1. Fabric structure
2. Fiber type
3. Relaxation/finishing route
4. Yarn linear density

Three properties are very important

**Areal density, fabric width, and shrinkage after washing**

# Loop shape

- On the machine



- Out of the machine



- Wet relaxation: width increase a little bit
- Soak in water with agitation: both height and width increase

- Courses per inch (CPC) directly proportional to  $1/\text{loop length} = Kc/l$  ( $1/\text{cpc} = \text{loop height}$ )
- Wales per inch (wpc) is directly proportional to  $1/\text{loop length} = Kw/l$  ( $1/\text{wpc} = \text{loop width}$ )
- Stitch density (s) is directly proportional to  $1/l^2 = Ks/l^2$  ( $1/s = \text{loop area} = \text{loop pitch}$ )
- $C.p.c/w.p.c = Kc/Kw$  called poison's ratio, shape factor.
- Take up rate = loop length/loop pitch

- Fabric width = number of needles/wpc
- Fabric thickness = in dry and wet relaxed state thickness,  $t$  is directly proportional to tightness factor. But in the fully relaxed or stable state it is independent of tightness factor.
- Ariel density = mass per unit area ( $\text{gm}/\text{m}^2$ )

# Effects of dimensional properties on fabric properties

## 1. Air permeability

- $Q = K(FA)(\Delta p)^{1/2}$
- Where
- $Q$  – Volume flow rate per unit fabric area
- $FA$  – free area (fractional area of the total fabric surface not occupied by yarns)
- $K$  – Proportionality constant dependent upon fabric geometry and other fluid flow factors
- $\Delta p$  – pressure differential across the fabric

## 2. Thermal conductivity

- The amount of heat (in calories or British thermal unit) that flows through an insulating material is given by

$$Q = \frac{KA (T_2 - T_1)t}{d}$$

Where Q – total quantity of heat transmitted through the material

- K – Thermal conductivity constant
- A – Area through which the heat is flowing
- d – Thickness
- T<sub>1</sub>, T<sub>2</sub> – temperatures of warm and cool surfaces
- t – Time of heat flow

### **3. Wicking of fabrics**

- The flow of liquid along the surface of fabric
- Mov.t is enhanced along the courses of weft knitted fabrics

### **4. Moisture Absorption**

Depends on

- a. Type of fiber
- b. Type of yarn
- c. Fabric structure: water molecules stay in the space between loops and slowly absorbed or transmitted

# Summary of fabric properties

	Property	Plain	txt rib	txt purl	Interlock
1	<b>Appearance</b>	Different on face and back V-shape on face Arcs on back	Same on both sides	Same on both sides	Same on both sides
2	<b>Extensibility</b>				
	Lengthwise	Moderate	Moderate	Very high	Moderate
	widthwise	High	Very high	High	Moderate
	Area	Moderate – high	High	Very high	Moderate
3	<b>Thickness and warmth</b>	Thicker and warmer than plain woven	Much thicker and warmer	Very much thicker and warmer	Very much thicker and warmer
4	<b>Unroving</b>	Either end	From end knitted last	Either end	From end knitted last
5	<b>Curling</b>	Tendency to curl	No tendency	No tendency	No tendency

6	<b>End uses</b>	Ladies stocking, shirts, cardigans, dresses etc..	Socks, cuffs, waist bands, collars, mens outwear and under wears	Children clothing, thick and heavy outwears	Under wear, shirts, suits, trouser suits, sports wear219
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# Properties of weft Knit. machines

	Flat machines	Circular machines	Straight bar
Gauge (E)	3 - 18	5 - 40	14 - 50, max 90
Machine width	Up to 78.7inches	Upto 30inch dia, max. 60inch dia	2 - 16 sections, 36inch Totally = 72 - 576inchs
Needle type	Latch	Latch1bearded	Bearded
Needle bed type	Single1double	Single1double	Single1double
Products	Jumpers, pullovers, cardiagans, dresses, suits, trousers etc _ _ _	Seam free hose, tights, sports socks, trousers, vests, thermal wear, etc _ _ _	Jumpers, cardigans, dresses, suits, fully fashioned hose, underwear, etc _ _ _

# Properties of warp machines

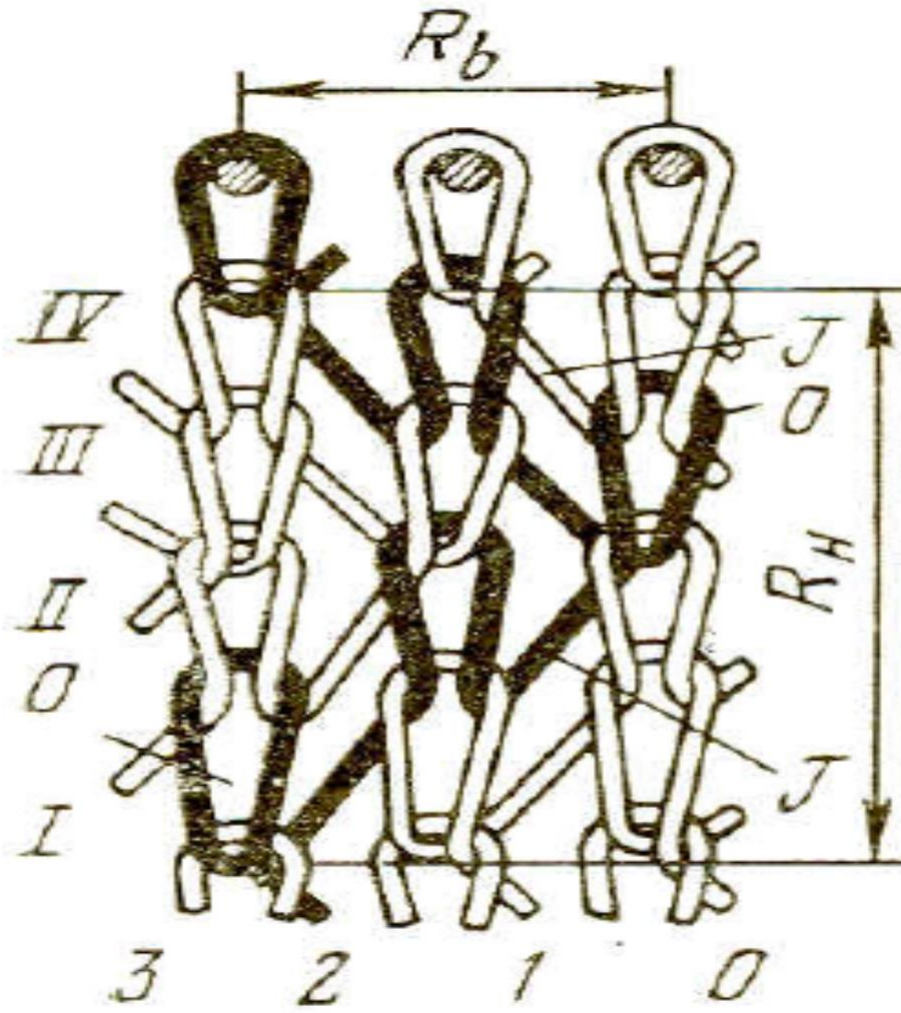
	<b>Tricot machine</b>	<b>Raschel machine</b>
Gauge (E)	18 - 40	12 - 32
Machine width	84 - 210 inches	75 - 210 inches
Needle type	Beardedl compound	Latchlcompound
Number of needle bars	1 or 2	1 or 2
Number of guide bars	2 to 8	2 to 78
Products	Lingerie, shirts, outwears, leisure wears, sports wears, swim wear, car seat covers etc - - - .	Curtains, nets, table clothes, bed covers, geotextiles, medical textiles, velvets, upholstery etc - - - ..

# 1. Warp Knitted Structures and Notations

## 1.1. Notation of warp knitted structures

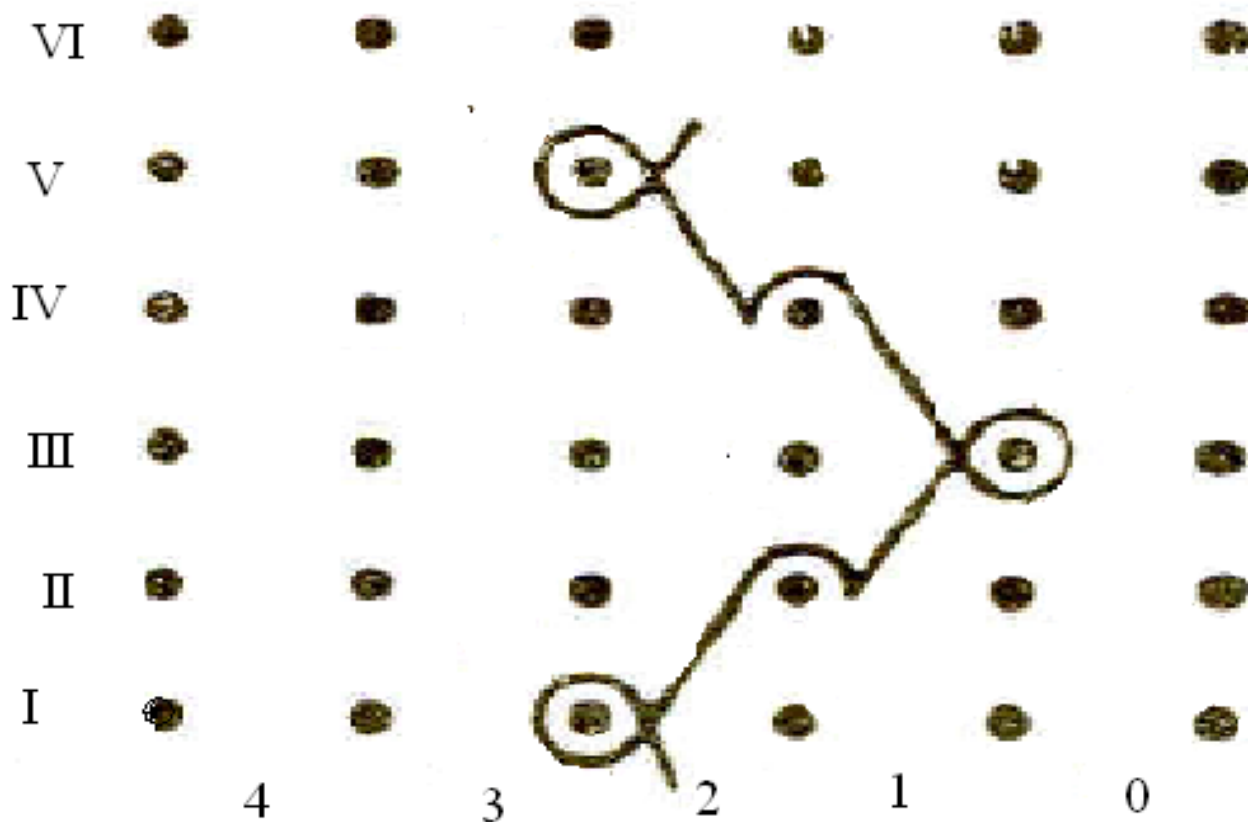
### A. Graphical Representation

- use dot or point paper method
- Prepare rows and columns of dots that represent overlaps/needles
- Use points to designate the needles of one bed, and crosses-the needles of the other bed (for two-bed machines).
- Write the rows no. on the left side (courses) from bottom to top as it is on the structure



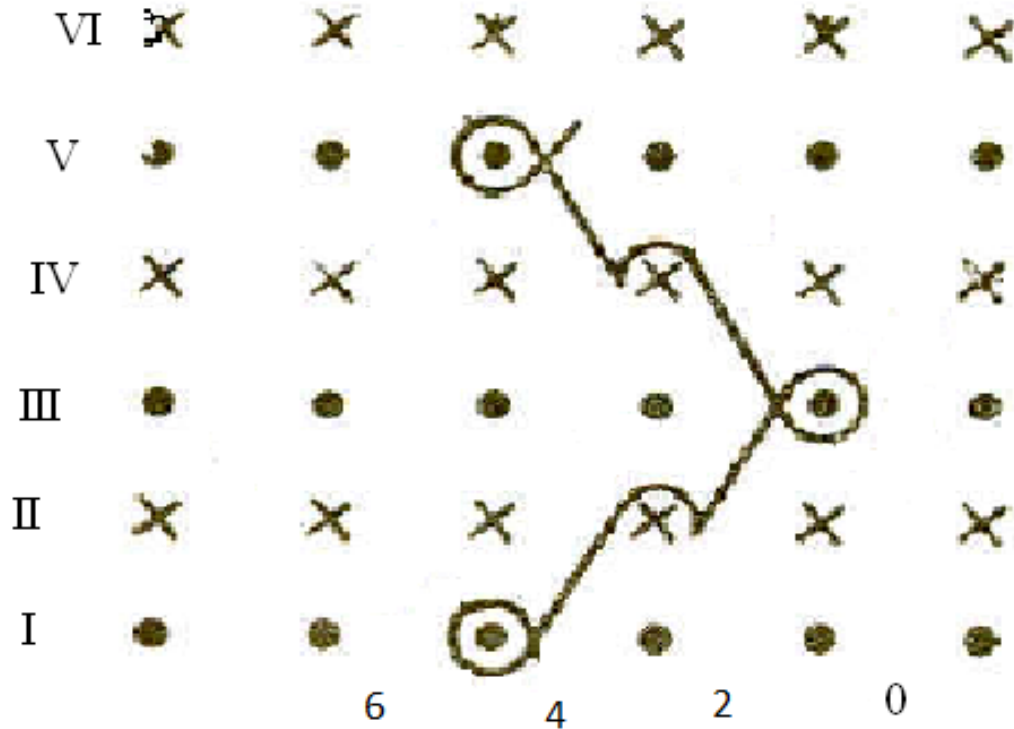
- Give **numbers** to the empty spaces between two consecutive needles **from right to left**  
**whole numbers** for single bed  
**even number** for double bed

- Draw the path of a yarn in a **design area** only
- Use **closed loop** for closed loops and **open loop** for open loops



## B. Design Area Representation

Dw x Dh



Dw = 3

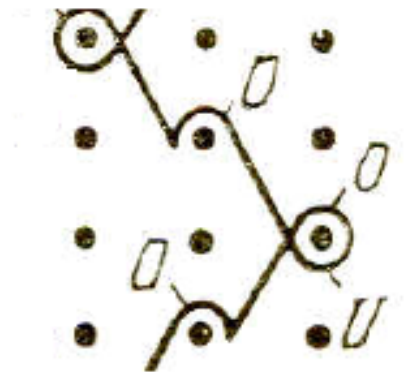
Dh = 4

**Pattern height** = **number of courses** where pattern looping over on a yarn path

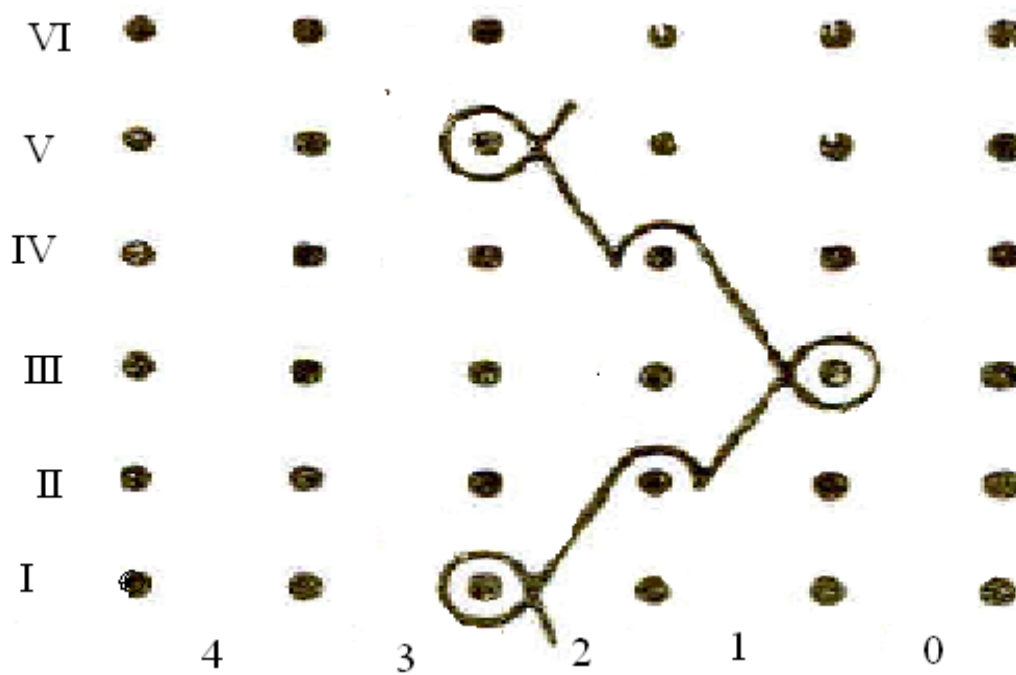
**Pattern width** = **number of wales** where the single thread passes

## c. Numerical record graph

- Two types:- two stage and three stage records
- In a dot paper representation yarn parts laying on the needle (o) and under the needle (u) are shown
- Only yarn laying on the needles (o) is used to name loops by two stage record but both for three stage record
- Assign two numbers for 2 stage and three no. for 3 stage
- Start from bottom end of yarn & go towards up (i.e. in the knitting direction)

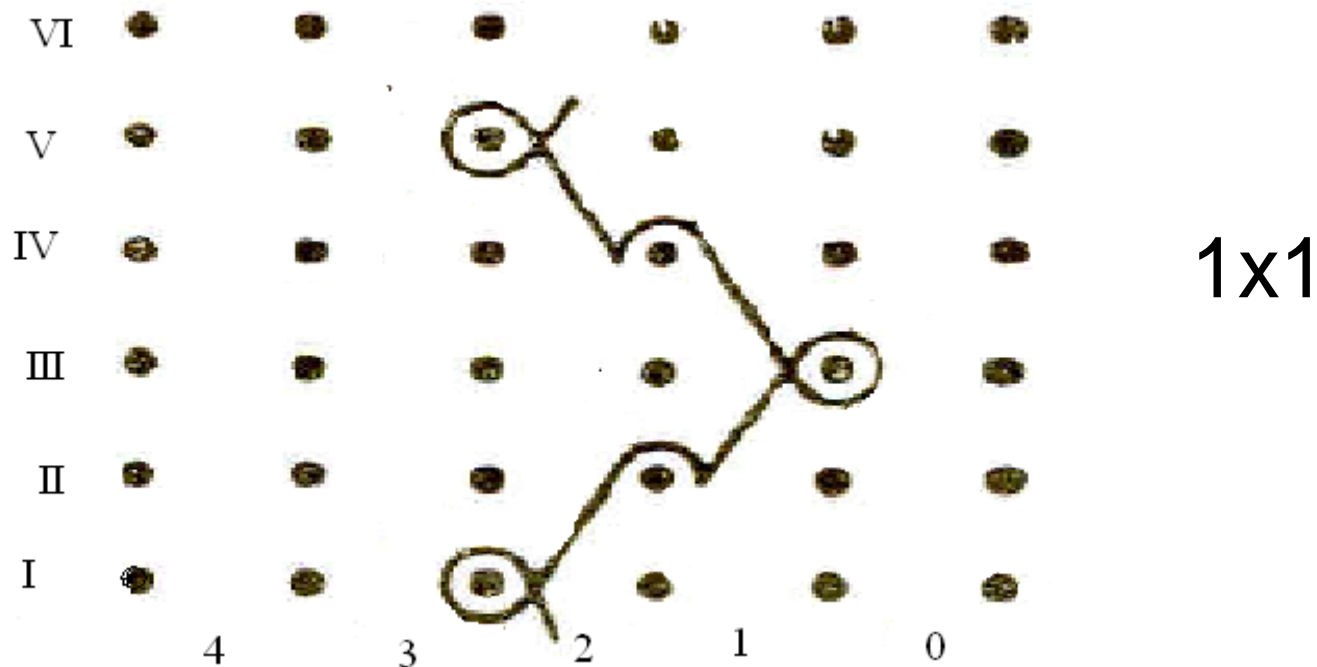


No Course	Numerical two-stage record	Numerical three-stage record
I	2 - 3	2 - 3 - 2
II	2 - 1	2 - 1 - 1
III	1 - 0	1 - 0 - 0
IV	1 - 2	1 - 2 - 2
1	2 - 3	2 - 3 - 2



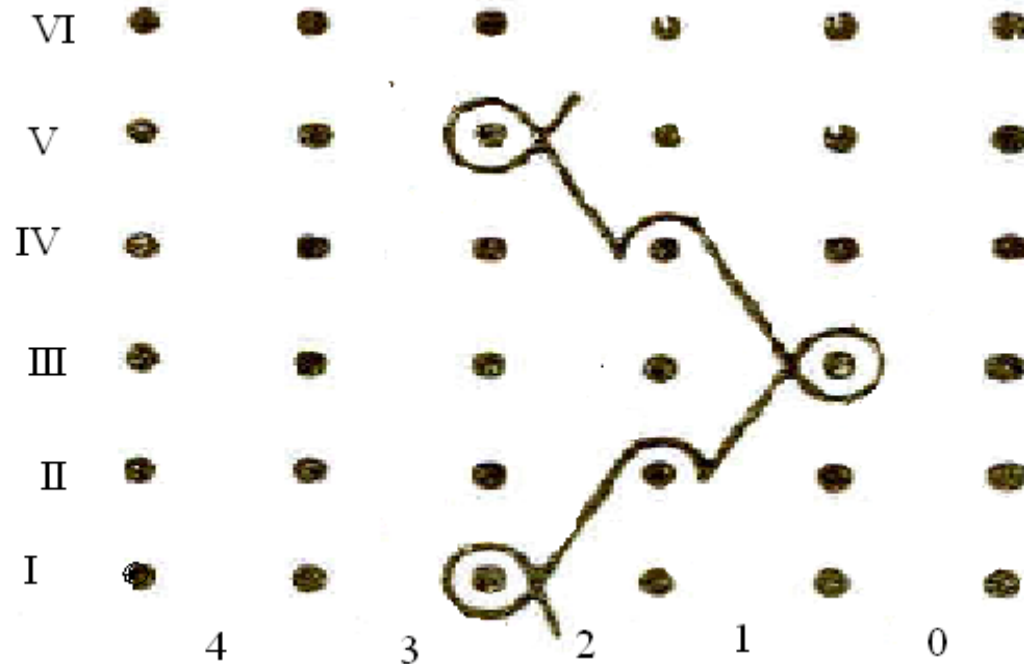
## D. Degree of shifting representation

- Represented as  $w \times 1$ ,
- $w$  - the number of wales shifted to form second loop/between two consecutive overlaps
- $1$  - the number of courses shifted is one



## E. Number of overlaps in one direction/line

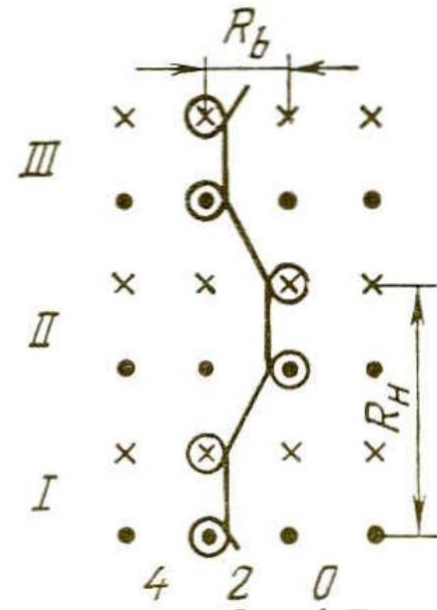
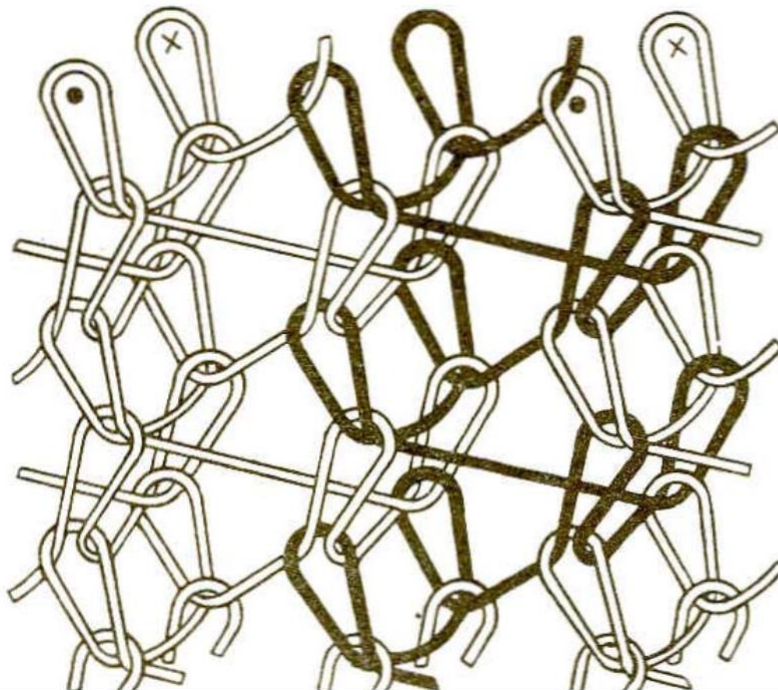
- The number of needles a single warp is being knitted on



- $N = 3$

## F. Sides of under laps

- The under laps (the ingoing and outgoing under laps) of a given overlap can be **single sided** or **double sided** relative to wale lines
- Loops in a given side of a fabric can therefore be single sided, double sided or combination of the two
- This determines the inclination of the overlaps



# 1.2. warp Knitted Structures

## Kinds of basic warp knitted stitches

Basic Knitted warp stitches may be: chain, tricot, & atlas

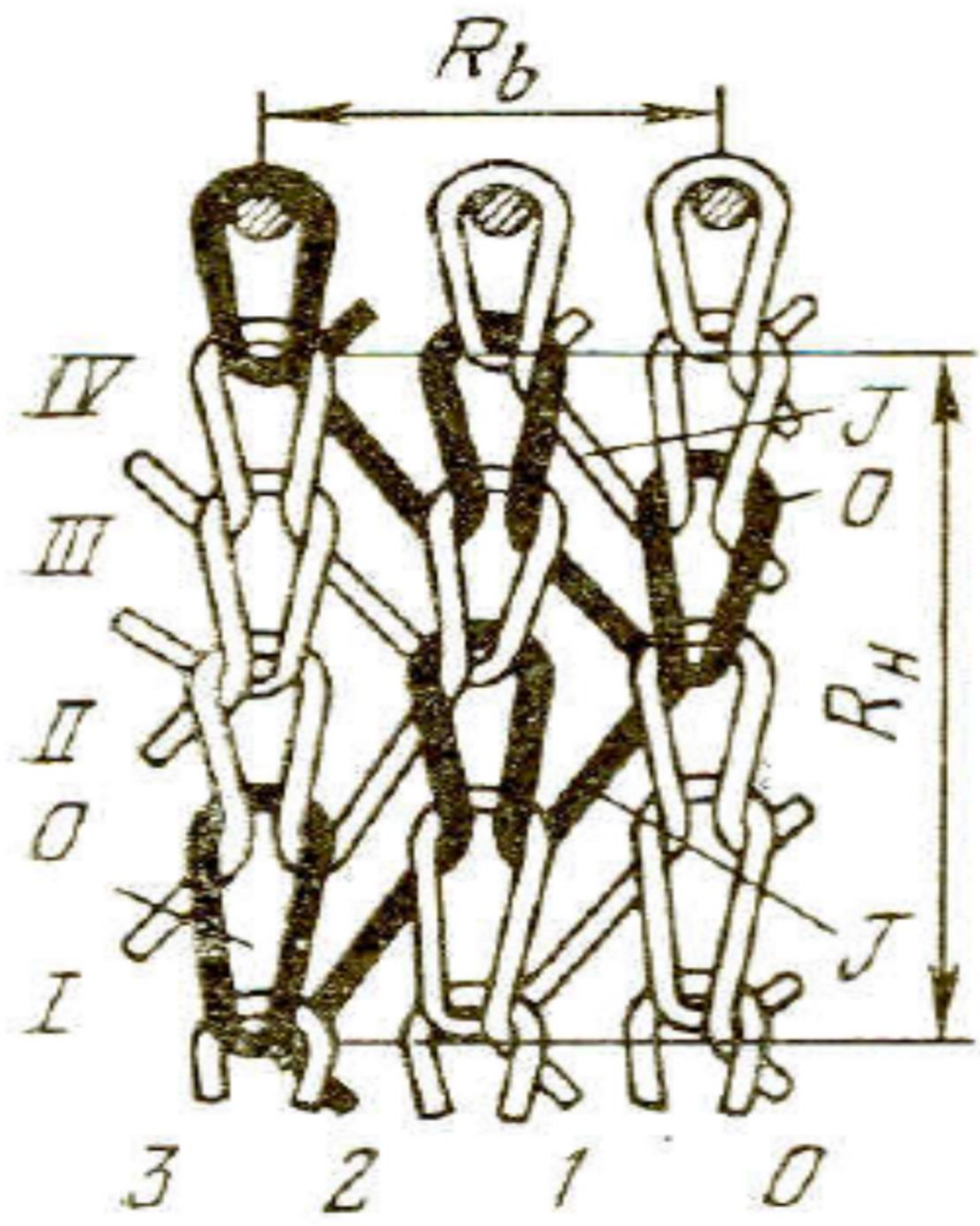
→ derivatives of basic structures

→ single and double-bed structures

→ single and double-bar structures

› The warp yarns, after forming loops in one course, pass into the following course, and therefore

› the number of loops formed in the course is the same as the number of yarns in the warp.



# Warp knitting structures

```
graph TD; A[Warp knitting structures] --> B[Chain]; A --> C[Tricot]; A --> D[Atlas]; B --> B1["-Derivatives<br>-Single & double bed<br>-Single & double bar"]; C --> C1["'Derivatives<br>'Single & double bed<br>'Single & double bar"]; D --> D1["'Derivatives<br>'Single & double bed<br>'Single & double bar"];
```

## Chain

- Derivatives
- Single & double bed
- Single & double bar

## Tricot

- 'Derivatives
- 'Single & double bed
- 'Single & double bar

## Atlas

- 'Derivatives
- 'Single & double bed
- 'Single & double bar

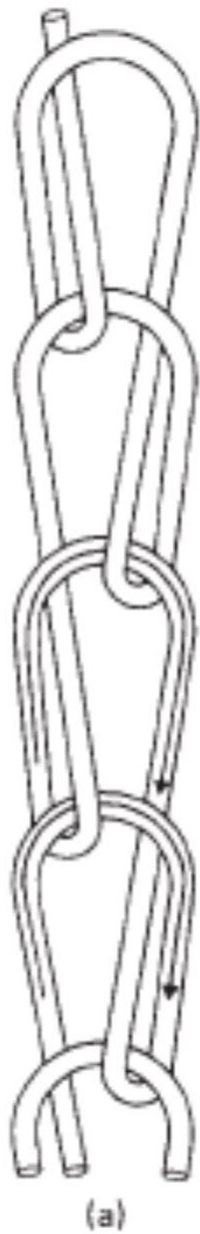
# A. Basic warp knitted stitches & their derivatives.

## 1. Plain chain/Pillar stitch = single bed + single bar

is formed by **lapping the yarn on the same needle** in all loop courses.

- No movement of a yarn from wale to wale/needle to needle
- It may be with **closed loops** or with **open loops**
- Plain chain curls into a spiral towards the face and has a slight extensibility.
- Plain chain is the most important element in **knitted nets, curtains, lace, fringe, cords**, etc.

$W \times 1 = O \times 1$   
 $D_w \times D_h = 1 \times 2$   
 $N = 1$



$W \times 1 = O \times 1$   
 $D_w \times D_h = 1 \times 1$   
 $N = 1$



Fig. 23.6 Open and closed lap pillar stitches.

- The pillar stitch forms **separate Wales**, which must be **connected together by the under laps** of a second guide bar. Or used in **combination with other stitches**
- Generally, pillar stitches are made by **front guide bars**, either to produce **vertical stripe effects** or to **hold the inlays** of other guide bars into the structure.
- Open-lap pillar stitches are common
- They can be **unroved from the end knitted last**.
- **Closed-lap pillar stitches** are employed on **crochet machines** because the lapping movement is simple and necessary when **using self-closing needles**

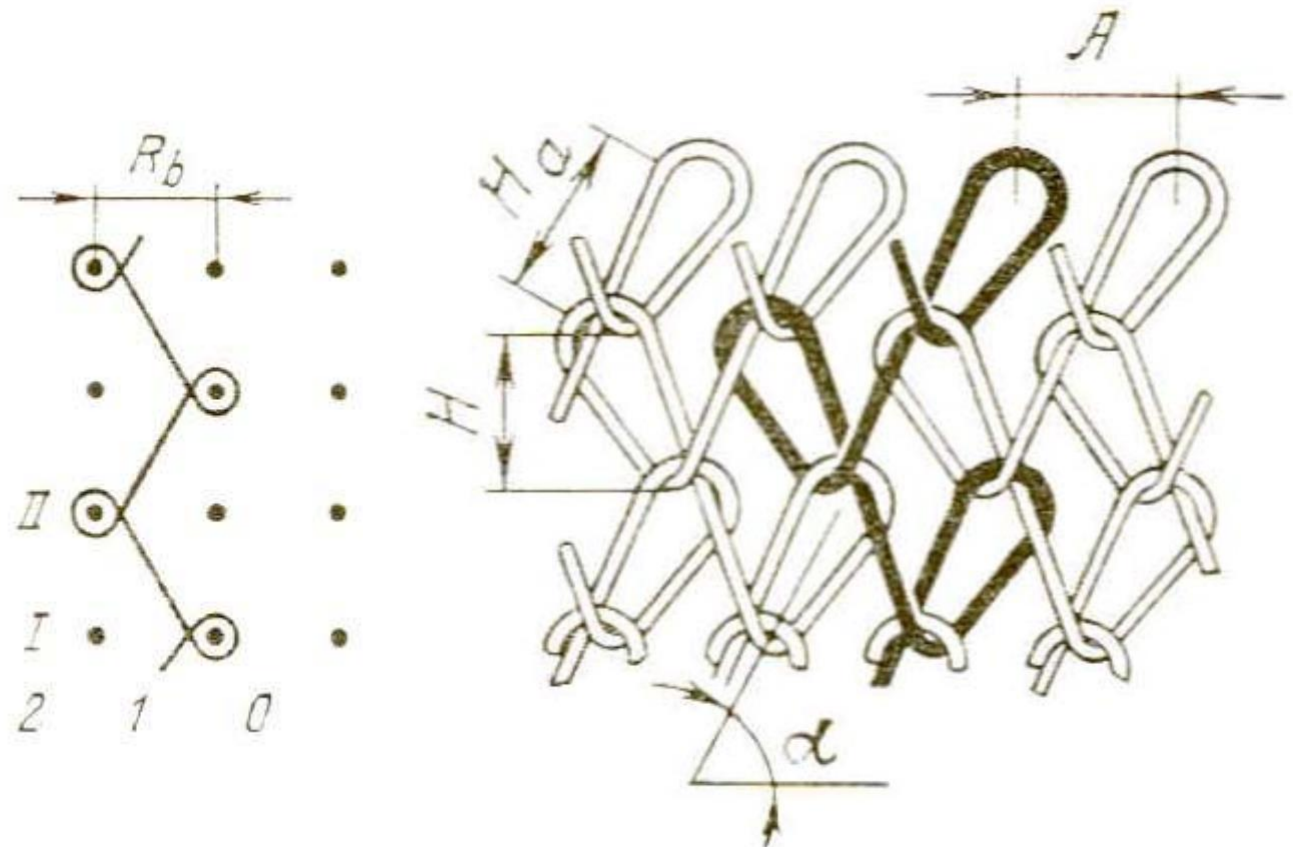
## 2. tricot and its derivatives

### i. Single tricot

- The tricot loops are disposed in an alternate order in two adjacent Wales
- All loops in single tricot are single-faced structures
- This tricot may be formed of closed, open, or alternate loops
- In a course, when overlaps are inclined to the left the outgoing underlaps are inclined to the right and vice versa.
- The degree of loop inclination, which is determined by the angle  $\alpha$ , increases with the yarn elasticity and density of knitted fabric.

- Due to over laps inclination, loops in a wale show **zigzag structure**. → less curling at edges
- Single tricot ravel only in the **direction reverse to knitting/from** the end knitted last
- This is the main drawback of knitted fabrics with a tricot structure.

$W \times 1 = 1 \times 1$   
 $D_w \times D_h = 2 \times 2$   
 $N = 2$   
 1-0/1-2



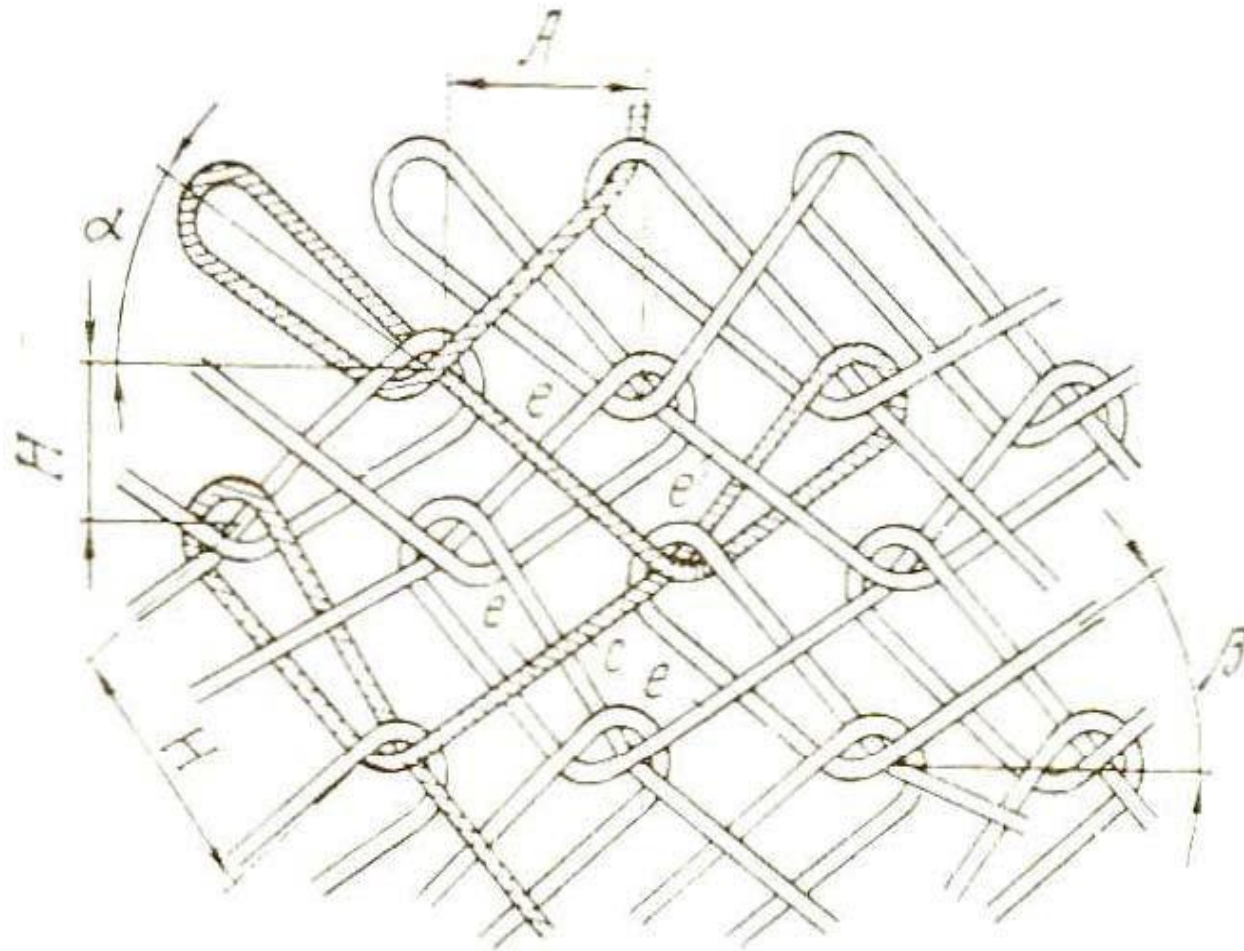
## ii. tricot derivatives

- Tricot derivatives are classified based on  $w \times 1$ ,
- **1 x 1:- Single tricot**  
1 thread crosses between wales  
it shifts one wale
- **2 x 1:- two tricot, or half tricot or *Cord lap***  
two threads cross between Wales  
it shifts two wales
- **3 x 1:- three tricot, T'tricot, locknit, charme, velour lap or satin lap**  
three threads between wales and shifts 3wales
- **4 x 1:- four tricot, Velvet lap**  
four threads between wales and shifts 4wales

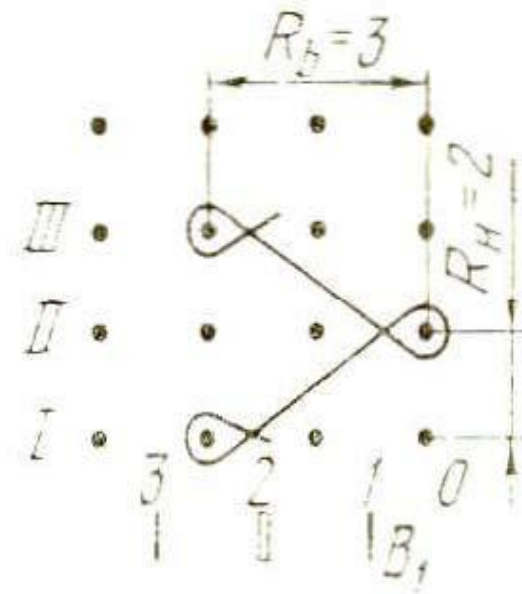
## a. Half tricot

- The loops in the half-tricot stitch have only **single-side under laps**,
- Therefore the Wales (visible from the face) have a **zigzag shaped structure**;
- From the reverse side of the structure, the loop skeletons are **intersected by under laps**.
- Half-tricot structure curl at the edges, i.e. along the line of **courses towards the face**, and
- Along the line of **Wales towards the reverse side**.
- Half-tricot **ravels with difficulty**

# Half tricot and its representation



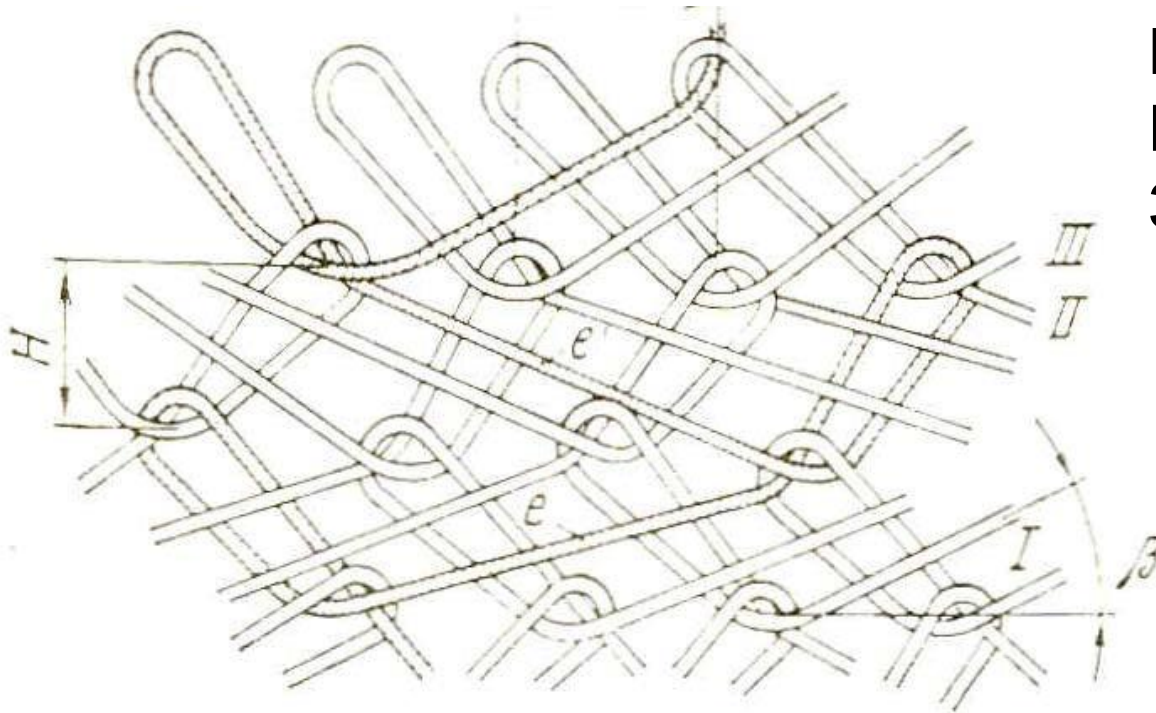
$W \times 1 = 2 \times 1$   
 $D_w \times D_h = 3 \times 2$   
 $N = 2$   
 $2-3/1-0$



## b. charme or locknit

- differs from half-tricot in the length of under laps.
- With an increase in derivation, the **stitch repeat** in width also **increases**,
- i.e. for four-tricot  $Dw = 5$ , for five-tricot  $Dw = 6$  **etc...** with an increase in the value  $Dw$ , the number of under laps crossing a loop also increases.
- Consequently the **mass of  $1\text{m}^2$**  of fabric becomes **greater**, and
- The **angle** of under lap inclination to the line of the loop course **decreases**, resulting in the **reduction of fabric extensibility** in width and
- Resulting in **higher lustre** of the reverse side of the fabric

- Charme and other tricot derivatives are even **more difficult to ravel** than half-tricot, and this may occur only in the sense reverse to knitting;
- They curl at the edges the same as half-tricot

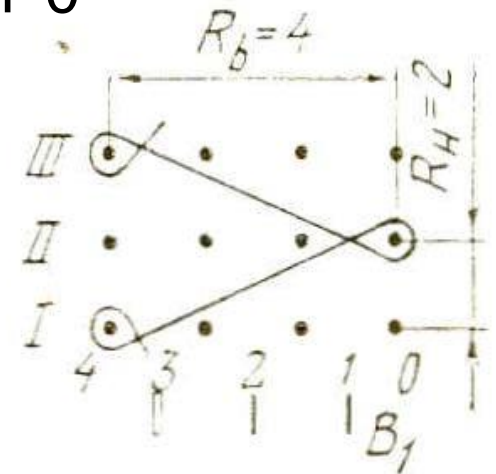


$$Wx1 = 3x1$$

$$DwxDh = 4x2$$

$$N = 2$$

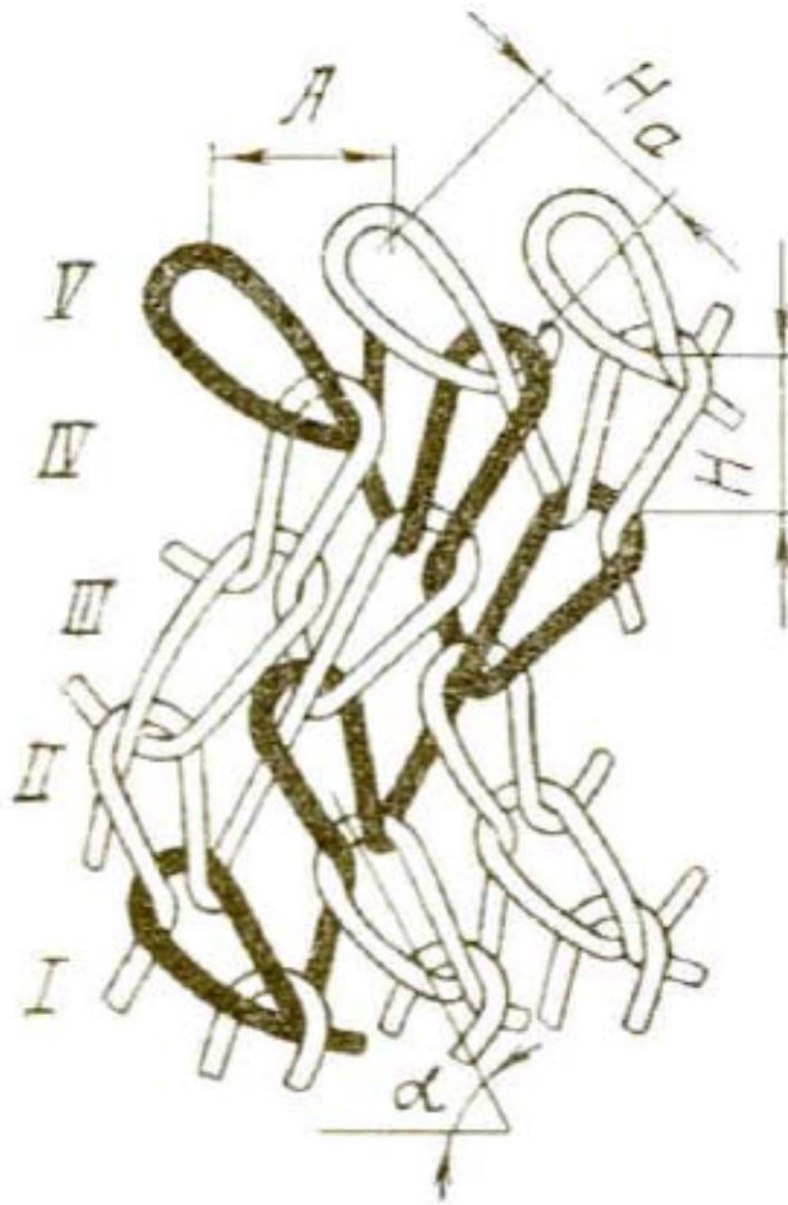
$$3-4/1-0$$



Structure and representations of charme/locknit

### 3. Atlas and its derivatives

- is a stitch in which each yarn consecutively forms loops in a multitude of adjacent wales/ $N \diamond 3$  adjacent wales.
- The minimum design area is  $D_h = 4$  &  $D_w = 3$
- An over laps and outgoing under laps are oppositely inclined to the vertical
- Due to the inclination, knitted tricot fabrics, when manufactured of single color yarns have cross stripes of different shades, and
- when of multi-colored yarns, characteristic zigzag designs.
- Single atlas curls at the edges, and ravel in the direction reverse to knitting;

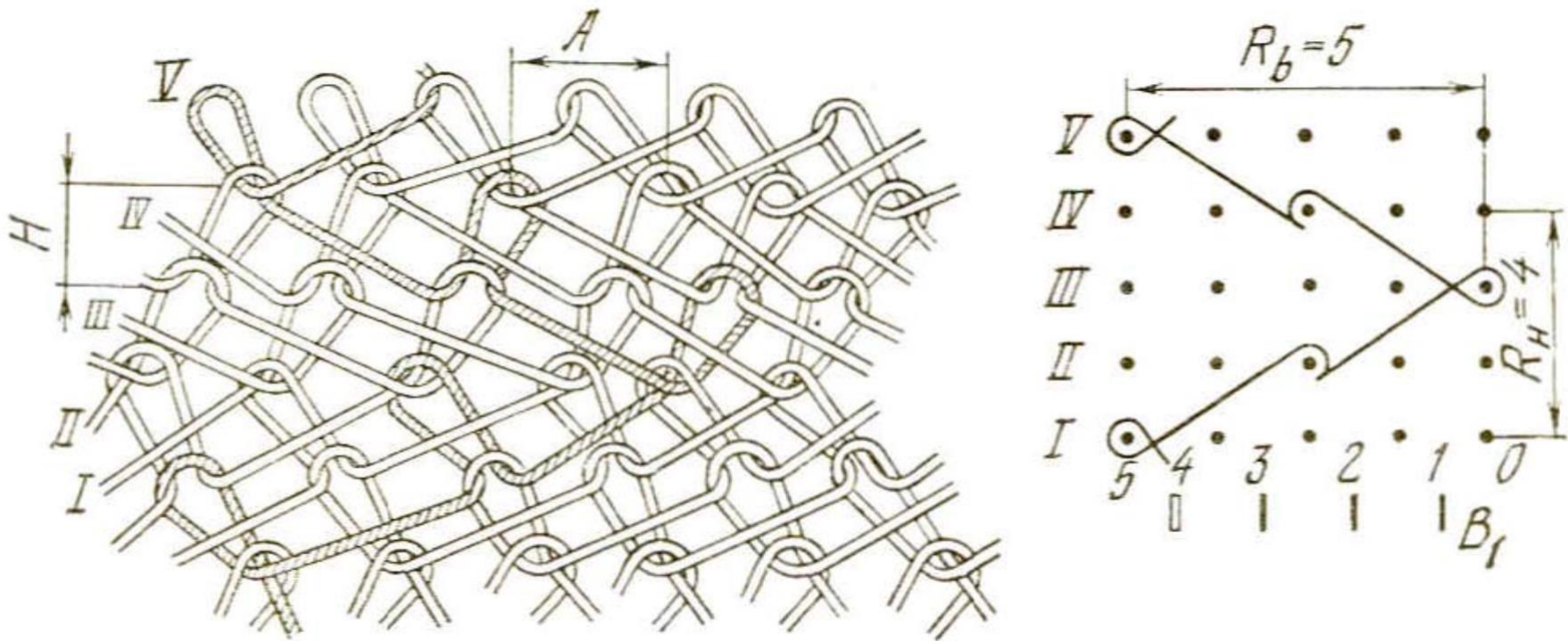


Single atlas

# Atlas derivatives

- have a structure similar to that of tricot derivatives;
- In the atlas derivatives of the half-tricot type, the yarns form loops after every one wale in the direction over a length of several courses,
- The smallest repeat of half-tricot in width is  $Dw, min = 5$ ,
- The charme type atlas  $Dw, min = 7$ .
- The atlas of the type four-tricot,  $Dw, min = 9$  and so on;
- Atlas derivatives are heavier than tricot derivatives due to the increased length of their under laps.

- They are **less extensible** in width,
- can be **unravalled with difficulty** only in the direction reverse to knitting,
- They curl from the edges in the same way as the **standard single atlas**.

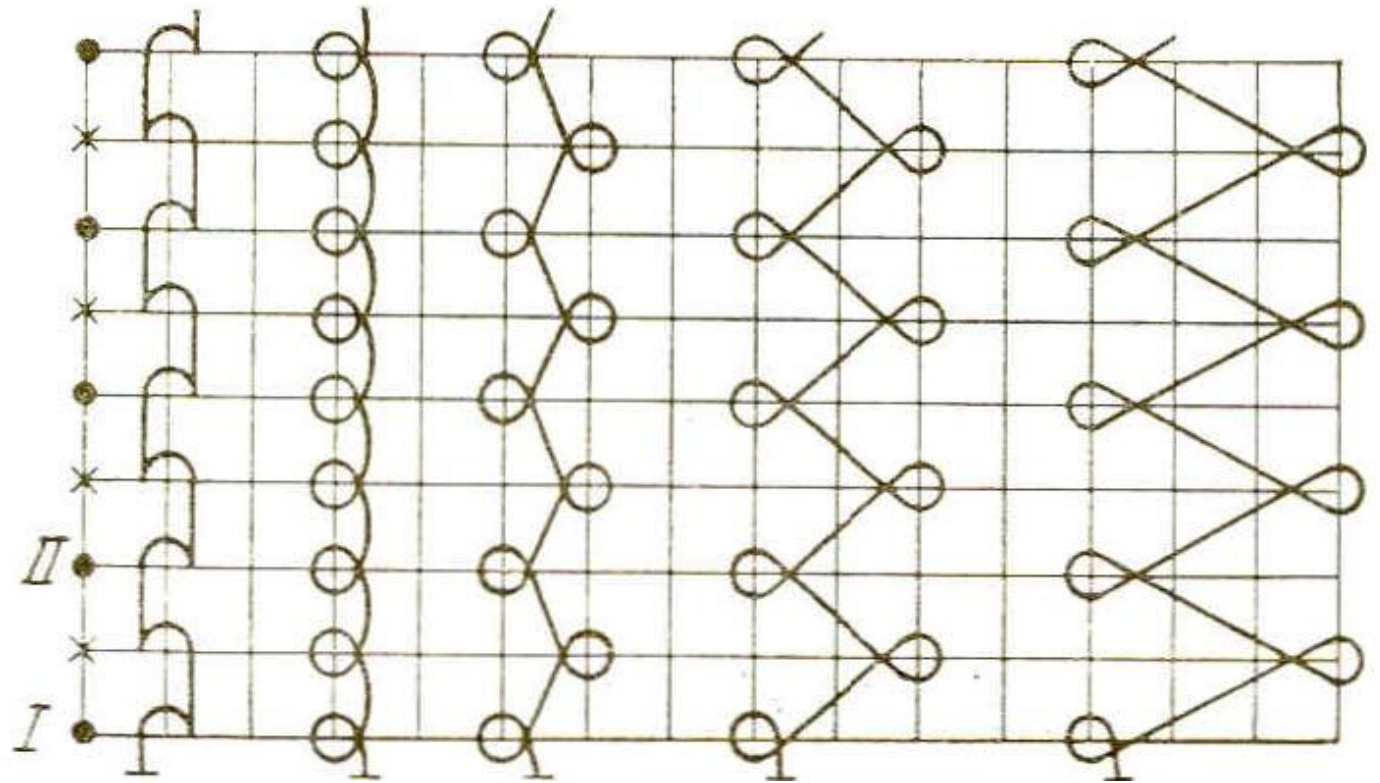
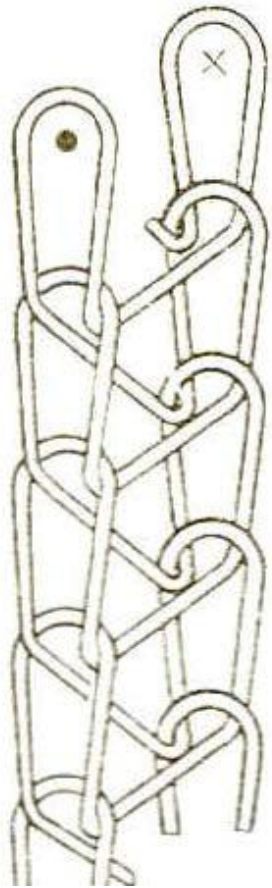


Structure and notation of half-tricot type atlas

## B. Double'bed structures

### i. Double chain

- Loops of one yarn form two **Wales**: a face and a reverse wale.
- When knitting a double chain, the yarn may be laid not only on the opposite needles of the bed, but **on adjacent ones as well**.
- In all cases, **separate Wales** are formed which are **not interconnected**.
- Double chain **does not curl** and **ravels** only in the **direction reverse to knitting**.
- In case of yarn breakage in one wale and chain tensioning, **this wale** may ravel, so that the **double chain** is transformed into a **plain chain**.

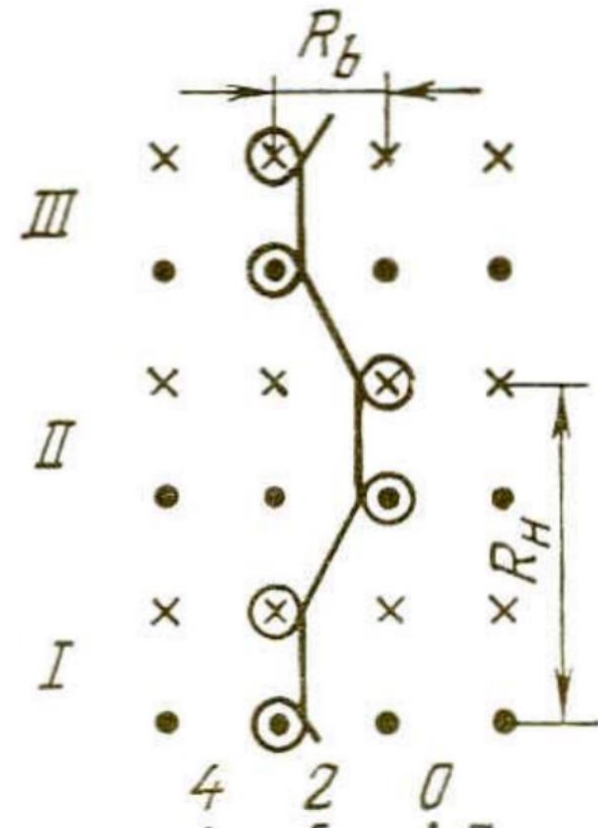
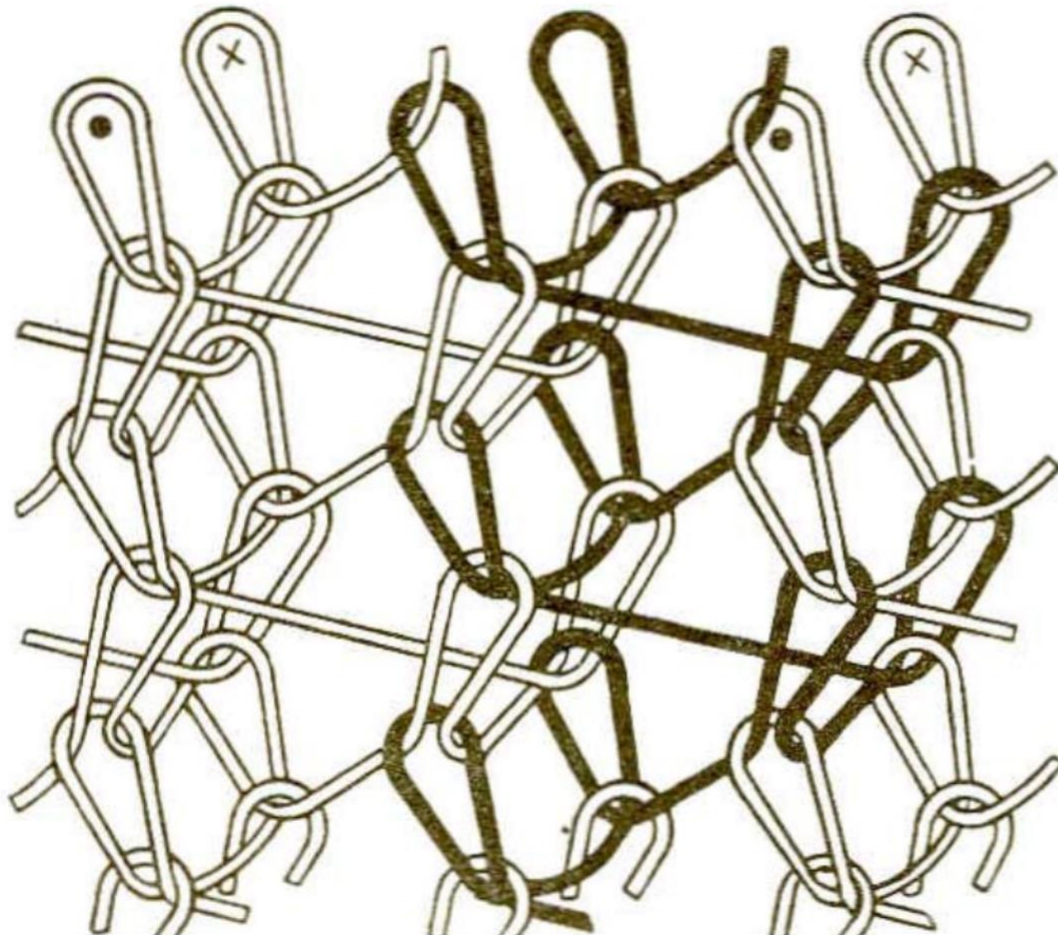


Double chain and its derivatives

## ii. Double tricot

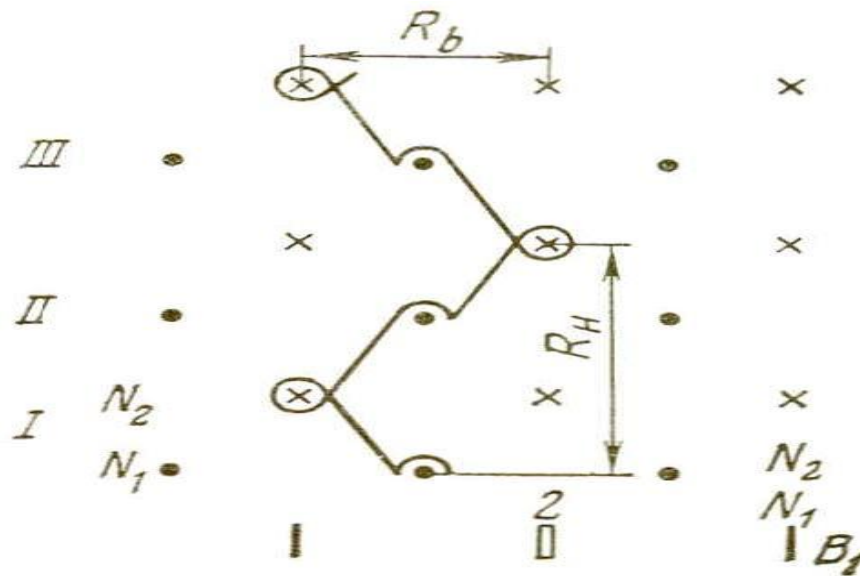
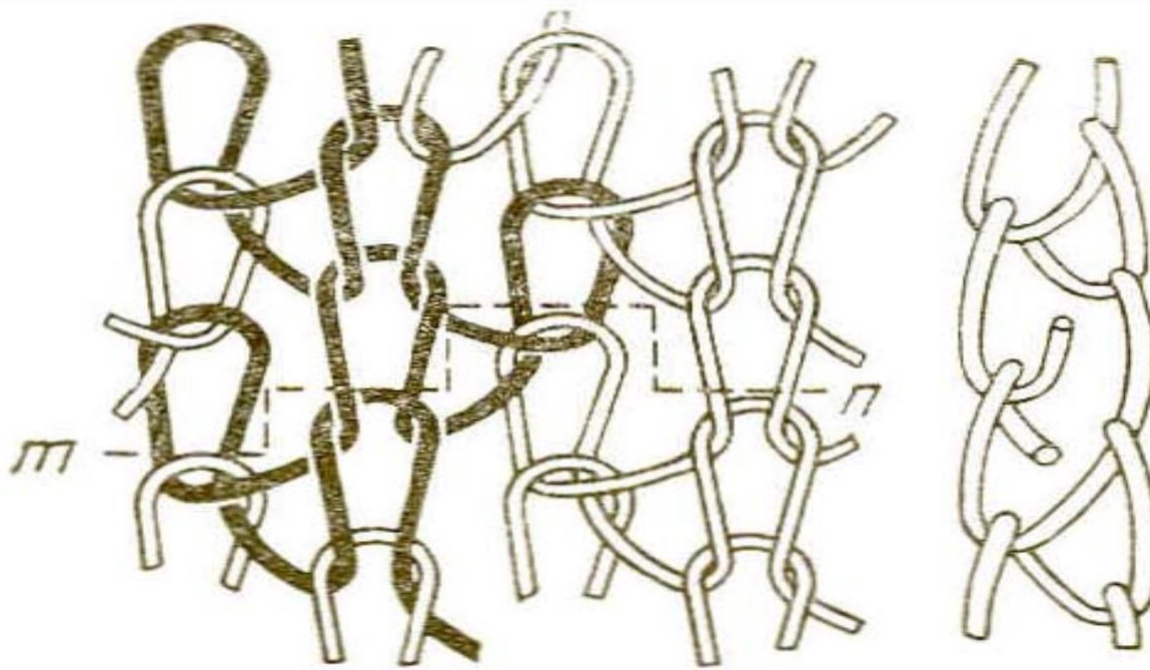
- Each yarn consecutively forms **two loops** in the **first course** & **first wale** which are the face and reverse loops,
- Next, in the following **course** & **neighboring wale** forms another **two loops** which are face and reverse sides, etc...
- Both sides of double tricot have the **same structure**
- Wales are disposed in **zigzag**.
- Knitted fabric of this structure ravel only in the direction **reverse to knitting**.

# Double tricot structure and representation



# Double rib tricot

- is a double-bed warp stitch obtained from one warp by a staggered (rib) disposition of needles in the beds
- The stitch is obtained by consecutively laying the yarn in three Wales/three needles
- It has single and double sided under laps
- On one side of the fabric the under laps are single sided while on the other side double sided
- Both sides of the knitted fabric have a zigzag shaped texture,
- The inclination of loops being greater on the fabric side formed by loops with single-side junctures.
- Double rib tricot does not curl at edges, and
- ravel only in the direction reverse to knitting.



Course N <sup>o</sup>	Numerical two-stage record
I	2-4
	3-5
II	4-2
	3-1

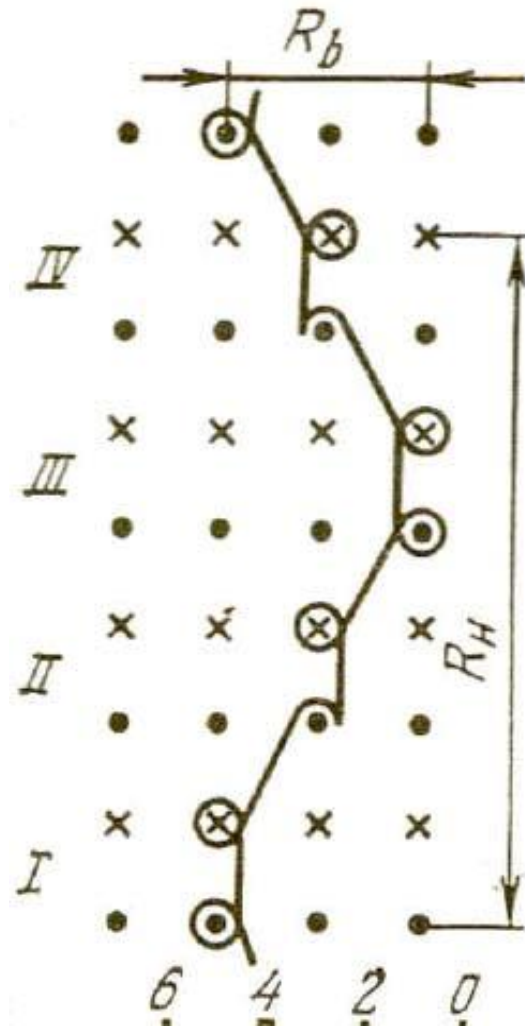
(c)

Structure and notation of double rib tricot

### iii. Double atlas

- The loops are consecutively formed in **many adjacent Wales** (3) first in one direction and then in the other.
- The minimum repeats of double atlas in width and height are  $Dw = 3$ ,  $Dh = 4$ .
- Knitted fabric of double atlas stitch **does not curl** and has the **same structure on both sides**;
- it ravel only in the direction **reverse to knitting**.

# Graphical representation of double atlas

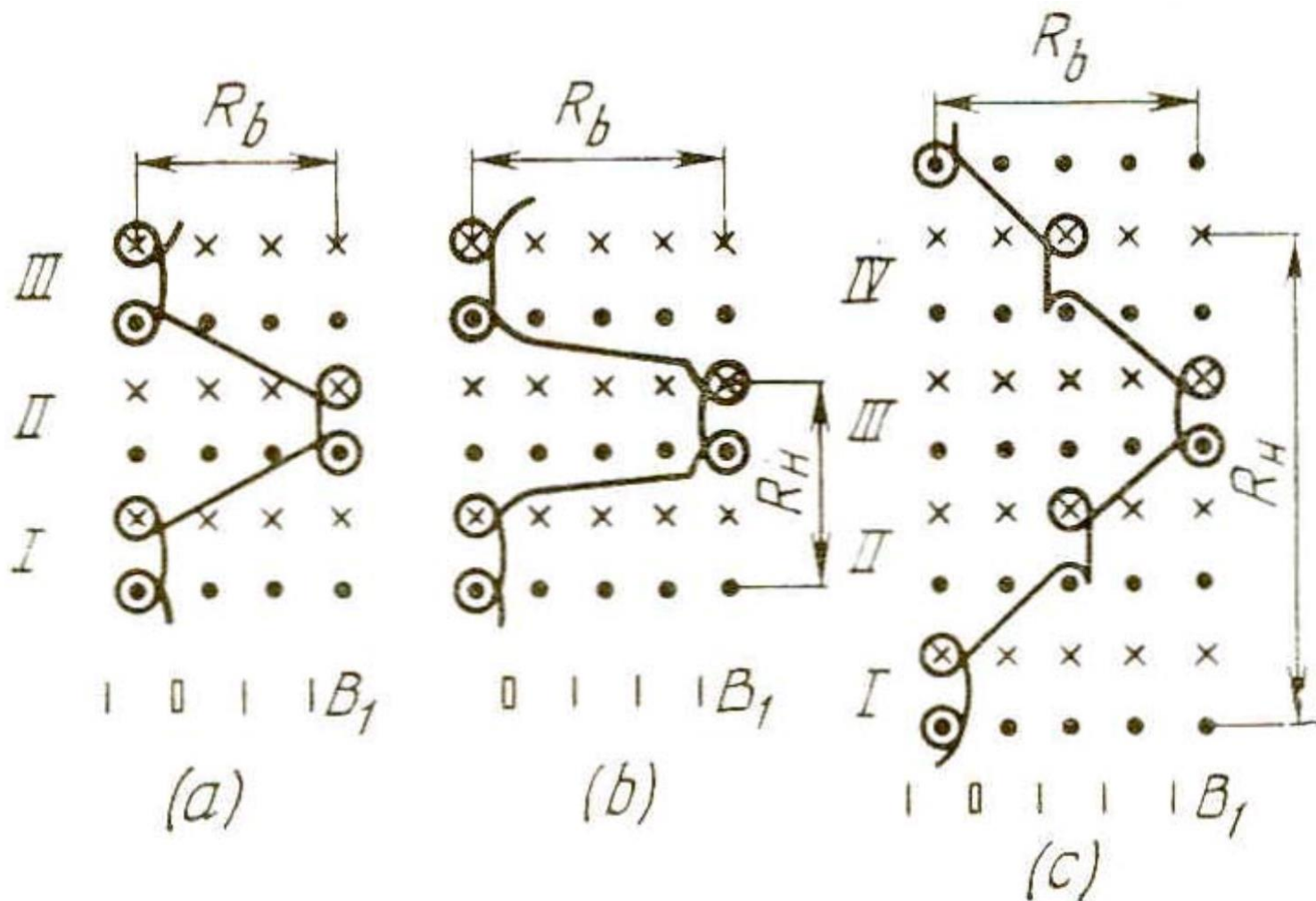


# Double derivatives of tricot and atlas

- In the same way as in plain warp knits, by combining **two double tricots** a half-tricot is obtained;
- By the combination of three tricots, a **double three-tricot (charme)**, etc.
- By the combination of two atlases a **double two-atlas** is formed.
- With increased derivation, the length of under laps is increased, the **extensibility** is **reduced**, and the **mass** of knitted fabric is **increased**.

# Graphical representation of

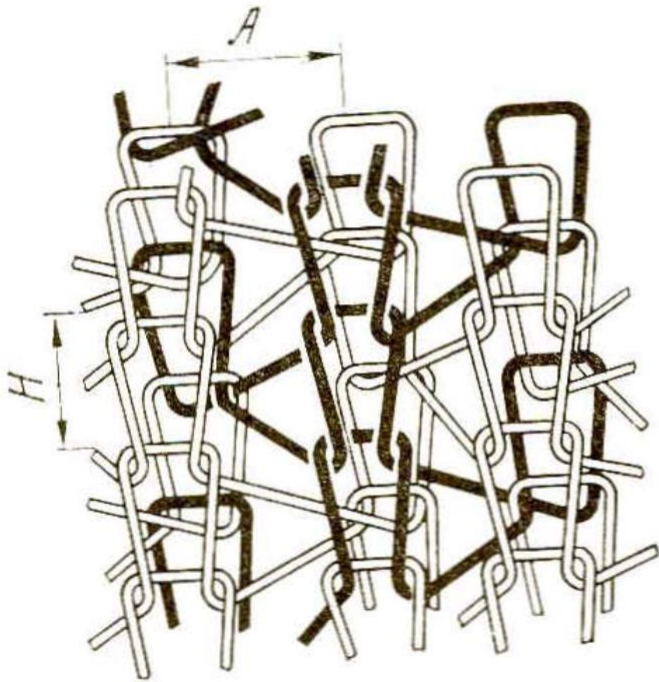
- a. double charme
- b. double four tricot
- c. double two atlas



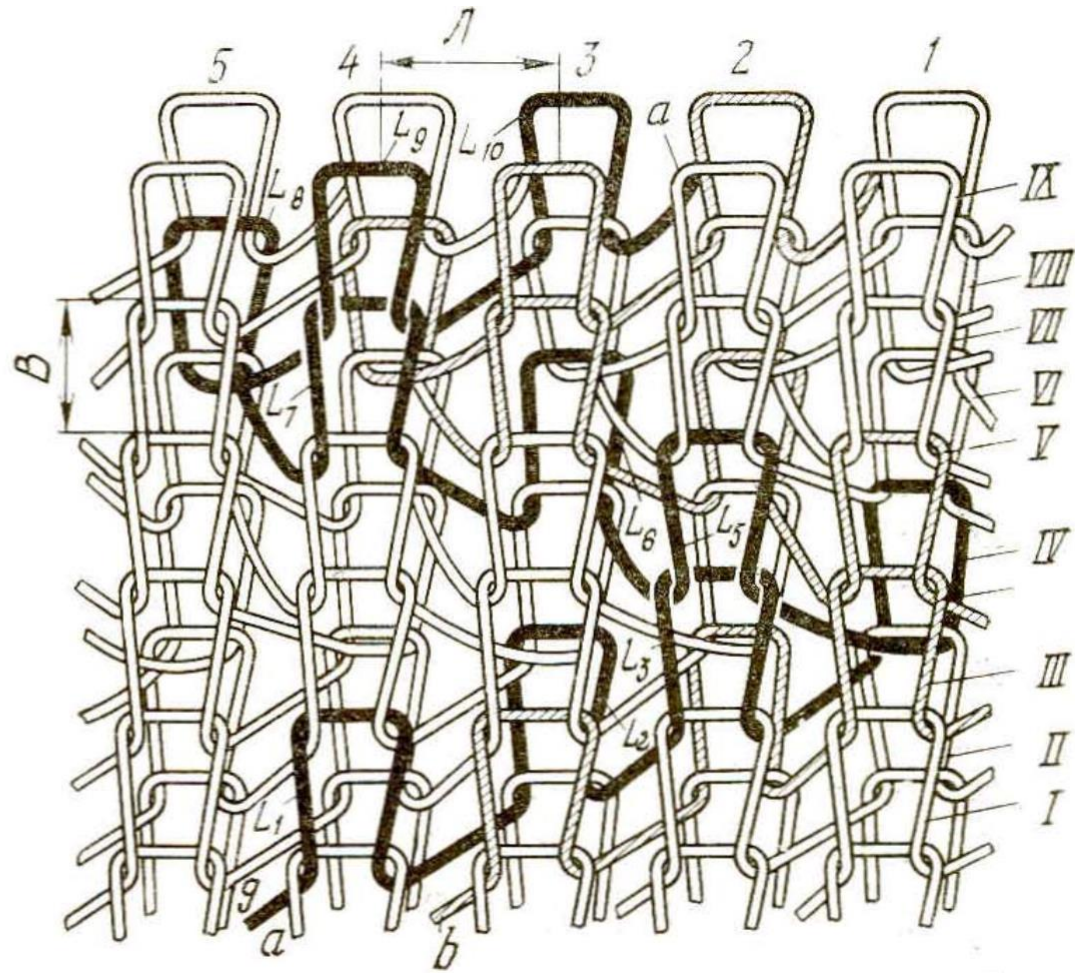
## iv. Interlock warp knits

- Interlock tricot ( $Dw = 3$ ;  $Dh = 2$ ) and
- interlock atlas ( $Dw, \text{min} = 4$ ;  $Dh, \text{min} = 4$ ) are formed just like weft interlock of two rib warp-knitted tricot and atlas
- The face and back sides have different structures:
- In tricot (1x1, N=3 interlock) one side is **single side junctures**, the other is double,
- In atlas (1x1, N = 5 interlock) one side is **double** while the other is both single and double junctures
- In tricot **one side** has loops with **two-side under laps**, while **the other** has loops with **one-side under laps**
- In **atlas also sides** of loops with one-side and two-side under laps.

- Interlock derivative of **half-tricot (2x1, N=3 interlock)** with repeats  $Dw = 5$ ,  $Dh = 2$  is formed of **two derivative rib tricots**,
- While the interlock derivative **triple tricot (charme)** with repeats  $Dw = 7$ ,  $Dh = 2$  formed from **three interlock charme**, i.e. 3x1 etc.
- The **interlock derivative atlases** have a similar structure.
- The greater the derivation (wx1) of interlock warp structures, the more **their mass and thickness**, while their extensibility in width decreases.
- The Wales have a **zigzag structure**;
- The **inclination of Wales** with **two-side under laps** is less than with one-side under laps.
- All these structures **do not curl** at the edges and ravel only in the sense reverse to knitting.



(a)



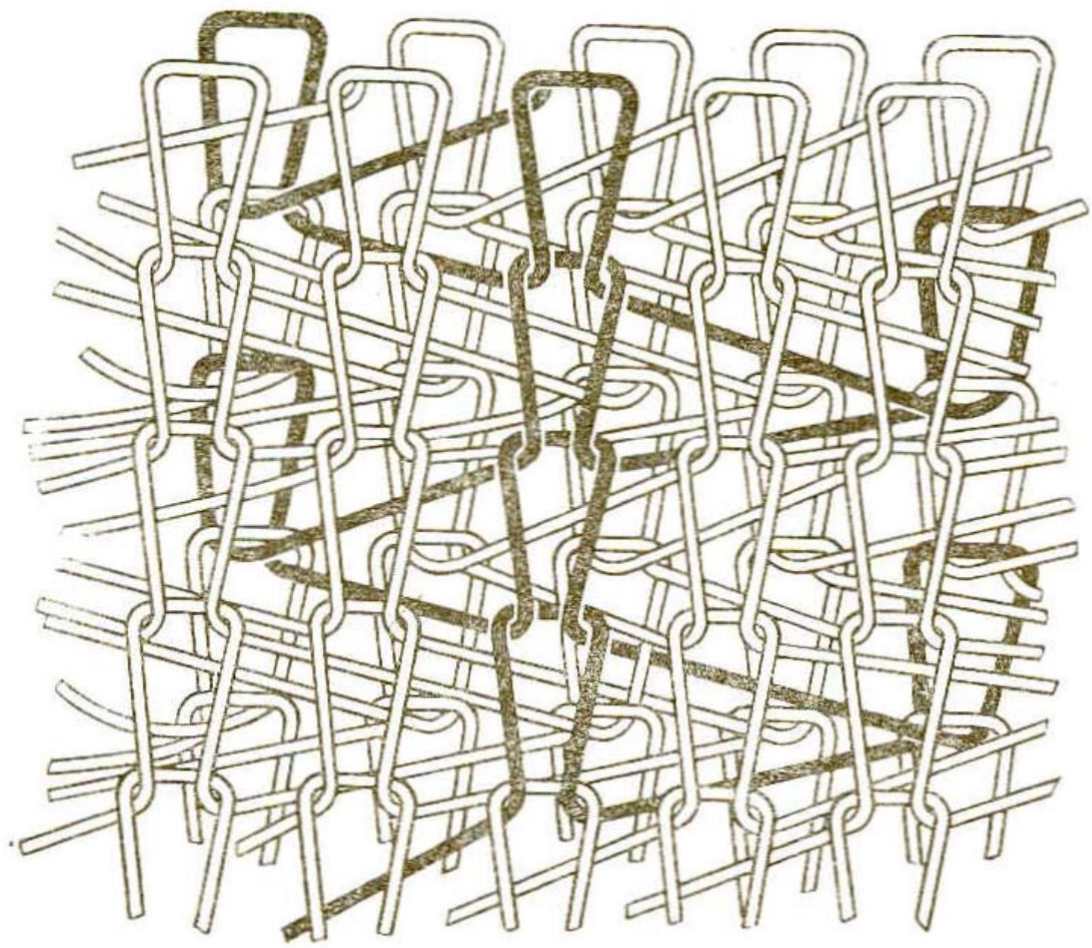
(b)

Structure of

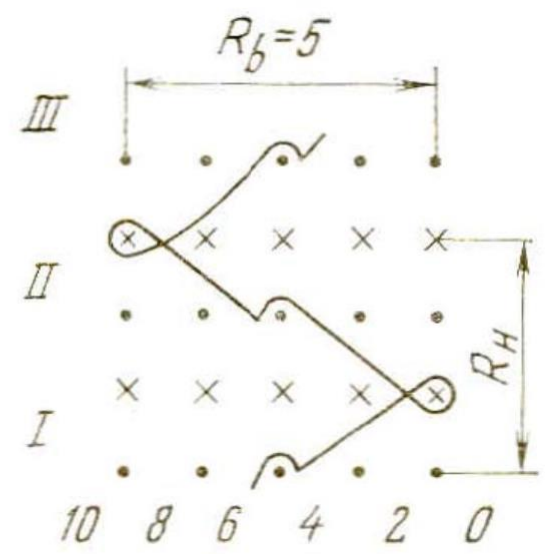
(a) interlock tricot (1x1,  $N=2+1$ );

(b) interlock atlas (1x1,  $N=3+2$ )

# Interlock derivative of half tricot and its graphical representation

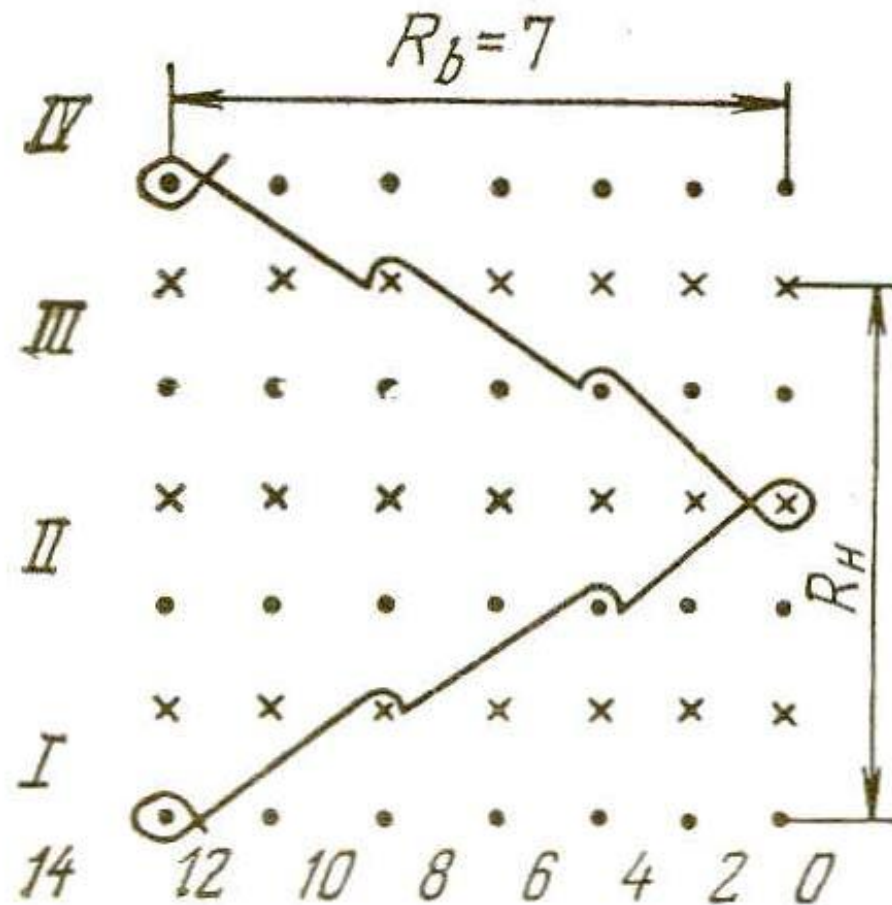


(a)



(b)

# Graphical representation of interlock derivative of two atlas (2x1, N=2+2)



## c. Multiple guide bar structures

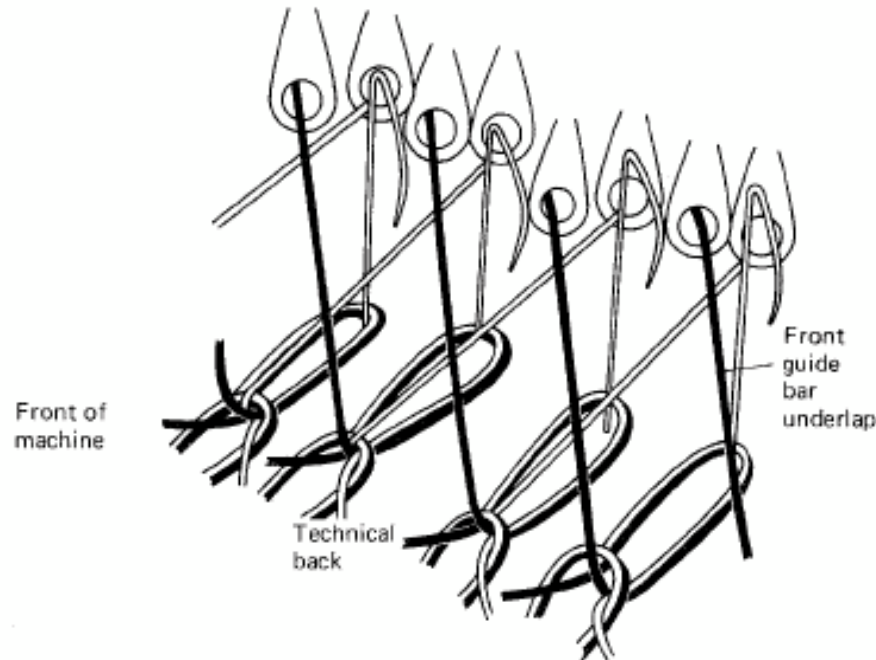
- Single guide bar structures have poor strength, low cover, lack of stability
- Double guide bar structures increase design possibility
- There are many types of double guide bar structures
- Two guides for a needle
- Each loop in the fabric contain two threads,
- Front guide bar: the under laps are plated on the back of the fabric and the overlaps are plated on the face of the fabric,
- Back guide bar: under laps and over laps are sandwiched between those from the front guide bar

- Plain tricot structures knitted with two full set guide bars are most popular of all warp knitted structures and
- are mainly based on a two-course repeat cycle with a change of direction lap at each course.
- 
- The majority have been made on 28-gauge tricot machines using 40 denier nylon,
- But other gauges, yarn types and counts, and also raschel machines, are used.

# Rules governing two guide bar structures

1. As the **guides swing** through the needles to start their next overlap,  
→ the **back guide bar** is first to lay its under lap on the **technical back** and
  - the **front bar** is the last, so its under laps lie **on top on the back of the fabric**

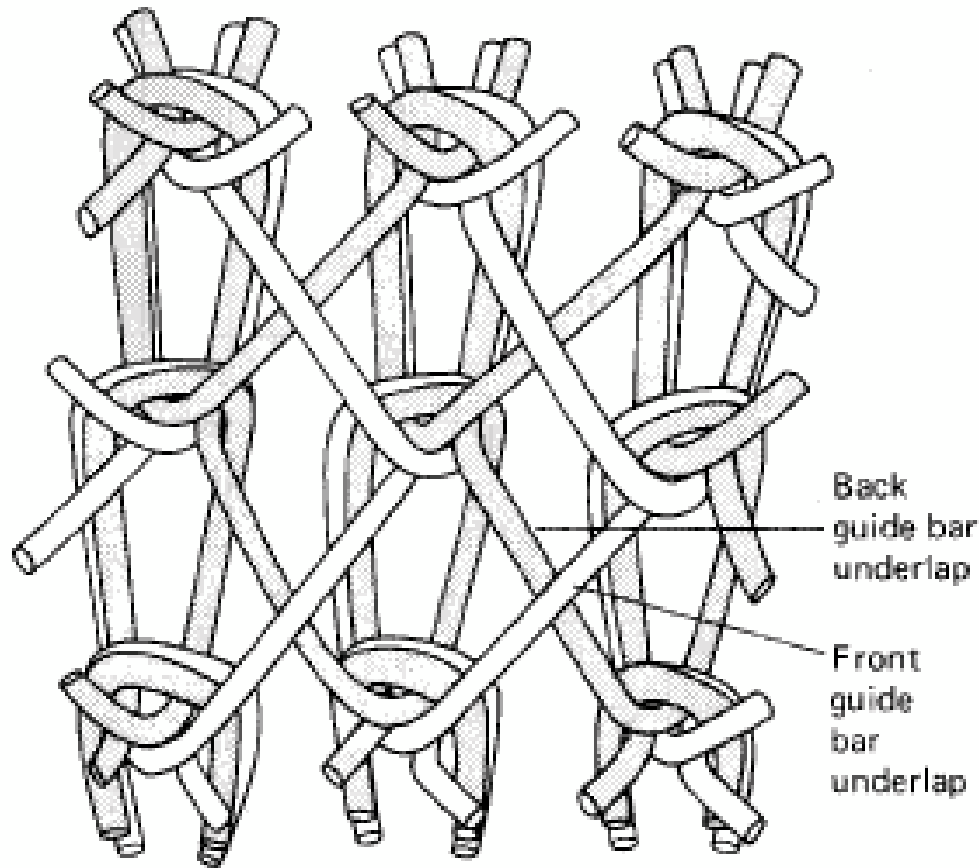
2. The **front bar thread** is the first to strike the needle on the return swing
- There fore it tends to occupy a lower position on the needle.
  - If this position is retained it will show on the **under surface**, which is the technical face



3. A low setting of a guide, a longer run-in, an open instead of a closed lap, or a short underlay movement, will all tend to cause a warp thread to occupy a low position on the needle,
- Carefully arranged lapping movement can thus overcome the normal plating dominance of the front guide bar threads on both surfaces of the structure.
  - A structure showing the under laps of the front guide bar on the surface of the technical back, but the overlaps of the back guide bar on the surface of the technical face, is produced →
  - if the front bar makes a 2 ¥ 1 closed lap and the back bar makes a 1 ¥ 1 open lap in opposition to it

4. If the **two bars overlap** in opposition, the **yarns tend to twist** over each other in the overlap so that the **back bar thread tends to partly show** on top of one side limb.
  
  5. If the **two bars underlap** in opposition they tend to balance the tension at the needle head, producing a **more rigid upright overlap stitch**.
- **On the technical back**, the under laps will cross over each other in the middle between Wales and this improves the strength of the structure.

# 1x1, N=2 double bar single tricot

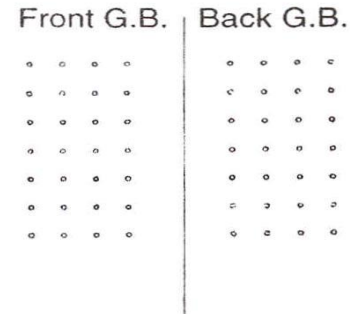
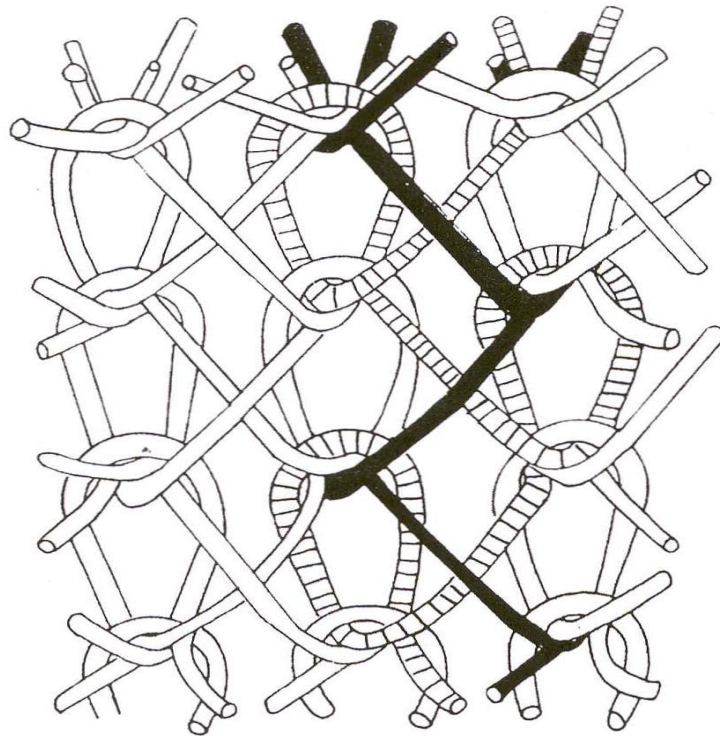


Plating appearance on the technical back of a two guide bar fabric.

6. A **short movement** will cause the **under lap** to lie at an angle and its laps will be under **the greatest tension**.
- If the **front guide bar** makes the **shortest under lap**, it will **tie the longer under laps** of the back bar securely into the rigid structure.
  - If the front bar makes the **longer under lap**, this **floats freely** across the back and allows **more movement of the yarn** within the structure giving it **more elasticity** and a **greater tendency to curl towards the technical face** at the top and bottom.

- The two guide bars may make their **under laps** in the **same or opposite directions**.
- If made in the same direction, the fabric will show **distortion** similar to the single bar fabric as the **loops will be inclined**.
- If, however, the under laps are made in **opposite directions**, an **equal tension** will be imposed in both directions, and **loops will be upright**.

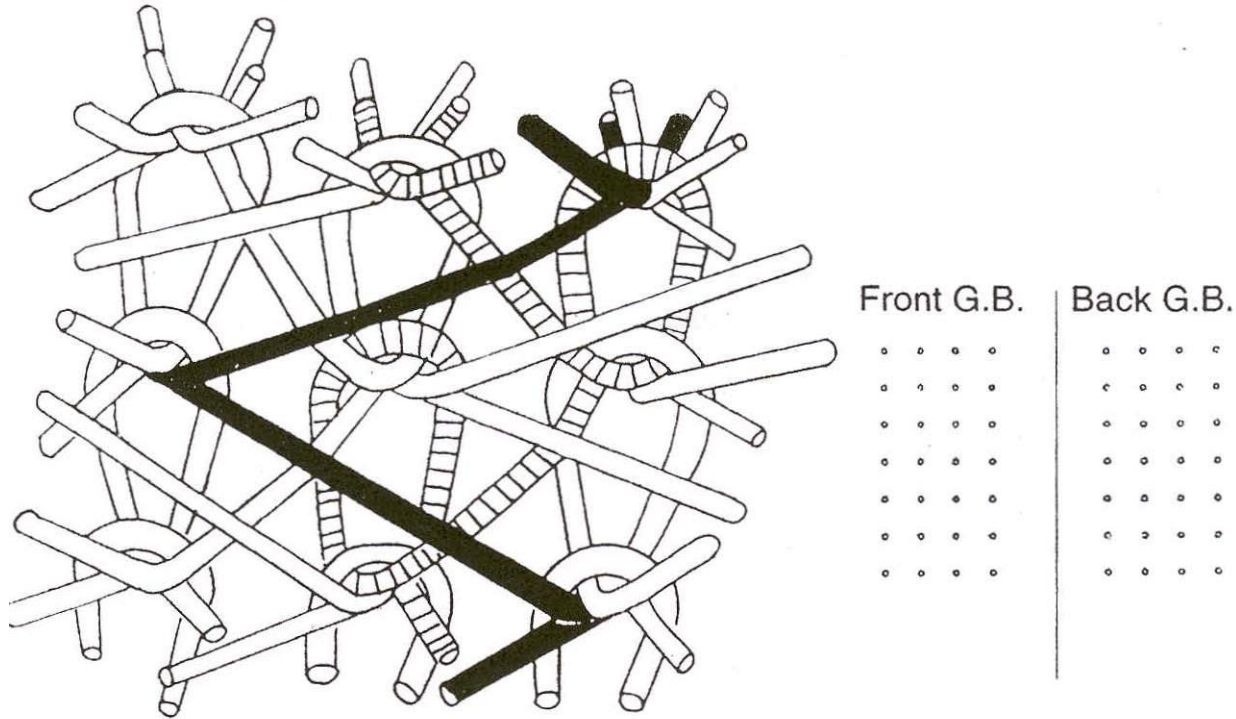
# 1. Double bar full tricot $\rightarrow$ 1x1, N=2 with 1x1, N=2



5.25 Full tricot.

- The two laps balance each other exactly as they cross diagonally in-between each wale
- It tends to split between the **Wales** during stretching

## 2. Locknit → 2x1, N=2 tricot with 1x1, N=2 tricot



5.26 Locknit.

- Most common, 70 – 80% of warp knit
- It has a soft handle and is very suitable for lingerie/women's under wear

The longer underlaps of the front bar on the back of the fabric

- improve extensibility,
  - improve cover,
  - improve opacity,
  - give a smooth, soft handle and
  - give good drapability.
- 
- Its greater cohesion reduces snagging and splitting.
  - Its tendency to curl towards the face at the top and bottom, and towards the back at the sides, can be reduced by heat setting.

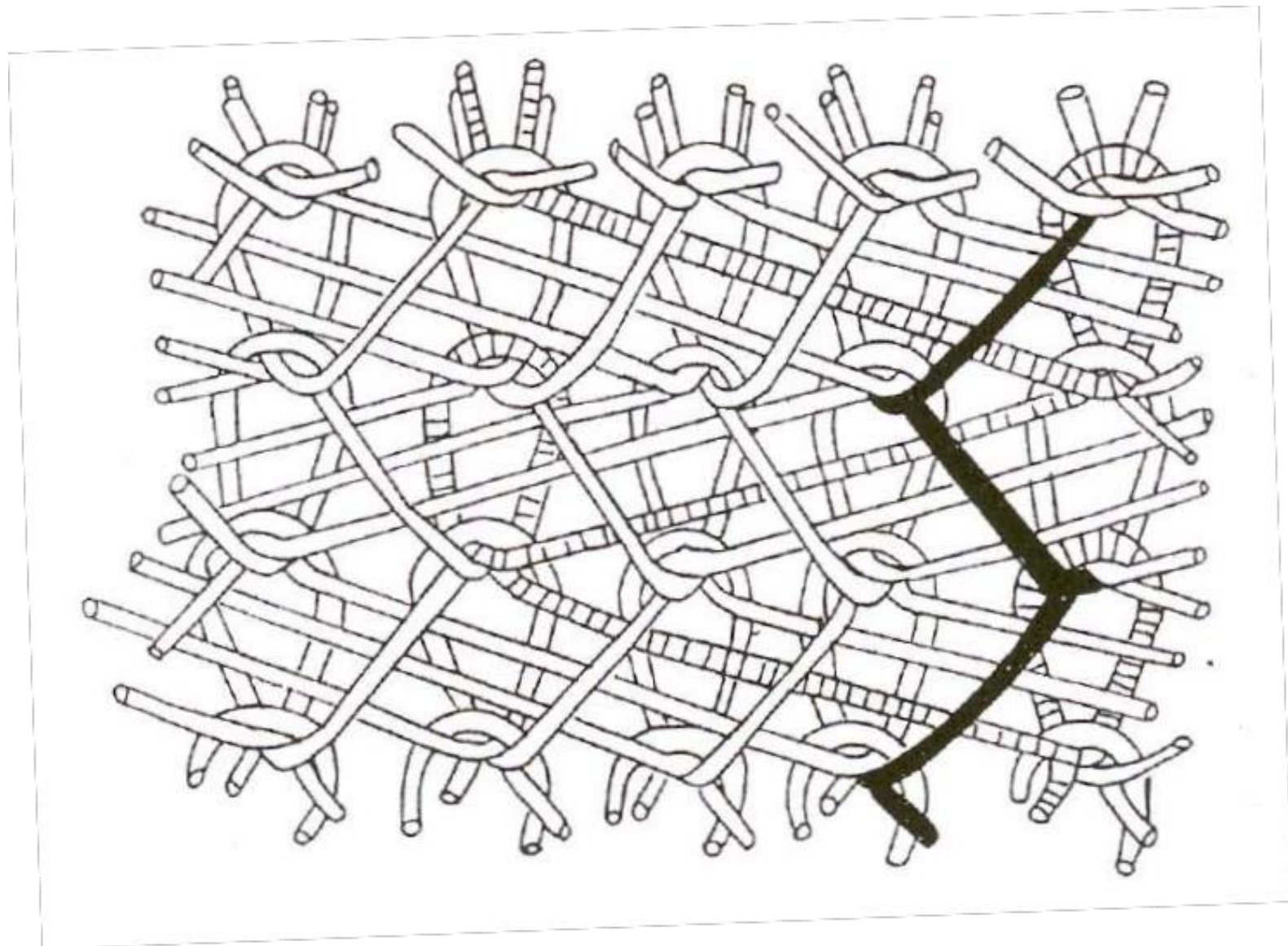
### 3. Reverse locknit → 1x1, N=2 tricot with 2x1, N=2 tricot

- The lapping movements for the bars are reversed to give reverse locknit,
- The back one to front and front one to back
- The fabric properties are completely changed
- The **short under laps** will now appear on **the back** of the fabric
- The short under laps **trap-in the longer ones** to give a more **stable and stiff structure**, with far **less width shrinkage** from the needles than ordinary locknit.
- has a **reduced extensibility** and **no curling**, and **lower shrinkage** in finished width

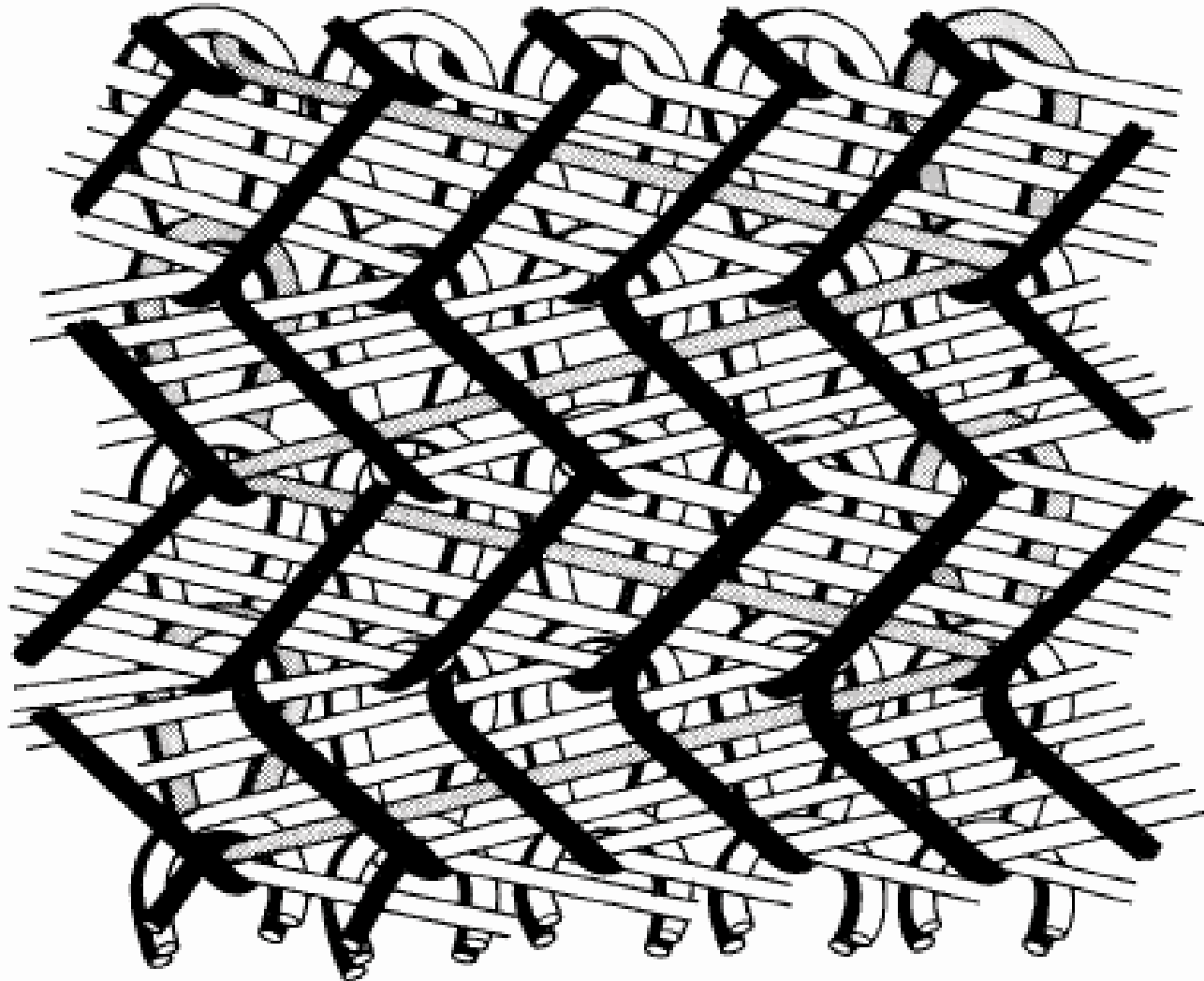
## 4. Sharkin Structure → 1x1, N=2 tricot with w $\diamond$ 3x1, N=2 tricot

- Front guide bar shifts 1 wale to right but back guide bar shifts 3 or more
- The longer back guide bar under laps give more rigid/stable and heavier fabric
- more stable and stiff structure, with far less width shrinkage from the needles than ordinary locknit.
- The long back guide bar under laps are locked firmly in the body of the fabric by the short under laps of the front guide bar

3x1 sharkin



Technical back of 4x1 sharkskin fabric.



## 5. Satin structure

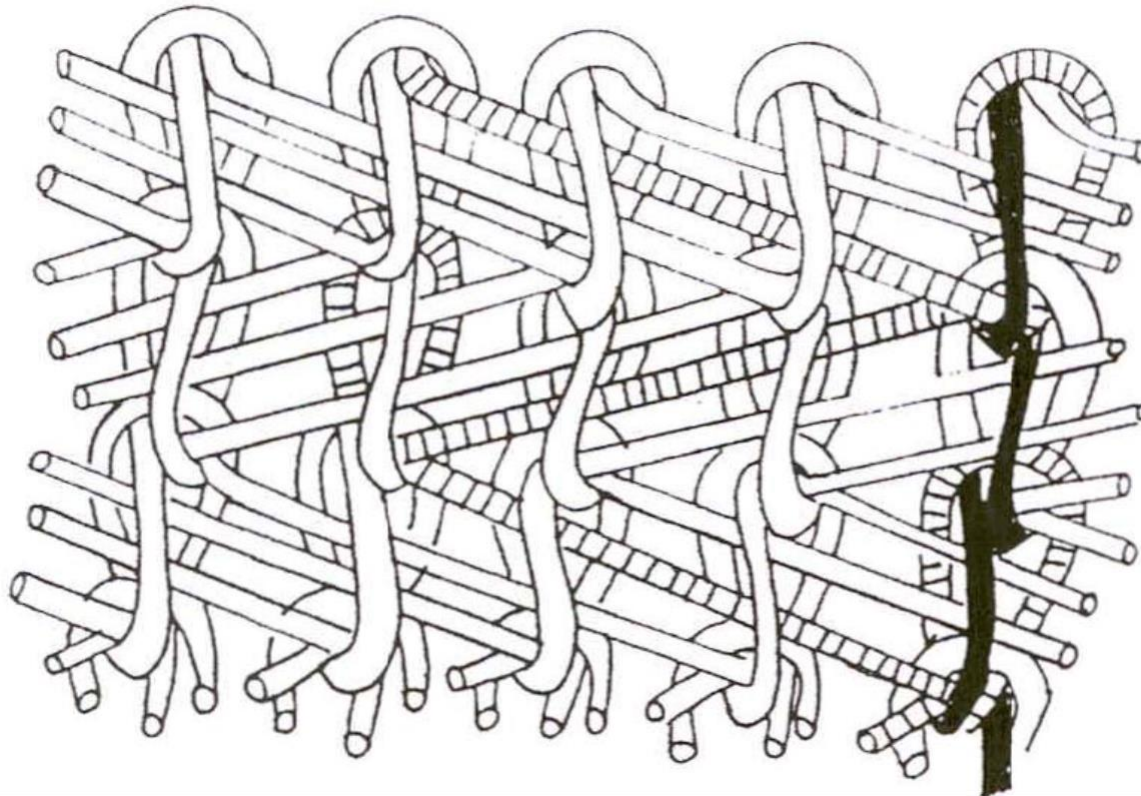
- If the guide bars making a **sharkskin** are reversed, then **satin** structure is formed
- i.e. front guide bar shifts **3 or more wales** to right but back guide bar shifts **1 wale**
- Satin is a **lustrous soft fabric** similar to the woven satin.
- compared to locknit, giving even **greater elasticity**,
- When threaded with continuous filament yarn, the long floats produce a lustrous light reflective surface.

## 6. Loop raised Structure

- Because of the **long floats** on the back of the fabric, satin laps are used to make **loop-raised** fabrics on the **technical back during finishing**
- The **raising machine** is set so that the **under laps are raised** into loops without actually breaking any filaments.
- In order to achieve the **maximum raising effect**, the two guide bars in a loop-raised fabric are normally made to **traverse in the same direction**, and
- The **density and height** of pile can be increased by **increasing the front guide bar underlaps** to four, five or six needle spaces
- *Veilour and veivet structures*

## 7. Queenscord → $O \times 1$ , $N=1$ chain with $w \diamond 1$ , $N=2$ tricot

- even greater rigidity than sharkskin.
- Because the front **guide bar** makes the shortest possible **under lap**, the chain stitch **tightly ties-in** the back bar **underlaps**

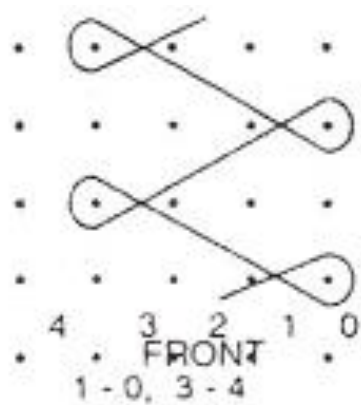


- Both **sharkskin** and **queenscord** structures can be made **more stable**, **heavier** and **stronger** by

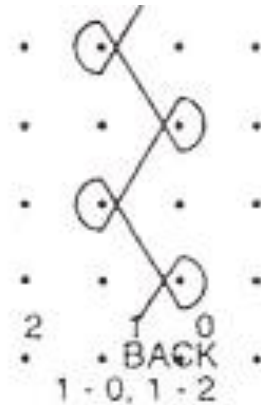
→

- increasing the **back guide underlaps** to four or five needle spaces

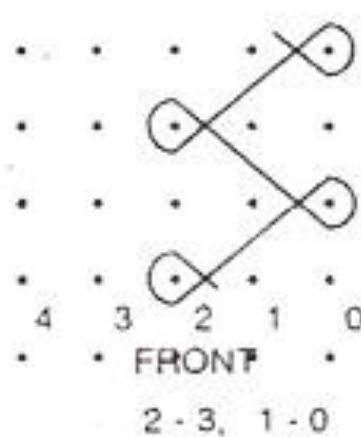
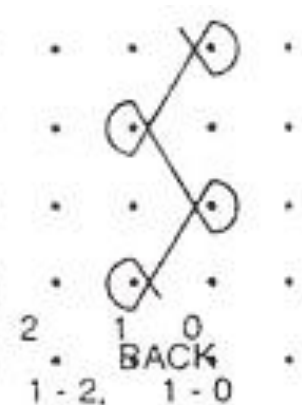
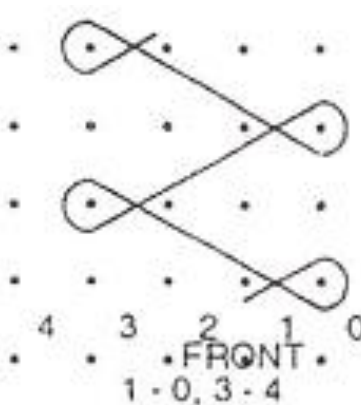
Some two-guide bar full set structures. (a) Loop raised, (b) satin, (c) locknit, (d) full tricot,



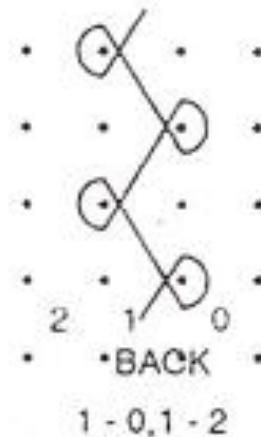
(a)



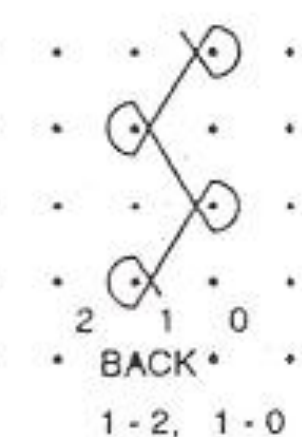
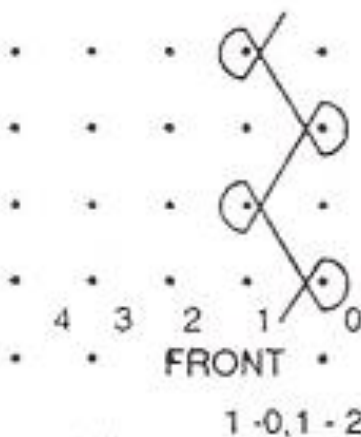
(b)



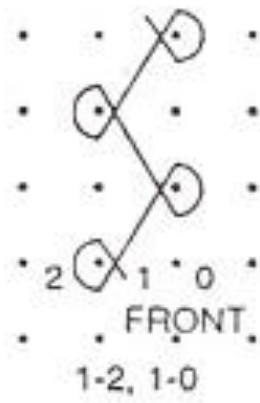
(c)



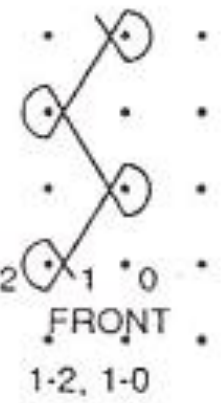
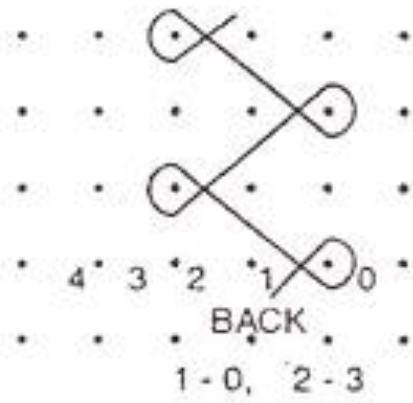
(d)



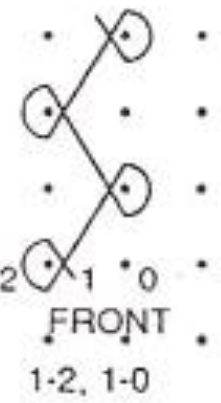
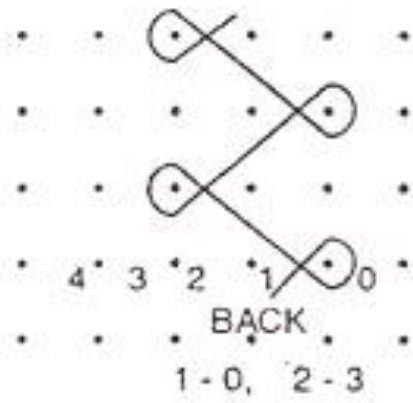
(e) reverse locknit, (f) sharkskin, (g) queenscord, (h) laid-in fabric.



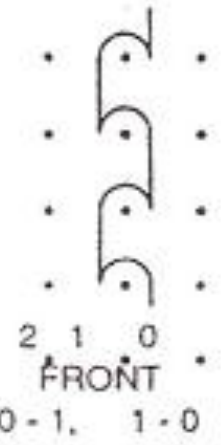
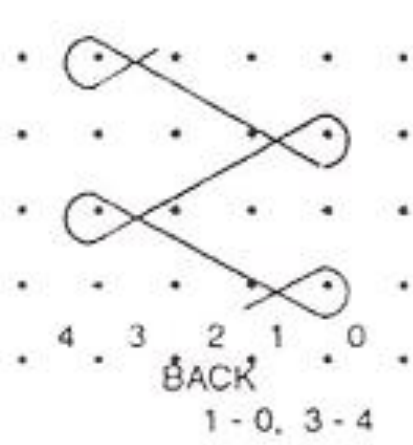
(e)



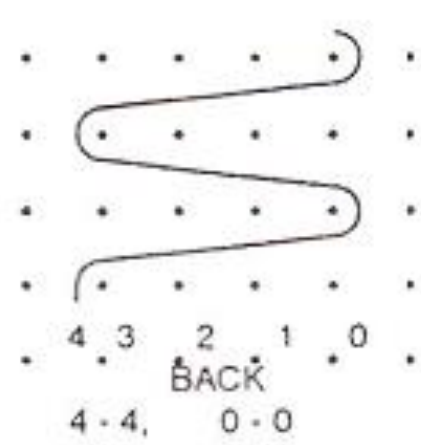
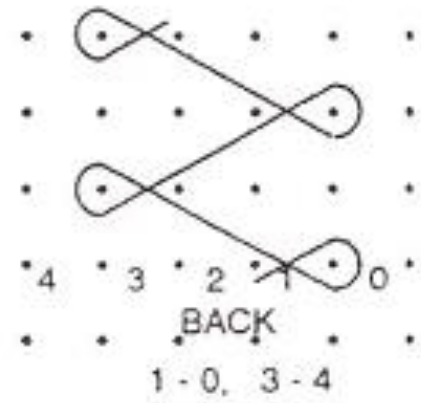
(g)



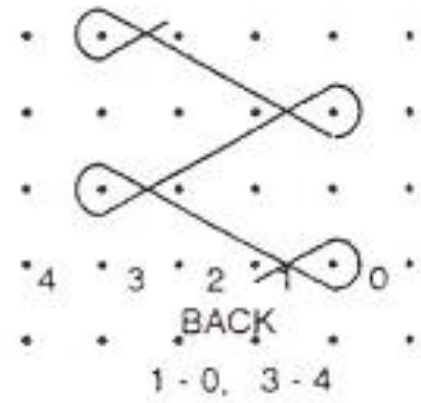
(f)



(h)



(g)



(h)

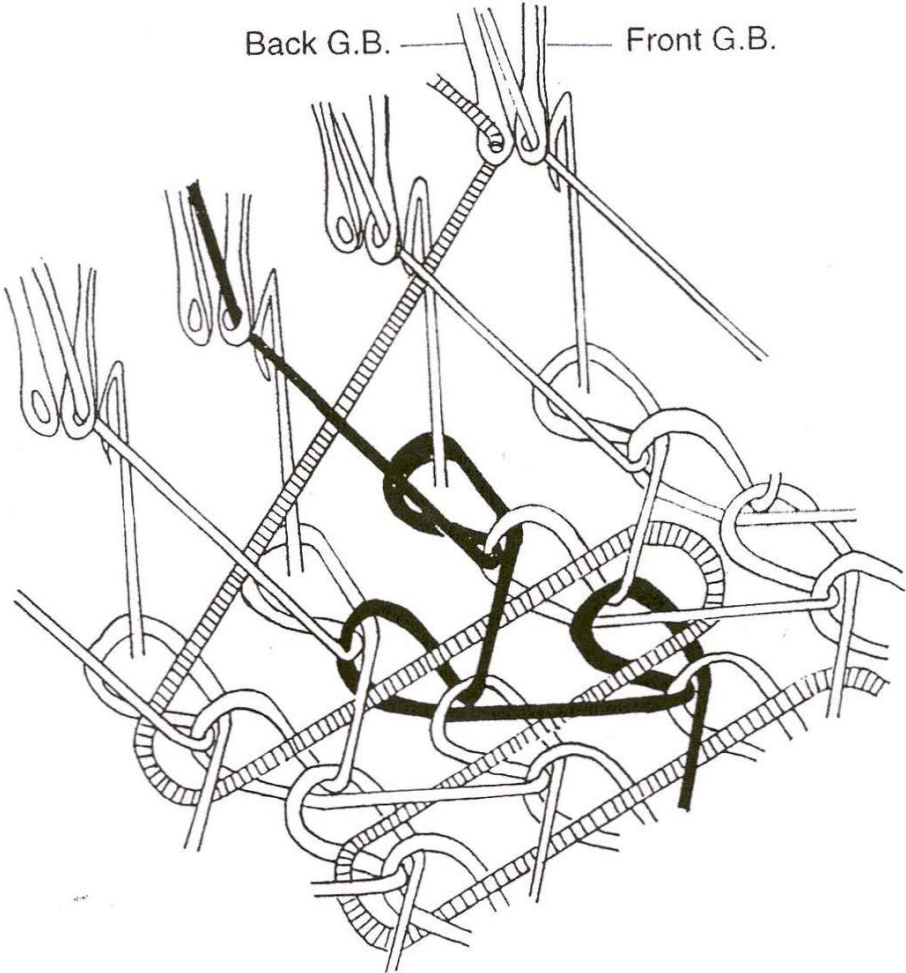
## 8. Laid'in structure

- Yarns are introduced into the fabric **without actually knitting**.
- The yarn is threaded in a back **guide bar**
- **No over laps** for the back guide bar
- laid-in thread never goes **round the needle**, and therefore **very thick** or **fancy yarns** may be introduced into the fabric, such as **heavy worsted** yarn or **metallic threads**.



Back G.B.

Front G.B.



## 2. Basic warp knitting principles

### i. Construction of warp knitted fabrics

- **Shogging** and **swinging** movements are used to form overlaps and underlaps of knitted structures
- Swinging to front, shogging to side, swinging back forms an **overlap**
- An **underlap** is formed by single shogging
- In a warp knitted structure, 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**
- Beams supply the warp sheets in parallel form to the guide bars

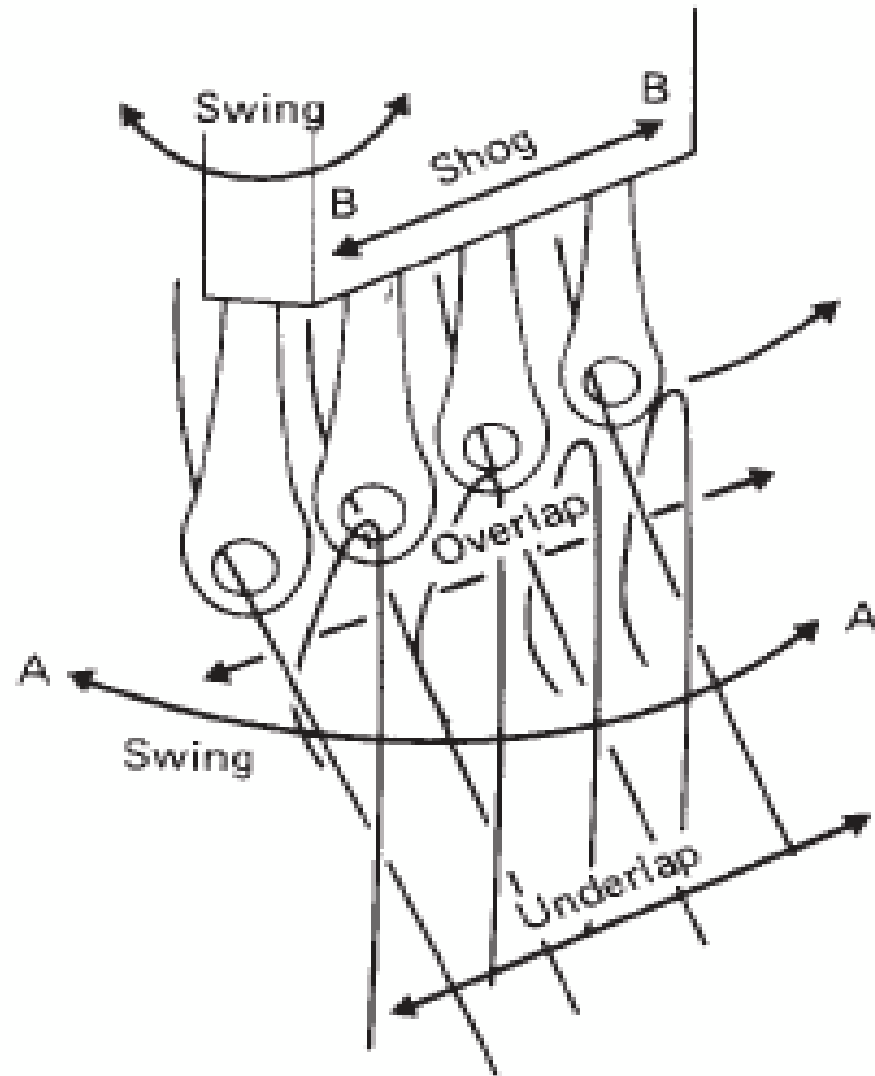


Fig. 23.1 Guide bar lapping movement.

## ii. warp beams

- To ensure uniform conditions of **warp feed** and **tension**, the yarn ends are supplied from flanged beams attached to shafts that 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 the warp sheet;
- For example, a warp sheet **84 inches** wide might be supplied from
  - **A full-width beam** of 84 inches
  - **Two beams** each 42 inches wide,
  - **Four beams** each 21 inches wide.

# The warp beams

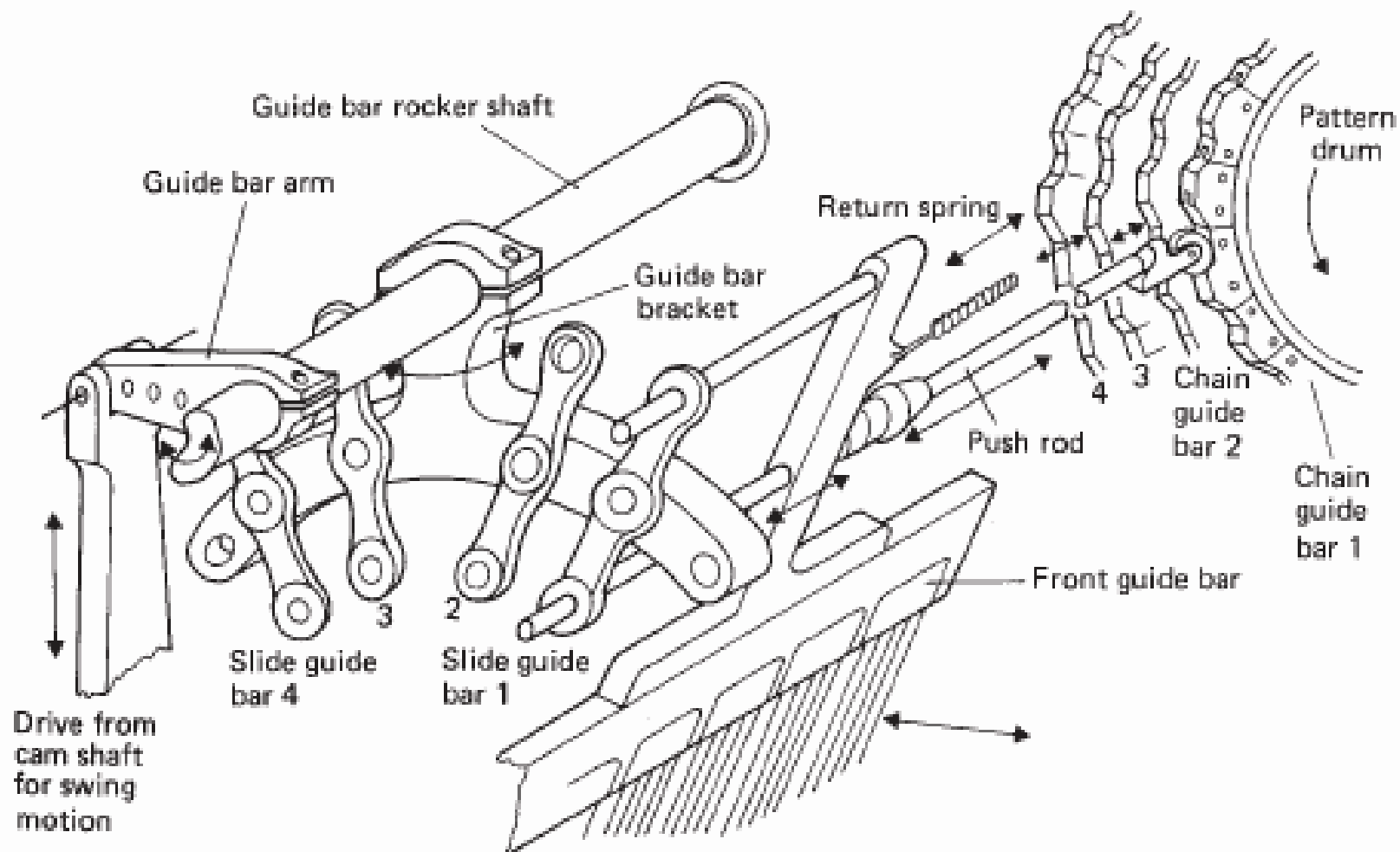


### iii. Guides

- **Warp guides** are thin metal plates drilled with a hole in their lower end through which a warp end may be threaded.
- They are held together at their upper end as a single unit in a **metal lead** and are spaced to the same gauge as the needles.
- The leads are attached to a guide bar so that the **guides hang down** from it, with each one occupying a position, when at rest, **midway between two adjacent needles**.
- 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.

## iv. guide bars

- Each **guide bar** is normally supplied with a warp sheet from **its own beam** for knitting
- The minimum number of guide bars and warp sheets for commercially acceptable structures is usually two.
- The **occurrence, timing, direction and extent of each shog** is separately controlled for **each guide bar** by its pattern chain links or pattern wheel
- The guide bars are shogged independently sideways, parallel to each other



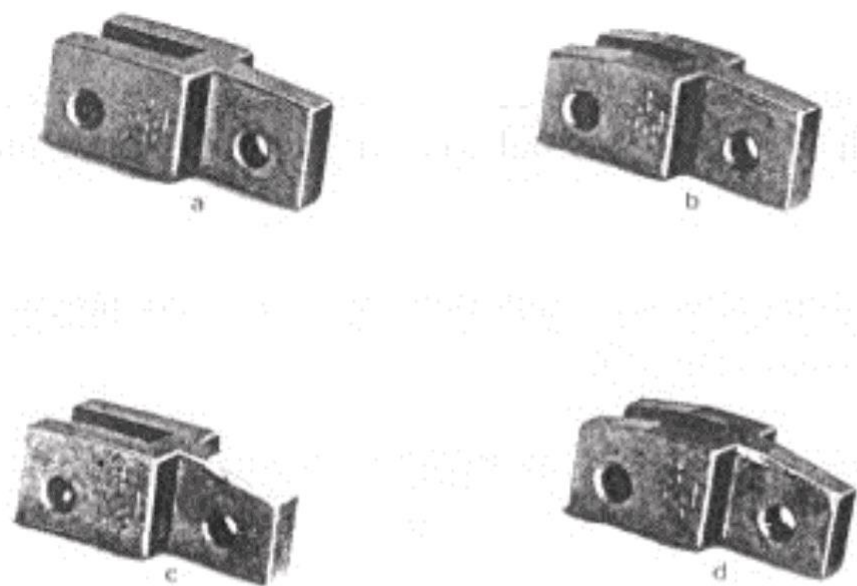
Guide bar swinging and shogging mechanism [Reprinted by permission of *Knitting Times*, official publication of the NSKA in the USA].

## v. Pattern mechanism

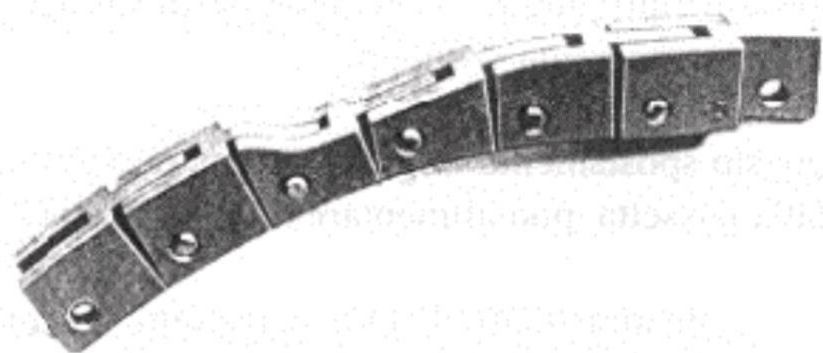
- The shogging movement is initiated by varying the radius of the continuously **turning pattern shaft**
- a. In the form of **different heights of pattern links** that pass over a **pattern drum** attached to the shaft,
- b. In the form of **carefully-shaped solid metal circular cams**, termed pattern wheels, attached to the shaft
- An increase in height from one link to the next pushes the end of the guide bar, shogging it positively into the machine;
- A decrease in height from one link to the next 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.

## vi. The chain links

- The tail of the preceding link fits into the fork of the succeeding link.
- The links are held together by pins that are pushed through holes in the sides of the fork and tail.
- Chain links require accurate grinding at the fork and/or the tail so that a smooth transition and an accurately timed shog occur
- Too sharp a gradient will produce an early-timed shog and too gradual a gradient a late-timed shog for the knitting sequence.
- There are four types of link: plain unground, fork ground, tail ground and fork and tail ground.
- With *direct transmission* of the shogging movement from chain links to guide bar the exact distance shogged is the **difference in heights** between the two successive links

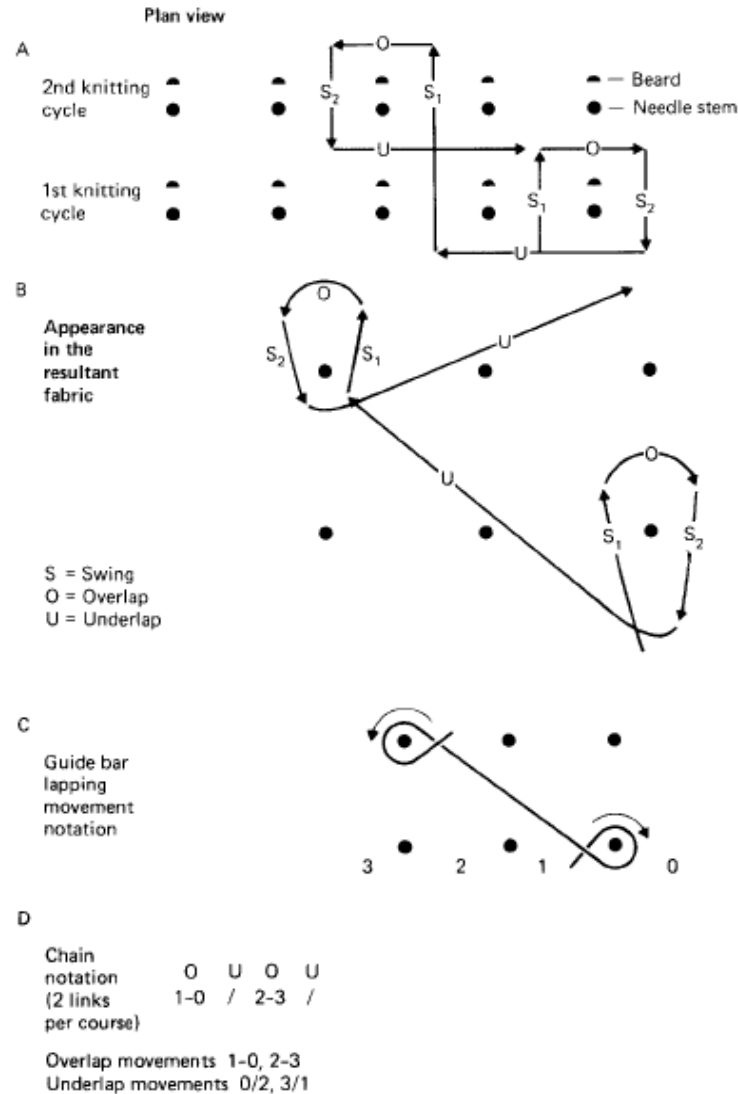


*Picture 128 – A chain link*



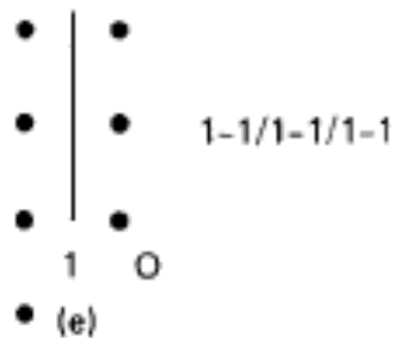
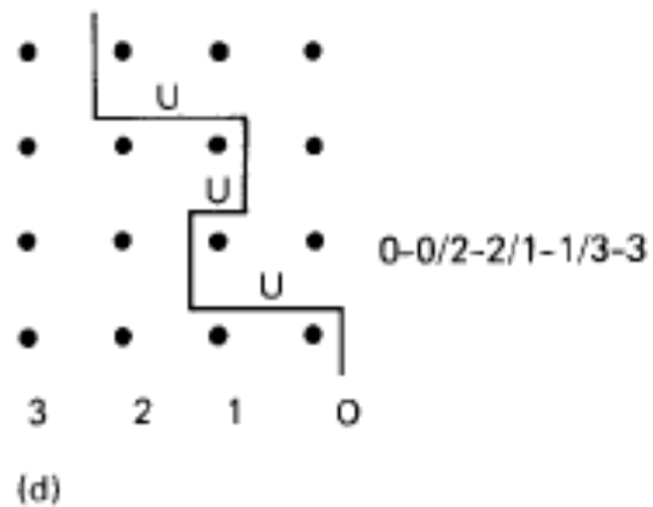
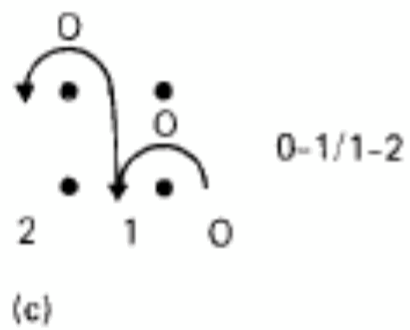
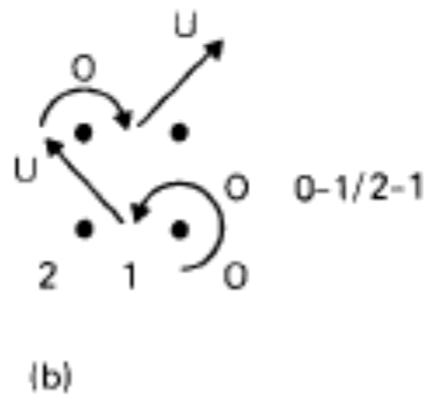
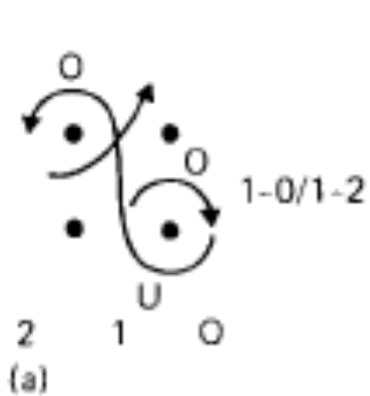
*Picture 129 – Chain with links of different height*

# Warp knitting lapping and chain notation.

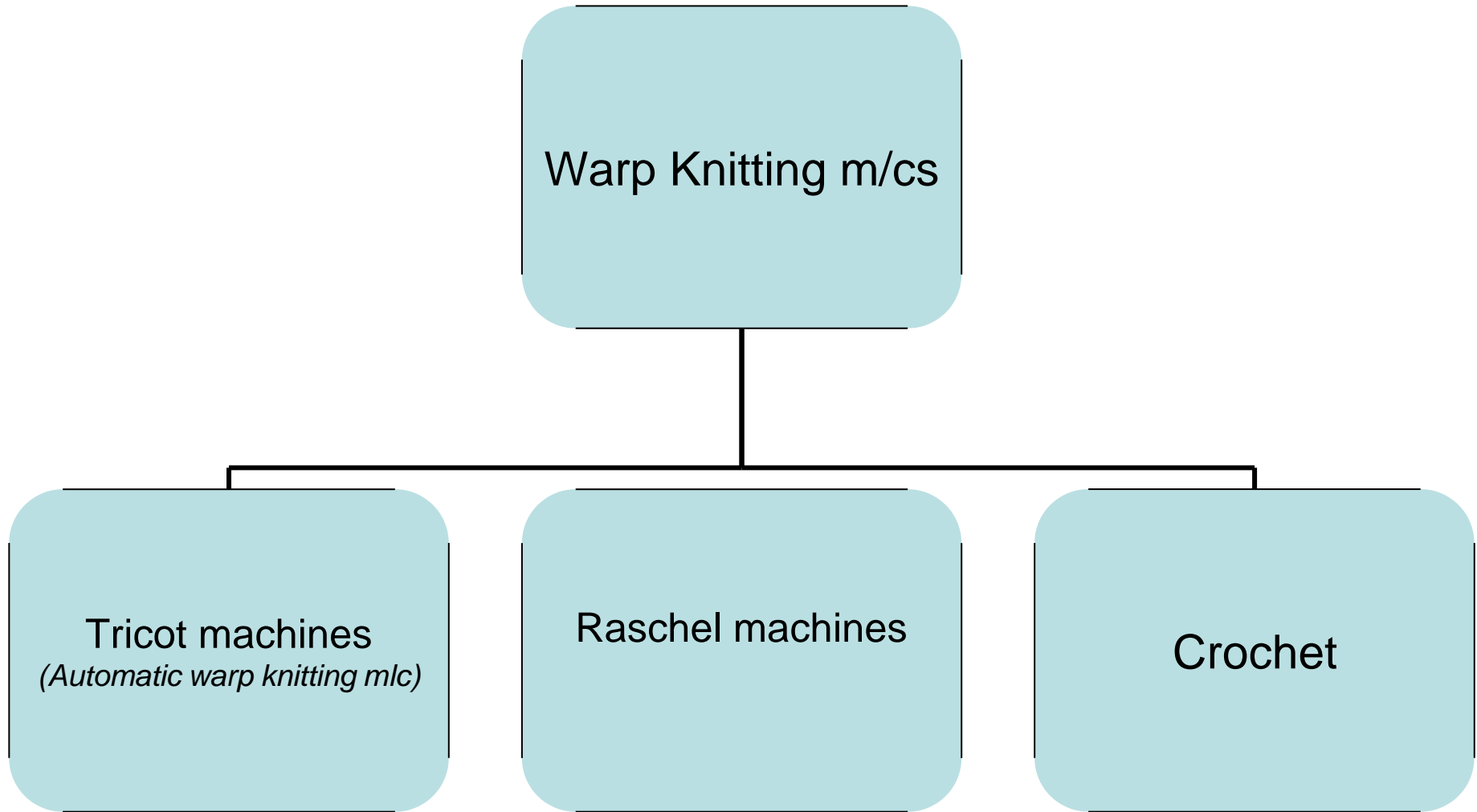


# The five basic overlap/underlap variations

1. An overlap followed by an underlap in the opposite direction (closed lap) (a).
  2. An overlap followed by an underlap in the same direction (open lap) (b).
  3. Only overlaps and no underlaps (open laps) (c).
  4. Only underlaps and no overlaps (laying-in) (d).
  5. Neither overlaps nor underlaps (miss-lapping) (e).
- Movements 4 and 5 require the overlaps of another guide bar in front in order to hold them into the structure.



# Classes of warp knitting machines

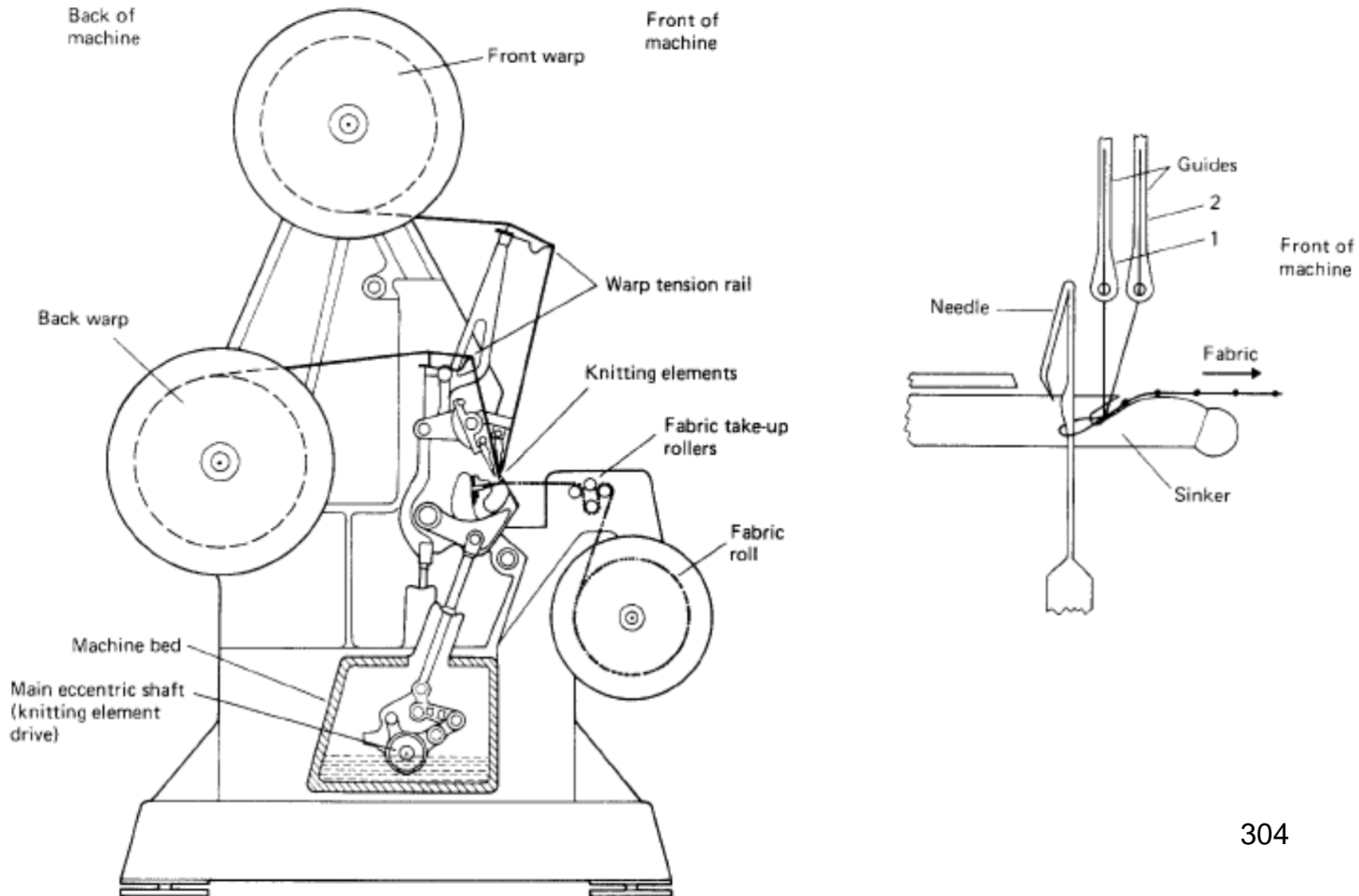


# Differences of tricot and raschel machines

1. Latch needles are generally used in raschel machines, while bearded or compound needle machines are referred to as tricot machines.
  - Compound needle raschel machines are also now fairly common.
  - The compound needle is the most commonly used needle on warp knitting equipment.
2. Raschel machines are normally provided with a trick plate, whereas tricot machines use a sinker bar
3. In raschel machines the fabric is taken up parallel to the needle stems; in the tricot machines, however, it is taken up at approximately right angles to the needles.

4. Raschel machines are normally in a coarser gauge; they are also slower compared with tricot machines, because more guide bars are frequently used and they also require a longer and slower needle movement.
5. Raschel machines are much more versatile in terms of their ability to knit most types of yarns such as staple yarns, etc.  
Only **continuous-filament yarns** can be successfully knitted on most **tricot machines**.
6. Generally, warp beams are on the top of the machine on raschel machines; on tricot machines, they are generally at the back of the machine.

# The tricot machine



# The knitting cycle of the bearded needle tricot machine

## *The rest position (a)*

- › The **needles** have risen to 2/3 of their full height from knock-over and have their beards towards the back of the machine.
- › The **pressers** withdrawn and the **guides** are at the front of the machine
- › The **sinkers** are in forward position, holding the old overlaps in their throats

## 2. *Backward swing and overiap shog (b, c).*

The guides

- › Swing through the needles to the beard side
- › Shog to side, yarn overlaps across the beards

## 3. *The return swing and second rise (c, d).*

- › The guides swing to the front
- › the needles rise to their full height so that the newly-formed overlaps slip off the beards onto the stems above the old overlaps.

#### **4. Pressing (e).**

- › The **needle bar/needles** descends so that the open beards cover the new overlaps.
- › There is a slight pause whilst the presser advances and closes the beards.

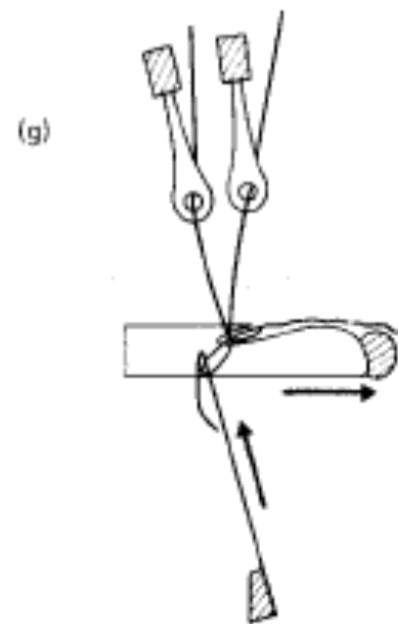
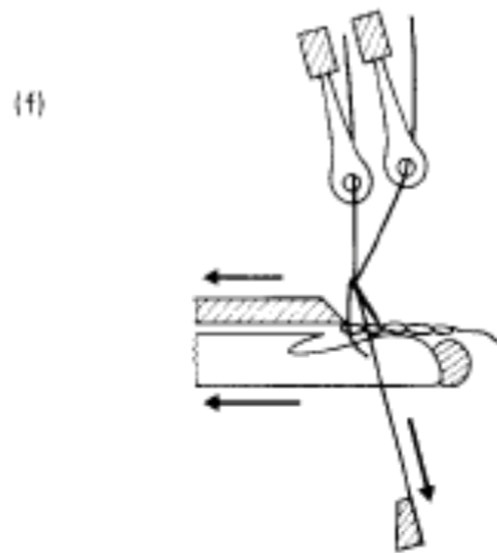
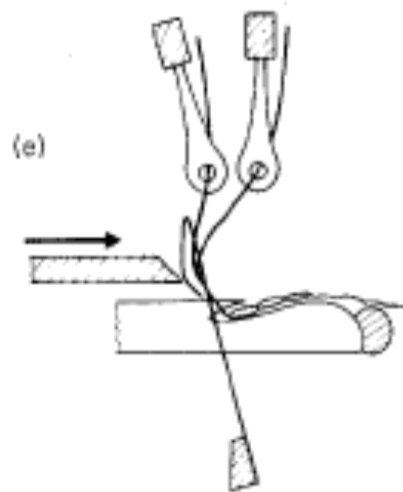
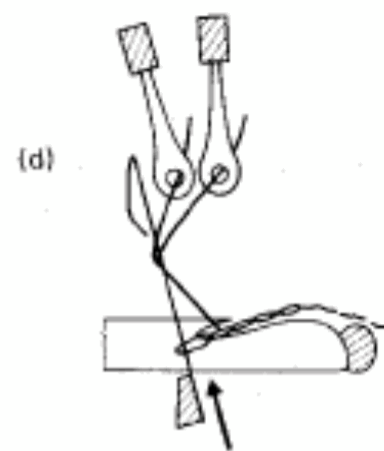
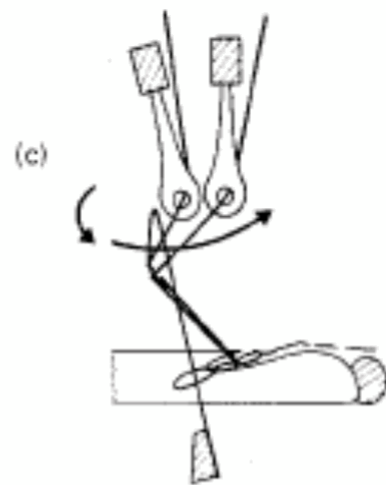
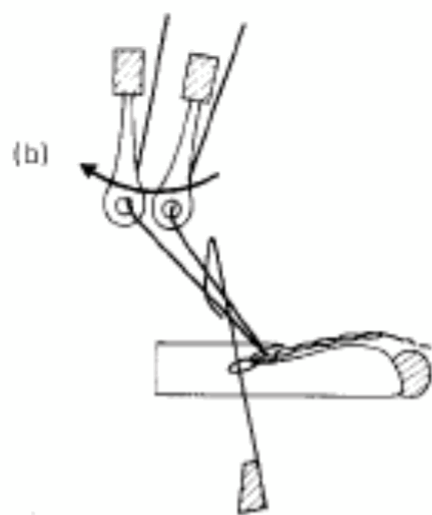
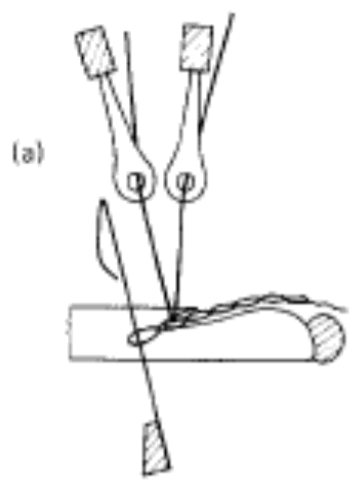
#### **5. Landing (f).**

- › As the **sinkers withdraw**, the upward curve of their bellies lands the **old overlaps** onto the **closed beards**.

#### **6. Knock-over and underlap shog (g).**

- › The presser is withdrawn
- › The continued **descent of the needle bar** causes the old overlaps to be knocked-over
- › The **underlap shog** which can occur at any time between **pressing and knock-over**

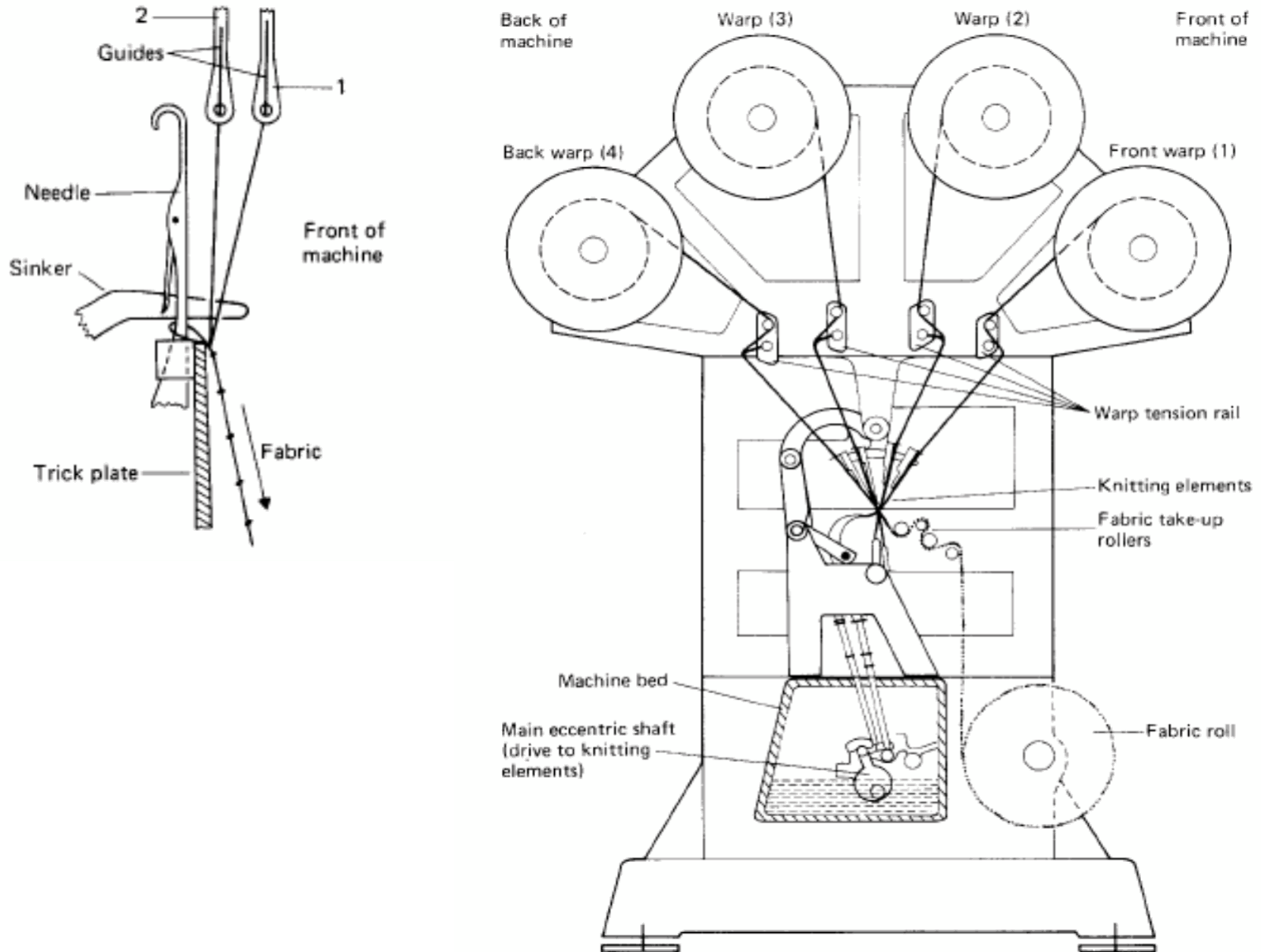
7. *The sinkers now move forward* to hold down the fabric loops and push them away from the ascending needles, which are rising to the rest position.



# The Raschel machine

- *Raschei machines* originally had a gauge expressed in **needles per 2 inches** (5 cm)
- Now, the standard **E gauge** (needles per inch) is generally used.
- There is a wide gauge range, from **E 1 to E 32**
- Raschel sinkers perform only the function of holding down the loops whilst the needles rise
- They are **not joined together by a lead** across their ends nearest to the needle bar **so they can move away clear** of the needles, towards the back of the machine, for the rest of the knitting cycle.
- The needle **trickplate verge** acts as a **fabric support** and knock-over surface.

› The warp beams are arranged **above the needle bar**, centred over the rockershaft, so that warp sheets pass down to the guide bars on either side of it



# The knitting action of the single needle bar raschel machine

## 1. *Holding down.*

- › The **guide bars** are at the front of the machine, completing their underlap shog.
- › The **inker bar** moves forward to hold the fabric down whilst the **needle bar** starts to **rise** from knock-over.

## 2. *clearing*

- › As the needle bar rises to its full height, the old overlaps slip down onto the stems after opening the latches,
- › The **inker bar** then starts to **withdraw** to allow the guide bars to overlap.

## 3 *Overlap.*

- › The guide bars swing to the back of the machine and then shog for the overlap.

## 4. *Return swing.*

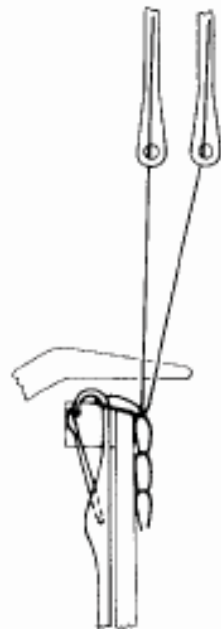
- › As the guide bars swing to the front, the warp threads wrap into the needle hooks.

## 5. *Latch closing.*

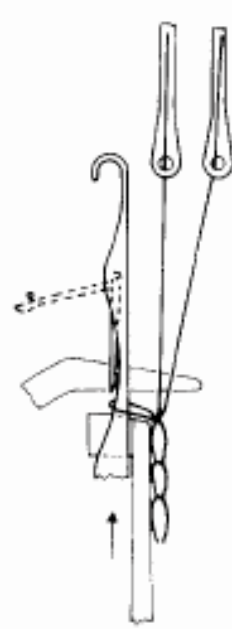
- › The needle bar descends so that the old overlaps contact and close the latches, trapping the new overlaps inside.
- › The sinker bar now starts to move forward.

## 6. *Knocking-over and underlap.*

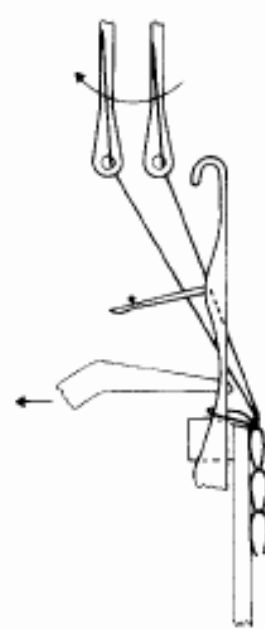
- › As the **needle bar** continues to **descend**, its head passes below the surface of the trick-plate, drawing the new overlap through the old overlap which is cast-off
- › As the sinkers advance over the trick-plate, the **underlap shog of the guide bar** is commenced.



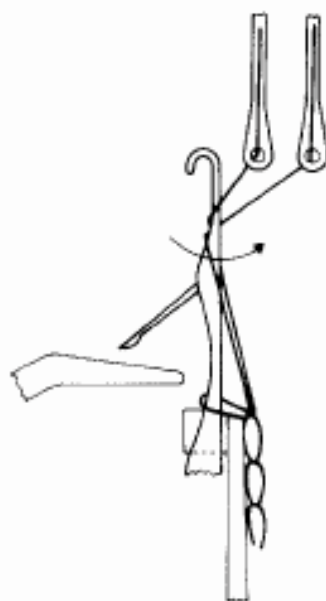
(a) Holding down  
(underlap)



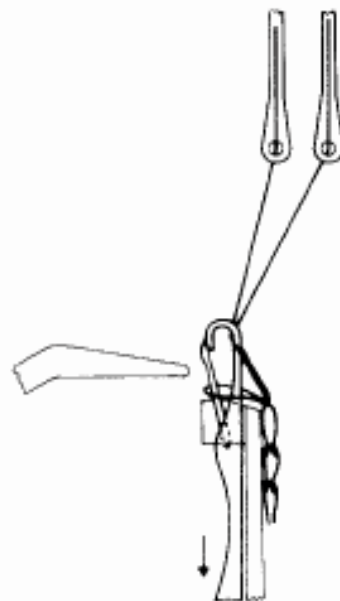
(b) Clearing



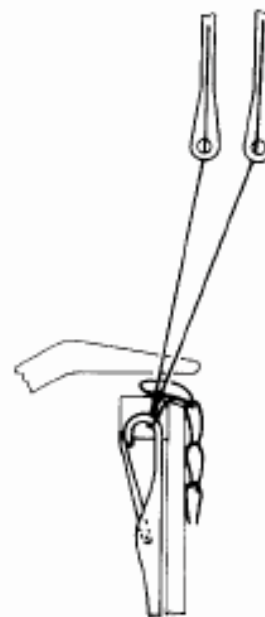
(c) Overlap



(d) Return swing



(e) Latch closing



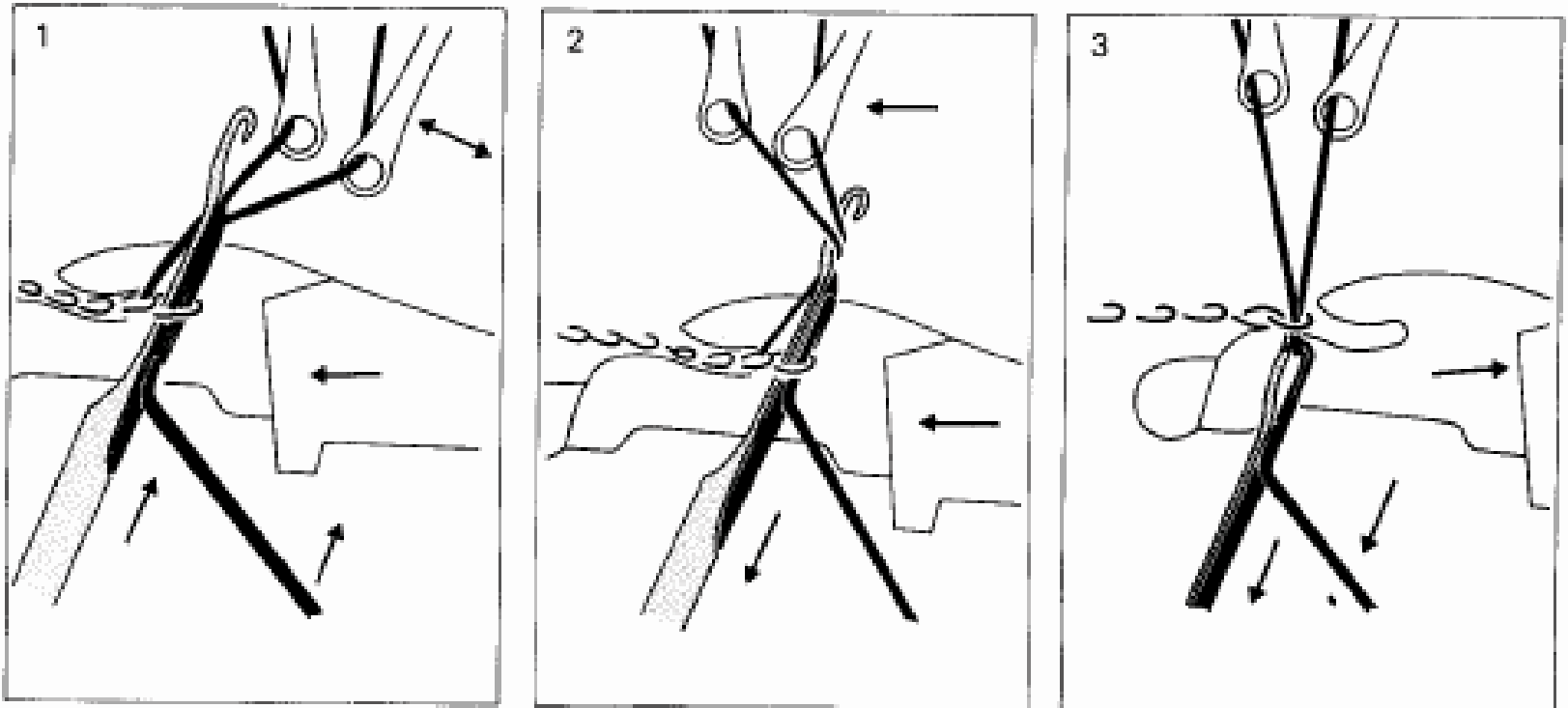
(f) Knocking over

# The knitting action of the compound needle warp knitting machine

1. *Needle rise and guide bar swing.*
  - With the **sinkers** forward holding down the fabric,
  - **The hooks and tongues** rise, with the hook rising faster, until the head of the latter is level with the guide holes and is pen.
  - The **guides** then swing through to the back of the machine
2. *The overlap and return swing.*
  - The **guides** shog for the overlap and swing to the front of the machine;
  - Immediately, **the hooks and the tongues** start to descend with the tongues descending more slowly, thus closing the hooks.

### 3. *Landing and knock-over.*

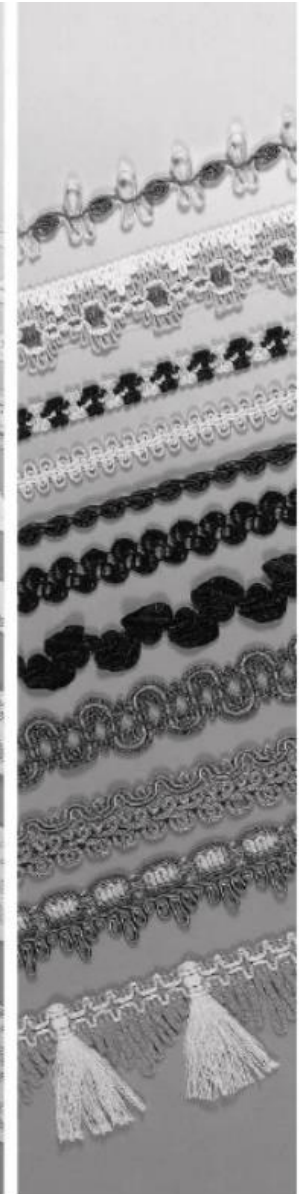
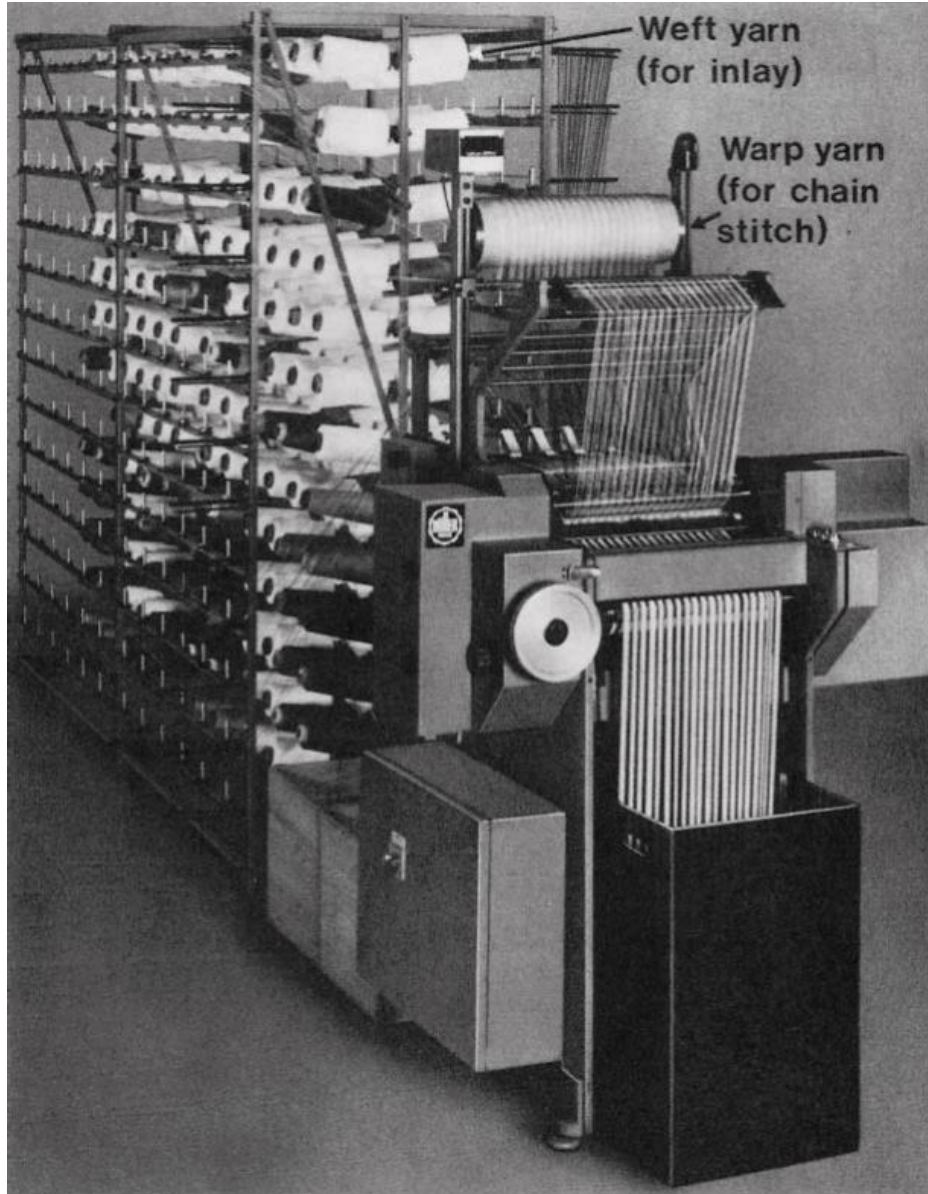
- The **sinkers** start to withdraw as **the needles** descend so that the old loop is landed onto the closed hook and then knocked-over as it descends below the sinker belly.
- At this point the underlap occurs before the needles begin their upward rise and the sinkers move forward to hold down the fabric



# The crochet machine

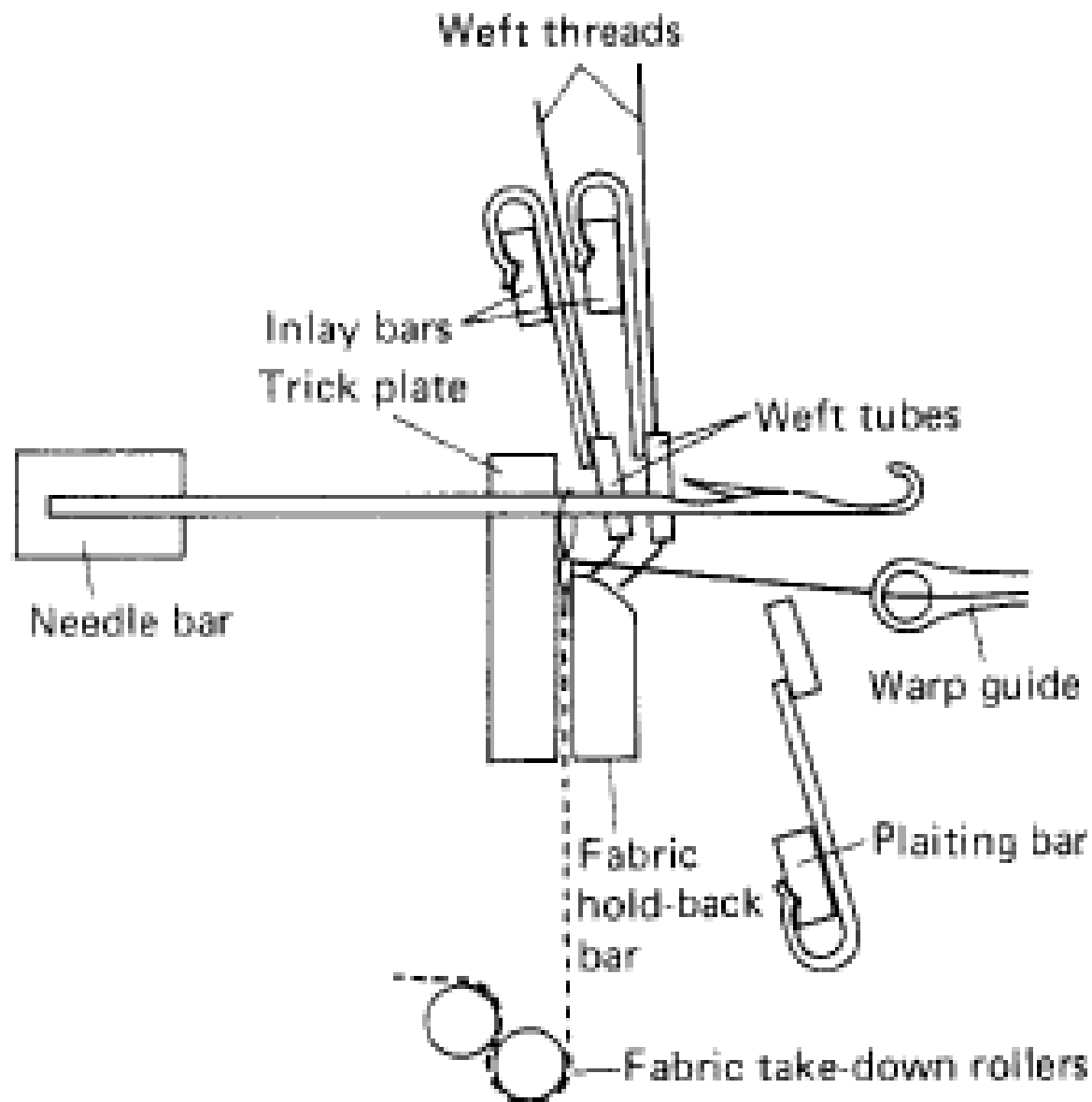
- In hand crocheting, a hook is used to draw a new loop through the old loop with the chains of loops being joined together at intervals.
- On crochet machines, the warp chains are separate from the weft inlay and it is the latter threads that join the chaining wales to each other.
- The *crochet gaiion* machine, as developed by *Sander and Grarr* and popularised by *Khoier*, is essentially a highly versatile raschel

# The crochet machine



- A *single horizontal needle bar* whose simple reciprocating action can be used to operate *individually-tricked latch*, carbine or embroidery needles.
- The *carbine bearded needle* is used for fine structures and has a side ways crimped beard placed in a permanently-pressed position.
- Although warp threads can only be fed into the beard from the left (necessitating a unidirectional closed overlap), 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.

- *Embroidery or iace needles* 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 needie* patented by *Muier* 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* operate at uneconomic speeds and have a short life due to latch breakage.



Knitting elements in a crochet machine [*Knitting International*].

- *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.
- *closed iap piliar stitches and iniay threads controlled and supplied as separate warp and wert 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 and underlap shog is fixed and is controlled from an **eccentric cam** whilst its upwards and downwards swing is derived from a **rocker-shaft**.
- The **warp yarn** is often placed **low** at the **front** of the machine.
- *The wert yarn, often placed above and towards the back of the machine, supplying the carrier tubes, which are clipped to the spring-loaded iniay bars.*

- These bars are fitted above the needle bar and are 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 **16 weft inlay bars**, which may be electronically controlled.
- *Special attachments* are available for producing fancy effects such as cut or uncut fringe edges, pile, braiding and snail shell designs.

- The **weft inlay bars** may either be electronically-driven or mechanically controlled
- in the traditional manner by chain links or levers.
- Very approximately, the knitting widths of crochet machines may vary between 16 and 122 inches (**400 and 3100mm**).
- Gauges, often expressed in needles per centimetre, are between 2 and 10 (E 5 to E 24).
- Machines run at speeds between 200 and 350 courses per minute (or much more on simple structures).
- Crochet machines can process a range of filament yarns from 20dtex to 1000 dtex.

# The knitting action of the crochet machine

## 1. *The inlay*

- Whilst the needle is withdrawn into its trick during knock-over of the previous warp overlap, the weft inlay tube is lowered.
- As it traverses in an underlap shog, the weft is laid below the level of the needle and on top of the warp thread that extends from its head to the warp guide.

## 2. *clearing the warp overlap.*

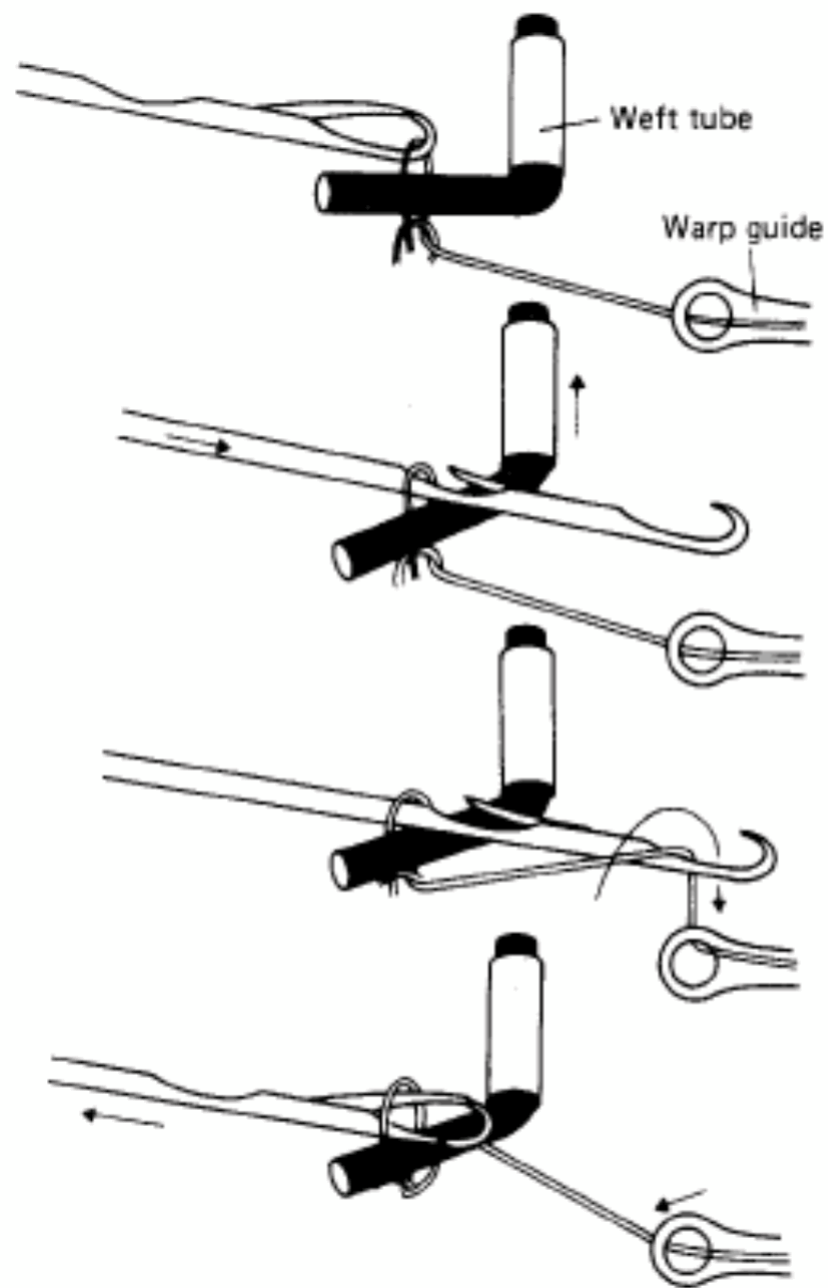
- The weft tube rises slightly on completion of its traverse movement to allow the needle to move out of its trick to clear its old warp overlap.

## 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.

#### 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.
- NB: The closed lap is used for the carbine needle but the alternating overlap of the open lap pillar stitch used with the conventional latch and bearded needles gives a more balanced loop structure.
- Tricot lapping with two guide bars produces a secure fabric which does not unrove.



Knitting action of a crochet machine [*Knitting International*].



Fig. 24.11 A range of crochet fabrics [Comez].

# Electronics in knitting

- Resistors:- Nickel-chromium wires, ceramic as a core, carbon-insulating powder composition, carbon-ceramics
- Inductors:- copper, iron **etc.**
- Capacitors:- dielectric (air, mica, ceramic, paper, polyester, polystyrene, plastics.), silver compound coating, lead, carbon, aluminum, phosphorus **etc.** as plates
- Diode & transistors:- germanium, silicone, **etc.** and combination of other elements

# Circuits

- Silicon circuit boards
- **Logic gates**:- logic decisions (0 & 1 combination)
- **Optoelectronic devices**:- emitters (ele. → ligh.), sensors (ligh. → elec.)
- Amplifiers, transformers, rectifiers (half and full), filters
- Logic gates develop signals of 1's and 0's  
ex. 100110111

# Logic families

- Resistance-transistor logic
- Diode-transistor logic
- Transistor-transistor
- CMOS complementary metal oxide semiconductor

# Basic computer elements

- Logic families develop flip flops
- Combination of flip flops forms registers, counters..
- Clock: timing and control
- These in turn form RAM/Rom, Data buss, ALU: arithmetic logic unit, Controllers

# Electronic goods:

- Therefore electronic goods are resulted  
Ex. Computer, TV, Mobile, Camera, optoelectronic devices, **transducers**, transformers, Rectifiers, filters, **etc.**

# Transducers

- Device that converts energy from one form to another form
- For measurement and control

Some of the transducers

1. Mechanical:- strain gauge type for measuring force, torque, and pressure
2. Thermal:- thermistors, thermocouples
3. optical:- photoconductive, photoemissive, and photo voltaic (solar cells)
4. Chemical:- PH and conductivity cells

# In textile

- CAD and CAM
- Photocells in automixers (blow room)
- Auto levelers in carding and drawing
- Display and setting units of air jet, rotor, etc..

# The disadvantages of mechanical control

- Knitting machines have developed with mechanically controlled and operated movements.
- The exacting requirements of modern knitting technology, however, emphasize the limitations of mechanical movements which are
  - expensive to manufacture,
  - slow and cumbersome in operation,
  - difficult to adjust or alter, and
  - subject to friction and wear.

- Mechanical pattern and programming data for controlling knitting machines is stored in the form of punched cards, chains, rack-wheels, peg drums, and needles butt arrangements.
- These are expensive in material, bulky in space on the machine or in storage, time-consuming to handle and alter, slow in operation, and provide restricted facilities.
- Hydraulics, fluidics, and electronics provide alternative systems of power transmission and signal storage with the requisite speed and precision.

# The advantages of electronic control and programming

- Electronics offer the decisive advantages of convenient power-supply, compatibility with existing mechanical components, micro-miniaturization of circuitry, and economical data storage.
- Electronic selection or machine control is compatible with higher running speeds and eliminates complex mechanical arrangements, thus reducing supervisory requirements.
- It provides greater versatility as regards design parameters, simplifies the modification of repeat sequences and size, style and pattern-changing operations, and, in some cases, enables changes to occur whilst the machine is knitting



# The compatibility of electronic signals and knitting data

- Electronic devices process information as binary digital logic signals that exist in two states, *ON* or *OFF*.
- This can be directly translated as *1* or *0*, *YES* or *NO*, *TRUE* or *FALSE*, or magnetic *ATTRACTiON* or *REPULSiON*.
- This information can just as conveniently be translated into knitting states such as *KNiT* or *TUcK*, *TUcK* or *MiSS*

# The computerized knitting machine

- automatic monitoring and adjustment facilities provided by microprocessor control on modern machines obviates the need for continual manual attention
- A single control unit can control a complete bank of machine
- It has means of receiving and transmitting electronically generated data to/from mechanically operating elements
- Electronics is also increasingly being employed in 'intelligent' stop motions, yarn feed systems, the design and preparation of knitting patterns, machine function control, pattern selection and striping.



# computer graphics and pattern preparation

- Of all knitting machines, the **modern electronic V-bed flat machine**, with its comprehensive **patterning** and **garment shaping** facilities, offers the greatest challenges as well as the greatest opportunities for the application of a CAD/CAM system
- *interactive computer graphics* enables a dialogue to occur between the operator terminal and the system, with the resulting development of the **design being immediately visually represented on the screen.**
- The position is defined and located by two numbers in the Cartesian co-ordinate system.
- On the horizontal (X) axis, the numbering increases positively from zero towards the right, whilst on the vertical (Y) axis, the numbering increases positively upwards from zero at any point on the design.

- Knitting patterns and programmes are quickly generated using automatic routines.
- These are checked and can be transmitted on-line to the eMS knitting machine.
- Simultaneous monitoring of production can also be achieved
- eomputer graphics provides a tool for the efficient creation and development of designs and overcomes tedious and repetitious aspects, enabling realistic representations of the knitted designs and garment shapes to be prepared, to be easily modified on the screen, and to be outputted as accurate, to-scale, colored, hard-copy prints.

- It provides a much quicker response to customer requests than is possible with traditional knit sampling techniques whilst postponing the expensive knitting operation until such requirements have been fully identified.
- Recognized standards for these systems are now becoming established so that there will be greater compatibility in the future and choice of system will be less dependent upon the preference for a particular make of knitting machine.

# The Stoll cAD pattern preparation system

- The *Stoii SiRiX* is a complete design, patterning and programming system originally specially developed from *Appie ii* PC software.
- It is used in every application in V-bed flat knitting.
- It uses icons and windows to graphically support the generation and development of knitting programmes for *Stoii eMS* electronic flat machines.
- It simplifies pattern drafting and speeds-up the processes required in the production of knitted fabric and garments.
- Fabric depiction and programme drafting is carried out on-screen, without the need to interrupt production on the machine

# The Shima total design system

- The *Shima Total Design System* is a totally-integrated knit production system that allows all stages – **planning, design, evaluation, production, and sales promotion** – to be integrated into a smooth work-flow:
  1. The designer, using computer-graphic paint software and a pressure-sensitive airbrush, creates concept drawings. Scanned-in images can be used to create storyboards.
  2. A fully-fashioned pattern for shaping is created, using a pattern CAD program for knitting. The working pattern is then displayed using *Knit Paint* software. Courses and wales are converted into numbers of loops. Jacquard, intarsia and structure patterns can be created separately.

- 3) When each pattern is complete, *Knit Paint* automatically combines all patterns into usable knitting data, customised to the required *Shima* machine. Machine data is converted for intarsia using the *auto yarn carrier selection function*.
- 4) The *ioop simulation programme* uses yarns either scanned or painted or created by the *yarn creation programme*.
- 5) The resulting simulated knit pattern can then be draped onto models using the *mesh-mapping function*. A mesh grid is created to conform to each fully-fashioned piece, such as the front body, back body, and sleeves, and the simulated knit pattern is draped directly over that piece. The *mesh mapping* allows shadows and wrinkles to be maintained from the original image.
- 6) A database of models wearing various types of knitwear (V-neck, crew neck, cardigan, etc) for which the mesh grids are ready-made is available.

# Knitted Garments

- All **knitted garments** can be classified in to four categories according to general production methods
  - a) Fully cut
  - b) Stitch shaped cut
  - c) Fully fashioned
  - d) Integral

## 1. **Fully cut**

- › Fabric is spread on cutting table.
- › All parts of the garment are cut from the fabric except trims.
- › The peaces are joined by sewing.

Ex. Circular knitting machines:- single jersey or plain web machine and double jersey or rib machine

## Advantages

- a. The relatively **low costs** of the fabric produced at **high speeds** with **low labor input**
- b. The opportunity for scale of production which particularly shows benefits at the cutting stage.

## Disadvantage

- a. The relatively high waste factors that occur even with small garment pieces. Such wastage ranges from 17% to 50% and is a significant cost burden on the garments produced
- b. The high labour cost of assembly of the garment

## 2. Stitch shaped cut

- › The majority of knitwear is produced by this method
- › It involves knitting of rectangles of fabric relating to the size of the portions of the garment to be made
- › The pieces known as "blanks" have the lower edge of the fabric sealed with a structure known as a 'welt' that prevents laddering and distortions of waistbands and cuffs
- › The term stitch shaped derives from different stitch structures with the length of the blank that distort it from the rectangle into a shape associated with the human body.
- › Wastage is about 10 – 20%
- › Circular and flat knitting machines are employed both are usually rib machines with two knitting beds . Some are purl type

### 3. Fully fashioned

- Fully fashioned is the process whereby portions of a garment are shaped at the selvages 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

Has two advantages

- a. There is little or no cutting waste
  - b. The edges of the garment pieces are sealed and not liable to fraying, so can be joined by simple non-bulky seams
- › Straight bar frame is common example
  - › Hand flat knitting machine can also produce men's heavy rib sweaters and fine gauge ladies suits and dresses
  - › Modern electronically controlled v-bed flat machines are also used with a wide range of patterning

# Integral

- Are essentially knitted in one piece with little or no seam
- Example is beret which is knitted sequentially in a series of triangles leaving the beginning and the end to be joined into a three dimensional shape
- Jumpers, skirts, ladies and gents millinery/women's hat can be produced

# 1. welts

- A *welt* is an **attractive** and **secure** edge of a knitted article that helps to prevent laddering or unravelling 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.
- Welts particularly occur at **hems, waistbands, cuffs, collars, and facings**.

# 1.1. The plain fabric welt

- On machines with no facilities for **rib welt sequences**, the plain fabric is formed into either a turned-over *inturned-welt* or a *mock rib welt*.
- The ability to produce a knitted welt sequence usually distinguishes an **article-producing machine** from a **fabric-producing machine**.
- Some machines start at the **closed toe end** or finger-tip and finish with the **welt end of the article**.
- The last knitted course will unrove backwards from the last knitted loop unless it is secured.
- Sometimes the **curling edge of plain fabric** is used as the start of a garment or the **curl of a collar** instead of a **welt**.

## 1.2. The inturned welt

- The *inturned welt* is used particularly for manufacturing ladies' hose and sports socks on circular machines (Fig. 16.1) and some knitwear on Cottons Patent machines (Fig. 16.2).

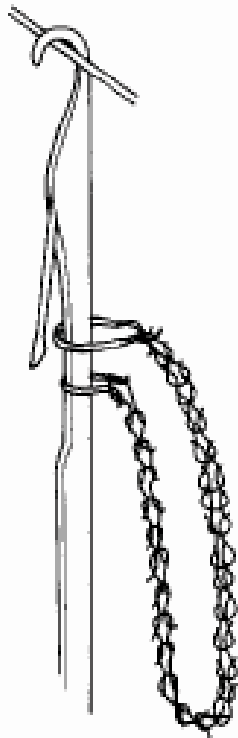


Fig. 16.1 Turned welt on latch needle machine.

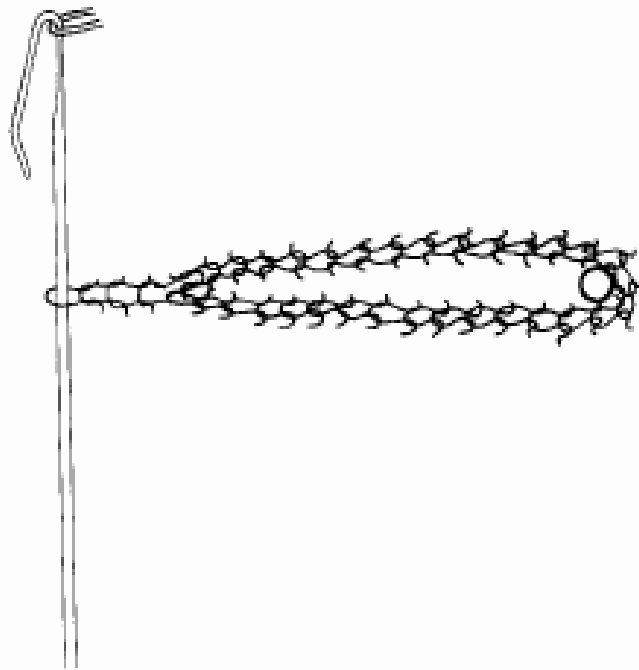


Fig. 16.2 Turned welt on bearded needle machine.

- **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 welt is then turned by transferring the held course back onto the needles that knit it into the structure.
- A *picot edge* at the turn of the welt is achieved either by an alternate needle tuck sequence or by alternate needle loop transfer.
- **Cottons Patent plain machines** often produce garment panels by knitting onto a **rib border** that has been run onto the needles, having been previously knitted on a **V-bed rib machine**.

## 1.3. Accordion 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.

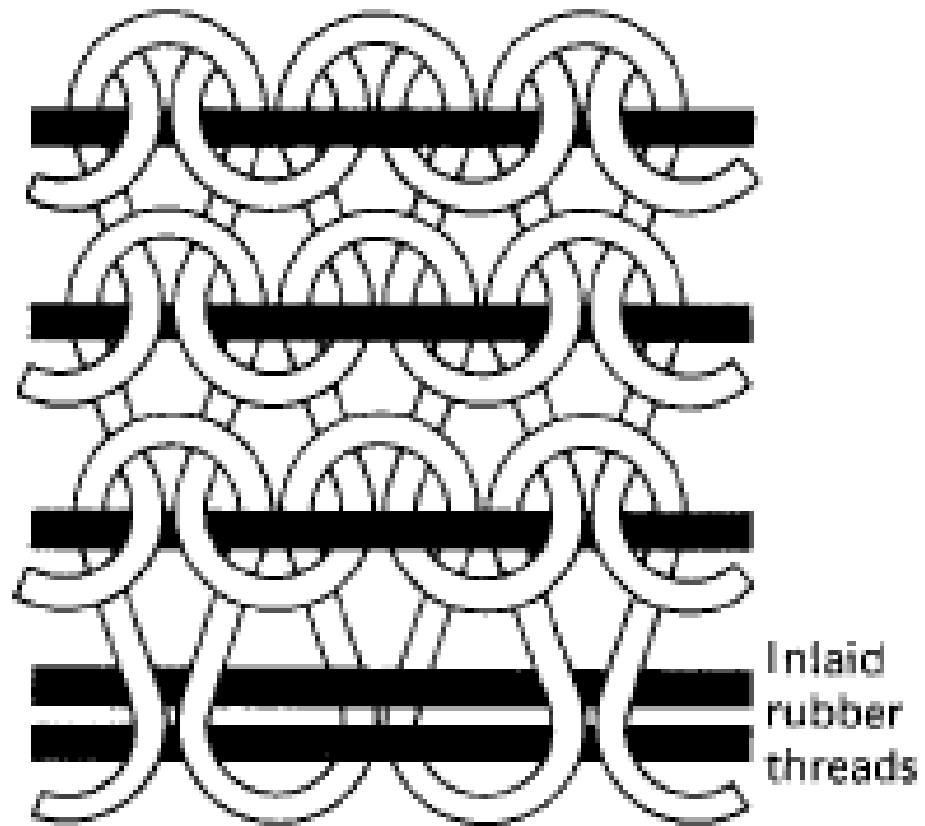


Fig. 16.3 Accordion welt top.

## 2. 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 setup** course.
- 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.

# The tubular welt

- The *tubular welt* (Fig. 16.4) 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/loose during washing and wear unless knitted tightly.
- Apart from old Cottons Patent Rib Frames, most garment-length knitting machines can knit this welt.
- The *spiit 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/women scarf, to fit over the cut edge of a garment to which it is then linked by a through stitch.

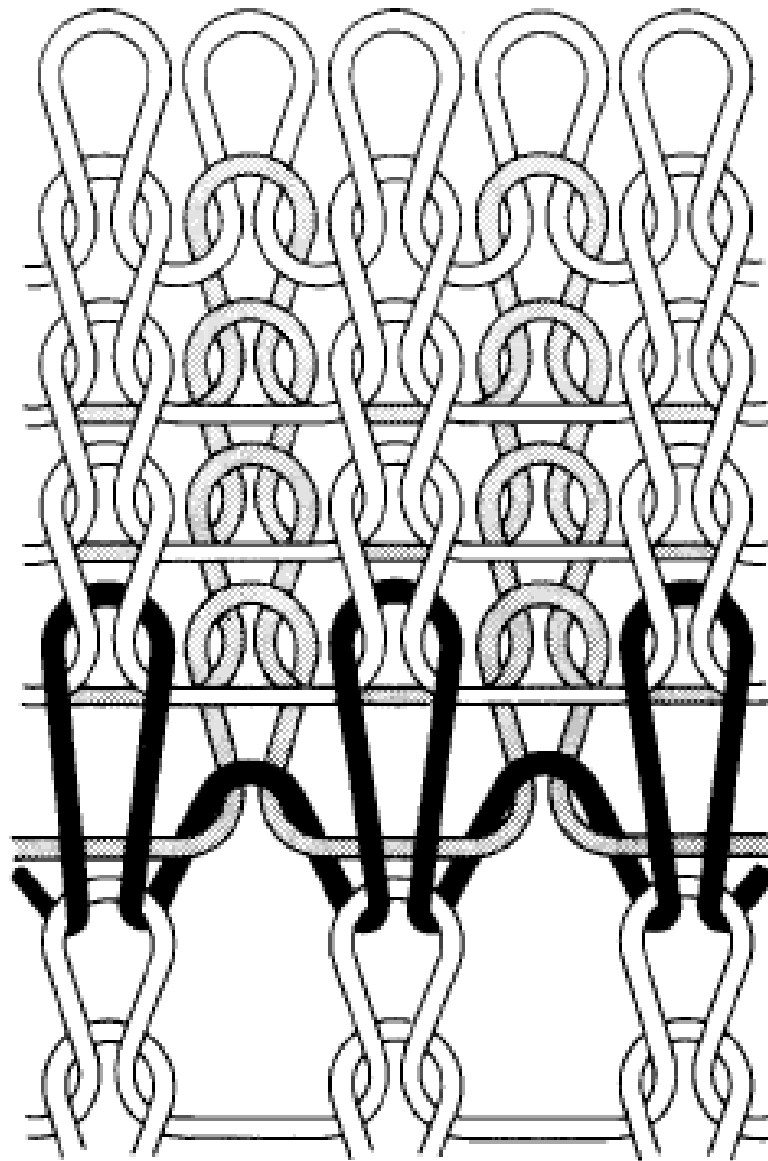


Fig. 16.4 Tubular welt.

# The roll welt

- *The roii welt* (Fig. 16.5) 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 roii welt* is knitted for sleeves with **turn-back cuffs** and for **turn-over top socks**.

Welts produced  
on two sets  
of needles

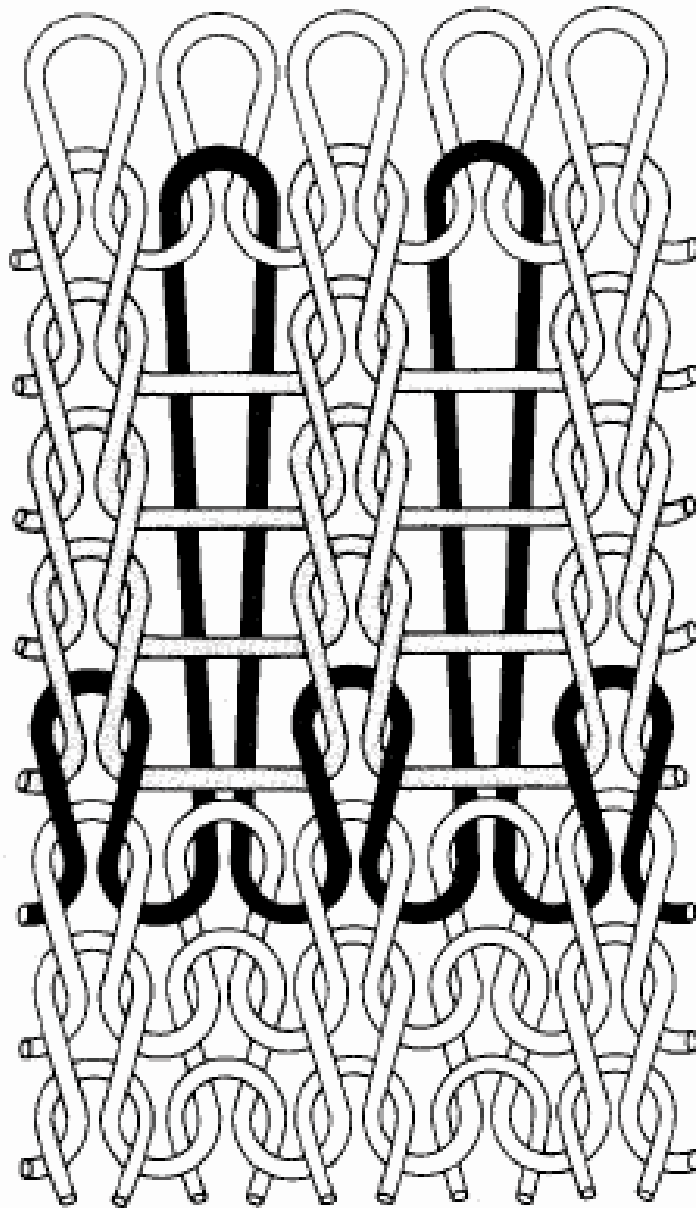


Fig. 16.5 Roll welt.

# The racked welt

- The *racked welt* (Fig. 16.6) 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 machines.
- It is produced by racking the needle bed by one needle space after the set-up course and retaining this arrangement.

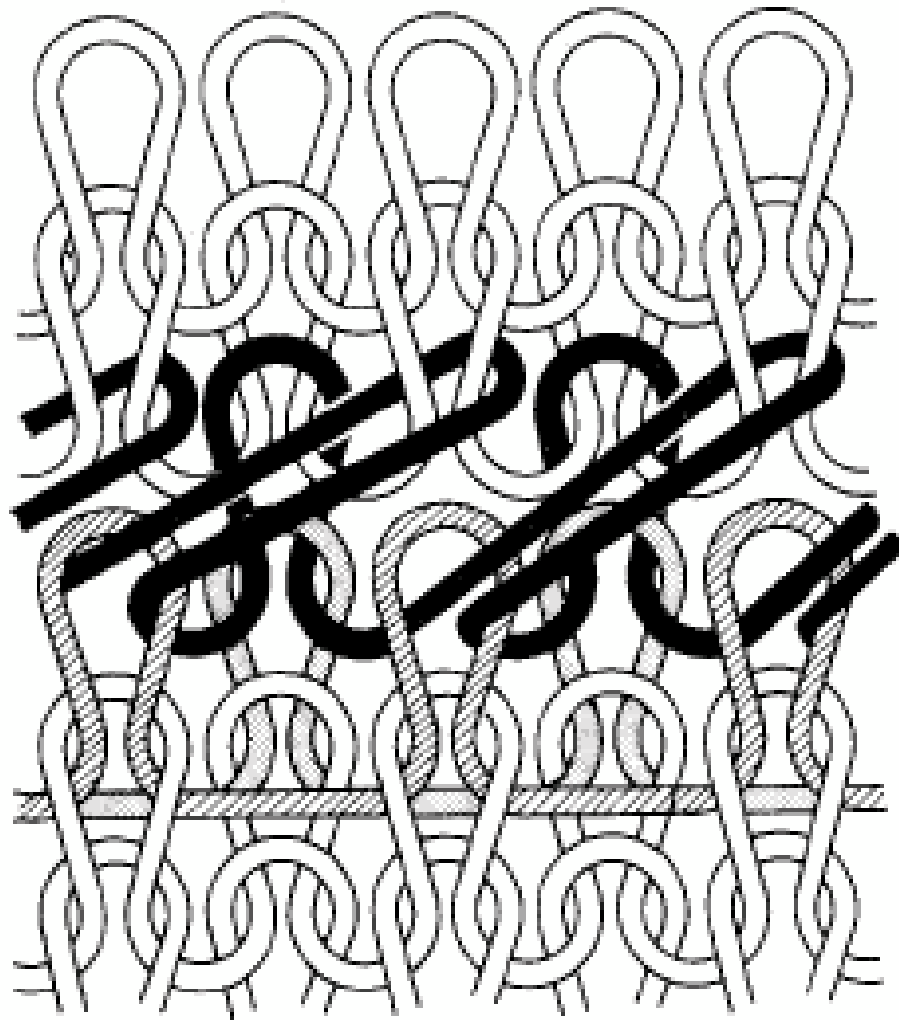


Fig. 16.6 Raked welt.

# 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 takedown 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.
- The draw thread is usually a **smooth strong yarn** that may be knitted as a slack/loose, plain tubular course to facilitate easy removal.
- The tubular draw thread course **does not unrove accidentally** during wet processing.
- A second 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.
- 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.

# Imparting shape 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 coordinated from the same central control mechanism.

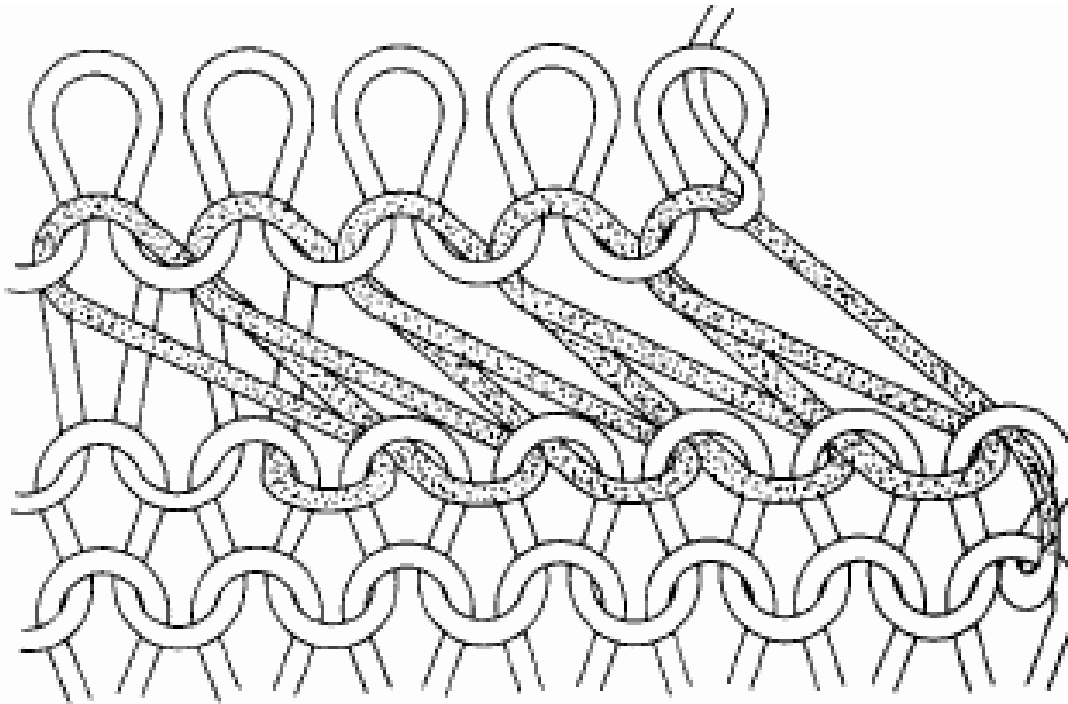
## **The three methods of width shaping are:**

1. varying the number of needles in action in the knitting width,
2. changing the knitting construction, and
3. altering the stitch length.

# 1. wale fashioning

- ***Wale fashioning*** is the normal manner of shaping (symmetrically or asymmetrically) on **straight bar frames** (Figures 16.7 and 16.8).
- It involves the transfer of loops from one needle to another within the same needle bed, either transferring onto **selvedge needles** that are **to start knitting (*widening*)** or **transferring from needles** that are to cease knitting (***narrowing***).
- The fashioning technique has, in the past, been generally restricted to **plain fabric structures** although there were a few rib straight bar frames.
- There is now an increasing number of **automatic V-bed flat machines** with additional beds of **fashioning points** or rib loop transfer needles.

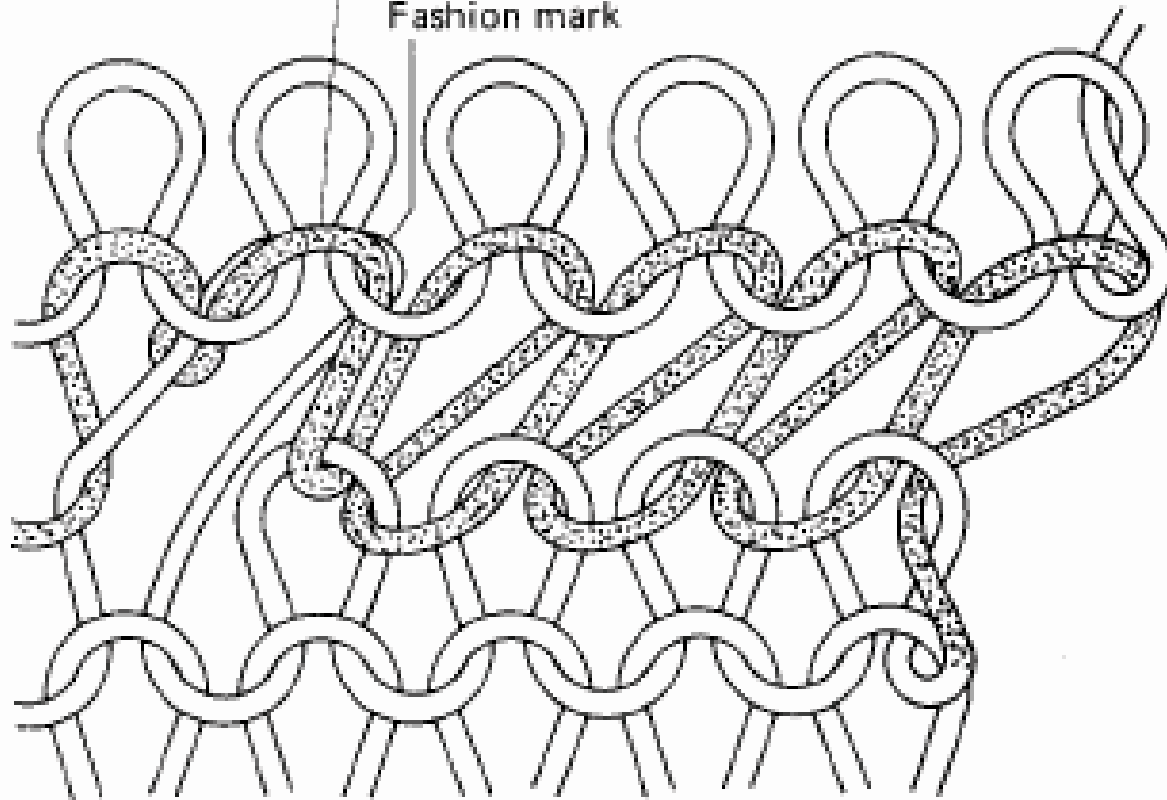
- Each transfer bed operates onto a specific needle bed (Fig. 16.9)



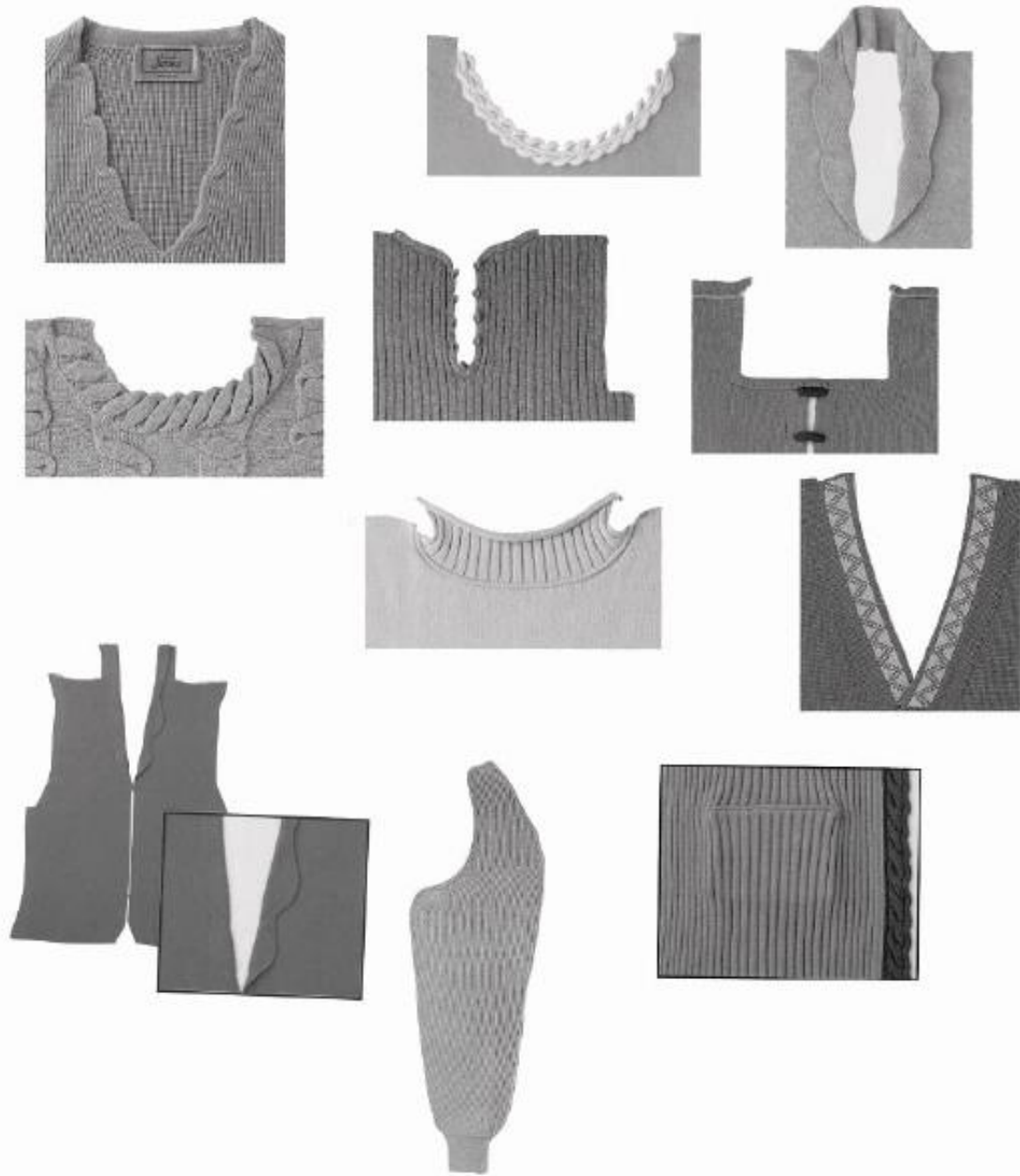
**Fig. 16.7** Wale fashioning (narrowing).

Needle loop of previous course and  
sinker loop of fashion course

Fashion mark



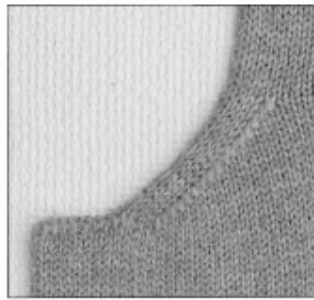
**Fig. 16.8** Wale fashioning (widening).



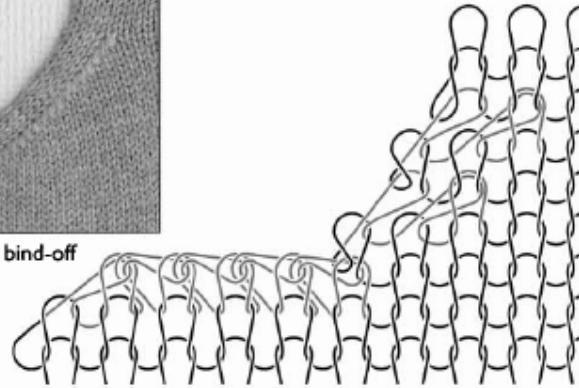
**Fig. 16.9** Integrally shaped rib garment pieces. The machine has an additional bed containing the transfer points [Shima Seiki].

- Fashioning can also be achieved by **needle-to-needle rib loop** transfer, **racking one bed**, and transferring back to the original needle bed, but this technique requires **receiving needles to be empty of loops**.
- The **shaping angle** is varied by changing the **fashioning frequency** (i.e. the number of plain courses between each fashioning course), aided by the possibility of **four needle** or **two-needle** as well as **single-needle** narrowing.
- A **block of loops** is transferred at a time, so that the transferred loop effect (*rashion mark*) is **clearly visible in the garment**, away from the selvedge, as this is a hall-mark of classic fully-fashioned garments.

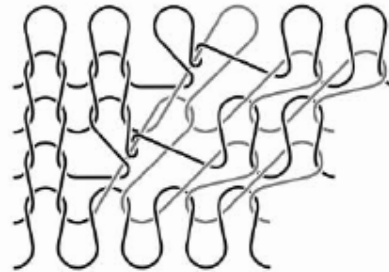
- *Widening* involves transferring the loops of a group of needles outwards **by one needle**, thus leaving a needle without a loop that would produce a hole if it was not covered by the **action of filling-in**.
- Figure 16.8 shows the effect of using a **single filling-in point** that is set slightly in advance of the innermost fashioning point.
- It has an independent vertical movement and takes a stitch from the previous course, placing it onto the empty needle.
- Another technique in order to cover the hole is to use **two half-points** to **transfer the half limbs** of two adjacent needle loops sideways.
- A similar technique has been developed for automatic **V-bed machines**, when it is termed a ***spiit stitch*** (Fig. 16.10).



Narrowing with bind-off



Widening with split-stitch (latch-type needle)



Widening with split-stitch (compound needle)

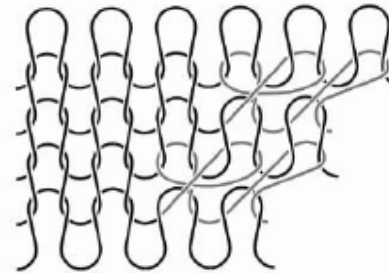


Fig. 16.10 Modern integral garment technology assures precisely-formed loops which are crucial to the production of shaped garments [Shima Seiki].

# The calculation of fashioning frequencies

Using the details shown in Fig. 16.11 as an example, the following sequence is necessary in order to calculate the required fashioning frequencies from the dimensions of a garment part:

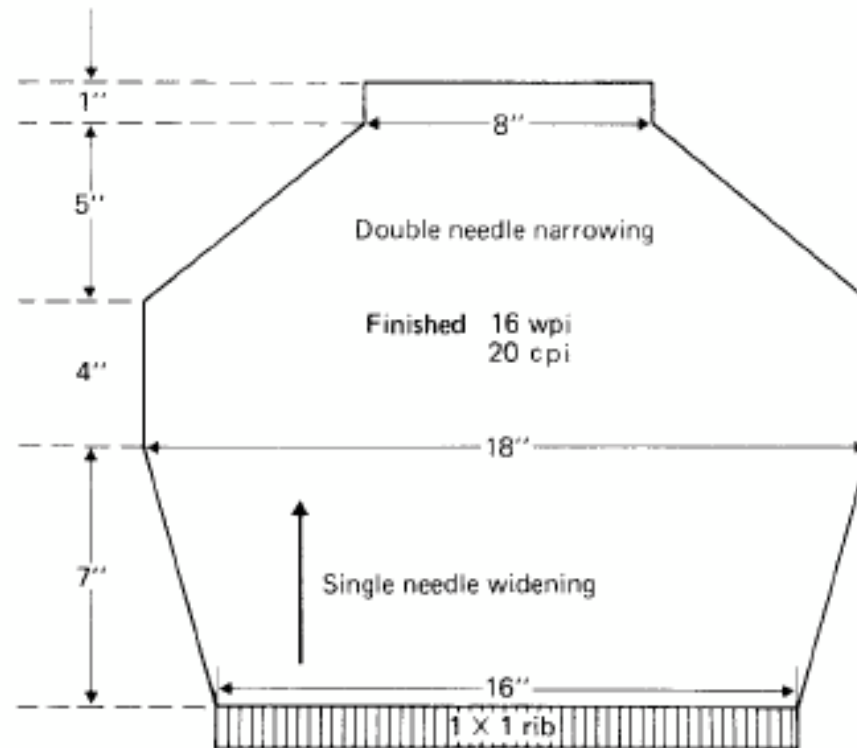


Fig. 16.11 Full-fashioned shaping calculation.

1. Convert the length dimensions in each section to total number of courses by multiplying the length measurement by the cpi. Thus,  $7 \times 20 = 140$ ;  $4 \times 20 = 80$ ;  $5 \times 20 = 100$  courses
2. Convert the width dimensions at the start of each section to total numbers of needles by multiplying the width measurement by wpi. Thus,  $16 \times 16 = 256$ ;  $18 \times 16 = 288$ ;  $8 \times 16 = 128$  needles
3. Calculate the total number of needles increased or decreased from one section to another by taking one total from the next

4. 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,  $80/2$  gives 40 double needle narrowings
- 5) 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 15 fashionings in 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
6. 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.

# Needle selection shaping

- In *needle selection shaping*, the selvedge needle(s) is **introduced or withdrawn** from the knitting width by means of needle selection.
- It is more convenient on **automatic V-bed flat machines** to employ the jacquard selection to introduce empty needles for widening and to take needles out of action for narrowing
  - (i) by transferring and re-transferring rib loops in conjunction with needle bed racking,
  - (ii) by pressing-off loops, or
  - (iii) by causing needles to hold their loops for large numbers of traverses (Fig. 16.12) [1].

Fig. 16.U Garment shaping by holding loops on a V-bed Oat machine thus knitting wales with different numbers of course. (A) is the commencing course and (8) the pressed-off course. A presser foot device was employed [KlittiJ19 Inlema/ionalj.

- It is even possible to introduce or remove a selvedge needle from the knitting action during tubular plain knitting on a V-bed flat machine, thus achieving a certain amount of shape in the tube.
- The full shaping potential of the V-bed flat machine can only be exploited if the conventional roller take-down system is replaced by an arrangement capable of accommodating itself to varying rates of production and fabric widths and even to separated garments or garment pieces.

## 2. Shaping by changing the knitted stitch structure

- *Stitch shaping* is the imparting of shape into selvedged or tubular weft knitted structures by changing the nature of the stitch structure **without altering the total number of needles** that are in action.
- It may be used for garment-shaping sequences in knitwear, jerseywear and underwear produced on latch needle machines.
- It is a simpler and faster method than fashioning and does not require specially-shaped elements, but it can only be used for a few definite step-changes of shape rather than the graduated shaping technique of fashioning.

- In the sleeve and body panels of knitwear, the tuck stitches will cause half and full cardigan to throw out wider than the 1 × 1 rib border (Fig. 16.13).
- In ladies' stitch-shaped vests, patterned rib eyelet will produce a similar effect in the bust and skirt sections, compared with the 2 × 2 rib waist and border
- In plain tubular fabric articles such as some socks and gloves, elastic may be inlaid on an alternate tuck/miss basis on the same needle sequence, so that the fabric concertinas into a narrower elastic 'mock rib' effect for the tops.

### 3. Shaping by altering the stitch length

- Changes of stitch length by alteration of **stitch cam positions** are carried out at particular points in a garment-length knitting sequence.
- Even **mechanical V-bed power flat machines** have at least **five pre-set positions** that can be automatically obtained during traversing of the cam carriage.
- On both **circular and flat machines** it is also possible to change from **synchronized** to delayed timing in **1 ≠ 1 rib** knitting and thus **produce tighter** and more 'elastic' rib courses suitable for rib borders.
- In ladies' hosiery, a *graduated stirrening* or tightening of the stitch length occurs to obtain a certain amount of shape between the thigh and the ankle.

- The introduction of a certain percentage of elastane yarn into the construction of a weft or warp knitted fabric improves extension and recovery properties and therefore its form-fitting properties.
- The percentage elongation of the elastane yarn may be controlled during fabric finishing by heat-setting [3].

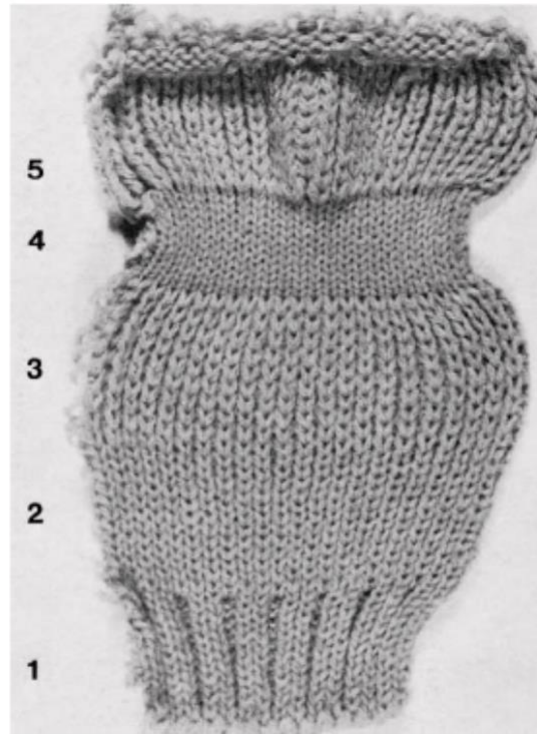


Fig. 16.13 Stitch shaping (1 = 2 × 2 rib; 2 = 1 × 1 rib; 3 = half-cardigan; 4 = tubular courses; 5 = full cardigan).

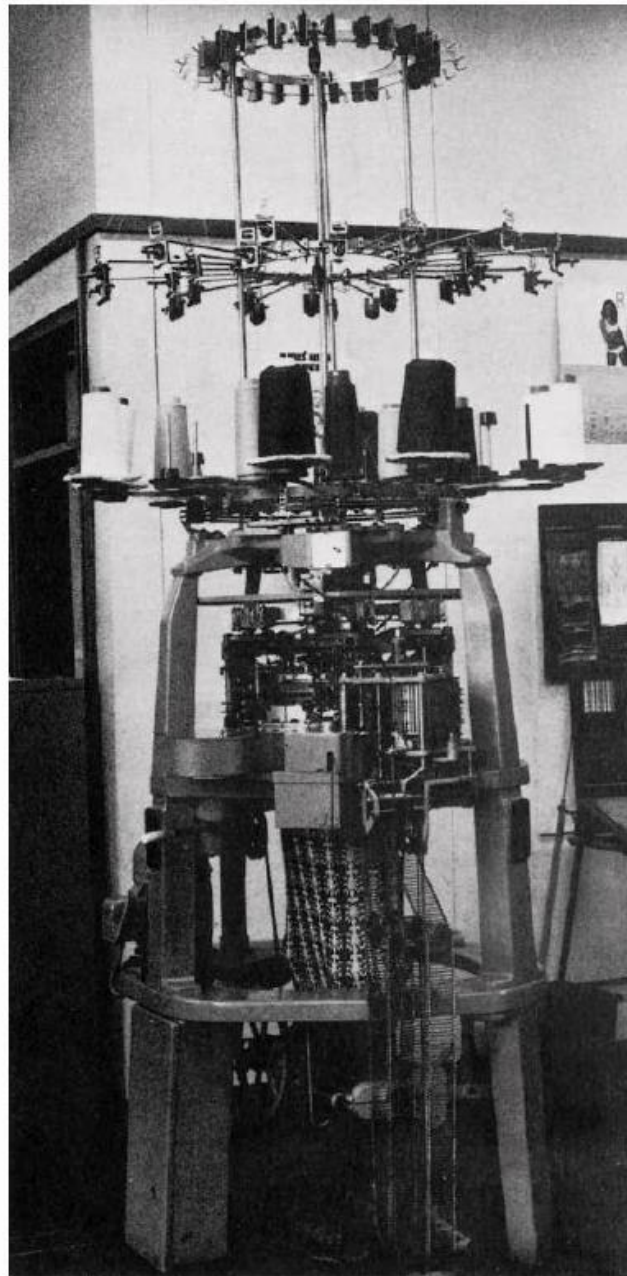
# circular garment-length machines

## circular versus flat machines

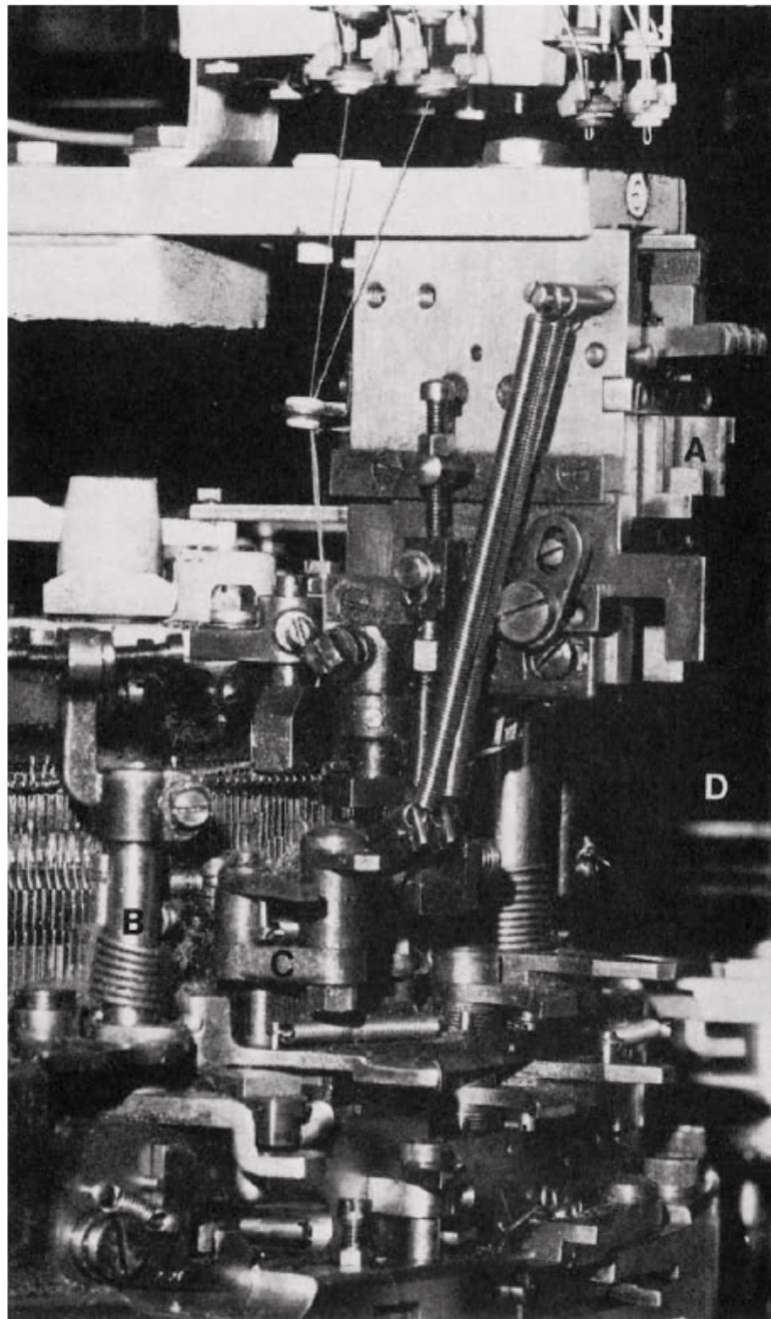
- On the basis of knitted stitches per minute against the capital cost of the machine, **circular garment-length machines** are generally **more productive** than V-bed flat machines for cut-and-sew knitwear.
- Prior to computer controls, the **price/performance** ratio was 1 : 3 in favour of body-width circular machines.
- Against electronic V-bed flat machines, however, **circular machine builders** had to move to **less versatile large-diameter machines** (33-36 inches) in order to achieve a ratio of even 1.2 : 1.
- There are large numbers of **body-width RTR and SPJ mechanically-controlled** machines still in operation, as well as some that have been retro-fitted with electronic controls.

- Circular garment-length machines are mainly of the rib cylinder and dial type or of the double-cylinder purl type.
- Although more restricted in patterning capabilities than flat machines, they may offer advantages in productivity and fineness of gauge.
- Many are of the revolving cam-box type whose cams
- The peg drum control unit for the garment-length programme is now tending to be replaced by an endless film loop that is driven by a horizontal perforated roller.
- The film is advanced by one row of holes for each feed or transfer section that passes per cam-box revolution.
- When no changes are required, an economiser rack-wheel operates.

- On *Bentley* machines, the *Mechatape Pattern control Unit* was introduced to replace peg drums or trick-wheels and provide a virtually unlimited pattern depth, faster running speeds, easier pattern preparation and more rapid pattern changes.
- The control unit consists of a drum whose perforations correspond to the staggered rows of punched hole positions on a plastic film loop.
- Each row operates through the bank of horizontal levers onto the levers of a passing selection unit.
- The arrangement in the selection unit is fixed for a complete circuit of the machine whilst it selects onto the jack pressers arranged around the cylinder.



**Fig. 20.1** RTR circular garment length revolving cam-box rib machine. The peg drum control unit and timing chain are clearly visible. Also note the slipping belt take-down mechanism which draws down the stationary fabric [Walter Bullwer].



**Fig. 20.2** Close-up of RTR revolving cam-box showing the exterior striking levers (A = striper box; B = dial stitch cam adjustment and levers; C = cylinder stitch cam and adjustment levers; D = stationary striking lever post) [Walter Bullwer].

# The double-cylinder garment-length machine

- *Spiers* produced a successful machine of this type in 1930, termed the '*Spensa Puri*' machine.
- 
- It has a revolving cylinder and internal sinkers and is capable of knitting garment-lengths with a tubular welt and rib border.
- In 1956, *Wiidt (Meiior Bromiey)* replaced it with the model SPJ, which has an anti-clockwise revolving cam-box, no dividing cams or internal sinkers, and sliders with pointed noses for opening the latches of needles knitting in the opposite cylinder.
- As well as being mechanically more reliable for purl knitting, the patterning potential of this model was improved over the years.

- The main gauges are 6-12 npi with 2116's (Ne) worsted being an average count for 10-gauge.
- Machine diameters are 16-20 inches (40-50 cm approx.) with six feeds; 22 inch (56 cm) with eight feeds; and a 33-inch (84 cm) model with twelve feeds.

- The machine produces knitwear garments for adults, children and infants with a separating course, welt, 1 ¥ 1 or 2 ¥ 2 rib border, and a body or sleeve panel sequence.
- Stitch patterning may include any of the following in plain colour or striped-in colours: plain and purl, tuck rib, tuck purl, float stitch jacquard, and rib jacquard.
- The tricks of the top cylinder are held in alignment with the bottom cylinder by a dogless head, whilst the cam-boxes for the two cylinders are rotated in unison by means of a vertical cam-shaft and two pinions.

# The RTR garment'length machine

- This fully-automatic garment-length rib machine was introduced in 1938 by *Wiidt (Meiior Bromiey)* as a replacement for their RSB model of 1936, which had no facilities for **rib loop transfer**.
- Its anti-clockwise revolving cylinder and dial cam-box has **cam sections** of equal size whether they are for knitting feeders or rib loop transfer.
- A unit set in advance of the section can select the **cylinder needles** for the knitting or transfer action.
- The original RTR has **six cam sections**, four for knitting (2 and 3; 5 and 6) and two for transfer (1 and 4).
- Section 4 also has facilities via the **back butt** set-out of the dial needles for changing the rib, either by **collective dial-to-cylinder loop transfer** or by **dial needle loop press-off**.

- It soon became apparent that the machine's garment-length knitting sequence of draw thread separation course, tubular welt, 1 × 1 or 2 × 2 rib border or waist, body panel section, and press-off locking courses could be used for knitting jacquard, double-jersey, or coarse-gauge knitwear as well as stitch-shaped underwear.
- Depending upon the end-use of its model, panels can thus be knitted in 1 × 1 rib, dial-only knit, interlock milano rib, rib jacquard, or half- or full-cardigan with selective patterning in rib transfer, coloured stitches, miss, tuck, knit or raised cloque relief stitch.
- Articles that can be knitted include vests and panties, cut and sewn sweater dresses and trouser suits, jumpers, coarse-gauge cardigans, and sweaters.

# Jumberca cylinder and dial and double' cylinder machines

- The *Jumberca cylinder and dial*, and *double-cylinder* machines are **electronically controlled** and have almost unlimited selection in the cylinder and dial and in the bottom cylinder of the links-links machine.
- Stitch length is infinitely adjustable in each bed.
- The programmable width device adjusts the fabric width to the accuracy of a single needle.
- **Needles are taken out of action** so that floating threads join the
- two fabric edges of the open width fabric; this can save up to 15 per cent on yarn.
- The fabric remains in tubular form through the take-down rollers, thus maintaining uniform tension around the circumference and throughout the garment sequence

# Mecmor Variatex machines

- The *Mecmor Variatex* machines are a range of **circular cylinder** and dial, garment length machines that knit garment-lengths in open-width on **300 degrees** of the **machine's circumference**.
- The **revolving cam-box** model '180' has a diameter of **28 inches**, providing a maximum knitting width of **70 inches** (180 cm).
- The knitting width may be reduced according to requirements, thus economising on yarn.
- The garment-length is of **constant width**, The latest electronically-controlled models ('2500' onwards) have a revolving cylinder and dial with a 40-inch diameter.
- In a standard model there could be twelve knitting systems and six transfer stations.

# The 'seamless' bodywear garment machine

- The *seamiess bodywear garment machine* knits **body-width underwear garments** (Fig. 20.7) requiring little or no making-up and with no uncomfortable side-seams.
- The model SM8-8 is an eight-feed, fully electronic, single needle selection machine that can **produce a knitted-in welt**, and structures such as **openwork, stripes, jacquard, terry** and **plated fabrics**.
- Diameters range from 10 to 15 inches in gauges E 16 to E 32.
- An eight-feed cylinder and dial machine with four two-way transfer stations is being developed in a diameter range from **14 to 22 inches** and gauges **E 14 to E 16**.
- The **20 and 22-inch diameter** machines have twelve feeds and six transfer stations.



Fig. 20.7 Body-size seamless garment [Santoni].

# Speciality fabrics and machines

- Speciality fabrics include fleecy, plush, high pile and wrap fabrics.
- The surface effects of fleecy, plush or pile are developed during the finishing process usually on the technical back of single faced fabric.
- In *fleecy fabrics*, the fleece yarn fibres (usually in the form of inlaid yarn) become entangled and indistinguishable from the base yarn on the effect side, despite having been separately supplied during knitting.

- *invisible ribbing* (Fig. 14.1) is a plain plated structure composed of a face and binding yarn with a fleecy backing yarn tucked into the technical back at every fourth wale to mesh only with the binding yarn.
- The face yarn prevents the arms of the fleecy tucks being visible between the wales on the face, which would spoil its clean appearance.
- The fleecy inlay is spread across the technical back
- A popular gauge for sweat shirts and track suits is E 20, using 1/28's to 1/30's (NeB) cotton or acrylic yarn or 1/70's (Td) nylon and 1/9's to 1/12's (NeB) cotton or acrylic fleece yarn.

- A 30-inch diameter machine will give a finished width of **54-60 inches** (1.37m-1.52m).
- The standard sweatshirt weight is 250 to 300g/m<sup>2</sup>.

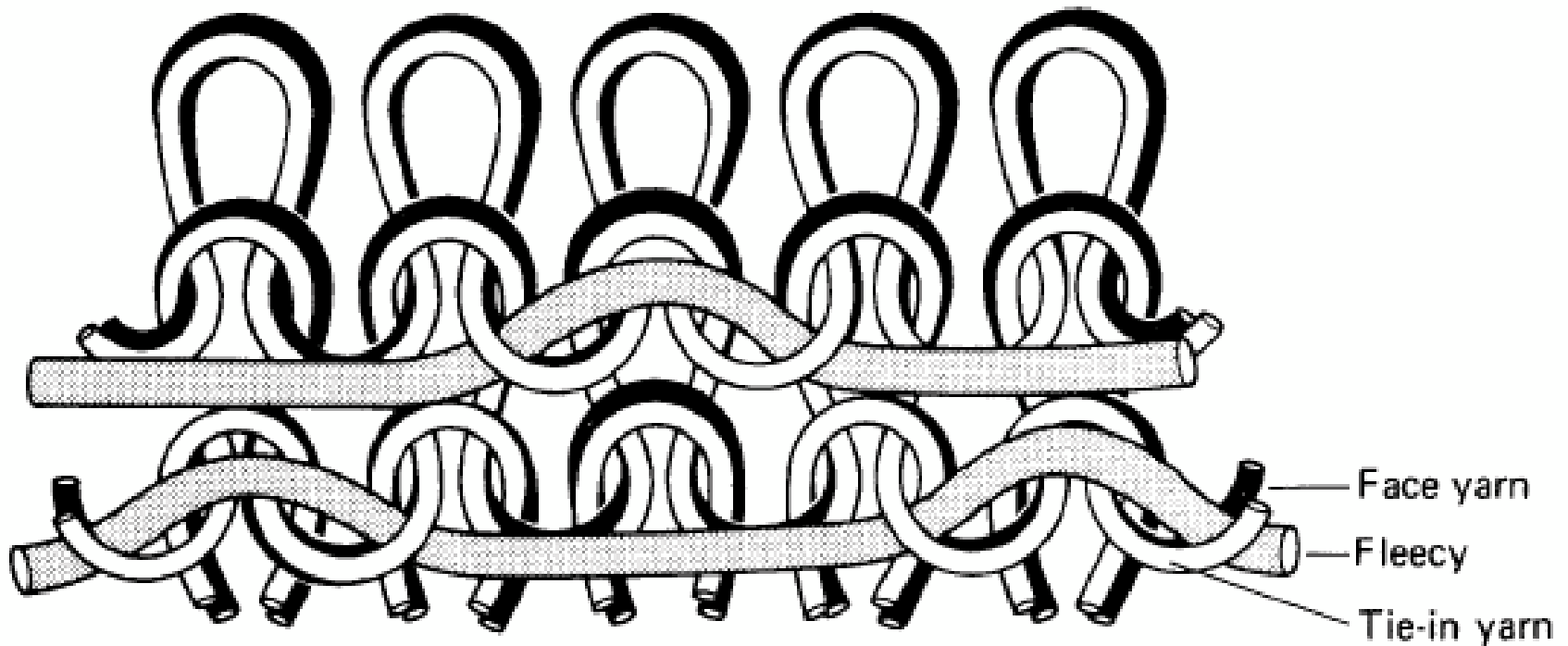


Fig. 14.1 Three-thread fleecy loop structure.

# The production of fleecy on sinker'top machines

- *Three-thread fleecy* was at first knitted as a quality fabric on the loop wheel frame (bearded needle)
- Three-thread fleecy is now produced mainly on single-jersey latch needle machines
- Pattern wheel selection was used for fleece yarn tucking.
- The preferred method today is to use a top needle butt and cam track for knitting the ground (face) and tie-in (binding) yarns, and four tracks and corresponding butt positions (which can be rearranged) for the fleecy tucking sequence.

# Fleecy interlock

- *Fleecy interlock* is a **plated fleecy fabric** consisting of a **main yarn**, which is fed to knit on both **needle beds** and a **fleecy yarn**, which is fed first, and at a lower level, below the latches of the dial needles whilst they are at clearing height.
- It does not enter their hooks or show on the dial side of the fabric (Fig. 14.3).

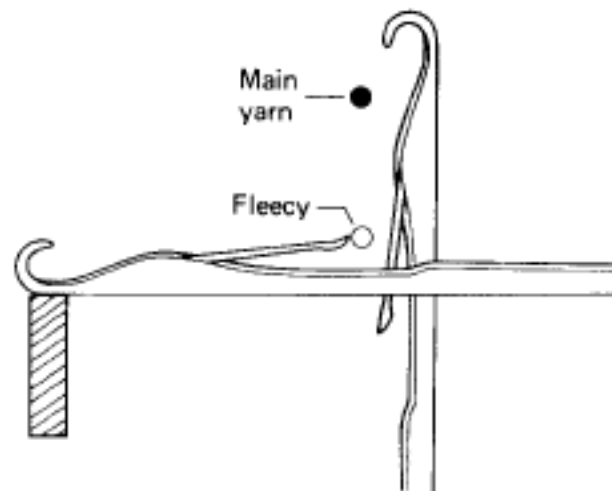
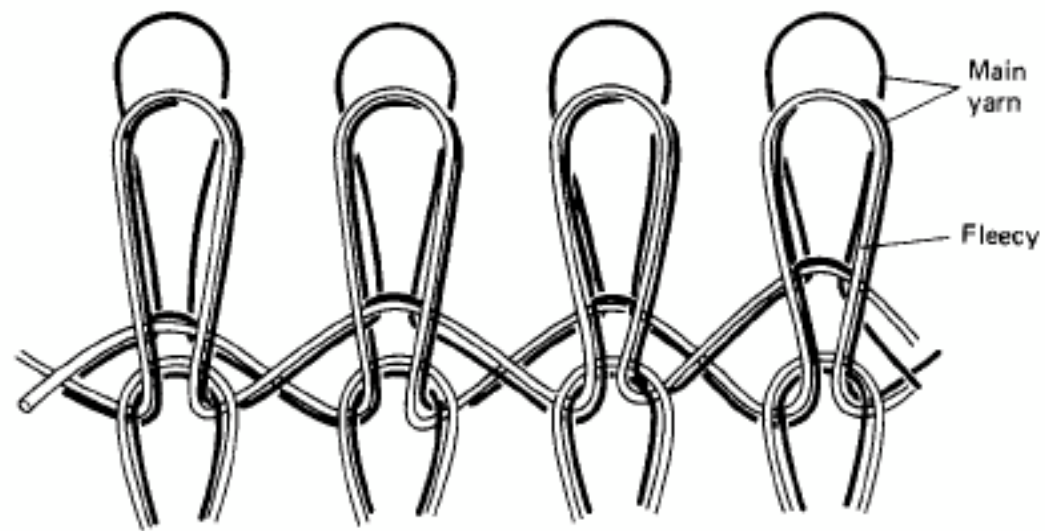


Fig. 14.3 Fleecy interlock.

# Plush

- *Single-sided piated plush* or *terry* is a popular leisurewear and sportswear structure that has the **form-fitting properties of single jersey** and is used in both fabric and sock form.
- The **elongated plush sinker loops** are formed over a **higher knock-over** surface than the normal-length ground sinker loops with which they are plated (Fig).
- The **plush sinker loops show** as a pile between the wales on the technical back of the fabric.
- *Henkei plush* or *veiour* is achieved during finishing, by cropping or shearing the plush sinker loops in both directions.
- This leaves 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 fibre.

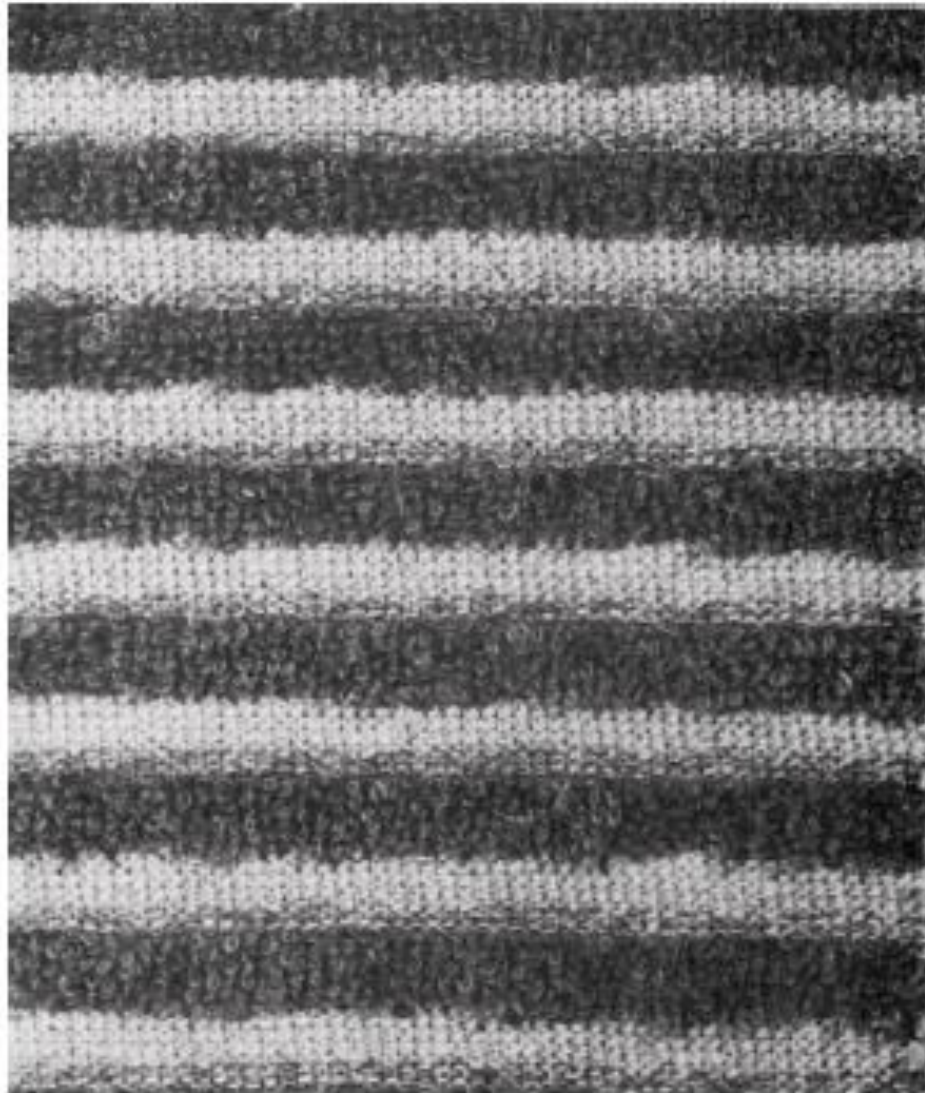


Fig. 14.4 Horizontal ribs with an ottoman effect on two-tone towelling [Alwin Wild, Switzerland].

# The bearded needle sinkerwheel machine

- In the past, this machine was renowned for the production of **high-quality plush fabric** but its **productivity was low**, with a speed factor of 500 and only 4 to 12 feeds in a diameter range of 10-44 inches.
- With the demand for increased production, knitters turned to the more **productive latch needle sinker top machines**, which were progressively refined to meet the needs for **high-quality plush**.

# Sinker plush knitted on single'jersey latch needle machines

- On the **sinker top latch needle machine**, the ground yarn is fed into the **sinker throat** and the sinker is then advanced so that the **plush yarn fed at a higher level** (Fig.) is drawn over the sinker nib.
- If the sinker is not advanced, the two sinker loops will be of equal size as they will both be drawn over the same knock-over surface.

The Following are the production of **one course of standard plush**:

1. The ground yarn is fed onto the open latch and into the throat of the sinker which is fully withdrawn.
2. As the needle descends the stitch cam, **the plush yarn** is fed into its open hook.

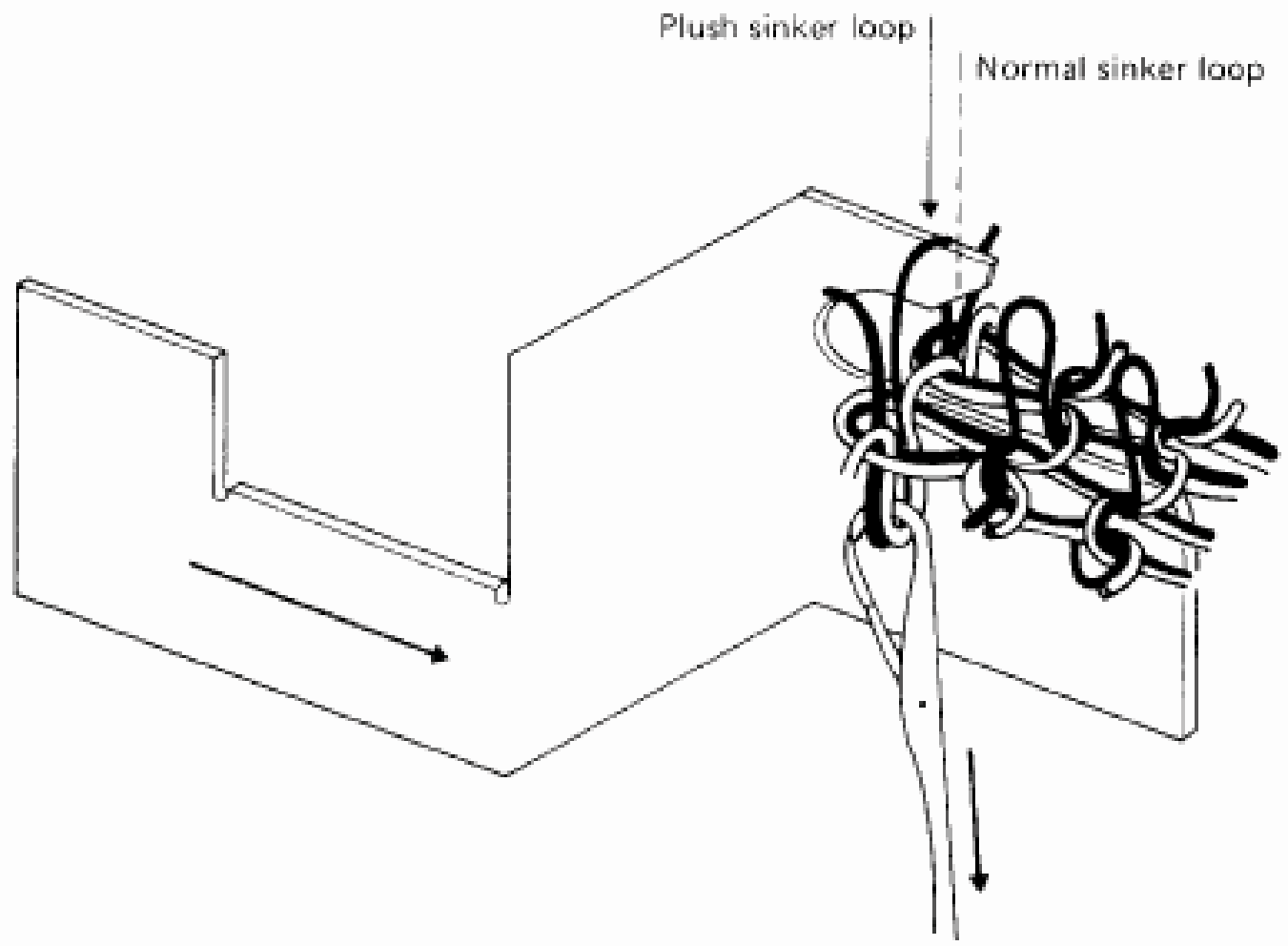
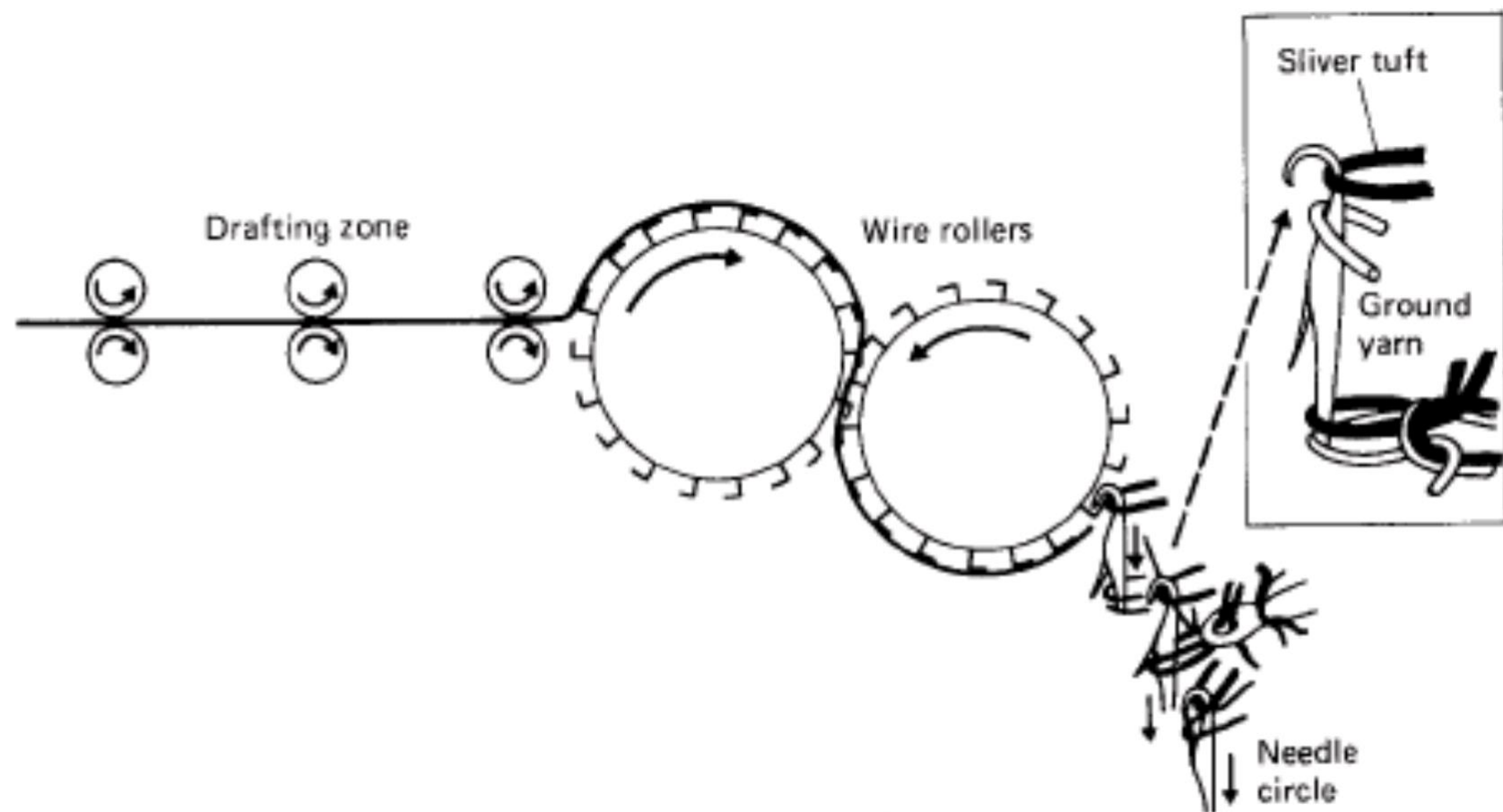


Fig. 14.5 Action of the plush sinker.

3. The sinker is advanced fully forward to **retain the plating relationship** and **tighten the plush loop** on the sinker step whilst the needle descends to knockover.
4. The loops are relaxed as the needle rises to clear.
5. The new plush loop is retained on the sinker step as the needle rises.
6. When the needle is at maximum clearing height, the sinker advances to retighten the plush loop.

# Sliver or high'pile knitting

- *Sliver or high-pile knitting* is **single-jersey** made on a circular machine having **sliver feeds** where the stock- or dope-dyed slivers are drawn from cans at ground level.
- They are then prepared by mini three-roller drafting card units followed by **two wire-covered rollers** that **draw and transfer** the thin film of fibres to the needles (Fig. 14.6).
- At each sliver feed, the needles are lifted to an extra high level where they rise through the wires of the doffer roller to collect a **tuft of staple fibres** in their hooks.



**Fig. 14.6** Sliver high pile machine.

# wrap patterning

- **Wrap patterning** was popular in single jersey, especially in underwear, for producing vertical stripe effects, often in conjunction with horizontal patterning
- The fingers or wrapping jacks, with their warp yarn pins, must rotate in unison with the cylinder in order for each to remain with its section of needles.
- Solid-colour warp insertion can be achieved with the *eamber wrapping method*, which may be used on any of their needle selection machines.
- The first selection system of the sequence **selects needles to receive the wrap yarn**, and the second selects the remaining needles to receive the weft ground yarn.
- According to machine model, diameter, and gauge (E 5-32), up to 100 or more fingers will successively pass through each section and be capable of wrapping across up to **eight or more selected adjacent needles**.

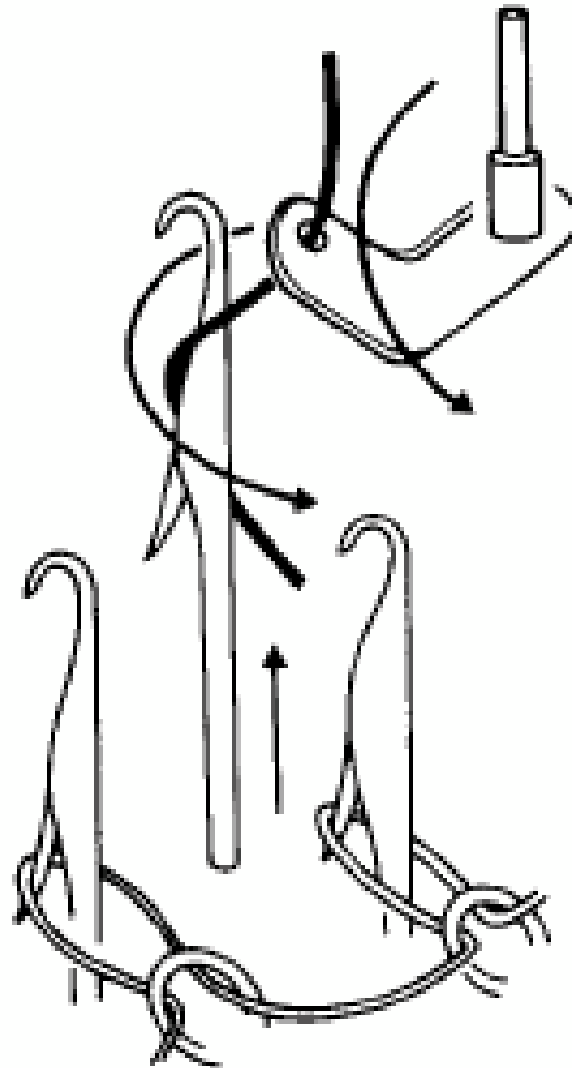


Fig. 14.7 Wrap pattering.

# Multi guide bar machines and fabrics

## The development of raschel lace

- *Kari Mayer* introduced the first raschel lace machine in 1956, using 12 guide bars.
- By 1964, 36 guide bars were achieved, followed by 42 in 1968.
- 
- Electronics began to replace mechanical guide bar control and, in 1981, 42- and 56-guide bar raschels without conventional chains were introduced.
- In 1985, the first '*Jacquardtronic*' lace raschel with 78 guide bars, electronic pattern guide bar control, and electronic jacquard selection was unveiled.

# The success of raschel lace

- Many factors have contributed to the success of warp knitting in the production of lace, curtain-net and elastic fabrics:
  1. The inability of the slow, traditional lace and net machines to meet rapidly expanding demands for these types of fabrics.
  2. An availability of fine, strong, uniformly regular, continuous filament yarns ideally suitable for high-speed warp knitting, such as nylon for lace, polyester for curtaining, and elastomeric yarns for elastic laces.

- 3) The greater suitability of the raschel machine for utilizing synthetic filament yarn than traditional lace machinery, with higher productivity.
- 4) Ability to achieve satisfactory imitations of mesh constructions such as tulle and marquissette by pillar inlay lapping movements.
- 5) Development of specific purpose machines with higher speeds and greater patterning capabilities encouraged by the introduction of the multi-guide bar lace raschel
- 6) Improvements in patterning techniques such as jacquard.

# Pattern guide bars

- On conventional multi guide bar machines, **pattern guide bars** are only required to **supply one thread each** for a pattern repeat width.
- Different yarn counts or types are used to achieve greater effect.
- To use **ordinary guide bars** for this purpose would be uneconomical as their weight would **lower the machine speed**.
- Also, only about **eight to thirteen shogging or displacement positions** are available so the patterning capabilities would be severely restricted.

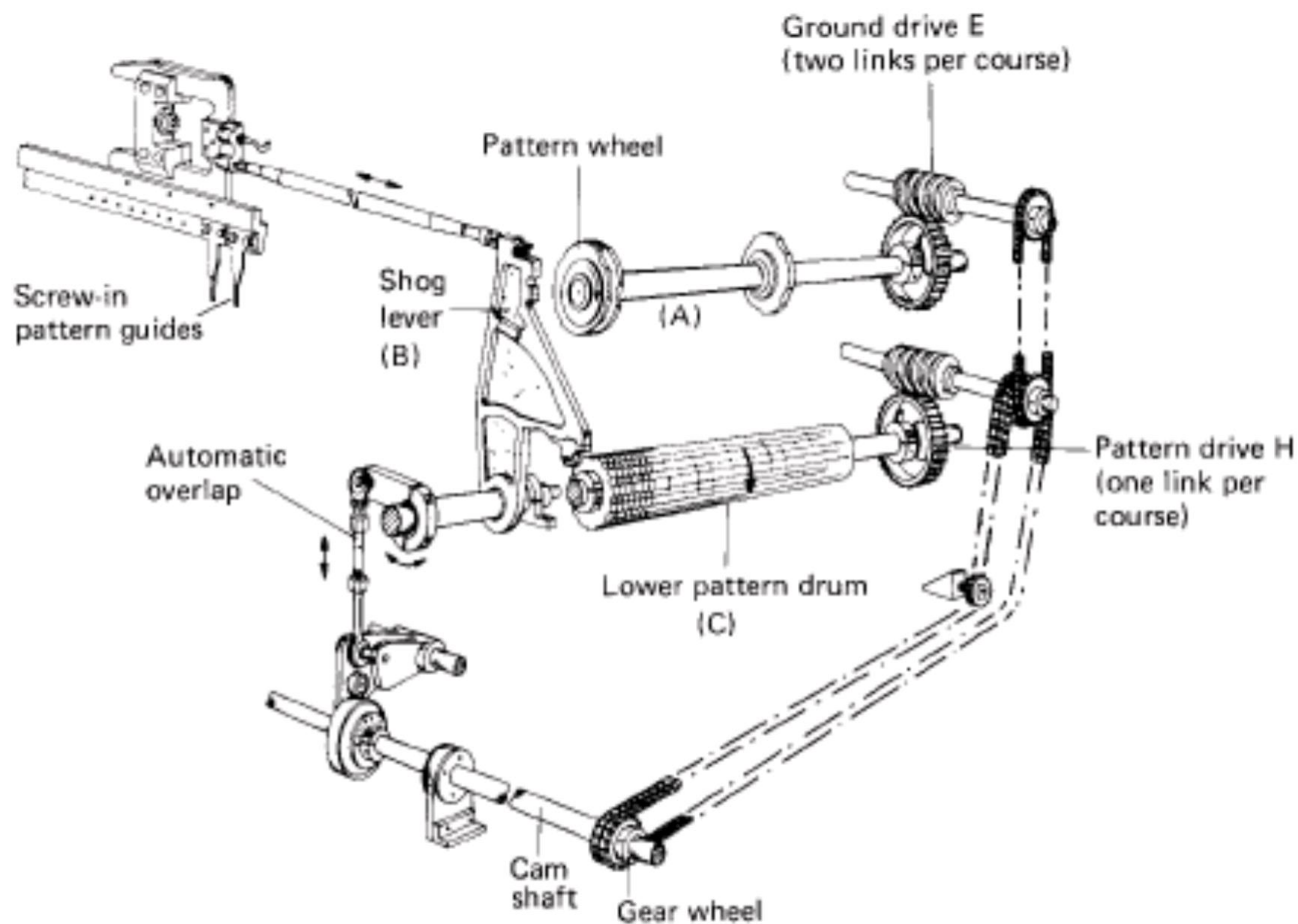


Fig. 28.2 Automatic overlap guide bar drive.

- Instead, **light-weight pattern guide bars** are used that have drilled holes to which *ringer guides* are screw-attached, only at the required spacing for the pattern.
- These bars are indirectly shogged by a lever arrangement (8) at a rate of one link per course (C), both for inlay and for fall-plate or embroidery patterning [1]
- In the last 2 cases, an automatic overlap mechanism is used.

# Multi'bar tricot lace machines

- Multi guide bar tricot machines with between **eight and eighteen** guide bars have been built in gauges of **E 24-28** for the production of fine gauge lace.
- **Two fully threaded bars** are used to knit the ground, such as reverse **locknit or queenscord**, with fine yarn such as 44 dtex nylon.
- Pattern bars behind the ground bars are used for inlay effects.
- Those bars in front are employed for **embroidery designs** in the form of overlaps and underlaps, in a textured yarn so that **they stand out** in relief on the technical back.
- The **knitted overlaps** show through from the **face** and the **underlaps float across the back** .

# chain links and electronic control of shogging

- Ground guide bars are generally controlled directly from links or pattern wheels moving at two links per course (A).
- The pattern guide bars are controlled indirectly through shogging levers (8), using only one link per course (either they only inlay or they are caused to automatically overlap in the same direction after the underlap is completed by an eccentric working onto the shogging levers).

# Raschel mesh structures

- *Mesh structures* can be produced by *piiiar stitchliniay*, which may be used alone or as the ground for designs produced by pattern bars.
- The overlaps and underlaps of the *front guide bar* knitting the mesh will hold (on *the technical back* of the fabric) the inlay pattern threads of guide bars behind it at each course.
- Mesh structures may be used alone or as the ground for designs produced by *pattern bars* .
- The three main raschel lace gauges are:
- 28-gauge (E 14), which is *coarse gauge* (Fig. 28.6) and is mainly used for dress-wear with the designs being emphasised by heavy outline threads;

- 36-gauge (E 18) which is the standard gauge (Fig. 28.7); and
- 48 gauge (E 24) which is **fine gauge**, provides better definition in designs, and is also used for lace edgings, etc. (Fig. 28.8).
- *Three-course tuiie* is the **standard mesh** for raschel lace, producing three courses on each wale with the inlay reinforcement lapping in unison.
- When the **pillar and inlay** lap in opposition, a square mesh known as *cross tuiie or bridai veii net* is produced.

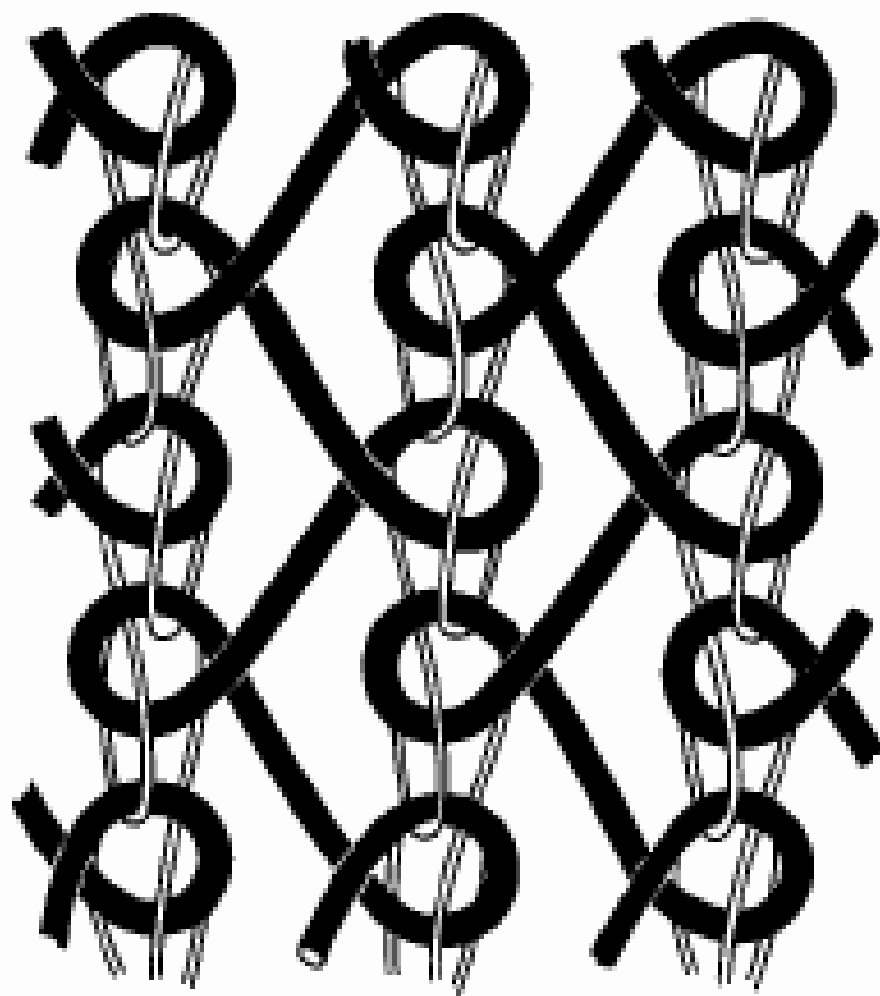


Fig. 27.5 Simple fall-plate loop structure.

# Elasticised fabrics

- Elasticised fabrics have long been used for foundation garments, and swimwear, but the introduction of fine-diameter elastane yarns whose elastic exten-sibility and recovery can be 'engineered' to particular requirements has extended the use of these structures into lingerie and active sports and leisure wear.
- Elasticised fabrics are knitted on high-speed raschel and tricot machines as well as in patterned form on multi guide bar lace machines.

# Productivity

- Productivity (P) is expressed in pattern rows per minute.
- In warp knitting this is same as courses but in weft knitting more than one course (and therefore feeders) may be required to produce one complete pattern row
- i.e. complete row of needle loops adjacent to each other
- In warp knitting  $P = R \times E$ , where R is the number of cam shaft revolution per minute and E is the machine efficiency

# Productivity in weft knitting

- $P = F \times R$  or  $T \times E / C$ , where
- $F$  is the number of active yarn feed points
- $R$  or  $T$  the number of machine revolutions or cam carriage traverses per minute
- $C$  is the number of courses or colors which comprise pattern row

# Quality control in knitting

1. Loop length and loop shape control
  - › The geometry of knitted structure is based on the prediction, measurement and control of individual loop length in a fabric
  - › Loop length is precisely controlled during knitting and loop shape is controlled after knitting during relaxation and finishing operation
  - › During knitting loop length is controlled by positive feed devices, storage devices, needle movement control and other suitable devices

# Warp let-off

- In warp knitting the beam rotate and release the length of warp used in a run-in this is called warp let-off
- Tension in the warp causes **it to be pulled** from the beam as it turns against a controlled friction. The fabric take up rollers helps to increase the pull
- Or the warp beams are positively driven to deliver a pre-determined run-in

# Robbing back

- As the needles descend the stitch cam, the tension required to pull yarn from the package increases rapidly

And

- it becomes easier to **rob back yarn** in the opposite direction from the **already-formed loops** of needles further back that are then beginning to rise from their lowest (knock-over) position.
- This results in the **loop length variation** in a fabric

# needle bounce and high speed knitting

- On circular knitting machines, higher productivity involves faster needle movements as a result of an increase in the number of knitting feeds and of machine rotational speeds.
- On **fabric machines**, the machine revolutions per minute have almost doubled and the number of feeders have increased twelve-fold over the past 25 years,
- so that as many as **4000 courses per minute** can be knitted on some plain machines, whilst on some high-speed seamless hose machines the tangential speed of the needles can be more than **5 metres per second**.

- To achieve this productivity, research and development has been necessary into **machine, cam and needle design**.
- '*Needle bounce*' is a major problem in high speed knitting.
- This is caused by the needle butt being suddenly checked by the impact of **hitting the upper surface** of the **up-throw cam** after it has accelerated away from the lowest point of the stitch cam.
- At this moment, **inertia** at the **needle head** may cause **it to vibrate** so violently that it may **fracture**; also the up-throw cam becomes pitted in this section

- To reduce this effect, a separate cam is often used to guide these butts at a more gradual angle.
- The smoother profiles of non-linear camming help to reduce needle bounce

## Stitch density

- *Stitch density* refers to the **total number of loops** in a measured area of fabric and **not to** the **length of yarn in a loop** (*stitch length*).
- It is the total number of needle loops in a given area

# Properties of weft Knit. machines

	Flat machines	Circular machines	Straight bar
Gauge (E)	3 - 18	5 - 40	14 - 50, max 90
Machine width	Up to 78.7inches	Upto 30inch dia, max. 60inch dia	2 - 16 sections, 36inch Totally = 72 - 576inchs
Needle type	Latchlcompound	Latchlbearded	Bearded
Needle bed type	Singleldouble	Singleldouble	Singleldouble
Products	Jumpers, pullovers, cardiagans, dresses, suits, trousers etc -	Seam free hose, tights, sports socks, trousers, vests, thermal wear, etc -	Jumpers, cardigans, dresses, suits, fully fashioned hose, underwear, etc -

# Properties of warp machines

	<b>Tricot machine</b>	<b>Raschel machine</b>
Gauge (E)	18 - 40	12 - 32
Machine width	84 - 210 inches	75 - 210 inches
Machine speed	2000 - 3500courses/min	500 - 2000courses/min
Needle type	Beardedl compound	Latchlcompound
Number of needle bars	1 or 2	1 or 2
Number of guide bars	2 to 8	2 to 78
Products	Lingerie, shirts, outwears, leisure wears, sports wears, swim wear, car seat covers etc - .	Curtains, nets, table clothes, bed covers, geotextiles, medical textiles, velvets, upholstery etc - ..