Coloured stitch designs in weft knitting

Colour is one of the five ingredients of fashion, the other four being style, silhouette, texture and pattern [1].

Ornamentation for design purposes may be introduced at the fibre, yarn, or dyeing and finishing stage, as well as at the knitting stage. Apart from different colours, it may take the form of sculptured or surface interest. In fibre form it may include a variation of fibre diameter, length, cross-section, dye uptake, shrinkage, or elastic properties. In yarn form it can include fancy twist and novelty yarns, as well as the combined use of yarns produced by different spinning or texturing processes. The dyeing process, which provides the possibility of differential and cross-dyeing of fabrics composed of more than one type of fibre, may occur at any point in manufacturing from fibre to finished article [2].

The finishing process may also utilise heat or chemically-derived shaping. Finally, printing and particularly transfer printing [3] can introduce colour designs onto plain colour surfaces, whilst embroidery stitching may provide relief designs in one or more colours (usually onto garment panels or socks).

The finishing process can completely transform the appearance of a relatively uninteresting structure, either as an overall effect or on a selective basis.

The knitting of stitch designs always involves a loss of productivity compared with the knitting of plain, non-patterned structures. Machine speeds are lower, less feeds can generally be accommodated, efficiency is less, design changes are time-consuming and dependent upon technique and machine type, and, in many cases, more than one feeder course is required to knit each pattern row.

At the knitting stage, apart from stitches for surface interest and other functional purposes, four techniques may, if required, be employed to produce designs in coloured stitches. These are *horizontal striping, intarsia*, *plating*, and *individual jacquard stitch selection*.

10.1 Horizontal striping

Horizontal striping provides the facility to select one from a choice of several coloured yarns at a machine feed position (Fig. 10.1). Even without striping selection facilities, by careful arrangement of the packages of coloured yarns on a large-diameter, multi-feeder machine, an elaborate sequence of stripes having a depth that is repeated at each machine revolution, is obtained.

However, machines with few feeds (particularly garment length and hosiery machines) would have severely restricted capabilities without the facility of yarn changing by striping finger selection, which can provide a choice of one from four or five yarns at a particular feed point during each machine revolution. The choice of yarns may include elastic yarn and separation yarn as well as a choice of colour.

On flat and straight bar frames, yarn carrier changes can take place during the pause in knitting on completion of each traverse. On circular machines, striping finger changes must occur whilst the needle cylinders or cam boxes rotate. A slight overlap of the two interchanging yarns is essential to maintain a continuous yarn flow at the knitting point.

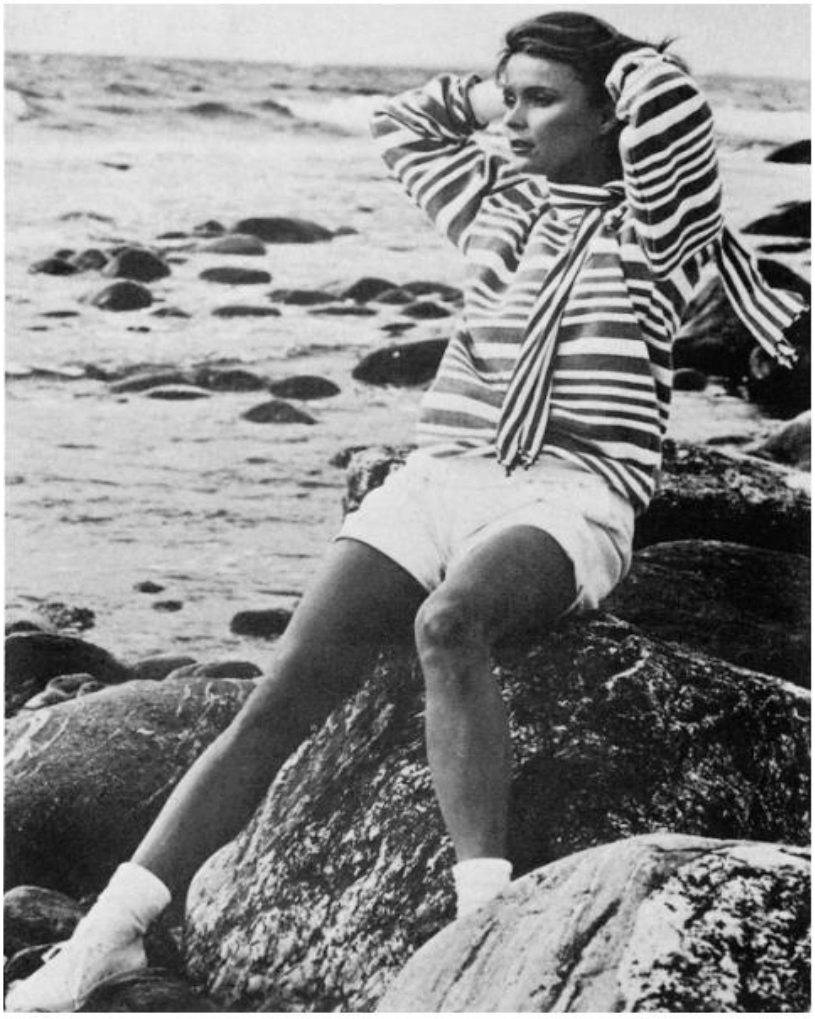


Fig. 10.1 An attractive use of horizontal striping [International Institute for Cotton].

As the yarn finger is withdrawn from the needle circle with its yarn cut free and securely trapped and held for later re-selection, the newly-selected finger in the same unit or box is simultaneously introduced into the needle line. Its trapper releases the held cut end of yarn, allowing it to flow from its package to the needles. The facility of an individual cutter and trapper for each yarn in the unit is mechanically more complex but it enables a yarn as thin as 30 denier nylon to be trapped alongside a yarn as thick as 5/1's (NeB) cotton.

Although striping is useful for the introduction of a draw-thread in a full-course and splicing reinforcement on a part-course basis, the mechanism is not precise enough for individual stitch patterning. Its speed of operation and versatility has, however, been improved by employing electronic control so that the *engineered* placing of stripes of specific widths in the length of a garment is now possible [4,5].

10.2 Intarsia

Intarsia (Figures 10.2 and 10.3) is a special method of producing designs in knitted loops that form self-contained areas of pure colours. Unequalled colour definition

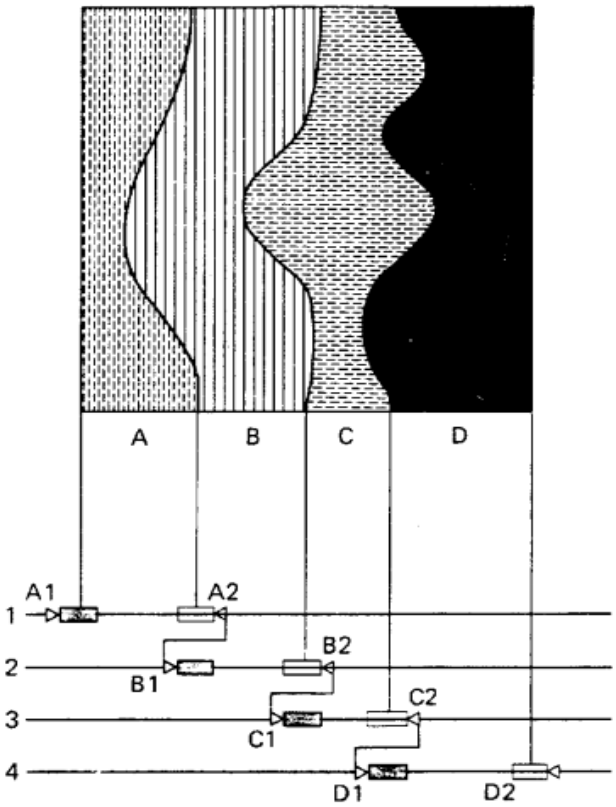


Fig. 10.2 Yarn carrier positioning for intarsia. Four zones are illustrated. Each colour (A, B, C and D) is supplied by its own yarn carrier, which travels only between its own carrier stops (which are capable of being repositioned). All carriers traverse in the same direction at a particular course. The stop blocks of adjoining colour zones (e.g. A2 and B1) are linked together so that when one yarn carrier traverse is decreased (for example, towards the left) the adjoining carrier traverse is correspondingly increased.

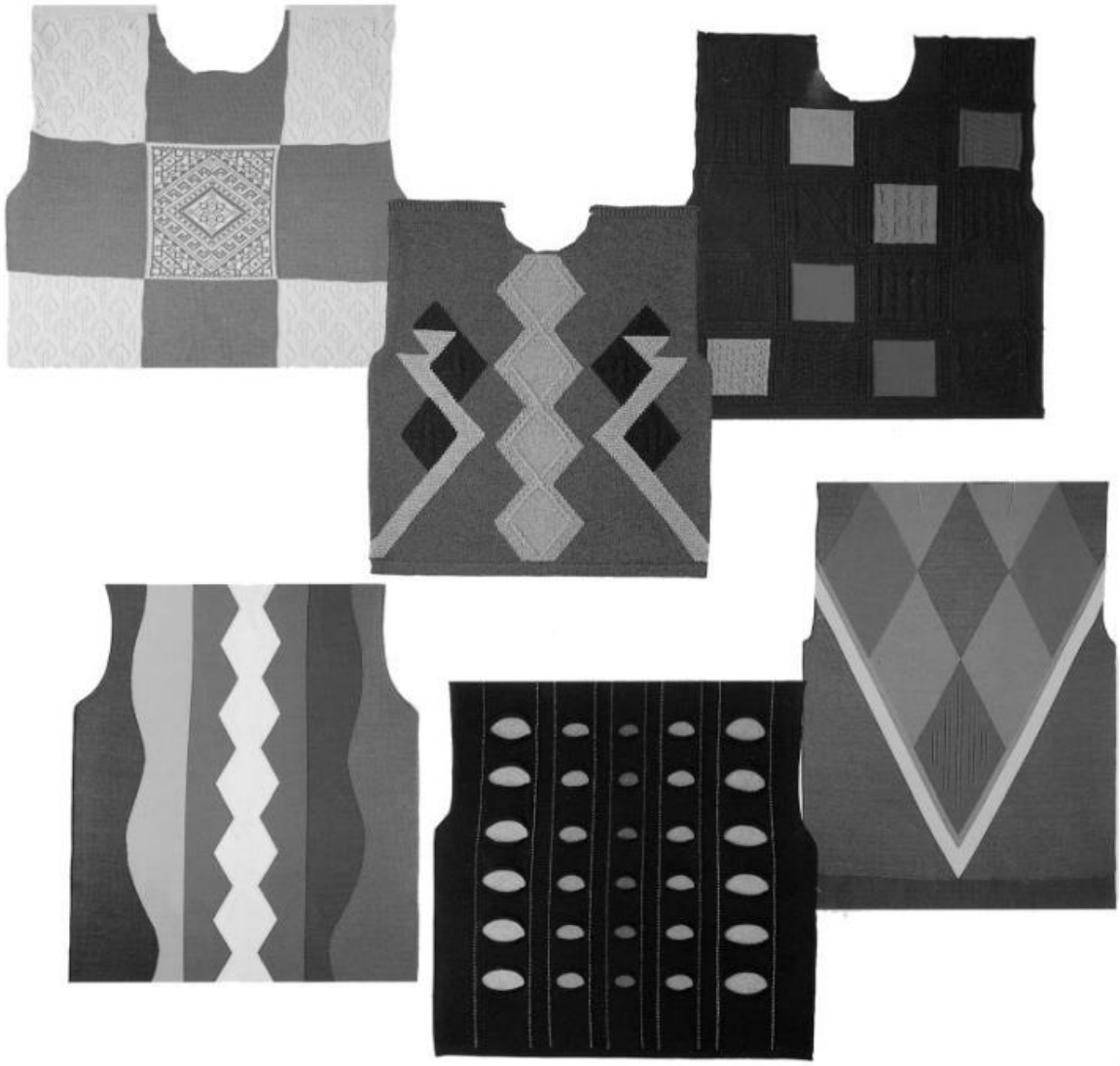


Fig. 10.3 Examples of intarsia designs knitted on an electronic V-bed machine

is achieved, with a large number of colours and no adverse effect on the physical properties of the structure such as reduction of extensibility.

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 coloured areas into a cohesively-knitted structure. Such a cohesive structure is achieved by slight overlap of adjoining areas and the intermeshing of loops in each wale. As well as plain and 1×1 rib, other stitches such as purl or cable may be utilised.

A design row of intarsia is divided into adjoining blocks of contiguous wales. Each block of needles knits a separate coloured area (*field*), for which it is exclusively supplied with its own particular yarn (Fig. 10.2). The yarn then passes to the course above and does not float across the backs of needle loops. If there are further

blocks of needles in the design row requiring the same colour, each will be supplied by a separate yarn.

The knitting action and supply of yarn for intarsia is from left-to-right at one course, and right-to-left at the next. This is the normal reciprocating movement found on all V-bed flat machines and straight bar frames. On circular, single-cylinder sock machines, it is necessary to oscillate the cylinder (similarly to heel knitting) instead of continuously revolving it.

Traditionally, intarsia was skilfully knitted by hand, laying the yarns into the hooks of each block of adjacent needles as they are cammed outwards, on hand-operated stationary needle bed machines such as the circular *Griswold* type sock machine or the flat bed *Dubied* model 00 machine.

High-quality woollen Argyle tartan socks and sweaters can be knitted, consisting of diamond-shaped designs crossed diagonally by one wale wide stripes termed *overchecks*.

Only on a hand-manipulated flat machine with hand-feeding of the yarn can a *pure join* of adjoining areas be achieved. As the edge yarn of an area rises to the next course, it crosses over and links to the edge yarn of the adjacent colour area.

Most automatic methods of knitting intarsia entail some way of overlapping (encroachment) of adjoining areas into each other, towards the right at one course and towards the left at the next. A slight saw-tooth effect across one, two, or more wales is thus produced at the join, which should be kept to a minimum, and the plating of knitted or tuck loops can be employed. Argyle socks can be knitted automatically with plated overchecks.

Intarsia designs for full-fashioned sweaters have generally been balanced geometrical shapes because of the screw spindle control of the carrier stops. However, intarsia patterning as an optional extra on electronic V-bed flat machines is becoming increasingly sophisticated (Fig. 10.3), with precise yarn positioning, needle selection and carrier traversing that may be controlled electronically.

Although intarsia ensures that expensive yarns are fully utilised on the surface of the design, it is only generally suitable for geometric type designs (although they no longer need to be symmetrical) and not for figure designs in small areas. It is a comparatively slow, expensive, specialised technique that is subject to the whims of fashion.

10.3 Plating

Plating is widely used for single jersey, plush, open-work, float and interlock fleecy. However, with the exception of *embroidery motif plating*, the use of coloured yarns to produce plated designs has diminished in weft knitting. Plating requires great precision and offers limited colour choice with poor definition compared with the improved facilities offered by jacquard knit and miss needle selection of coloured stitches.

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, set lower into the needles,

supply yarn in a reciprocating movement to a particular group of needles, so that the colour shows on the face.

The one major advance in pattern plating coloured yarns has occurred in *weft embroidery motif plating* on electronically-controlled, single-cylinder hosiery machines knitting so-called 'computer socks'. The main yarn is a fine, undyed filament nylon, which is continuously knitted throughout the sock. At each feed there is a group of coloured bulked yarns. A selected yarn is fed, in a plating relationship with the main yarn, to one or a group of adjacent needles according to the required design. The next adjacent needle(s) will receive a different coloured yarn, selected from the same group of yarns.

All the needles will thus receive a plated bulked yarn of some colour, whether they are knitting the motif or the ground colour. The designs appear to be pure colour intarsia because the main yarn is fine and is hidden by the plated, coloured bulked yarns. There are no floating threads on the inside of the sock because the yarn is cut and trapped when not in use. Care must be taken to ensure that the pattern threads are securely retained in the fabric.

Simple motif embroidery designs using warp threads have, for many years, been *wrap-knitted* on the side panels of double-cylinder half-hose. The technique is slow and less popular than weft embroidery patterning.

10.4 Individual stitch selection

Individual stitch selection is the most versatile and widely-employed method of knitting designs in colour, or different types of stitches in self-colour. It is based on the relative positioning of an element during a knitting cycle determining which stitch, from a choice of two or more, is produced in its corresponding wale at a particular feeder course of a machine revolution or traverse.

Latch needle weft knitting machines are especially suitable because their individually tricked and butted elements offer the possibility of independent movement. Depending upon machine and element design, and cam arrangement, one or more of the following stitches may be produced – knit, tuck, miss, plated, plush, inlay, loop transfer and purl needle transfer.

The following rules apply to individual element selection of stitches:

1 If each set of elements has butts of identical length and position, and the cam-track is fixed, each element will follow the same path and produce an identical stitch in its corresponding wale at that feeder course (Fig. 3.4).
2 If each feed in the machine has the same arrangement of fixed cams, identical stitches will be knitted in each wale at every feeder course (Fig. 7.1).
3 When the butts of adjacent elements are caused to follow different paths through the same cam system, different stitches may be knitted in adjacent wales of the same feeder course (Fig. 9.11).
4 When butts of the same element are caused to follow a different path through successive cam systems in the same machine, more than one type of stitch may be produced in the same wale (Fig. 9.4).
5 Unless the device is of the variable type that can present a different selection commencing in the first wale of each traverse or machine revolution, the design depth in feeder courses will be the number of operative feeds on the machine.

If the device is variable, the design depth will be increased by a multiple of the number of different selections available per device

10.4.1 Weft knitted jacquard

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

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

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

If striping is employed with jacquard selection, different colours can be selected at different design rows so that there are more colours in the total design than in one design row. For example, a four-feed machine with four-colour striping at each feed could knit 4 colours per design row but have a total of 16 colours in the design depth.

10.4.2 Single-jersey jacquard

Single-jersey jacquard (Fig. 10.4) in knit and miss stitches produces clear stitch definition, exemplified by the *fair isle designs* used in woollen cardigans and pullovers. The floats to some extent reduce the lateral extensibility of the garments and, when continuous filament yarns are used in gauges of E 18 or less, the floats on the technical back can create problems of snagging. Single-cylinder sock machines may knit 1 × 1 *float stitch jacquard*. Odd needles are selected to knit and miss whilst even

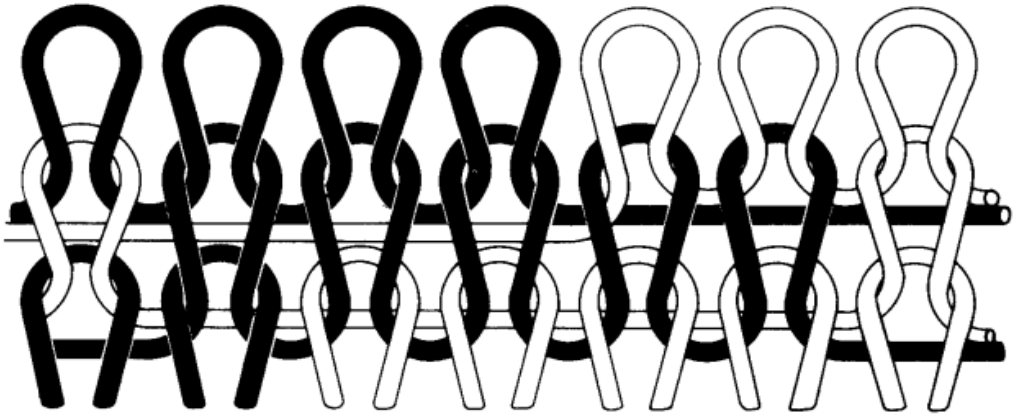


Fig. 10.4 Single jersey jacquard.

needles knit at every feed, thus reducing the coloured yarn floats on the technical back to a single wale. The clarity of the coloured pattern area is only slightly impaired.

10.4.3 Accordion fabric

Accordion fabric (Fig. 10.5) is single jersey with the long floats held in place on the technical back by tuck stitches. It was originally developed using knit and miss pattern wheel selection (Section 11.11). Needles required to tuck (if not selected to knit) were provided with an extra butt, in line with a tuck cam placed immediately after the pattern wheel selection.

In *straight accordion*, every odd needle was of this type, so every odd needle tucked when not selected to knit.

Alternative accordion provides a better distribution of tuck stitches; odd needles had a tuck butt position in line with cams placed at odd feeders, and even needles had another butt position for cams at even feeders. With both these types of accordion, tuck stitches occur close together, causing distortion of face loops and allowing unselected colours to 'grin' through between adjacent wales onto the face.

The third type of accordion – *selective accordion* – is most widely used, but it requires a three-step pattern wheel or other selection device that can select the tuck loops so that they are carefully distributed to create the minimum of stitch distortion on the face of the design.

10.4.4 Rib jacquard

Rib jacquard designs are achieved by cylinder needle selection. The dial needles knit the backing and eliminate floats that occur when cylinder needles only are selected to miss (Fig. 10.6). Tuck stitches are therefore unnecessary. There are two groups of these fabrics – flat jacquards and relief designs.

Flat jacquards are described by the size of the design area followed by the number of colours in one complete pattern row of loops and the type of backing.

On circular machines, the selection is on the cylinder needles only and the dial

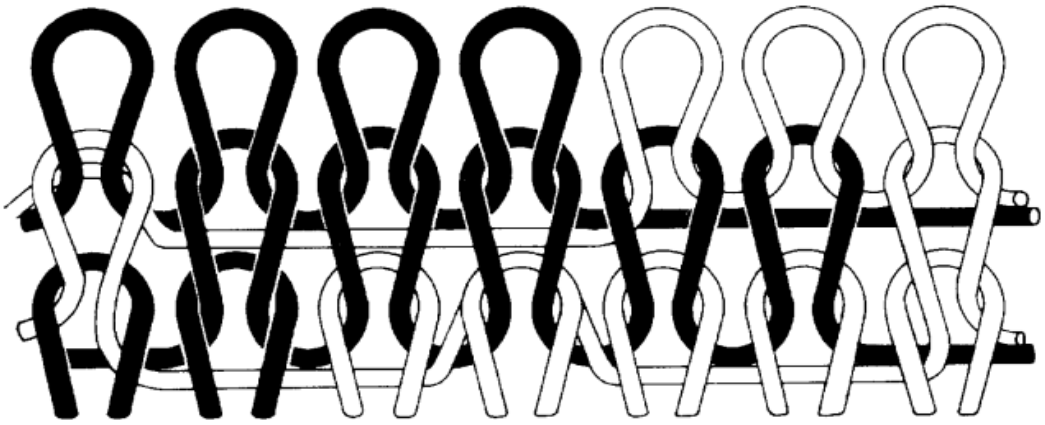


Fig. 10.5 Accordion fabric.

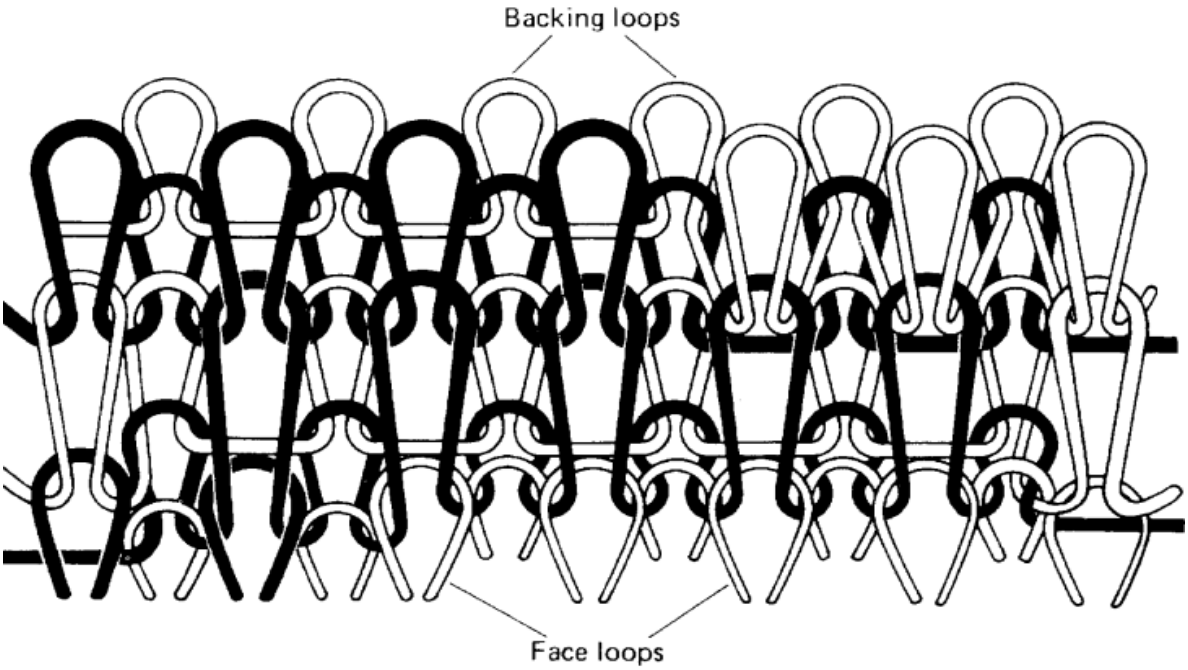


Fig. 10.6 Rib jacquard.

needles knit the backing loops, whereas on flat machines both beds may have selection facilities.

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

For double jersey fabrics, *birds eye* or *twill backing* (Fig. 10.7) is preferred as this is a more stable structure which is better balanced and has a pleasing, scrambled-colour appearance on the backing side. It is achieved by knitting the backing on alternate needles only and arranging for each colour to be knitted by odd backing needles at one feed and even needles at the next. The optimum number of colours is usually three.

On flat machines, it is possible to select only certain needles to remain in action to knit the backing; for example, 1 in 3 or 1 in 5. This is termed *ladder backing*. The backing needles virtually chain knit the floating threads in the back of the fabric. This produces a lighter fabric but there is less connection between the design and the backing sides of the fabric.

Whereas flat jacquard patterns have equal numbers of loops in each wale of the pattern repeat, *blister* and *relief patterned* fabrics do not. Links-links purl machines (particularly hosiery machines) may have facilities for knitting combined colour and stitch effects. Usually, the needles in one bed knit continuously so that the lateral extensibility of the structure is not too adversely affected. *Float bolt* patterning is more restricted. At the first feed, needles selectively transferred to the bottom cylin-

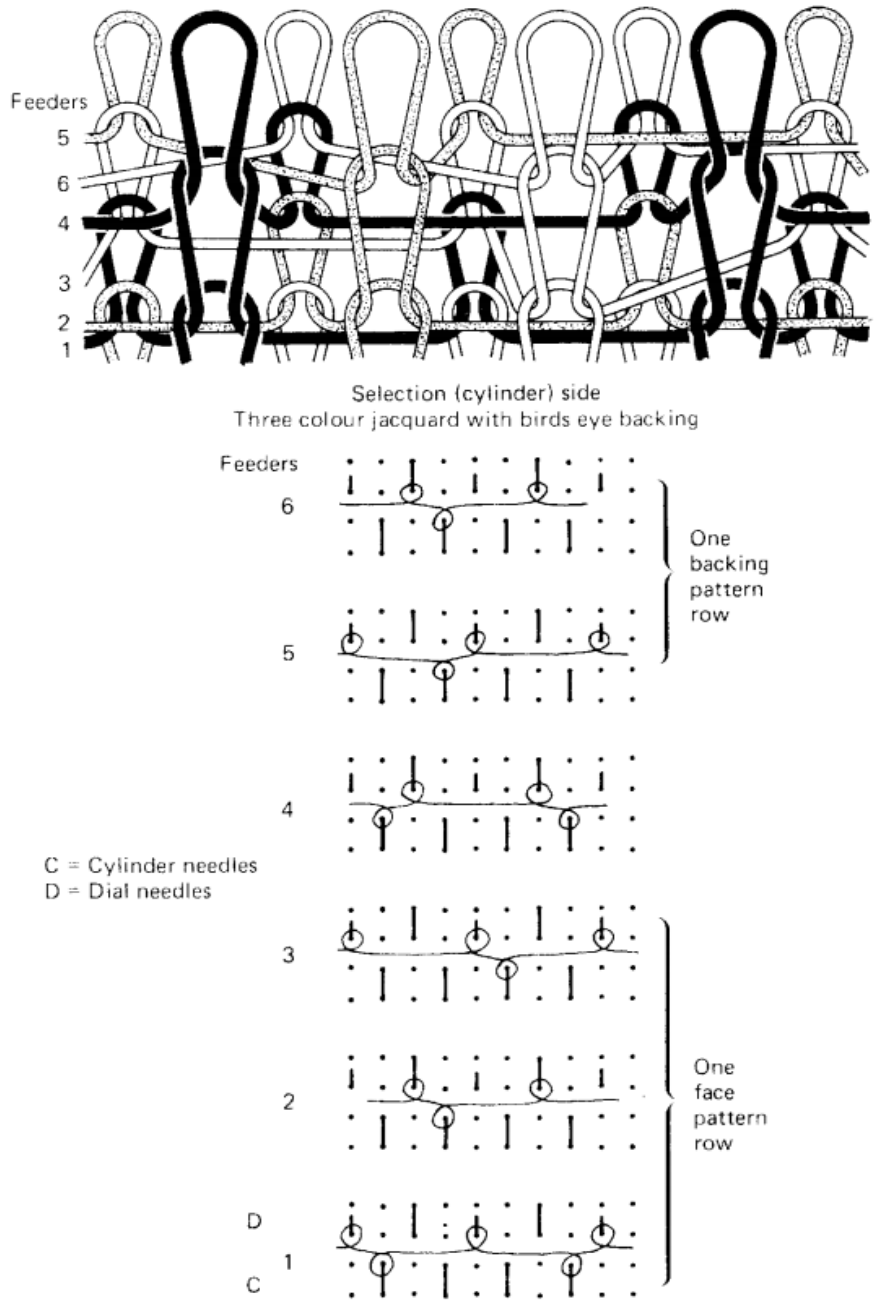


Fig. 10.7 Three colour jacquard with birds eye backing.

der knit together with those remaining in the top cylinder. At the second feed, the latter knit alone with the miss stitches floating at the back of the plain loops of the previous course. In combined links-links and three colour float jacquard, needles may be selected to knit in the bottom cylinder at any one of the three feeds. The needles which remain in the top cylinder knit at each of the three feeds, producing floats behind held plain loops (Fig. 10.8).

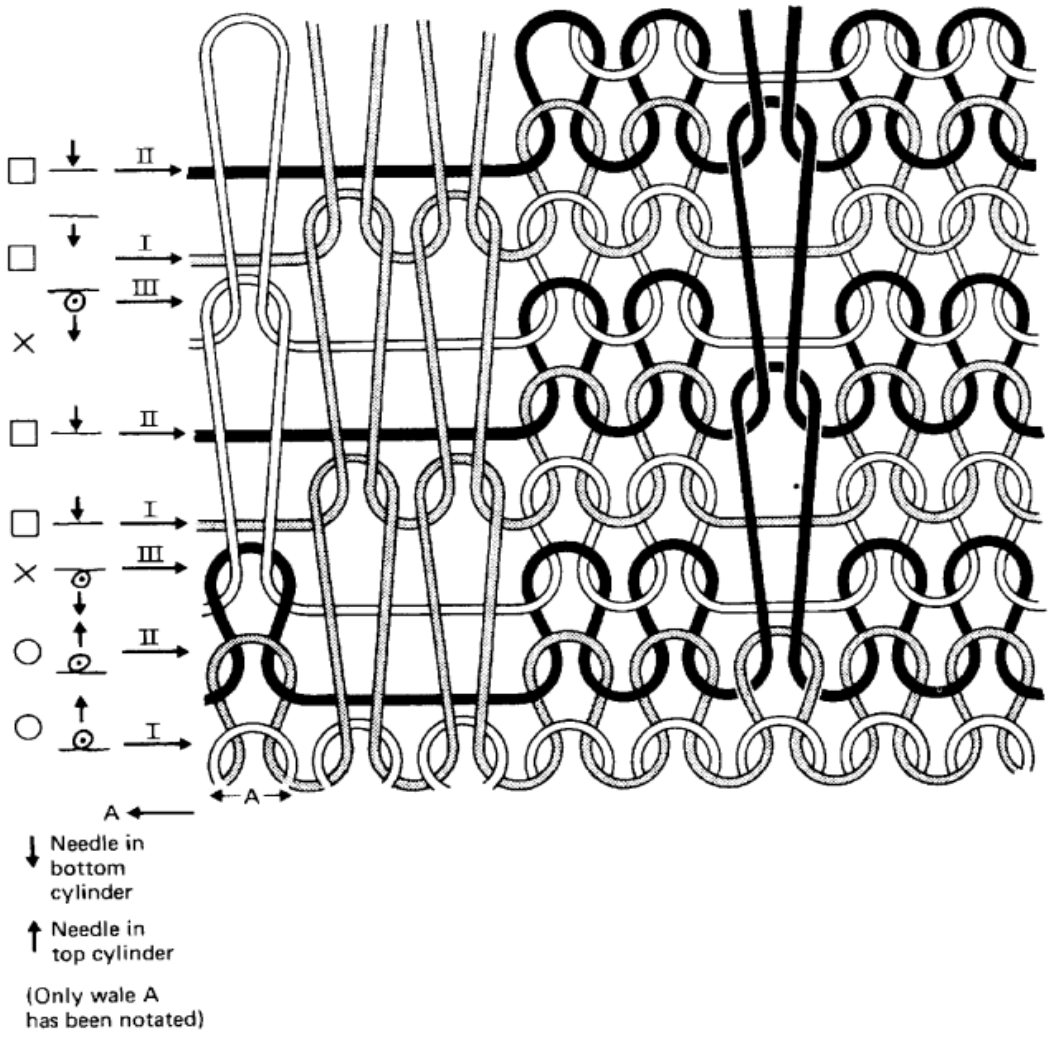


Fig. 10.8 Combined links-links and three colour float jacquard.

10.5 Jacquard design areas

The design area is controlled by the selection system of the machine:

Full jacquard implies unrestricted pattern depth in pattern rows and a width that may be the total number of needles in the machine.

Large area jacquard designs have a pattern depth that requires more than one machine revolution to be developed and therefore each feeder contributes two or more courses; the pattern width is usually more than 48 wales.

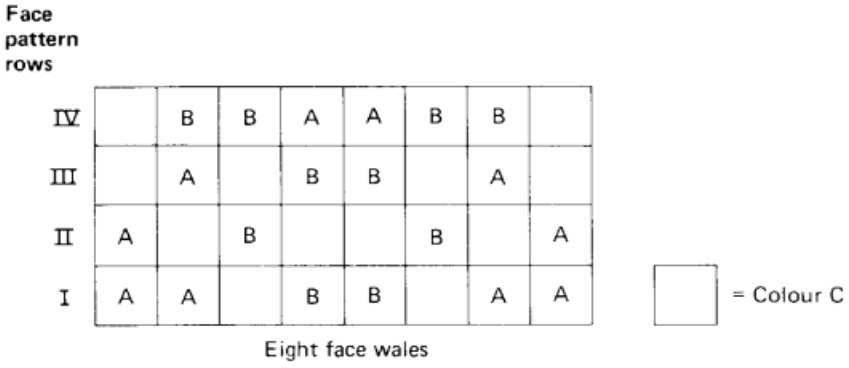
Small area jacquard has a pattern depth which is developed in one machine revolution so that each feeder contributes only one course from a fixed selection, and the pattern width is 48 wales or less.

10.6 Worked example

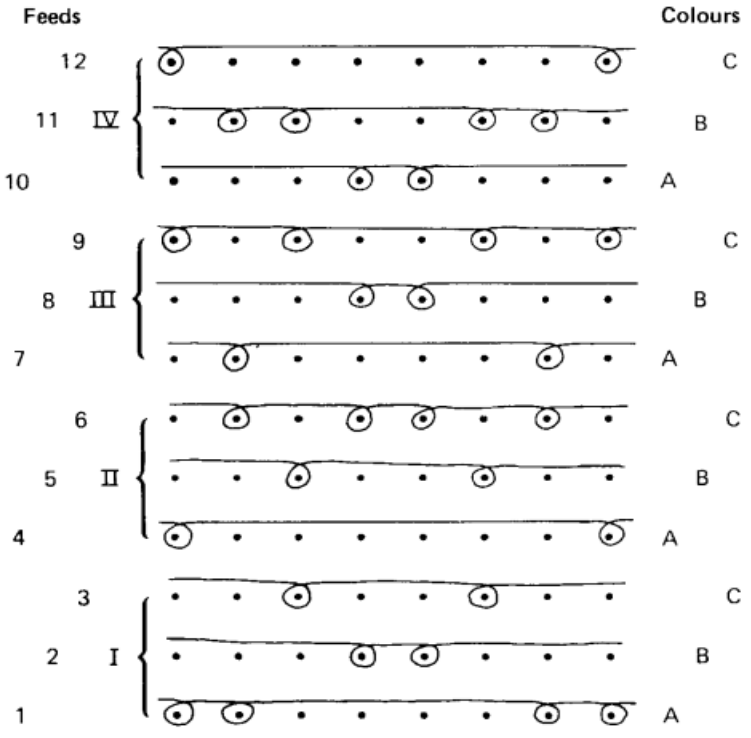
The squared diagram illustrates part of a three-colour jacquard design, each face stitch being represented by a square.

Using the running thread notation, provide:

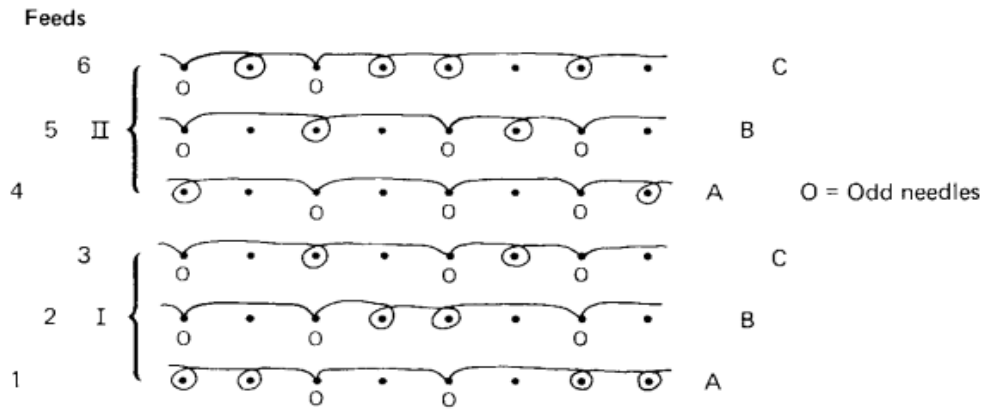
(a) A representation of the design for single jersey knit/miss jacquard.
(b) A repeat of the representation of the first two pattern rows for:
  (i) straight accordion,
  (ii) alternate accordion, and
  (iii) selected accordion.
(c) A representation of the first two pattern rows as rib jacquard with:
  (i) horizontally-striped backing,
  (ii) vertically-striped backing, and
  (iii) birds eye backing.



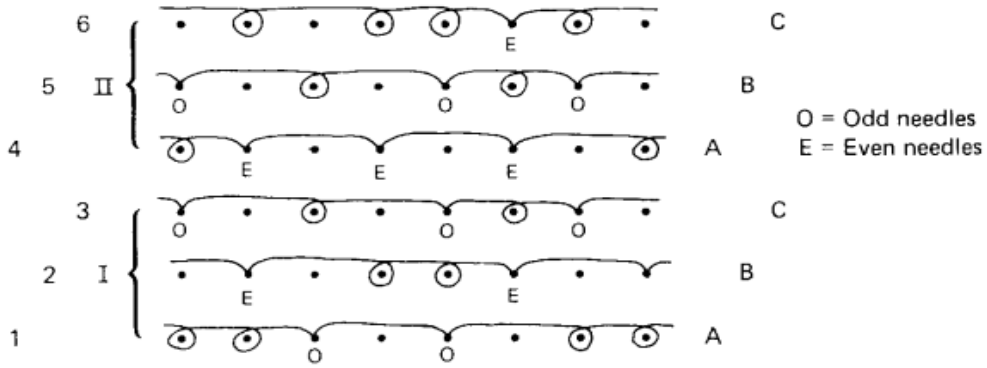
Eight face wales



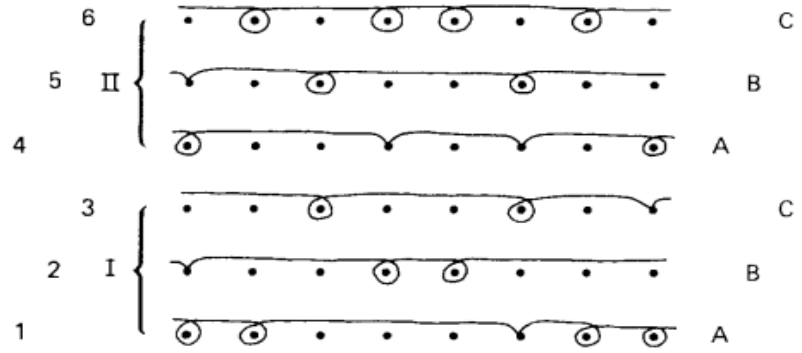
(a) Single jersey knit/ miss Jacquard



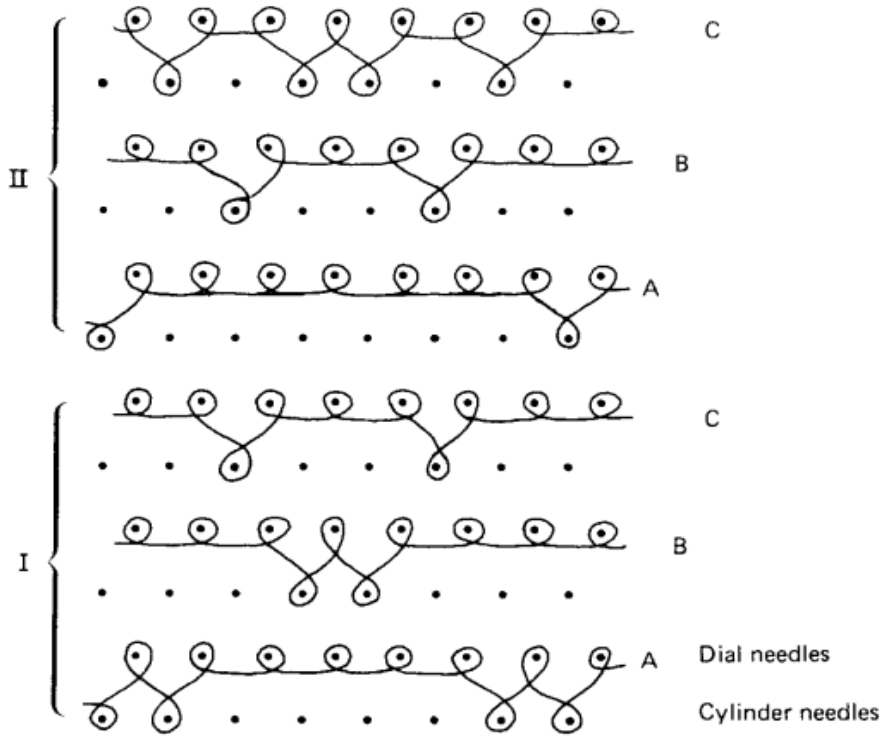
(b) (i) **Straight accordion** (tucking on non-knitting odd needles)



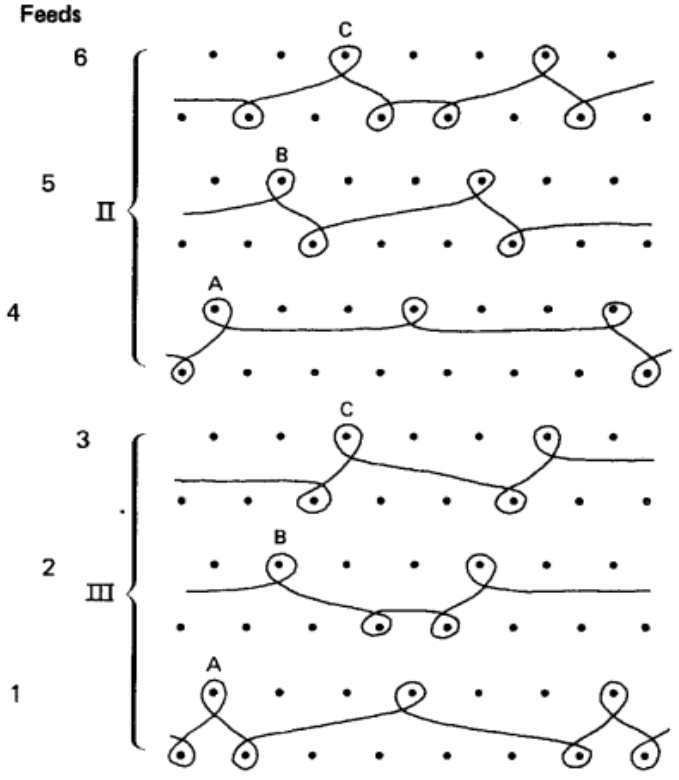
(b) (ii) **Alternate accordion** (tucking on odd needles at odd feeders and even needles at even feeders when non-knitting)



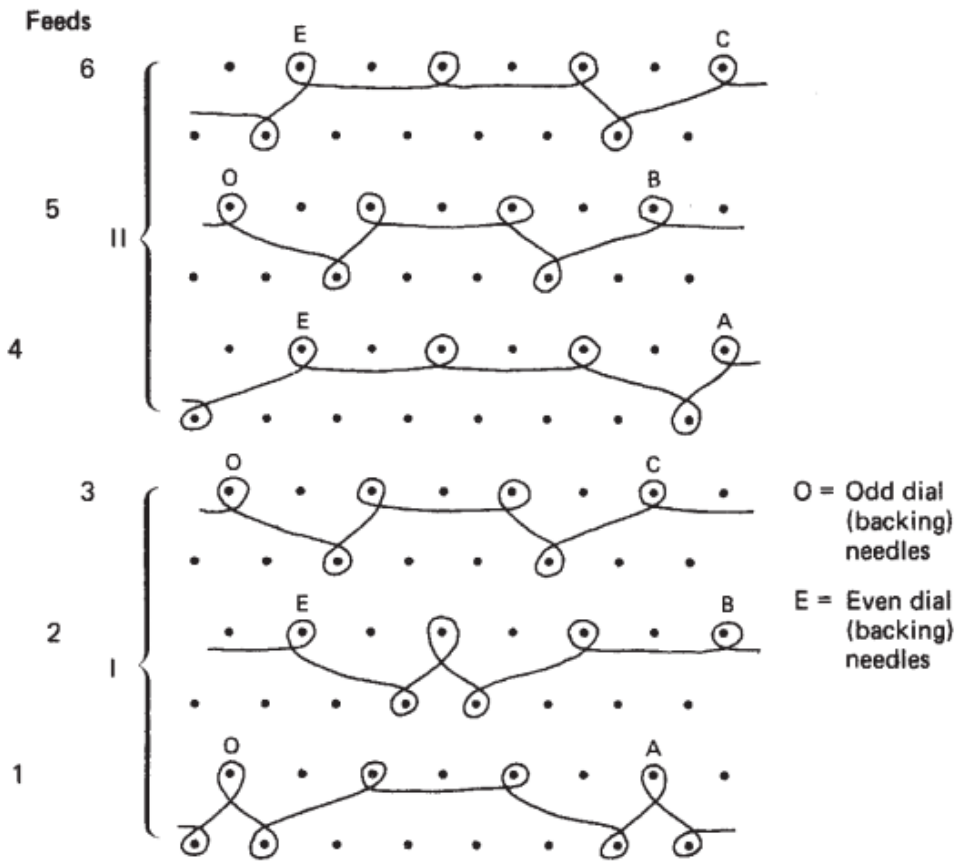
(b) (iii) **Selected accordion** (tucking only on carefully selected non-knitting needles)



(c) (i) Rib Jacquard with horizontally striped backing



(c)(ii) Rib Jacquard with vertically striped backing



(c)(iii) Rib Jacquard with birds eye backing